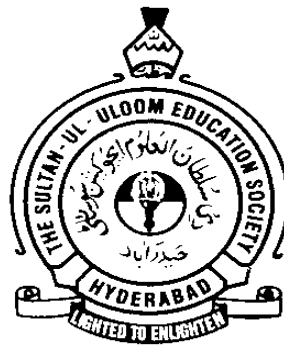# MUFFAKHAM JAH

COLLEGE OF ENGINEERING AND TECHNOLOGY

PC-651-EC

COMMUNICATIONS LAB

(With effect from the academic year 2016-2017)

STUDENT'S MANUAL

DEPARTMENT OF

ELECTRONICS AND COMMUNICATION ENGINEERING

Vision and Mission of the Institution

Vision

To be part of universal human quest for development and progress by contributing high calibre, ethical and socially responsible engineers who meet the global challenge of building modern society in harmony with nature.

Mission

- To attain excellence in imparting technical education from the undergraduate through doctorate levels by adopting coherent and judiciously coordinated curricular and co-curricular programs
- To foster partnership with industry and government agencies through collaborative research and consultancy
- To nurture and strengthen auxiliary soft skills for overall development and improved employability in a multi-cultural work space
- To develop scientific temper and spirit of enquiry in order to harness the latent innovative talents
- To develop constructive attitude in students towards the task of nation building and empower them to become future leaders
- To nourish the entrepreneurial instincts of the students and hone their business acumen.
- To involve the students and the faculty in solving local community problems through economical and sustainable solutions.

Vision and Mission of ECE Department

Vision

To be recognized as a premier education center providing state of art education and facilitating research and innovation in the field of Electronics and Communication.

Mission

We are dedicated to providing high quality, holistic education in Electronics and Communication Engineering that prepares the students for successful pursuit of higher education and challenging careers in research, R& D and Academics.

Program Educational Objectives of B. E (ECE) Program:

1. Graduates will demonstrate technical competence in their chosen fields of employment by identifying, formulating, analyzing and providing engineering solutions using current techniques and tools
2. Graduates will communicate effectively as individuals or team members and demonstrate leadership skills to be successful in the local and global cross-cultural working environment
3. Graduates will demonstrate lifelong learning through continuing education and professional development
4. Graduates will be successful in providing viable and sustainable solutions within societal, professional, environmental and ethical contexts

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

BANJARA HILLS, ROAD NO-3, TELANGANA
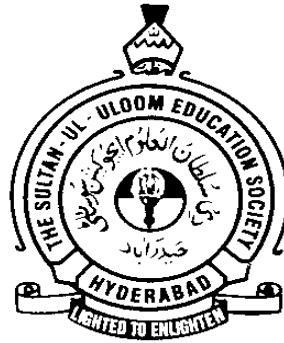
LABORATORY MANUAL

FOR

COMMUNICATIONS LAB

Prepared by: **Checked by:**

Approved by:

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRONICS AND COMMUNICATIONS ENGINEERING

(Name of the Subject/Lab Course): Communications Lab

Code: EC381   **Programme: UG**

Branch: ECE   **Version No: 1**

Year   : III   **Updated on:**

Semester :II   **No. of Pages:**

Classification Status(Unrestricted/restricted): Unrestricted

Distribution List :Department, Lab, Library, Lab Incharge

Prepared by: 1) Name :   **1) Name :**

          2) Sign   :   **2) Sign   :**

          3)Designation :   **3) Designation :**

          4) Date   :   **4) Date   :**

Verified by: 1) Name :   *** For Q.C Only**

          2) Sign   :   **1) Name :**

          3)Designation :   **2) Sign   :**

          4) Date   :   **3) Designation :**

                                                    4) Date   :

Approved by: (HOD) 1) Name:

              2) Sign :

              3) Date :

COMMUNICATIONS LAB

Instructions   4 Periods per week
Duration of University Examination   3 Hours
University Examination   50 Marks
Sessional   25 Marks

Course Objectives:

1. Demonstrate AM, FM, Mixer, PAM, PWM and PPM techniques.
2. Model analog, pulse modulation, PCM, Delta and Digital modulation techniques using CAD tools

Lab Experiments:

Part-A

1. AM generation and detection

2. FM generation and detection

3. Pre emphasis and De-emphasis circuits

4. Multiplexing Techniques (FDM and TDM)

5. Mixer Characteristics

6. Sampling , PAM, PWM, and PPM generation and detection

7. Generation and Detection of Analog and Pulse modulation techniques by using

   MATLAB/Simulink/Labview

Part-B

1. PCM generation and detection

2. Data formats / channel encoding and decoding.

3. Linear and Adaptive Delta Modulation and Demodulation

4. Modem characteristics.

5. ASK generation and Detection.

6. FSK and Minimum Shift Keying generation and Detection.

7. Phase shift keying methods (BPSK, QPSK) generation and Detection.

8. Generation and Detection of PCM, Delta modulation and Digital modulation Schemes

   (ASK. FSK, BPSK,QPSK) by using MATLAB/Simulink/Lab-view.

   General Note: At least 12 experiments are to be conducted.

COMMUNICATION LAB

GENERAL GUIDELINES AND SAFETY INSTRUCTIONS

1. Sign in the log register as soon as you enter the lab and strictly observe your lab timings.
2. Strictly follow the written and verbal instructions given by the teacher / Lab Instructor. If you do not understand the instructions, the handouts and the procedures, ask the instructor or teacher.
3. **Never work alone!** You should be accompanied by your laboratory partner and / or the instructors / teaching assistants all the time.
4. It is mandatory to come to lab in a formal dress and wear your ID cards.
5. Do not wear loose-fitting clothing or jewellery in the lab. Rings and necklaces are usual excellent conductors of electricity.
6. Mobile phones should be switched off in the lab. Keep bags in the bag rack.
7. Keep the labs clean at all times, no food and drinks allowed inside the lab.
8. Intentional misconduct will lead to expulsion from the lab.
9. Do not handle any equipment without reading the safety instructions. Read the handout and procedures in the Lab Manual before starting the experiments.
10. Do your wiring, setup, and a careful circuit checkout before applying power. Do not make circuit changes or perform any wiring when power is on.
11. Avoid contact with energized electrical circuits.
12. Do not insert connectors forcefully into the sockets.
13. **NEVER** try to experiment with the power from the wall plug.
14. Immediately report dangerous or exceptional conditions to the Lab instructor / teacher: Equipment that is not working as expected, wires or connectors are broken, the equipment that smells or "smokes". If you are not sure what the problem is or what's going on, switch off the Emergency shutdown.
15. Never use damaged instruments, wires or connectors. Hand over these parts to the Lab instructor/Teacher.
16. Be sure of location of fire extinguishers and first aid kits in the laboratory.
17. After completion of Experiment, return the bread board, trainer kits, wires, CRO probes and other components to lab staff. Do not take any item from the lab without permission.
18. Observation book and lab record should be carried to each lab. Readings of current lab experiment are to be entered in Observation book and previous lab experiment should be written in Lab record book. Both the books should be corrected by the faculty in each lab.
19. Special Precautions during soldering practice
    a. Hold the soldering iron away from your body. Don't point the iron towards you.
    b. Don't use a spread solder on the board as it may cause short circuit.
    c. Do not overheat the components as excess heat may damage the components/board.
    d. In case of burn or injury seek first aid available in the lab or at the college dispensary.

List of Experiments   **Page**

Analog Communications

1. AMPLITUDE MODULATION & DEMODULATION

Aim:

1.   To study the operation of Amplitude Modulation by observing the AM wave and to measure it's modulation index for various modulating voltages.

2.   To perform Demodulation of AM wave.

Apparatus:

Sl. No	Name of the component	Specifications or range	Quantity
1	Amplitude Modulation and Demodulation trainer kit	-------	1
2	CRO	20MHz	1
3	Function generator	1MHz	1
4	Regulated power supply	(0-30)V,1A	1
5	Connecting wires	----	As per required number

Theory:

Amplitude Modulation:

Modulation is defined as the process by which some characteristics of a carrier signal is varied in accordance with a modulating signal. The base band signal is referred to as the modulating signal and the output of the modulation process is called as the modulated signal.

Amplitude modulation is defined as the process in which the amplitude of the carrier wave is varied with the instantaneous values (voltages) of the message signal. This technique is also known as DSBFC that is Double Side Band with Full Carrier scheme. the general equation of Amplitude Modulated signal is given by

$$s_{AM}(t) = A_c \left(1 + k_a m(t)\right) \cos 2\pi f_c\, t.$$

If the type of Modulation is single-tone modulation then message signal is replaced by single tone $m(t) = A_m \cos 2\pi f_m t$.AM signal observed practically is Single-tone AM signal.

Demodulation:

The process of detection provides a means of recovering the modulating Signal from modulating signal. Demodulation is the reverse process of modulation. The detector circuit is employed to separate the carrier wave and eliminate the side bands. Since the envelope of an AM wave has the same shape as the message, independent of the carrier frequency and phase, demodulation can be accomplished by extracting envelope. An increased time constant RC results in a marginal output follows the modulation envelope. A further increase in time constant the discharge curve become horizontal if the rate of modulation envelope during negative half cycle of the modulation voltage is faster than the rate of voltage RC combination ,the output fails to follow the modulation resulting distorted output is called as diagonal clipping : this will occur even high modulation index. The depth of modulation at the detector output greater than unity and circuit impedance is less than circuit load ($R_L > Z_m$) results in clipping of negative peaks of modulating signal. It is called "negative clipping

The envelope of the modulating wave has the same shape as the base band message provided the following two requirements are satisfied

1. The carrier frequency f_c must be much greater than the highest frequency components fm of the message signal m (t) i.e. $f_c \gg f_m$.

2. The modulation index must be less than unity. If the modulation index is greater than unity, the carrier wave becomes over modulated.

Applications of Amplitude Modulation:

Amplitude modulation is used in a variety of applications. Even though it is not as widely used as it was in previous years in its basic format it can nevertheless still be found.

- **Broadcast transmissions:** AM is still widely used for broadcasting on the long, medium and short wave bands. It is simple to demodulate and this means that radio receivers capable of demodulating amplitude modulation are cheap and simple to manufacture. Nevertheless many people are moving to high quality forms of transmission like frequency modulation, FM or digital transmissions.

- **Air band radio:** VHF transmissions for many airborne applications still use AM. . It is used for ground to air radio communications as well as two way radio links for ground staff as well.

- **Single sideband:** Amplitude modulation in the form of single sideband is still used for HF radio links. Using a lower bandwidth and providing more effective use of the transmitted power this form of modulation is still used for many point to point HF links.

- **Quadrature amplitude modulation:** AM is widely used for the transmission of data in everything from short range wireless links such as Wi-Fi to cellular telecommunications and much more. Effectively it is formed by having two carriers 90° out of phase.

These form some of the main uses of amplitude modulation. However in its basic form, this form of modulation is being sued less as a result of its inefficient use of both spectrum and power.
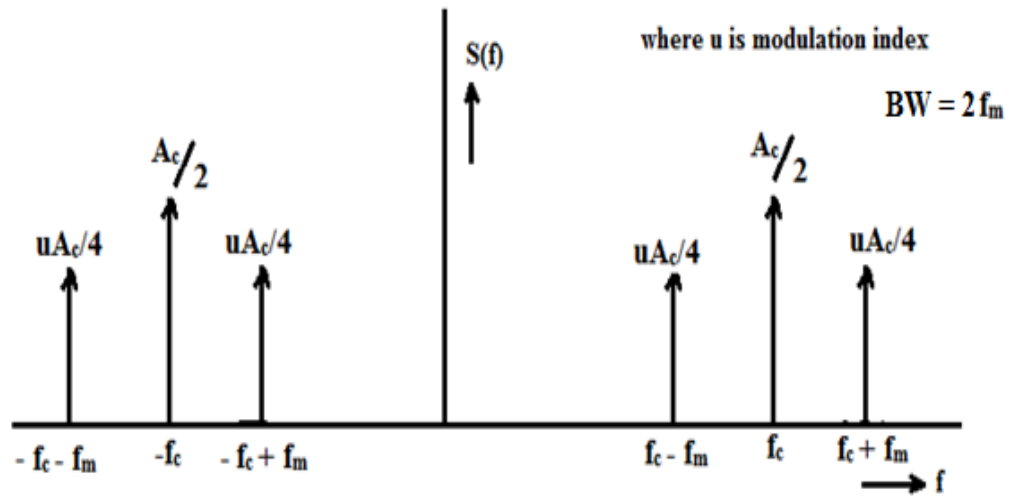
Amplitude modulation advantages & disadvantages

Like any other system of modulation, amplitude modulation has several advantages and disadvantages. These mean that it is used in particular circumstances where its advantages can be used to good effect.
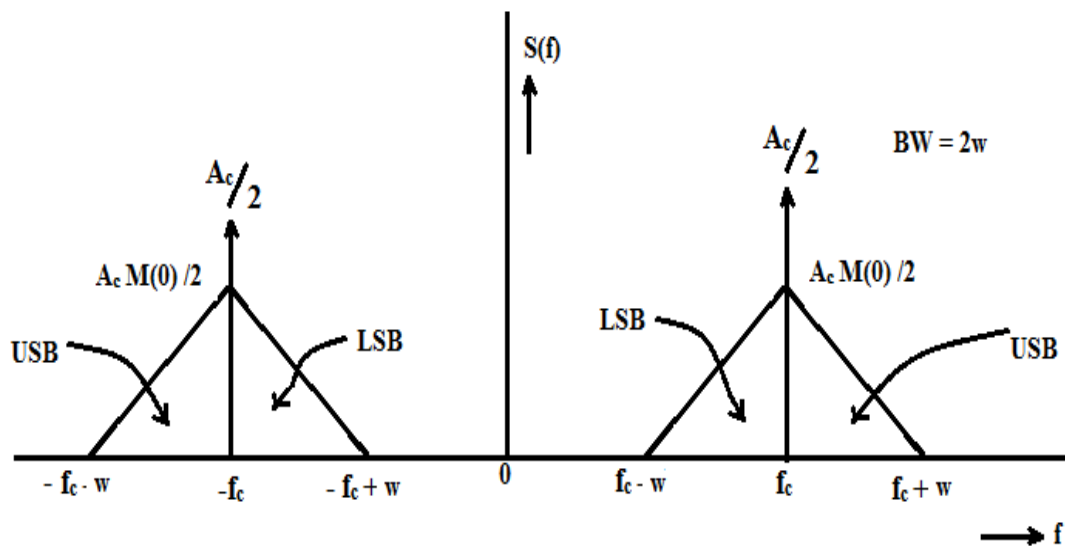
The AM range is 535 - 1605 KHz (stations are assigned between 540 and 1600 KHz every 10 KHz). The FM range is 88 - 108 MHz (with broadcast frequencies, or stations, assigned between 88.1 and 107.9 MHz every 0.2 MHz).

In order to determine the bandwidth of an amplitude modulated signal it is necessary to understand the make-up of the signal. The amplitude modulated signal consists of a carrier with two sidebands that extend out from the main carrier. This results from the modulation process. The two bands are known as Upper Side Band (USB) and Lower Side Band (LSB). The spectra

for General AM signal and Single–tone AM signal are shown in the following figures. It can be seen in both cases BW of AM signal is twice the BW of message signal.


Frequency Spectrum of Single-tone AM

Frequency Spectrum of Amplitude Modulated Signal

Advantages	Disadvantages
• It is simple to implement	• An amplitude modulation signal is not efficient in terms of its power usage
• It can be demodulated using a circuit consisting of very few components	• It is not efficient in terms of its use of bandwidth, requiring a bandwidth equal to twice that of the highest audio frequency
• AM receivers are very cheap as no specialized components are needed.	• An amplitude modulation signal is prone to high levels of noise because most noise is amplitude based and obviously AM detectors are sensitive to it.
• Coverage area of AM receiver is wider than FM. AM is a long distance Communication.	• AM receivers are less immune to Noise.

Circuit Diagram:

Amplitude Modulator

Amplitude Demodulator

Carrier Generator
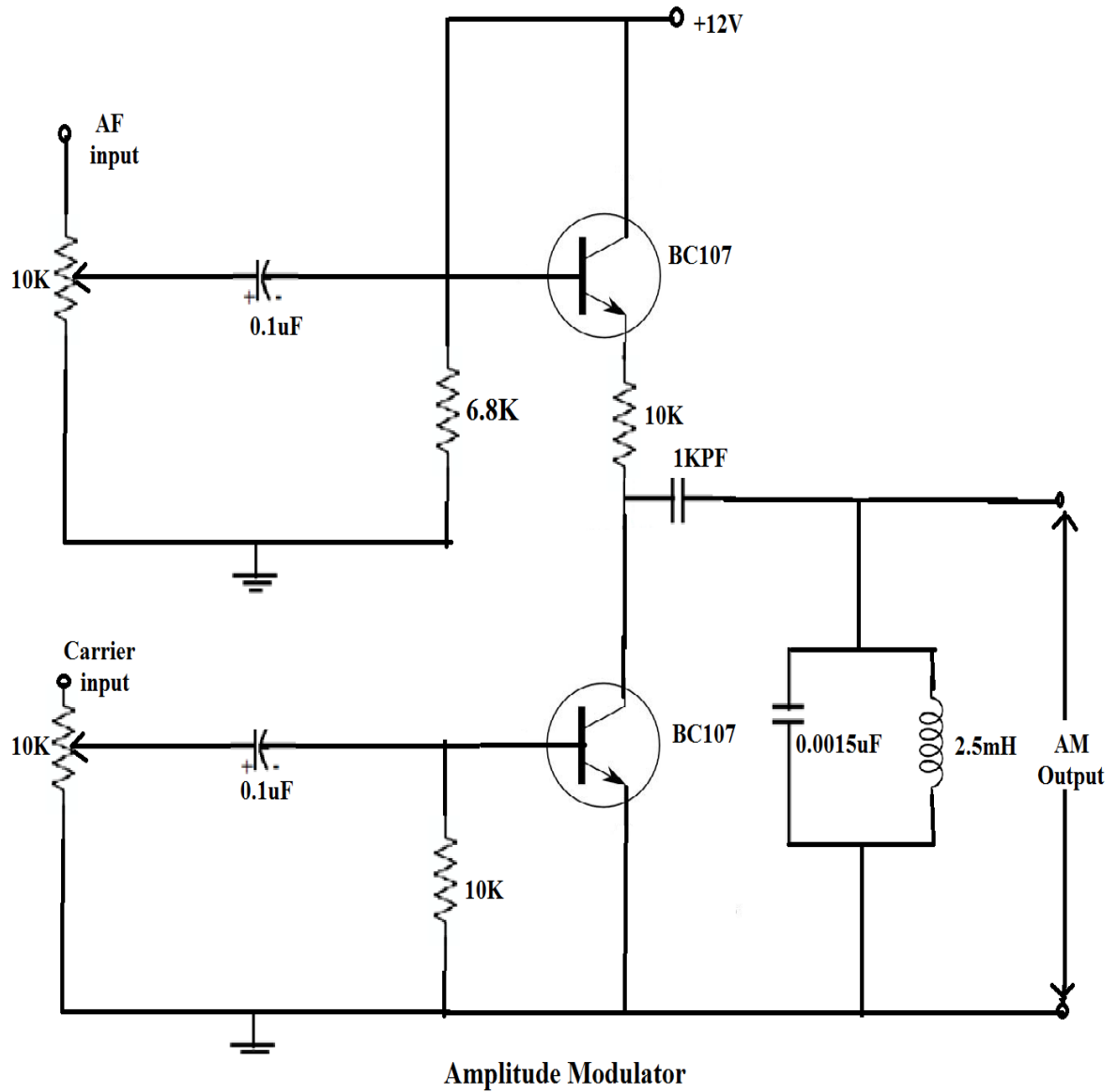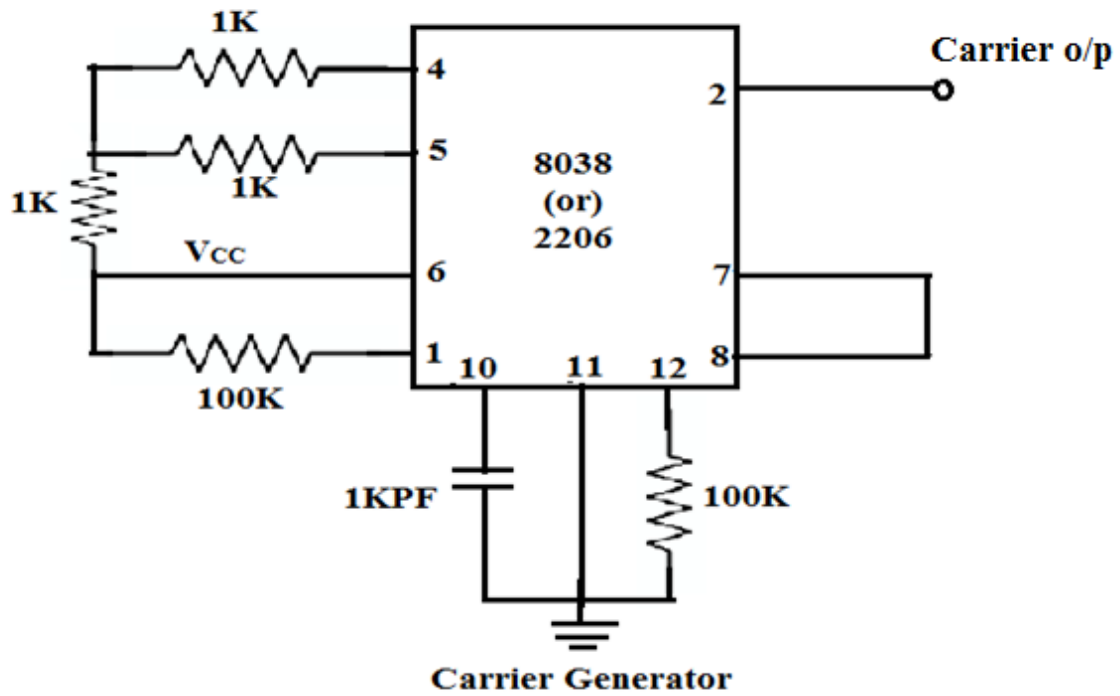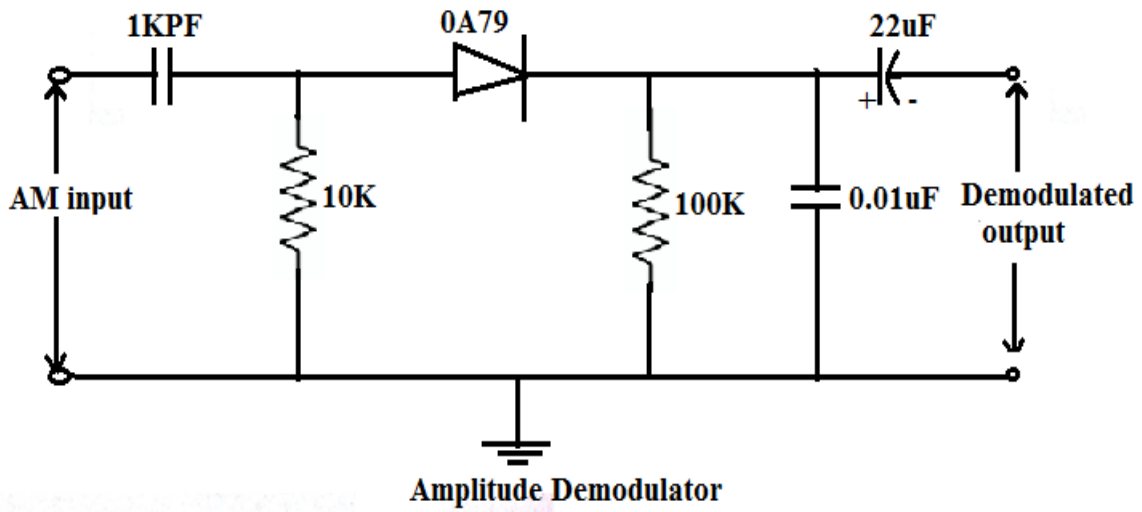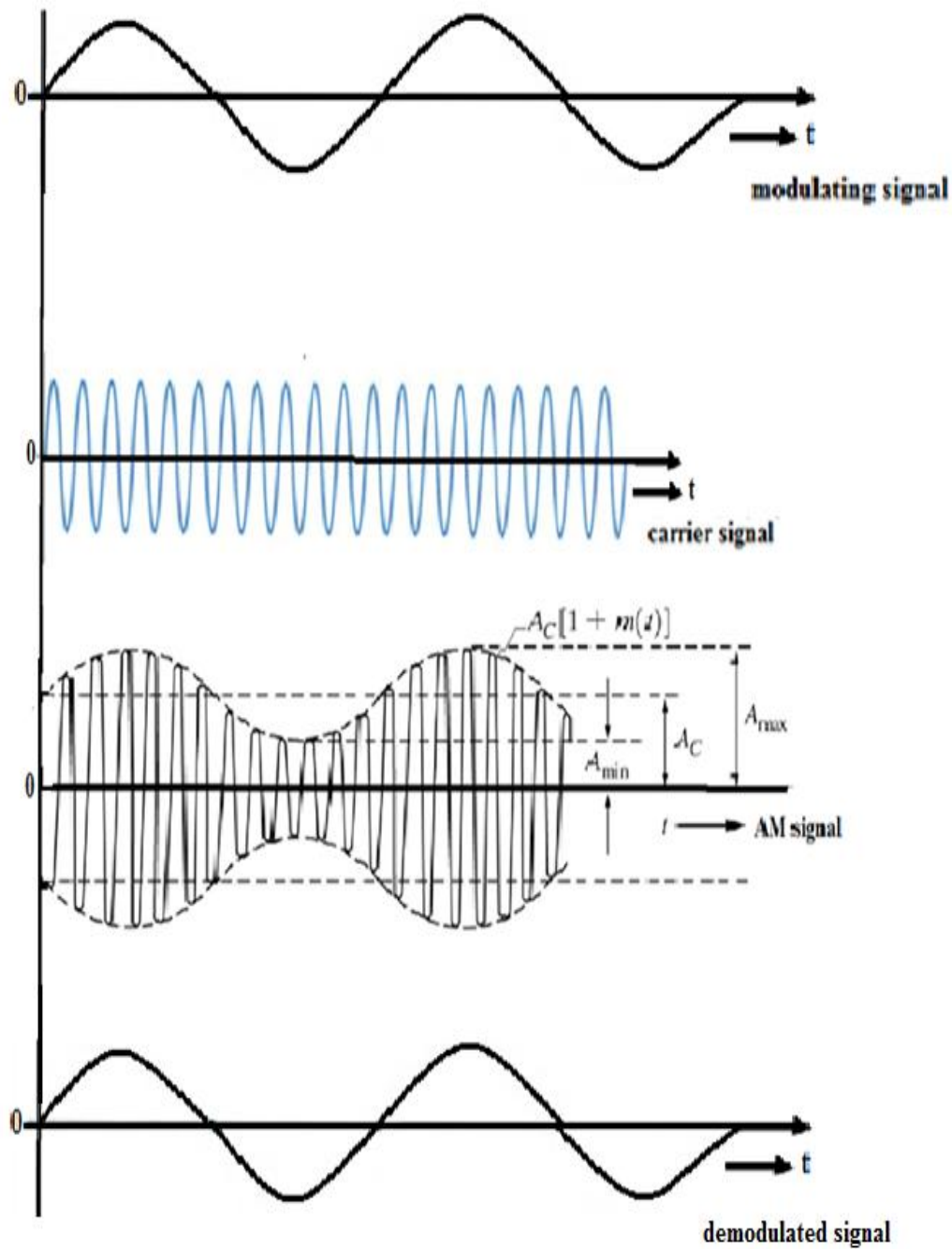
Model graphs:

Fig: Waveforms of Amplitude Modulation

Experimental procedure:

Modulation:

1. Generate an AF signal (message signal) of 1 KHz frequency and 2V peak-peak amplitude using function generator.
2. Switch on the trainer. Observe the output of the Carrier generator (at pin2 of IC8038/2206) and measure its amplitude and frequency.
3. Now connect AF signal to AF I/P and carrier signal to Carrier I/P of the modulator as shown in the circuit diagram.
4. Observe the Modulator O/P signal at AM O/P by making necessary changes in AF I /P.
5. Vary the amplitude of message signal (by keeping frequency of message signal as constant) and observe the effect on AM signal by calculating Modulation Index (μ).
6. Vary the frequency of message signal (by keeping amplitude of message signal as constant) and observe the effect on AM signal by calculating Modulation Index (μ).

Demodulation:

1. Connect the Output of Amplitude Modulator to the input of demodulator circuit.
2. Now observe the output of demodulator and measure its frequency.
3. Check the phase difference between message and demodulated signals.

Tabular form: Modulation

Carrier voltage V_c= constant

Sl. No	Message amplitude /voltage V_m	V_{max}	V_{min}	$\mu = \dfrac{V_{max} - V_{min}}{V_{max} + V_{min}} X\ 100\%$
1	0.8	1.2	0.8	20

Demodulation:

Sl. No	Message frequency f_m	Demodulated signal frequency
1	1 K	1.1 K

Precautions:

1. All connections must be done carefully.
2. Switch off power supply before making connections.

Result &Discussions: Thus the Amplitude modulation and demodulation is performed practically.

1. As the amplitude of message signal **increases**, the Modulation index **increases** and vice versa.
2. When message signal and carrier signal are **in-phase** it represents $V_{max.}$
3. When message signal and carrier signal are **out of phase** it represents $V_{min.}$
4. The phase difference between Message signal and demodulated signal are **not same**.

2. FM MODULATION & DEMODULATION

Aim:

1.   To study the operation of Frequency Modulation by observing the FM wave.
2.   To measure it's modulation index for various modulating voltages and frequencies.

Apparatus:

Sl. No	Name of the component	Specifications or range	Quantity
1	frequency Modulation and Demodulation trainer kit	-------	1
2	CRO	20MHz	1
3	Function generator	1MHz	1
4	Regulated power supply	(0-30)V,1A	1
5	Connecting wires and Probes	----	As per required number

Theory:

Angle modulation is a technique in which the angle of the carrier is varied with instantaneous values of message signal. Angle Modulation has been divided into two types.

i.   Phase Modulation.   ii. Frequency Modulation.

Frequency modulation is defined as the process in which is the frequency of the carrier wave is varied with the instantaneous values (voltages) of the message signal.

FM signal is given by $S_{FM}(t) = A_c \cos(2\pi\ f_c t + 2\pi k_f \int_0^t m(\tau)\, d\tau)$

FM has been divided into two types Wideband FM and Narrow Band FM. FM range is 88Hz to 108MHz.FM has both advantages and Disadvantages

Advantages:

1. FM is more immune to Noise compared to AM. Hence there is a significant amount of increase in Signal-to-Noise Ratio at the output.
2. It operates at Very High Frequency.
3. Amplitude of the Frequency Modulated signal is almost unaffected.
4. Frequency allocation allows for a Guard-Band which reduces adjacent Channel Interference.


Disadvantages:

1. Requires more complicated and costlier circuits at its Demodulator.
2. A much wider channel is needed for FM, typically 200 KHz.


Applications of FM:

1. We commonly see AM and FM in radio broadcasting. FM transmission provides a superior sound quality than that of AM, but with a reduced coverage. It is because of the high Bandwidth it offers. And so most radio music stations use FM to provide good quality sound.
2. AM is used for video signals in TV's, ranges from (535K Hz- 1750KHz).
    FM is used for sound signals in TV's, ranges from (88MHz-108MHz).

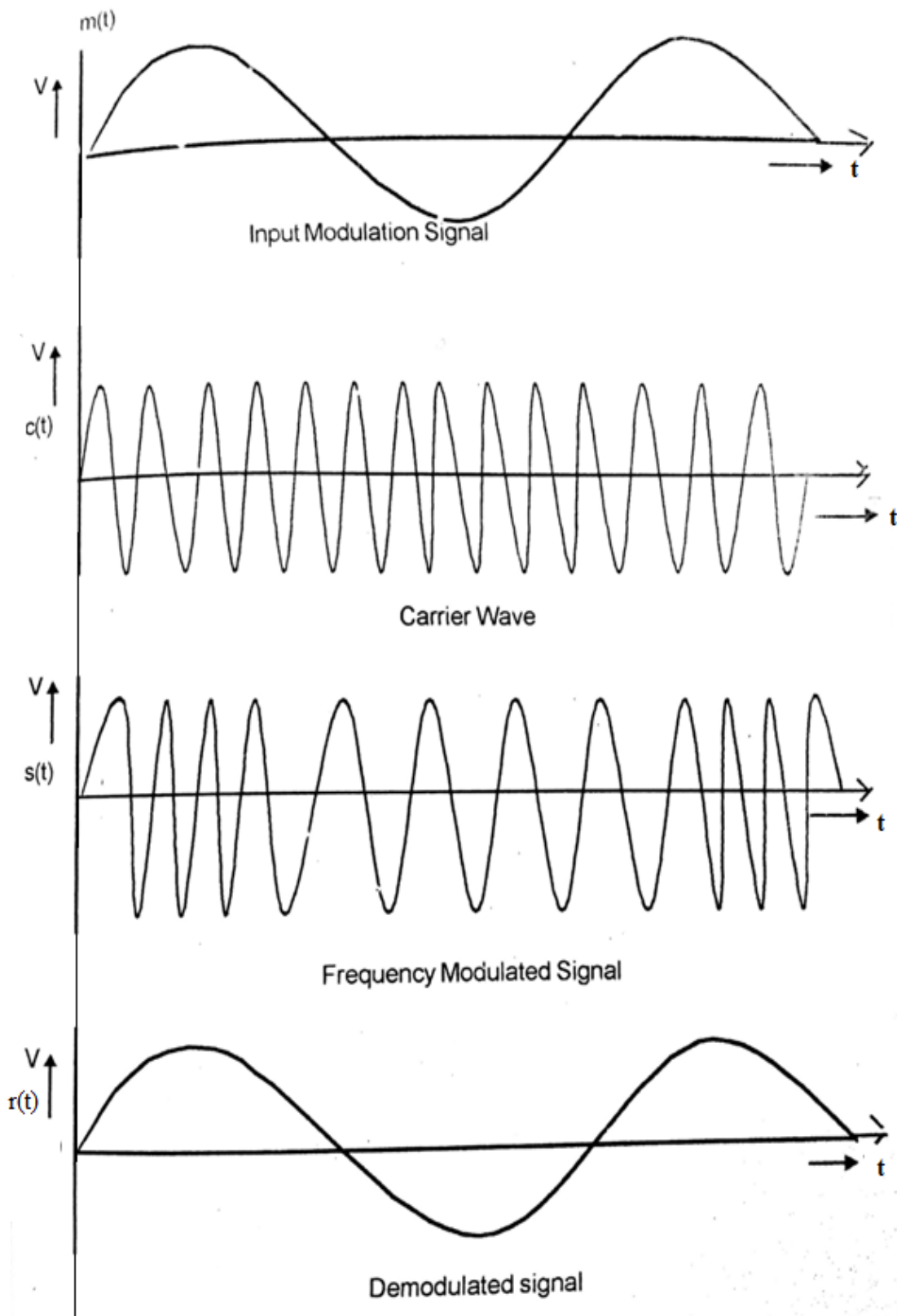| Frequency Modulation	Amplitude Modulation
FM receivers are more immune to Noise.	AM receivers are not immune to Noise.
All Transmitted power is useful, no power is wasted	Carrier and Side Band power is wasted.
Transmitter and Receiver circuits are complex.	Uses simple Transmitter and Receiver Circuits.
BW is higher and depends on modulation index	BW is low and is independent of Modulation index

Circuit Diagram:
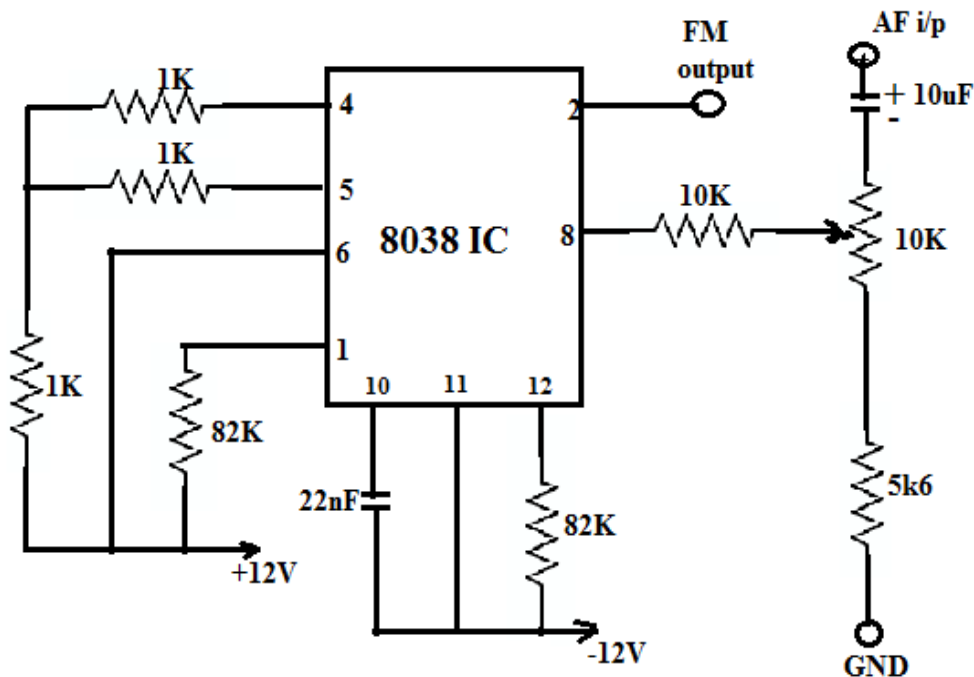
Circuit for Frequency Modulator

FM i/p
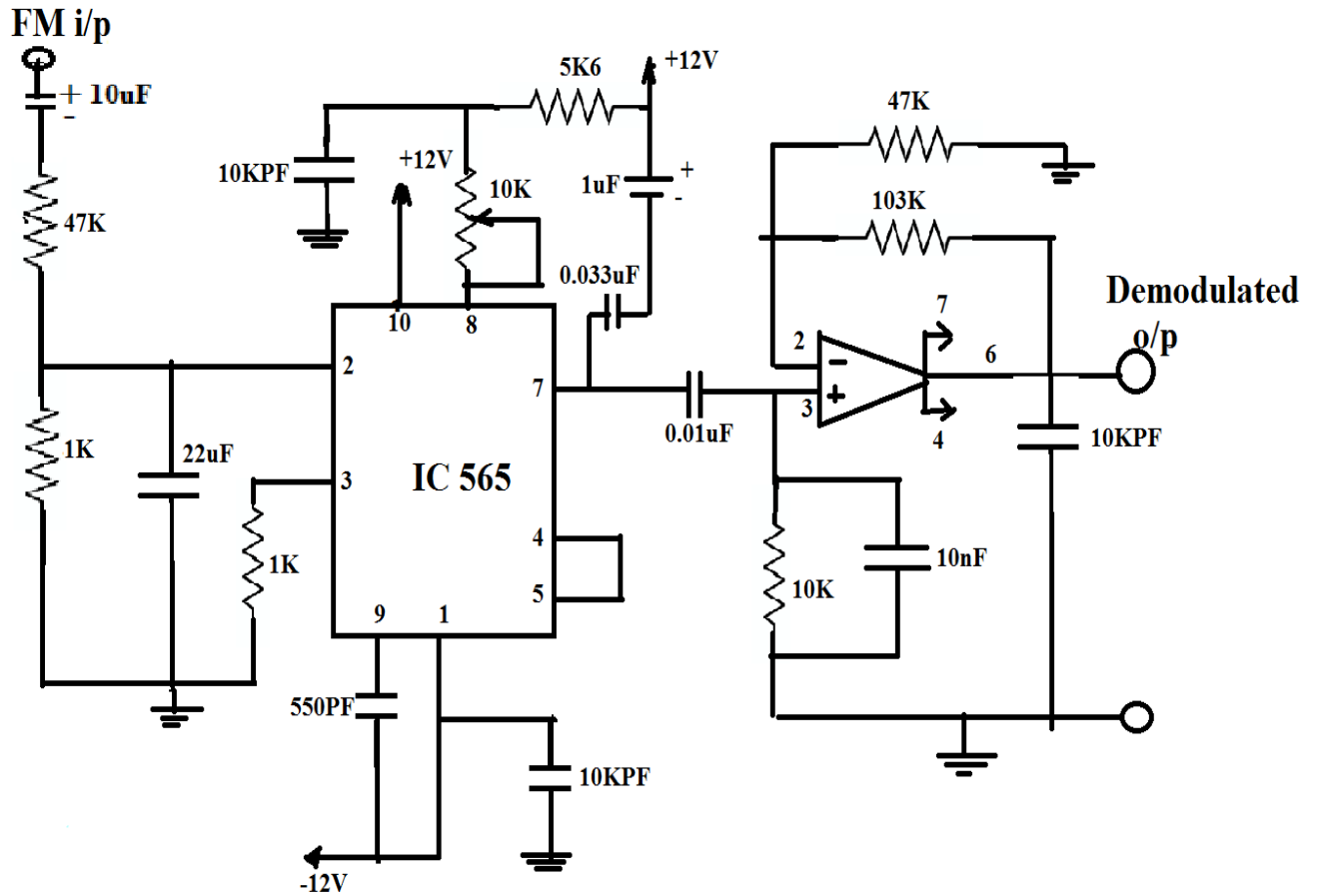
Circuit for Frequency demodulator

Modelgraphs:

Input Modulation Signal

Carrier Wave

Frequency Modulated Signal

Demodulated signal

Experimental procedure:

Modulation:

1. Switch on the trainer kit.
2. Connect CRO to the FM output and observe carrier frequency (and amplitude) of the wave at that point without any AF input.
3. Connect around (3 kHz to 10 kHz) with 2.4 volts sine wave (AF signal) to the AF input of the frequency Modulator.
4. Now observe the FM output on the first channel of CRO and adjust the amplitude of AF signal to get clear FM wave form.
5. Vary the modulating amplitude and frequency of the message signal and observe the effect on FM output.
6. Calculate modulation index in the first case by changing frequency of message signal (by keeping amplitude as constant).
7. Calculate modulation index in the second case by changing amplitude of message signal(by keeping frequency as constant)

Demodulation:

1. Connect the FM output to the FM input of Demodulator circuit .Observe the demodulated wave (second channel of CRO).
2. By vary the potentiometer provided in the demodulator section and see the output.

Tabular form: Modulation

Message frequency f_m= constant

Sl. No	Message amplitude /voltage V_m	F_{max}	F_{min}	$\Delta f = \dfrac{F_{max} - F_{min}}{2}$	$\beta = \dfrac{\Delta f}{f_m}$

Message amplitude V_m= constant

Sl. No	Message frequency f_m	F_{max}	F_{min}	$\Delta f = \dfrac{F_{max} - F_{min}}{2}$	$\beta = \dfrac{\Delta f}{f_m}$

Demoulation:

Sl.No	Message frequency	Demodulated frequency

Precautions:

1. All connections must be done carefully.
2. Switch off power supply before making connections.

Result & Discussions:

Thus the Frequency modulation and demodulation are performed practically.

1. Modulation index β decreases with respect to frequency of message signal when the amplitude of message signal is kept constant.

2. Modulation index β increases with respect to amplitude of message signal when the frequency of message signal is kept constant.

3. <u>PRE-EMPHASIS & DE-EMPHASIS</u>

Aim:

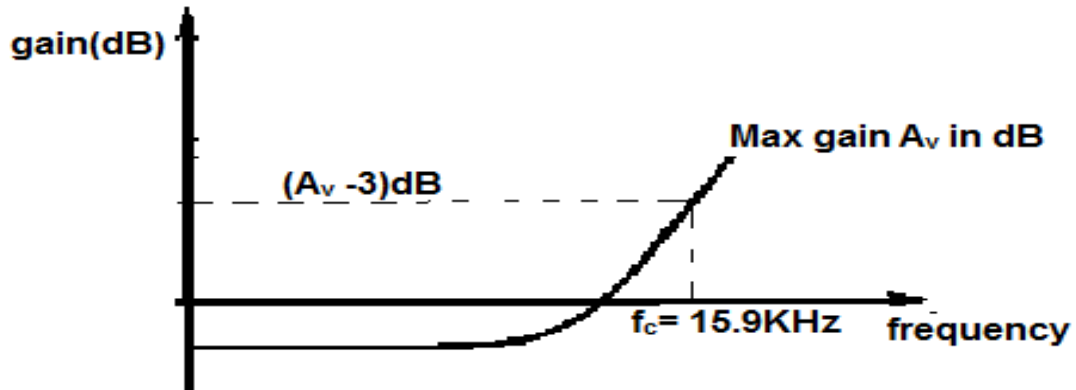To observe the effect of Pre-emphasis and De-emphasis on a given signal.

Apparatus:

Sl. No	Name of the component	Specifications or range	Quantity
1	Resistors	7.5KΩ,6.8KΩ	1 each
2	Capacitors	10nF,0.1µF	1each
3	Function generator	1MHz	1
4	CRO	20MHz	1
5	Connecting wires	----	As per required number

Theory:

The noise has greater effect on high 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 as de-emphasis.

Circuit Diagram:

10nF (103)

7.5K

R_1

R_2

1K

20mV,KHz

Output

+

-

Pre-emphasis circuit

R_1

6.8K

5V,100Hz

0.1uF

Output

+

De-emphasis circuit
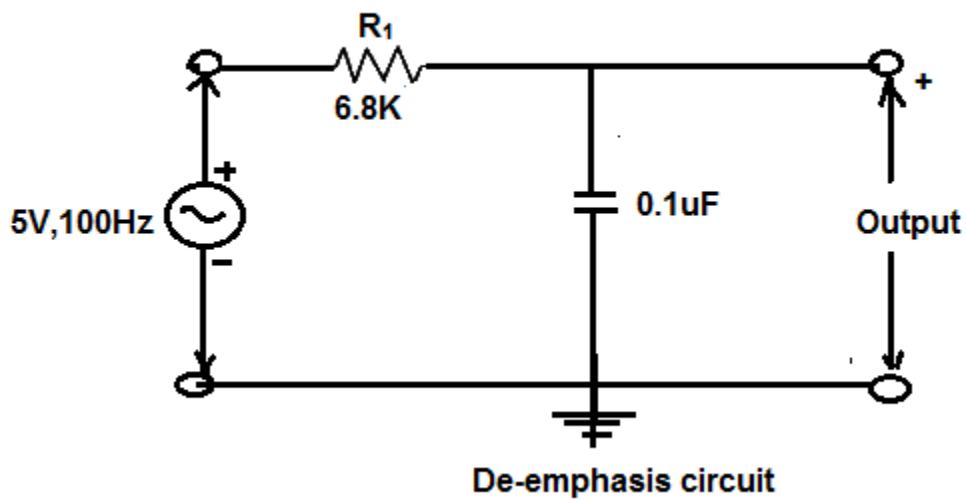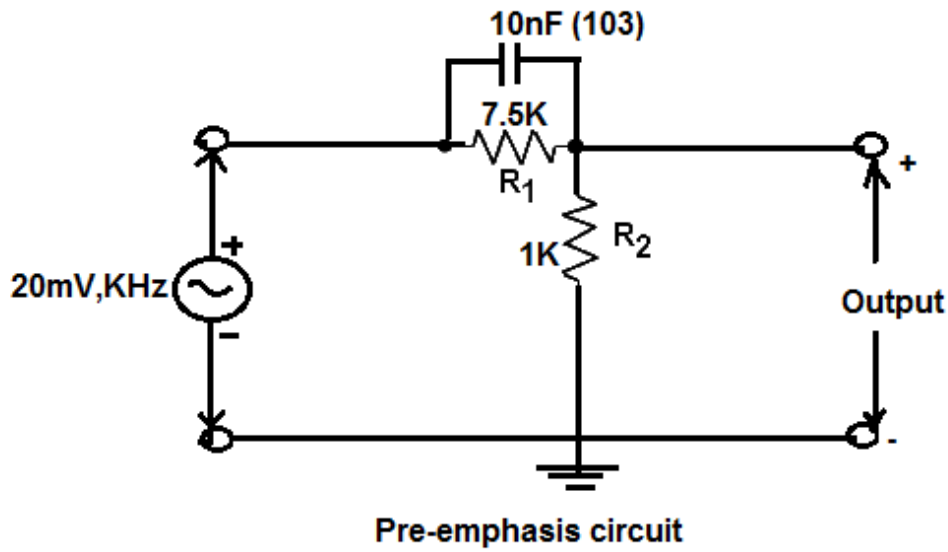
Model graphs:

Pre-emphasis curve
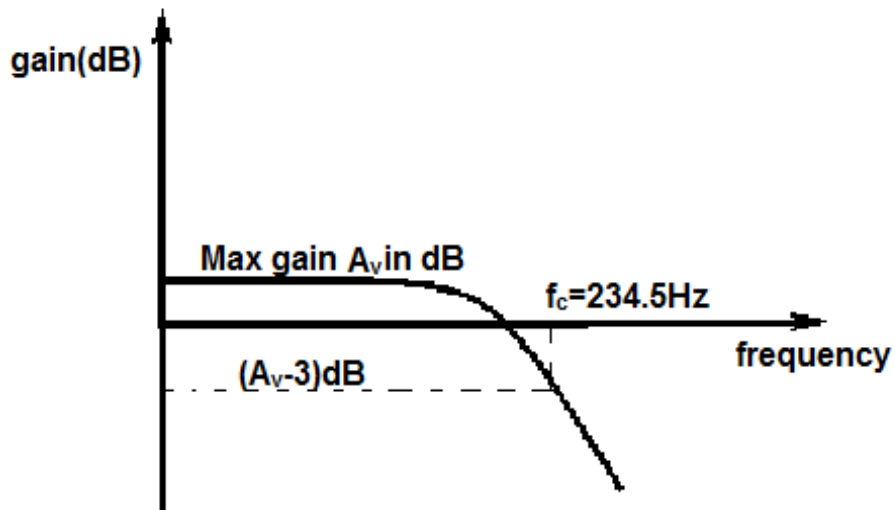
De-emphasis curve

Experimental procedure:

1. Connect the circuit diagram as per pre-emphasis circuit shown in figure.
2. Apply a sinusoidal signal of 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 in dB as $20 \log \frac{V_o}{V_i}$.
4. Similarly apply a sinusoidal signal of 5V, 100Hz to de-emphasis circuit .vary the input signal frequency from 100Hz to 20 KHz and calculate gain in dB as $20 \log \frac{V_o}{V_i}$ by observing output voltage V_o.
5. Plot pre-emphasis and de-emphasis curves.

Tabular form:

Pre-emphasis: $V_i = 20mV$.

Sl. No	Frequency of input signal (Hz)	Output voltage V_o (volts)	Gain in dB $A_v = 20 \log \frac{V_o}{V_i}$

De-emphasis: $V_i = 5V$.

Sl. No	Frequency of input signal (Hz)	Output voltage V_o (volts)	Gain in Db $A_v = 20 \log \frac{V_o}{V_i}$

Precautions:

1. All connections must be done carefully.
2. Switch off power supply before making connections.

Result & Discussions:

The effect of Pre-emphasis and De-emphasis on a given input signal is observed.

4. TIME DIVISION MULTIPLEXING

Aim:

To study the Time division multiplexing and De multiplexing using Pulse Amplitude Modulation and De-modulation and to reconstruct the signals using filters.

Apparatus:

Sl.No	Name of the component	Specifications or range	Quantity
1	DCLT002-PAM-TDM trainer kit	----	1
2	CRO	(0-30)MHz	1
3	Connecting wires and probes patch chords	----	Required number

Theory:

The TDM is used for transmitting several analog message signals over a communication channel by dividing the time frame into slots, one slot for each message signal. The four input signals, all band limited by the input filters are sequentially sampled, the output of which is a PAM waveform containing samples of the input signals periodically interlaced in time. The samples from adjacent input message channels are separated by Ts/M, where M is the number of input channels. A set of M pulses consisting of one sample from each of the input M-input channels is called a frame. At the receiver the samples from individual channels are separated by carefully synchronizing and are critical part in TDM. The samples from each channel are filtered to reproduce the original message signal. There are two levels of synchronization. Frame synchronization is necessary to establish when each group of samples begins and word synchronization is necessary to properly separate the samples within each frame. Besides the

space diversity & frequency diversity there is another method of sending multiple analog signals on a channel using TIME DIVISION MULTIPLEXING & DEMULTIPLEXING Technique.
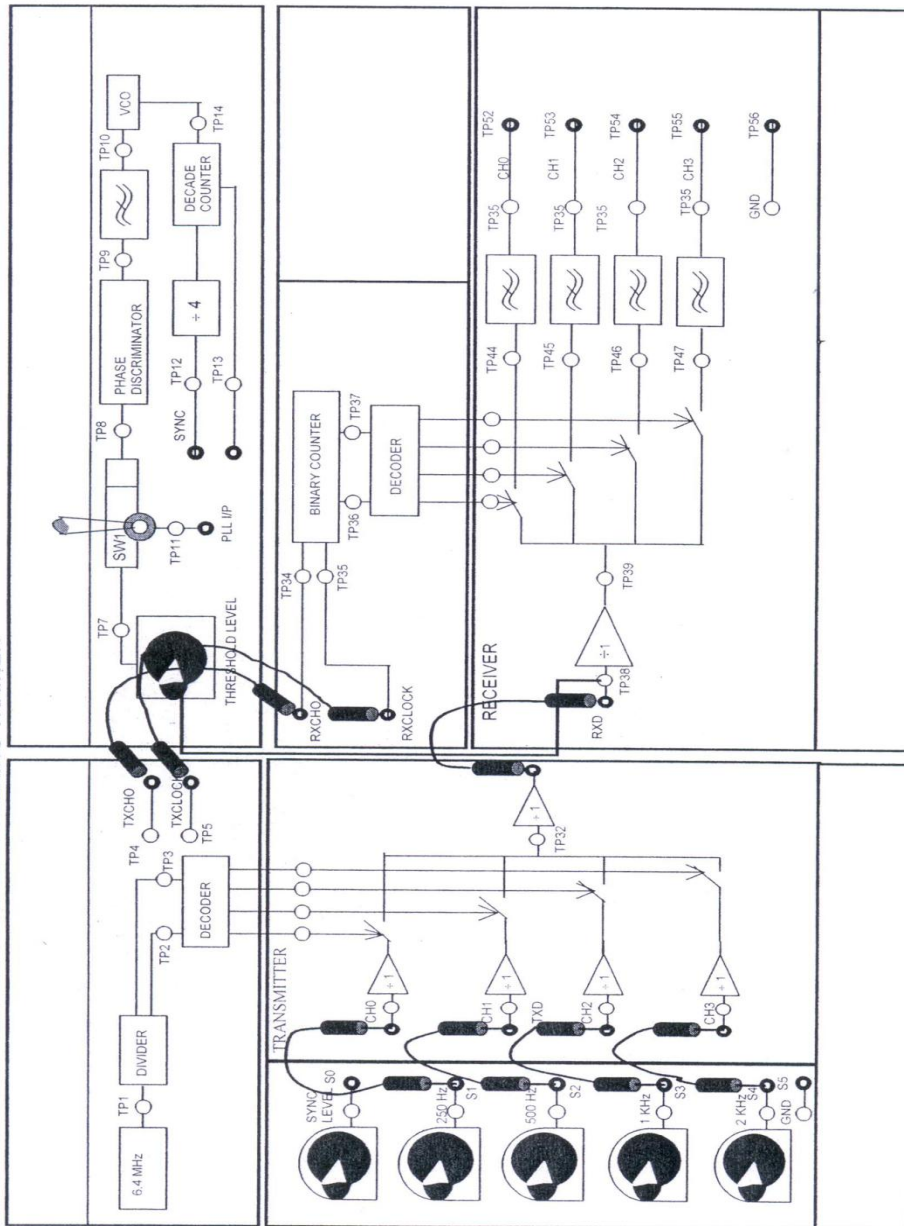
CircuitDiagram:

Model graphs:
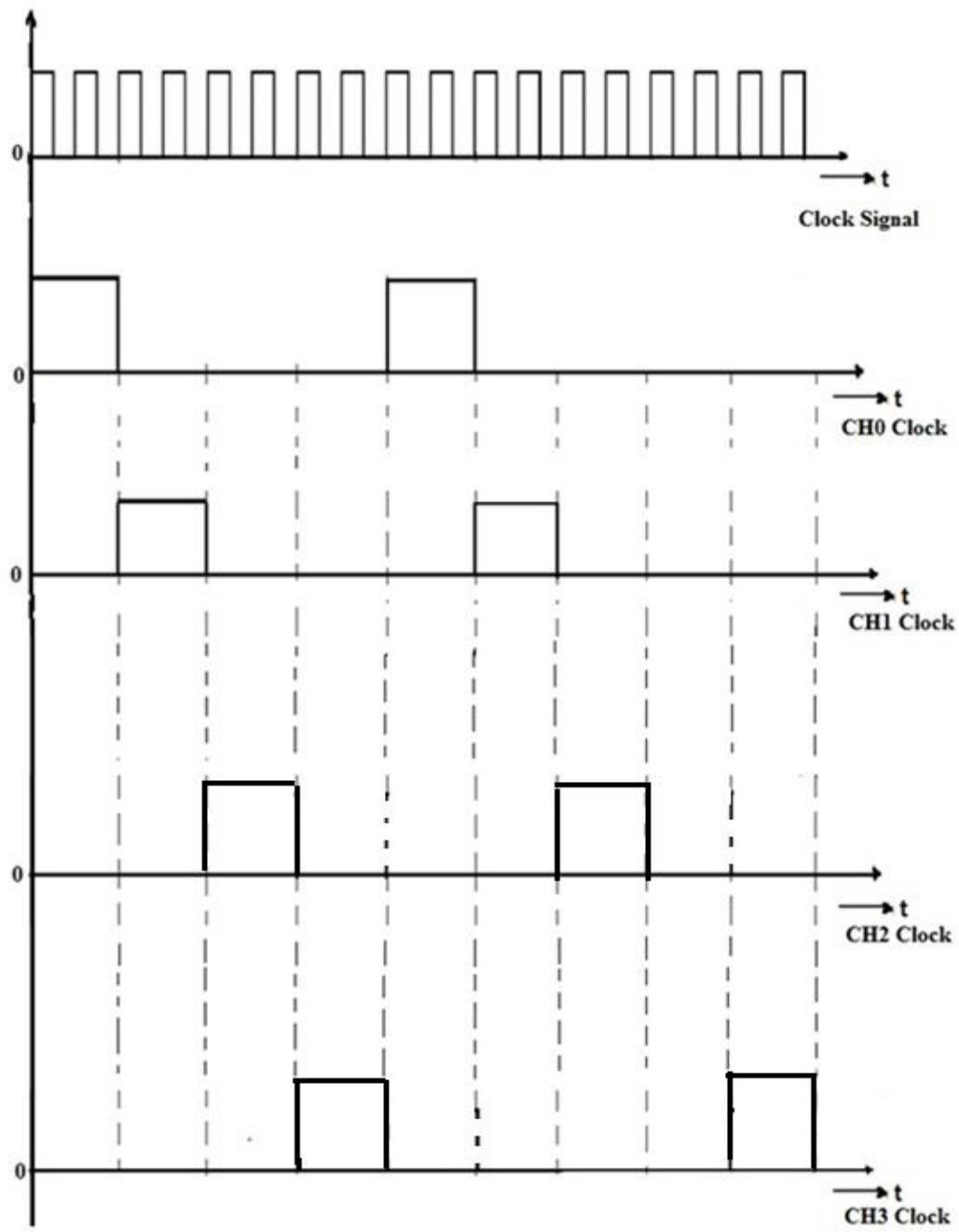
Waveforms for Clock and Channel Clock signals
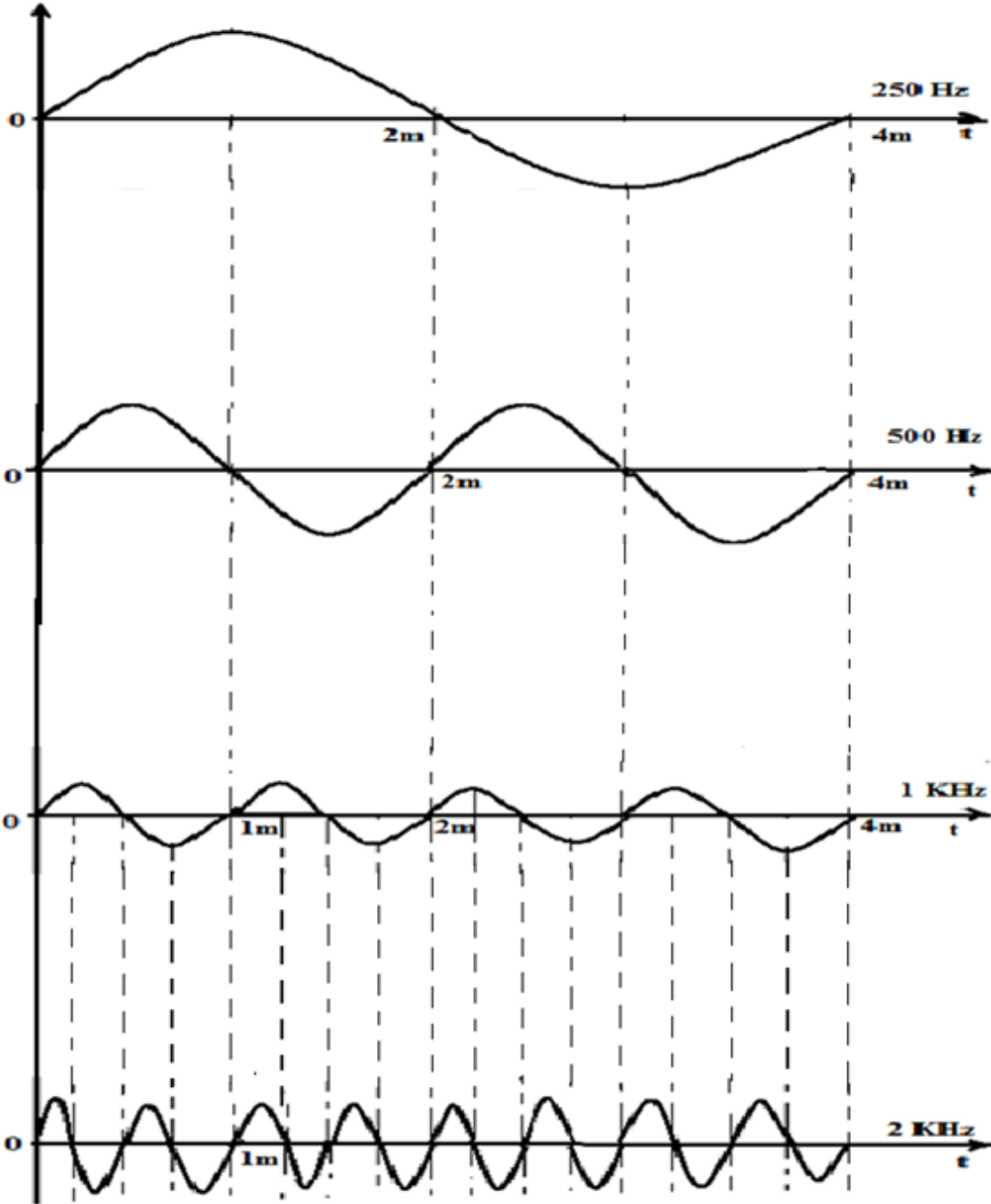
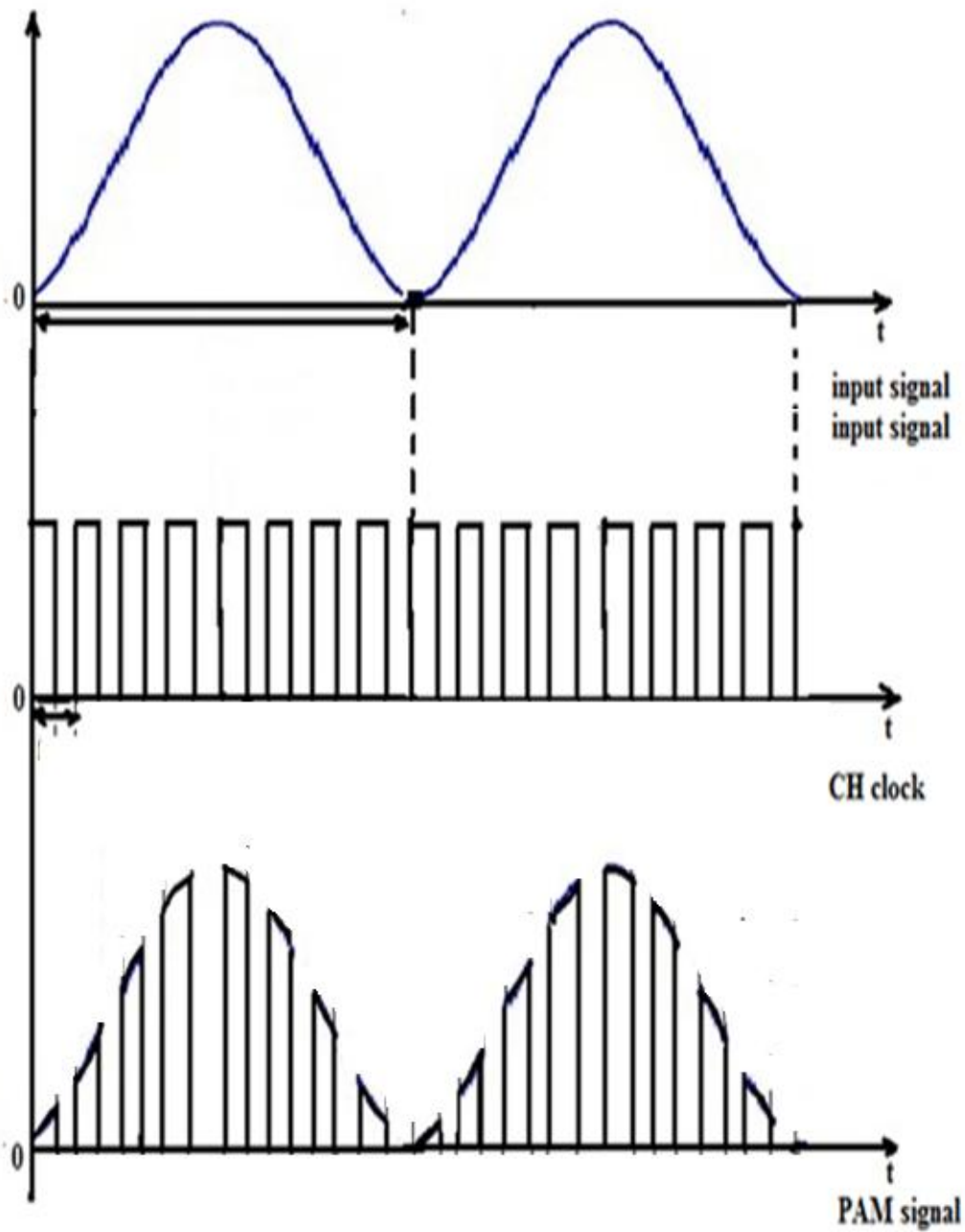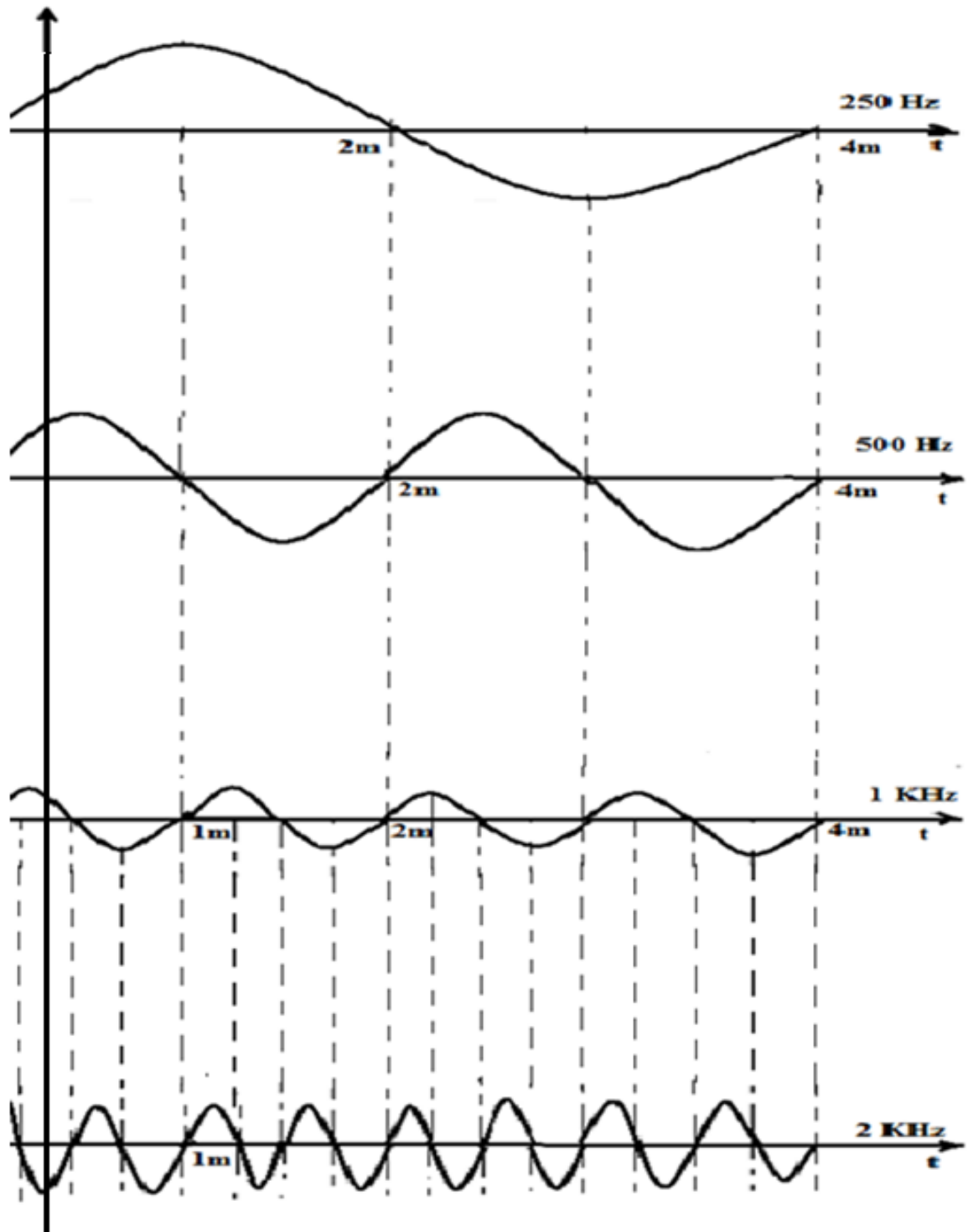**Waveforms for Different Message signals**

Generation of PAM signal with 1KHz message signal

input signal

CH Clock
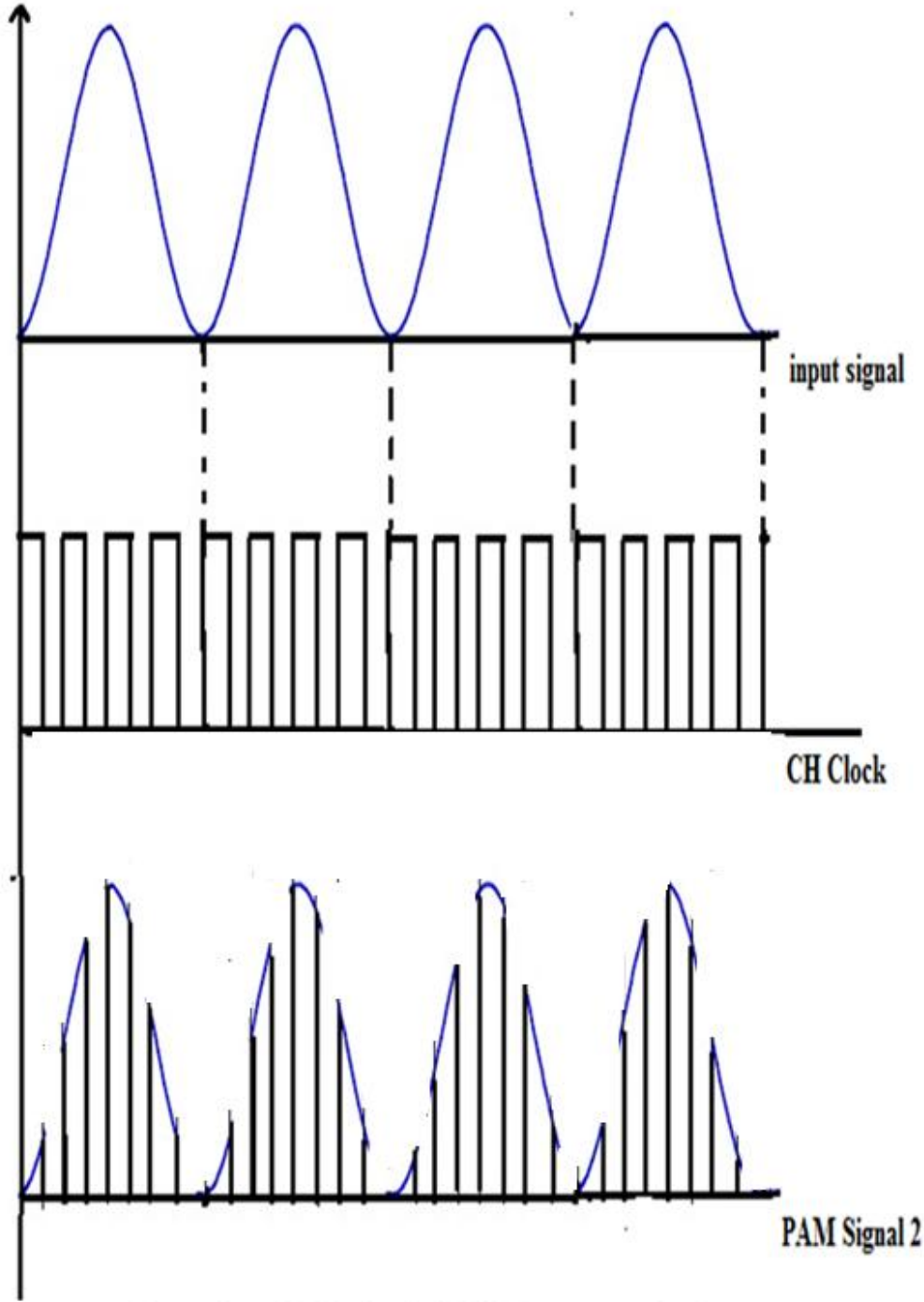
PAM Signal 2

Generation of PAM signal with 2KHZ message signal
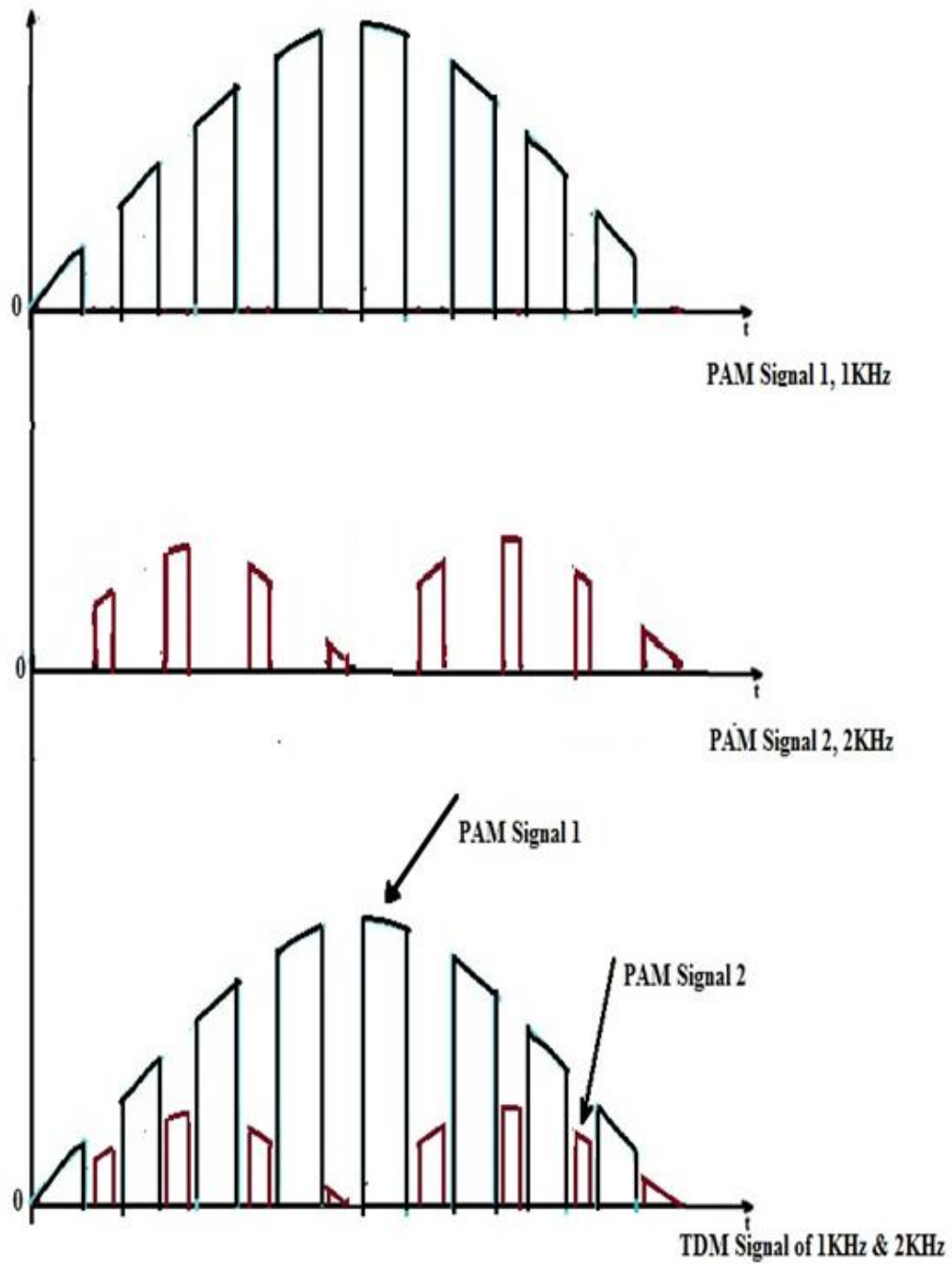
Waveforms of Time Division Multiplexing of Two frequencies

Waveforms of De-Multiplexed signals

Experimental procedure:

Multiplexing:

1. Observe four input signals at pins S_1, S_2, S_3 and S_4 and the Sync level S_0 and clock signals for CH0, CH1, CH2 and CH3 on the trainer kit.
2. Connect either any two channel inputs of 250 Hz, 500 Hz, 1 KHz, 2 KHz or all inputs to the input of transmitter at CH0, CH1, CH2 and CH3 respectively.
3. Observe multiplexed data at TDX (Transmitter Data) of PAM-TDM transmitter. Thus the signal is a multiplexed version of two signals or four signals.

De-Multiplexing:

1. Connect TXCLOCK (Transmitter clock) to RXCLOCK (Receiver clock).
2. Connect TXCH0 (Transmitter sync) to RXCH0 (Receiver sync).
3. Connect the TXD (Transmitter data) to RXD (Receiver data).
4. Observe multiplexed data at TDX for four input signals, Transmitter clock at TXCLOCK and transmitter sync at TXSYNC.
5. Observe the de multiplexed signals at the receiver across the output of fourth order low pass filter at CH0, CH1, CH2 and CH3.

Precautions:
   1. All connections must be done carefully.
   2. Switch off power supply before making connections.

Results & Discussions: Thus the Time Division Multiplexing and de multiplexing of analog signals using PAM-TDM trainer kit is performed and the waveforms are observed.

5. A. SAMPLING AND RECONSTRUCTION

Aim:

To study the signal sampling and its reconstruction.

Apparatus:

Sl.No	Name of the component	Specifications or range	Quantity
1	Sampling theorem verification trainer kit-DCLT001	-	1
2	CRO	20MHz	1
3	Connecting wires and patch chords	--	Based on requirement

Theory:

An analog Source of information produces an output that can have any one of a continuum of possible value at any time. The sound pressure from an Orchestra playing music is an example for analog source. There no of analog sources a signal generator is another analog source. An analog signal is an electrical waveform that can have any one of continuous amplitudes at any time. Voltage and current are examples of CT signals.

A digital source can be defined as the one which generates digital signals most sources are analog in nature and by using some mechanism an analog source can be converted into a

digital source. For example, temperature is an analog quantity, but when combined with a thermostat with output values of on or off, the combination may be considered as a digital source.

A digital signal may be defined as an electrical waveform having one of a finite set of possible amplitudes at any time. i.e, a binary signal is a digital signal. A communication system is required to transport an information bearing signal from a source to destination through a communication channel. Basically, a communication system may be analog or digital type. In an analog communication system, the information-bearing signal is continuously varying in both amplitude and time, and it is used directly to modify some characteristic of a sinusoidal carrier wave, such as amplitude, phase or frequency. In Digital Communication system, on the other hand the m(t) is processed so that it can be represented by a sequence of discrete messages.

Need for Digital Communications: The growth of Digital Communications is largely due to the following reasons:

1. Digital communications provide improved reliability.

2. The availability of wide band channels provided by geo-stationary satellites, Optical fibers and Co-axial cables.

3. The ever increasing availability of integrated Solid-state technology, which has made it possible to increase system complexity by orders of magnitude in a cost effective manner.

As we observed the advantages of digital communications, there is every possible need for converting the analog signal to digital form for compatibility. Three basic operations are combined to convert an analog signal to a digital signal by

Sampling: In the sampling process only sample value of the analog signal at uniformly spaced discrete instant of time are extracted and retained. i.e a continuous time signal is converted into a discrete signal.

Quantizing: In this the nearest level in a finite set of discrete levels approximates each sample value.

Encoding: In encoding, the selected level is represented by a code word that consists of a prescribed number of code elements.

Sampling theorem: The analog signal can be converted to a discrete time signal by a process called sampling. The Sampling theorem for a band limited (W Hz) signal of finite energy can be stated as follows that

''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 samples per second.

Circuit Diagram:
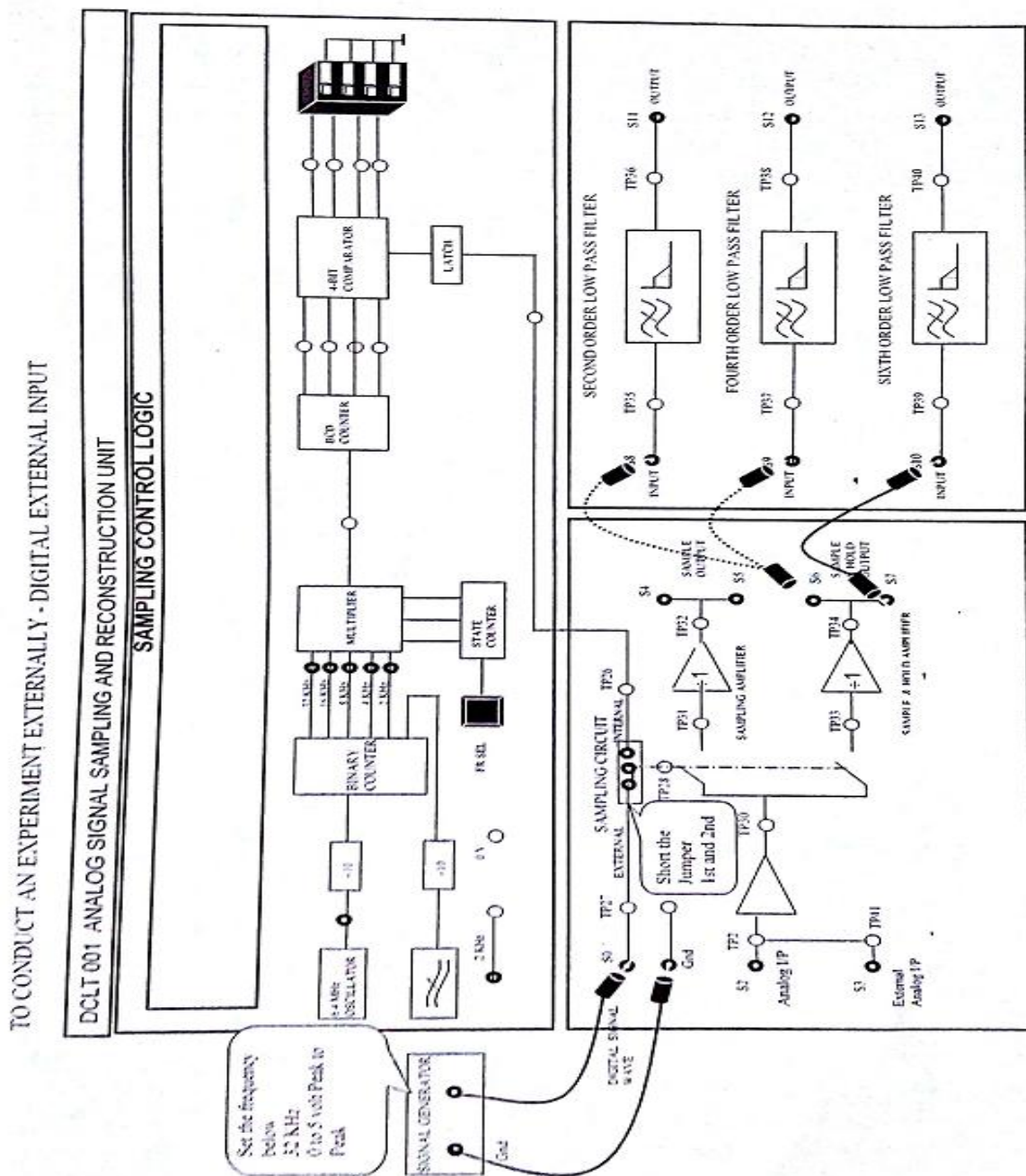
Experimental Procedure:

1. Observe the 2 KHz continuous signal on CRO by connecting any channel of CRO to 2 KHz input on the trainer kit.

2. Connect the 2 KHz 5V p-p signal generated onboard to the ANALOG INPUT, by means of the patch-cords provided.

3. Change FR SEL switch to observe INTERNAL SAMPLING FREQUENCY at TP26 as the switch position changes the corresponding LED at the output of Binary counter glows (for 32 KHz, 16 KHz, 8 KHz, 4 KHz or 2 KHz). Choose 16 KHz signal as the sampling signal with sampling frequency $f_s = 16$ KHz.

4. Connect the Sampling frequency 16 KHz signal in the INTERNAL mode, by means of the shorting pin provided.

5. By means of DIP switch setting, as indicated in the Duty Cycle Table vary the duty cycle of the sampling frequency signal from 10% to 90% in the discrete steps of 10% each.

6. Observe the effect of duty cycle on INTERNAL SAMPLING FREQUENCY in each case, the corresponding model graphs are given in Graph3.1 and Graph 3.2.

7. Keeps the position of DIP switch setting for 50% Duty Cycle for the INTERNAL SAMPLING FREQUENCY.

8. Now observe the Sampled signal at S_4 (TP32) for 30% duty cycle with $f_s = 16$ KHz and draw the corresponding sampled signal (count the number of samples with respect to 2 KHz).

   SAMPLE AND HOLD OUTPUT:

9. Observe the Sample and Hold amplifier output at TP34 and draw the corresponding signal.

   RECONSTRUCTION:

10. Connect sampled output at TP32 to INPUT (S_8, S9 and S_{10}) of SECOND, FOURTH AND SIXTH ORDER low pass filter to reconstruct original signal. Draw the reconstructed signal for FOURTH order low pass filter at TP38.

11. Connect sample and hold output at TP34 to INPUT (S_8, S9 and S_{10}) of SECOND, FOURTH AND SIXTH ORDER low pass filter to reconstruct original signal. Draw the reconstructed signal for FOURTH order low pass filter at TP38.

Model graphs:

Waveforms of Sampling and Reconstruction
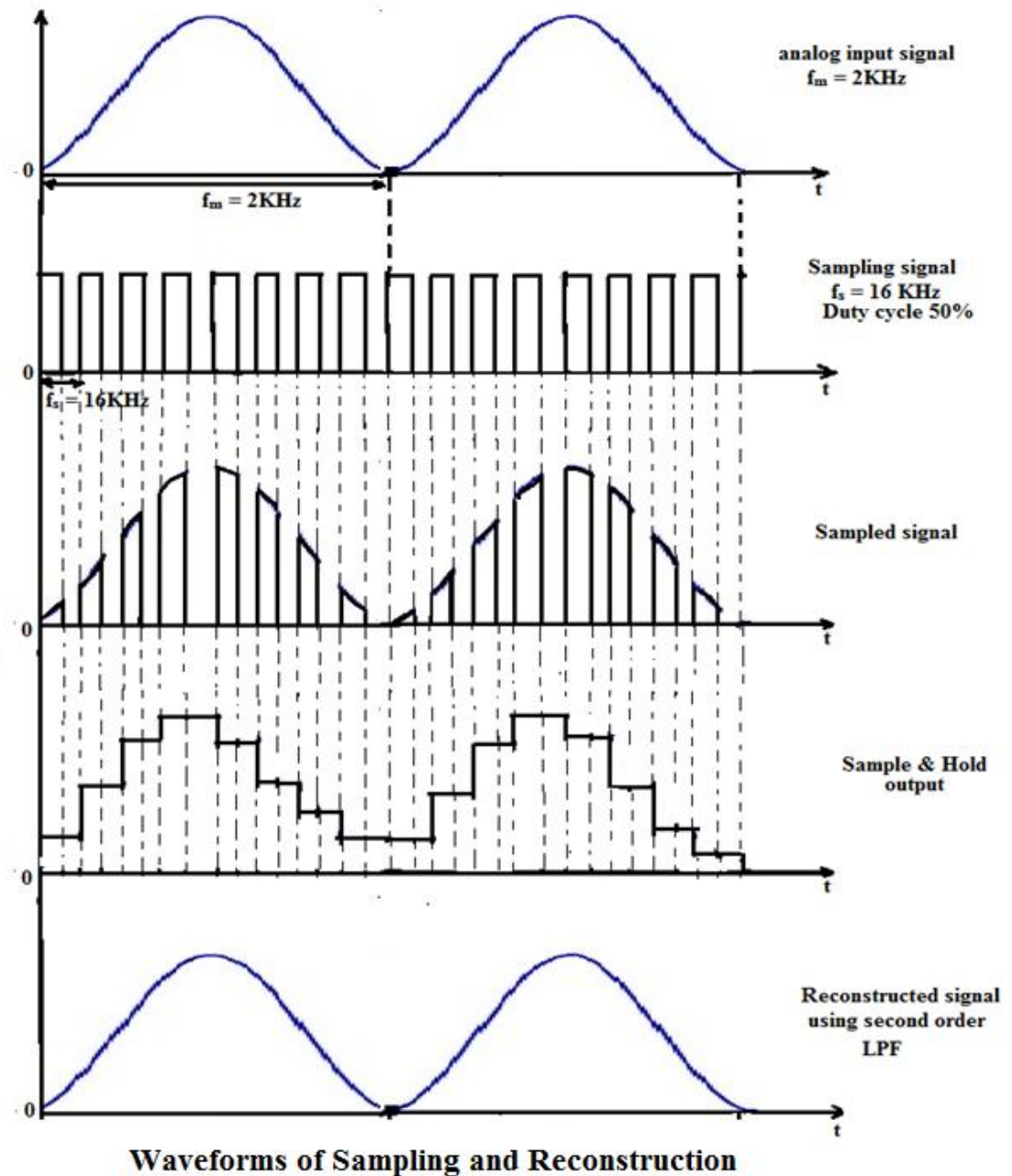
Precautions:

1. Connections must be done carefully.
2. Switch of the power supply before making connections.

Result & discussions:

1. Sampling of a signal and its reconstruction is performed practically.

2. The effect of duty cycle of the sampling frequency on the sampled signal is observed.

3. The effect of duty cycle on Sample and hold output signal is observed.

5. B. PULSE AMPLITUDE MODULATION

Aim:

To study the Pulse Amplitude Modulation and Demodulation using FT1503 Trainer.

Apparatus:

Sl.No	Name of the component	Specifications or range	Quantity
1	PAM Modulation and Demodulation experimental kit.(Built in DC Power supply +/- 5V /350 mA, ICs provided on the board TL084.LM565, 74LS163 each 1no, Provided with 2mm Sockets.)	-	1
2	CRO	20MHz	1
3	Connecting wires, Probes and patch chords	--	Based on requirement

Theory:

Pulse Modulation may be used to transmit analog information, such as continuous speech or data. It is a system in which continuous waveforms are sampled at regular intervals.Information regarding the signal is transmitted only at the sampling times, together with

any synchronizing pulse that may be required. At the receiving end, the original waveforms may be reconstructed from the information regarding the samples, if these are taken frequently enough. Despite the fact that information about the signal is not supplied continuously, As in Amplitude and Frequency modulation , the resulting receiver output can have regenerate the analog information signal.

Pulse Modulation may be subdivided broadly into two categories, Analog and Digital. In the former, the indication of sample Amplitude may be continuously variable, while in the later a code which indicates the sample amplitude to the nearest predetermined level is sent. Pulse Amplitude modulation is a form of analog communication which is discussed in the following section.

Pulse Amplitude Modulation

In this we have a train of fixed width of pulses. The amplitude of each pulse is made proportional to the amplitude of the modulating signal at that instant. In the PAM generation circuit, Synchronous clock is applied to the base of the transistor. Modulating signal is applied to the (unipolar positive) is given to the collector of the transistor. The output of the transistor (Collector current) varies in accordance with the amplitude of the modulating signal voltage resulting in modulated output.

Pulse Amplitude Demodulation

The Demodulation of Pulse Amplitude Modulation is quite a simple process. PAM signal is fed to a Low Pass Filter, from which the Demodulating signal emerges, whose amplitude at any time is proportional to the PAM at that time. This signal is given to an inverting amplifier to amplify its level. The demodulated output is almost equal amplitude with the modulating signal but is in phase shifted due to the modulation, demodulation process.

1 KHz Signal source (AF)

The circuit shown in the following figure uses two op-amps, one acting as non-inverting integrator and the other one as inverting integrator. The two op-amps are connected in cascade to form a feedback loop .the circuit oscillates with sinusoidal output. The sinusoidal oscillation

frequency is $f = 1/2\pi$ RC. In practice the resistor R_1 is made slightly larger than the other resistors to ensure a sufficient positive feedback for oscillations. The two zener diodes V_z, used to bound the output of the inverting integrator, so as to stabilize the amplitude of Oscillations.
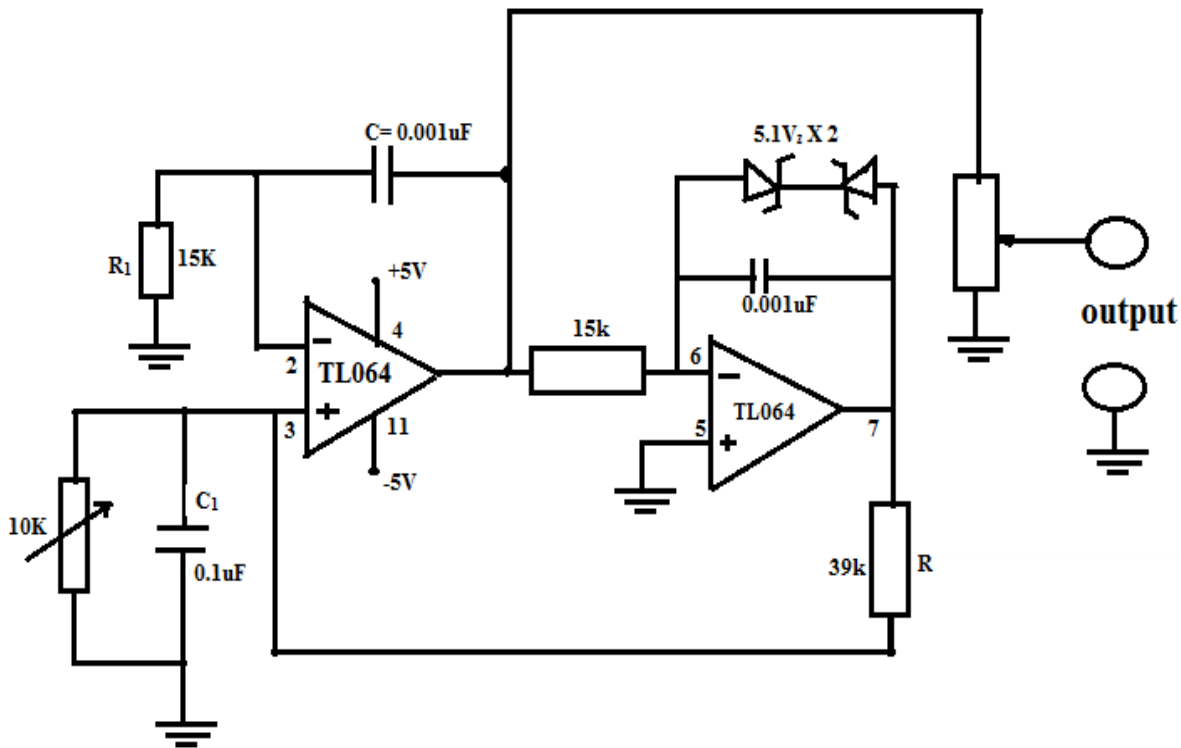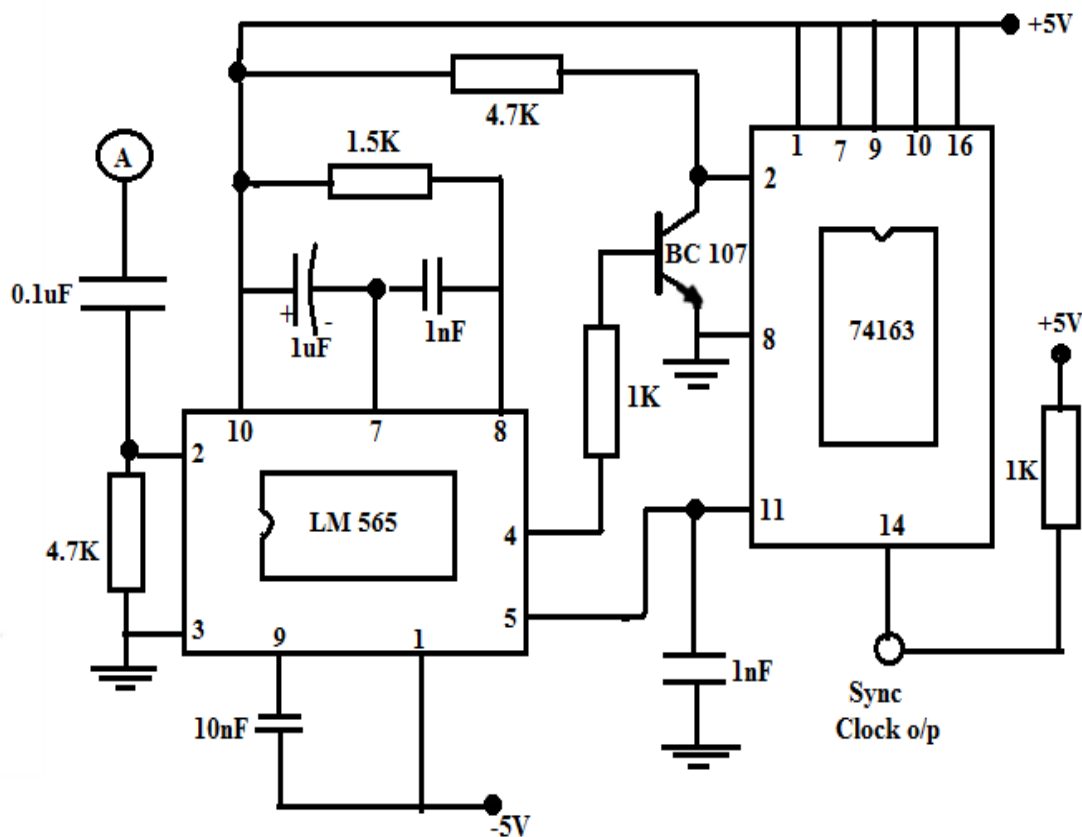

Fig: 1KHz Signal Source (AF)

Synchronous Clock generator

We are generating synchronous clock by using PLL technique .The NE 565 IC is a phase locked loop, which is widely used in application such as frequency multiplication and synthesis etc. This PLL device comprises of 4 basic elements phase comparator, low pass filter, error correction amplifier and VCO. The VCO is a free running multi vibrator whose center frequency is determined by an external timing capacitor and external resistor. It's center frequency can also be shifted to either side by application of an input voltage to the appropriate terminal of the IC .the frequency deviation is directly proportional to the input voltage and hence it is called a "Voltage Controlled Oscillator". The VCO output is presented to a phase detector where its phase is compared with that of the input signal .The detector produces a DC output whose

magnitude is directly proportional to the phase difference. The output of VCO is divided digitally by a number of times the multiplication is designed. Here the BC107 transistor acts as an interface to drive the logic circuit. The sub divided frequency is given to phase comparator which is a synchronous output.


Fig:Synchronous Clock Generator

Procedure:

1. Connect the AC adapter to the mains and the other side to the Experimental Trainer.
2. Observe the modulating signal generated by the 1 KHz Signal Source (AF) and note down the peak to peak amplitude and Time Period.
3. Observe the Carrier signal generated by 8 KHz Synchronous Clock Generator and measure the amplitude and frequency.
4. Apply the modulating signal generator output and Synchronous clock generator output to the PAM modulator
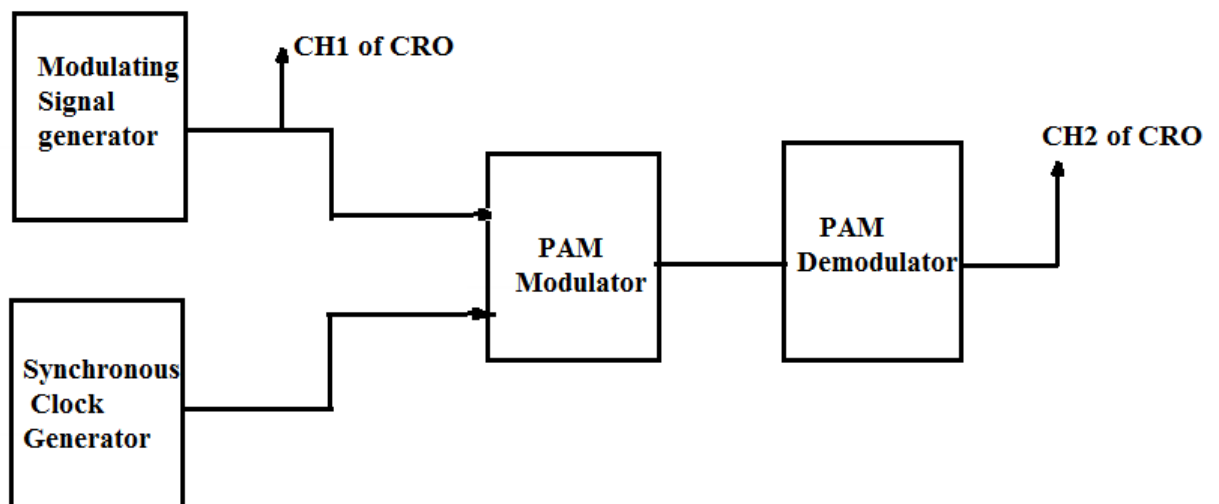
5. The testing procedure is given by the following figure
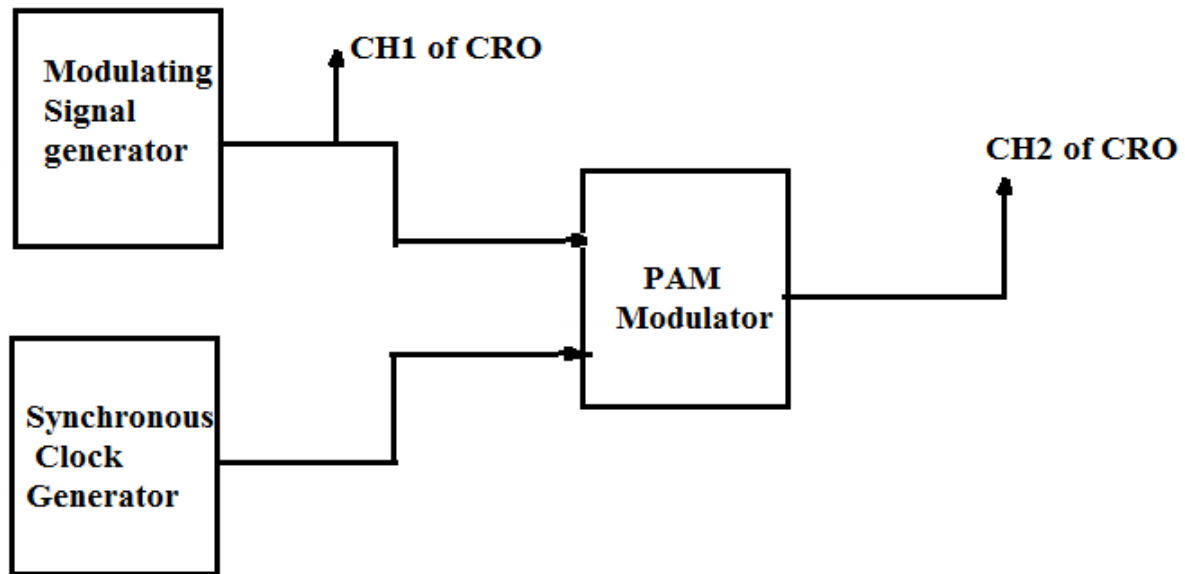
Fig: Testing procedure of PAM Generator

6. By varying the amplitude of the modulating signal, depth of modulation varies.

7. During demodulation, connect PAM output to the input of the PAM demodulator and observe the output of PAM demodulator.

8. Following figure shows the testing procedure.
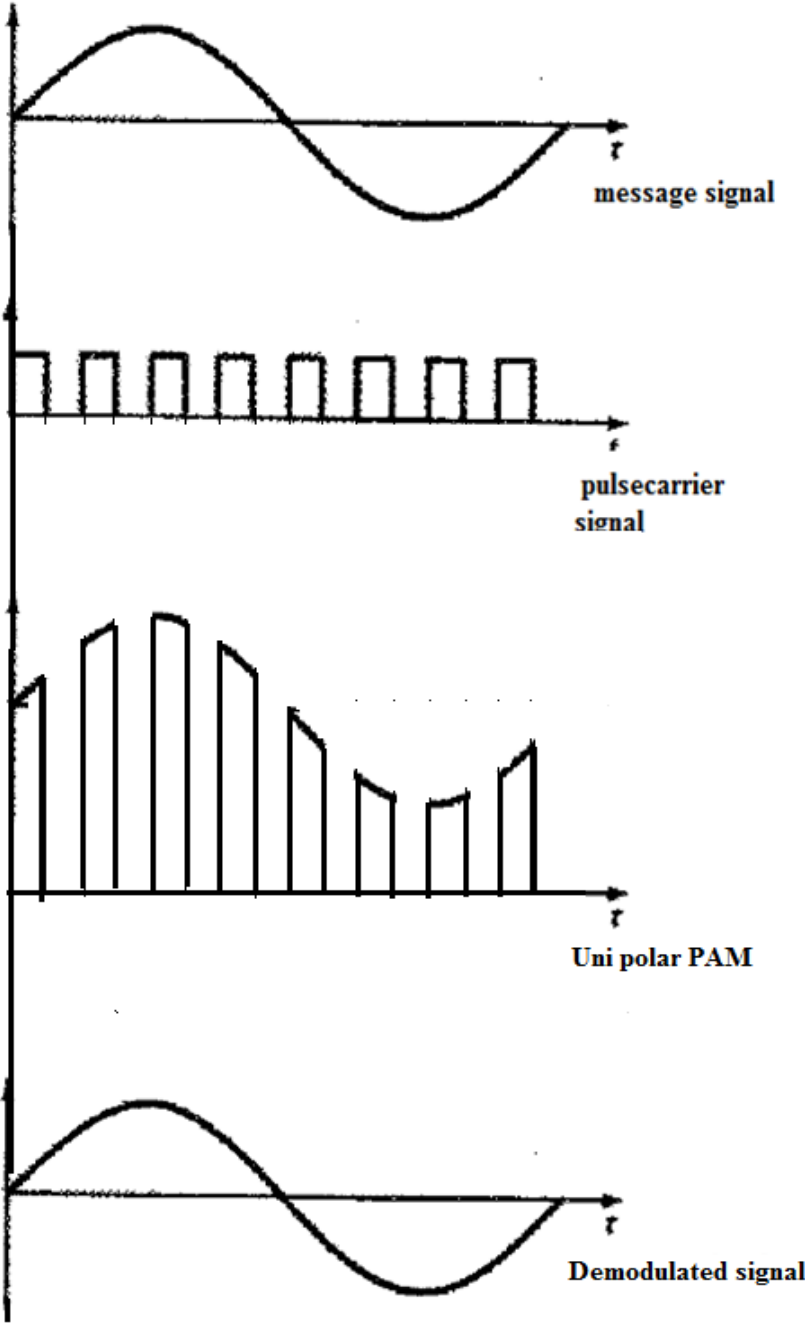

Fig: Testing procedure of PAM Demodulator

Circuit Diagram:

Model graphs:

message signal

pulsecarrier
signal

Uni polar PAM

Demodulated signal
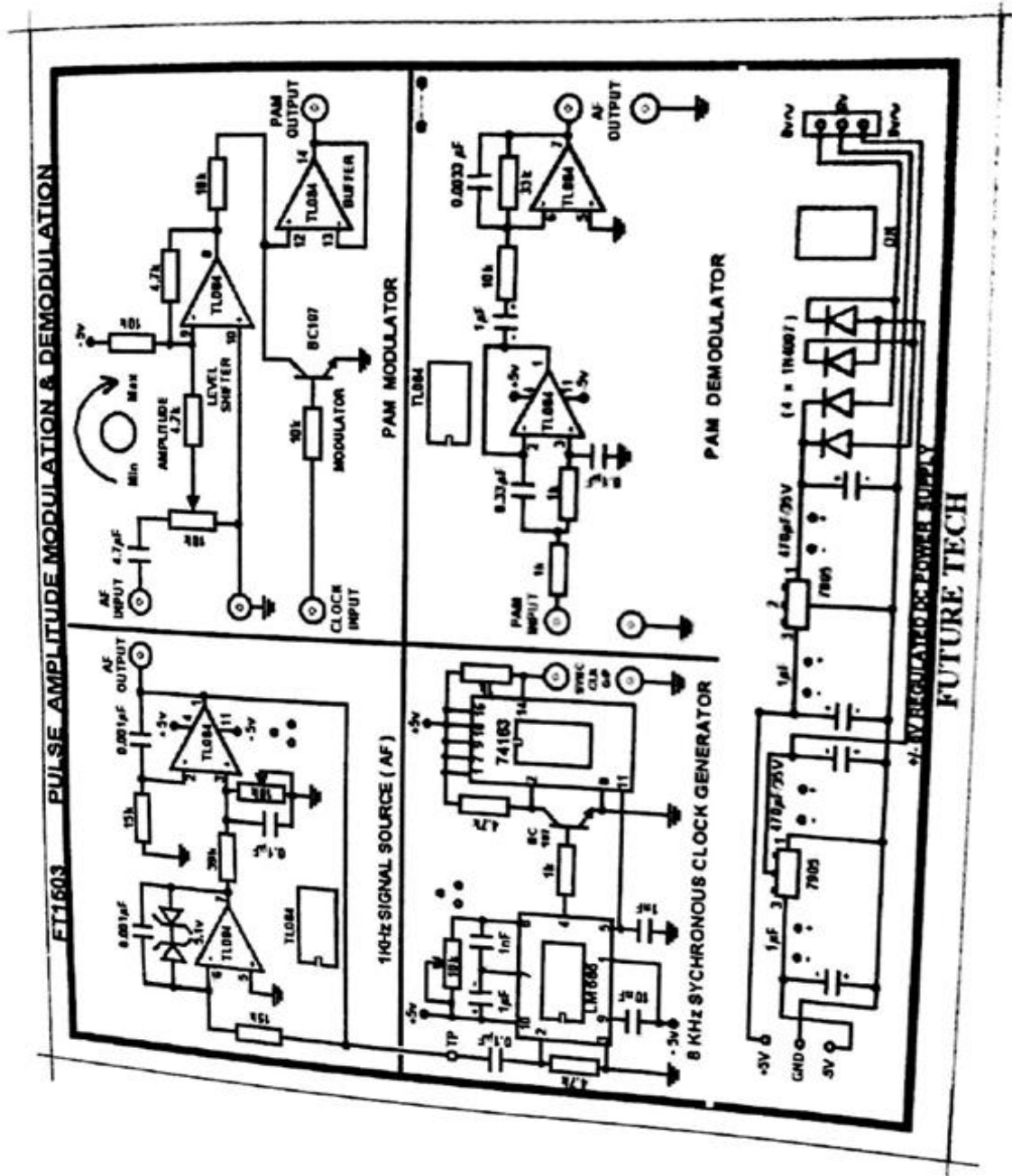
wave forms of Pulse Amplitude Modulation

Precautions:

1.   All Connections must be done carefully.
2. Switch off the power supply while making Connections.

Result & Discussions:

Pulse Amplitude Modulation and Demodulation is performed using FT1503 trainer. And the modulated and demodulated waveforms were observed.

5. C. PULSE WIDTH MODULATION AND PULSE POSITION MODULATION - DEMODULATION

Aim:

1.   To study the generation of Pulse Width Modulated signal using PPM trainer kit DCT3206.
2.   To study the generation of Pulse Position Modulated and Demodulated signals using PPM trainer kit DCT3206.

Apparatus:

Sl.No	Name of the component	Specifications or range	Quantity
1	PPM trainer kit DCT3206	----	1
2	CRO	(0-30)MHz	1
3	Connecting wires and probes patch chords	----	Required number

Theory:

Pulse modulation is used to transmit analog information. In this system continuous wave forms are sampled at regular intervals. Information regarding the signal is transmitted only at the sampling times together with synchronizing signals. At the receiving end, the Original signal may be reconstructed from the information regarding the samples. Pulse Modulation may be subdivided into two types, Analog and Digital. In analog the indication of sample amplitude is the nearest variable. In Digital the information is a code.

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. In a PWM wave the amplitude of all samples remain constant only the width of the samples is changing with respect to message signal amplitude.

The pulse position Modulation is one of the methods of the Pulse Time Modulation. PPM is generated by changing the position of a fixed time slot. The amplitude and width of the pulses is kept constant, while the position of each pulse, in relation to the position of the recurrent reference pulse is valid by each instances sampled value of the modulating wave. Pulse position Modulation into the category of Analog communication.PPM has the advantage of requiring constant transmitter power output, but the disadvantage of depending on transmitter receiver synchronization. PPM may be obtained very simply from PWM. However, in PWM the locations of the leading edges are fixed, whereas those of the trailing edges are not. Their position depends on pulse width, which is determined by signal amplitude at that instant. Thus, it may be said that the trailing edges of PWM pulses are, in fact , position modulated. This has positive going pulses corresponding to the trailing edge of an un modulated pulse is counted as zero displacement other trailing edges will arrive earlier or later. They will therefore have a time displacement other than zero. This time displacement is proportional to the instantaneous value of the signal voltage. The differentiated pulses corresponding to the leading edges are removed with a diode clipper or rectifier, and the remaining pulses, is position-modulated.

Circuit Diagram: Description

Modulating signal generator:

A 4.096 MHz clock is used to derive the modulating signal, which is generated by an oscillator circuit comprising a 4.096 MHz crystal and three 74HC04 (U_9) inverter gates. This 4.096 MHz clock is then divided down in frequency by a factor of 4096,by Binary counter 74HC4040(U_4) , and 2 KHz square wave on pin no.15. The frequency is selectable by means of SW1. This goes to input of fourth order low pass filter U_3(TL072) is used to produce sine wave from the square wave. The amplitude of this sine wave can be varied.
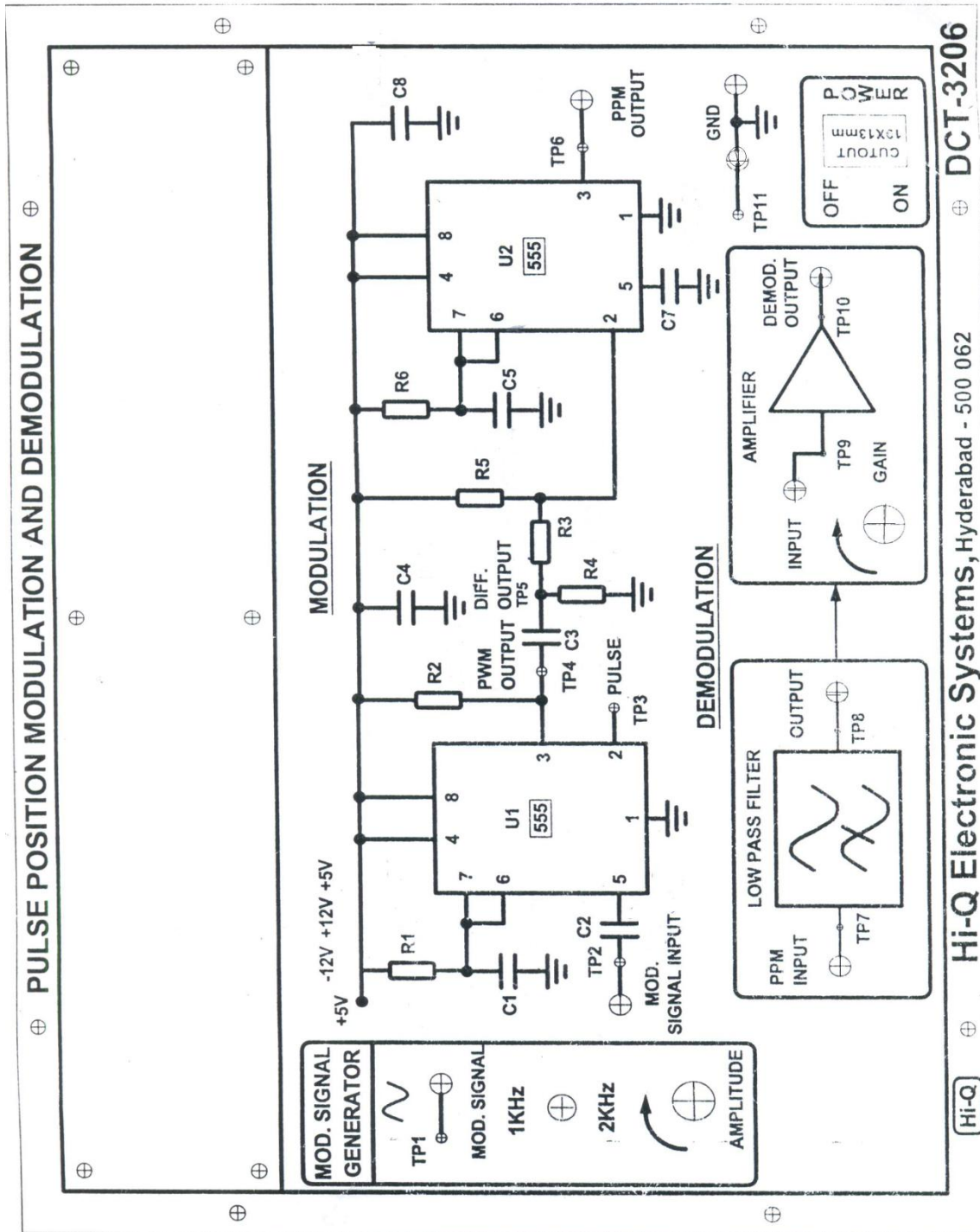
Modulation:

The circuit uses 555IC (U_1) a mono stable multi vibrator to perform the PPM. The message signal is given to pin no.5 & at pin no.2 the pulse carrier is of 32KHz frequency is connected internally & PWM, Differentiated PWM outputs are available at pins TP4,TP5.This differentiated output is fed to the 555 IC(U_2) in mono stable mode pin no.2. The PPM output is available at pin no 6.

Model graphs:
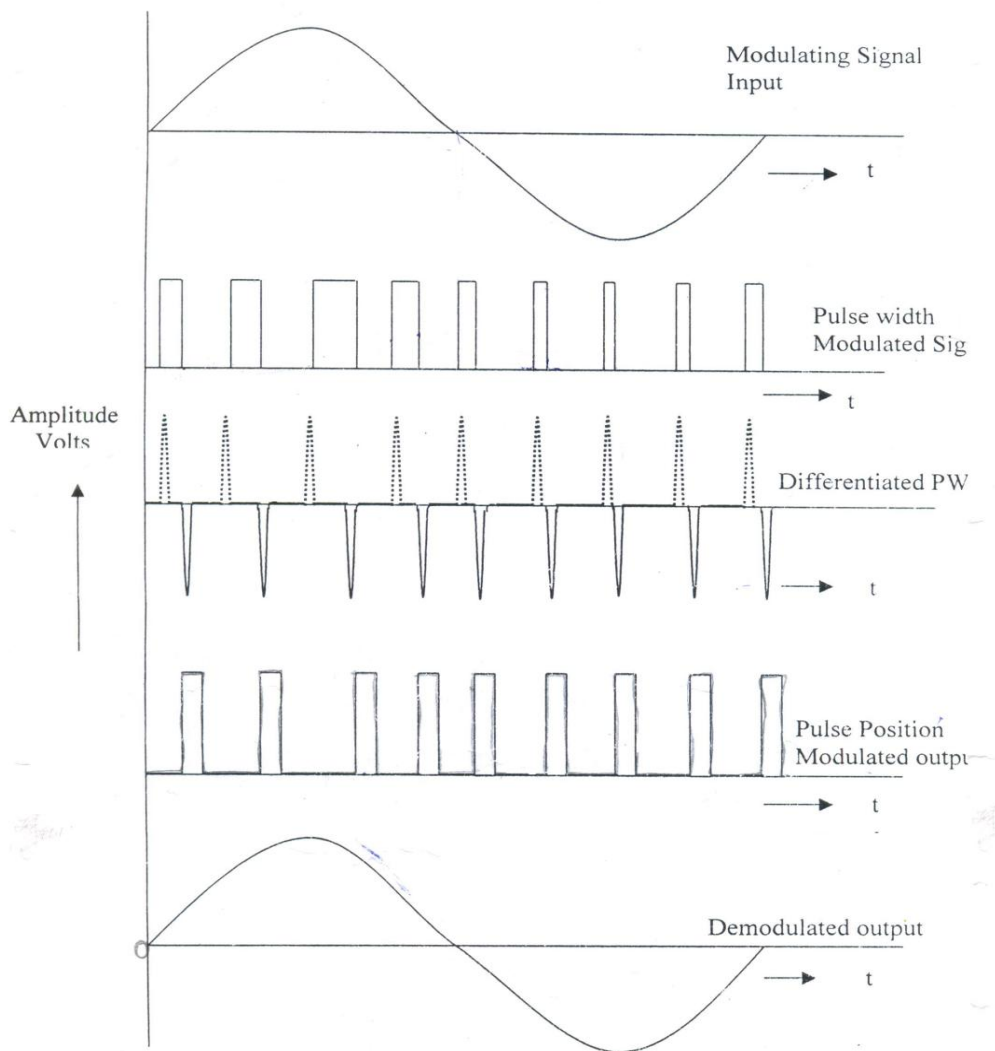
PULSE POSITION MODULATION AND DEMODULATION WAVEFORMS

Circuit Diagram:

Experimental procedure:

Procedure for PWM: modulation

1. Observe the signal generated by the Modulating signal generator at pin TP1 by connecting any channel of the CRO by keeping frequency in 1 KHz position and amplitude pot in max position.

2. Observe the pulse carrier signal at pin no2 TP3 of the 555 IC (U_1) measure its amplitude and time period.

3. Now interconnect TP1 of modulating signal generator with TP2 of 555IC (U_1) using connecting wire.

4. Switch on the power supply, observe the PWM wave in CH1 of CRO with respect to modulating signal in CH2 of CRO.

5. Plot the PWM wave carefully by counting the total number of pulses with respect to one complete cycle of message signal. And measure maximum and minimum durations of PWM wave at positive and negative peaks of modulating signal.

Procedure for PPM: modulation

1. Observe the signal generated by the Modulating signal generator at pin TP1 by connecting any channel of the CRO by keeping frequency in 1 KHz position and amplitude pot in max position.

2. Observe the pulse carrier signal at pin no2 TP3 of the 555 IC (U_1) measure its amplitude and time period.

3. Now interconnect TP1 of modulating signal generator with TP2 of 555IC (U_1) using connecting wire.

4. Switch on the power supply, observe the PPM output at TP6 in CH1 of CRO with respect to modulating signal in CH2 of CRO. Plot the PPM output wave carefully

5. By varying the amplitude and frequency of sine wave by varying amplitude pot and frequency selection switch to 2 KHz and observe PPM output.

Demodulation:

1. Connect PPM output generated in step no 9. As input to the Low Pass Filter in the Demodulation circuit at pin no TP7.

2. Switch on the power supply and observe the demodulated output at TP8 in CH1 of CRO with respect to original signal at pin TP2 of 555IC(U_1) in CH2 of CRO. Thus the recovered signal is true replica of modulating signal in terms of frequency.

3. As the amplitude of LPF output is less, connect this output to an A.C amplifier and observe the demodulated wave at pinTP10 by varying gain of the amplifier. This is amplified Demodulated output.

4. Repeat the same procedure for 2 KHz modulating signal.

Precautions:

1. All connections must be done carefully.

2. Switch off power supply before making connections.

Result & Discussions: The generation of PWM modulation, PPM modulation-Demodulation is studied using DCT3206 trainer kit.

6. <u>MIXER CHARACTERISTICS</u>

Aim:

To design and, to study the characteristics of mixer.

Apparatus:

Sl. No	Name of the component	Specifications or range	Quantity
1	Transistor BC107	f_T = 300 MHz P_d = 1W I_c(max) = 100mA	1
2	Capacitor	0.1µF	1
3	Inductance box	1mH	1
4	CRO	20MHz	1
5	Resistors	1KΩ,6.8 KΩ,10 KΩ	1 each
6	Function generator	1MHz	1
7	Regulated power supply	(0-30)V,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.

CircuitDiagram:
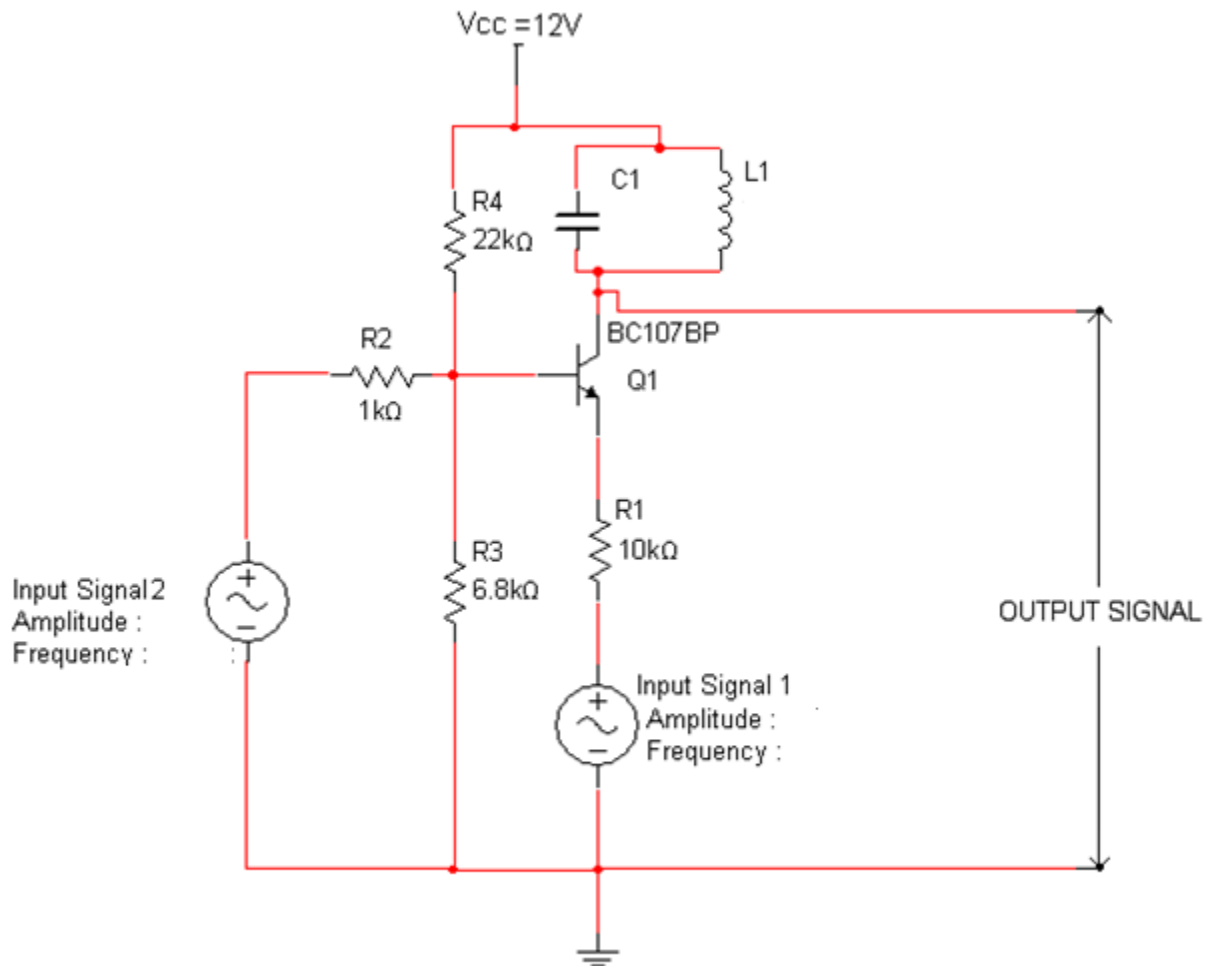
Experimental procedure:

1. Connections are made as per circuit diagram.
2. Connect the two input signals at input signal 1 and input signal 2 with two different frequencies.
3. Calculate the value of inductance L by assuming C= 0.1µF form the frequency of resonant circuit by using the formula $f_r = \dfrac{1}{2\pi\sqrt{LC}}$ where f_r =7 KHz.
4. Now adjust the value of inductor L is equal to the value obtained in the previous step.
5. Measure the frequency of the output signal. This frequency is the one of the output frequencies of the mixer (i.e. difference frequency).

Tabular form:

Sl. No	Name of the signal	Amplitude	frequency
1	Input signal 1	4V	
2	Input signal 2	4V	
3	Output signal when L=		

Precautions:

1. All connections must be done carefully.
2. Switch off power supply before making connections.

Result: Thus the designing of mixer is done for the difference frequency.

List of Experiments   **Page**

Digital Communications

1. <u>PCM GENERATION AND DETECTION</u>

Aim:

1.   To study the Generation of the Pulse Code Modulation Waveform.
2.   To perform Demodulation of   PCM wave.

Apparatus:

Sl. No	Name of the component	Specifications or range	Quantity
1	PCM trainer kit	-------	1
2	CRO	20MHz	1
3	Digital Multi Meter	----	1
4	Connecting wires, Probes and Patch chords.	----	As per required number

Theory:

Pulse Code Modulation:

Pulse Code Modulation is a Digital modulation which different from continuous modulation schemes like Amplitude Modulation and Frequency Modulation. PCM is a technique used to convert analog signals into binary form. In the absence of noise and distortion it is possible to completely recover a continuous analog modulated signal at the receiving end. But in real time they suffer from transmission distortion and noise to an appreciable extent. In the PCM

system, groups of pulses or codes are transmitted which represent binary numbers corresponding to modulating signal voltage levels. Recovery of the transmitter information does not depend on the height, width, or energy content of the individual pulses, but only on their presence or absence. Since it is relatively easy to recover pulses under these conditions, even in the presence of large amounts of noise and distortion, PCM systems tend to be very immune to interference and noise. Regeneration of the pulse enroute is also relatively easy, resulting in a system that produces excellent for long- distance communication.

PCM Encoding:

The encoding process generates a binary code number corresponding to Modulating signal voltage level to be transmitted for each sampling interval. Any one of the codes like binary, ASCII etc, may be used as long as it provides a sufficient number of different symbols to represent all of the levels to be transmitted. Ordinary binary number will contain a train of '1' and '0' pulses with a total of log 2^n pulses in each number. (N is no of levels in the full range). This system is very economical to realize, because it corresponds exactly to the process of analog-to-digital (A/D) conversion.

Quantization:

The first step is in the PCM system is to quantize the modulating signal. The modulating signal can assume an infinite number of different levels between the two limit values which define the range of the signal in PCM. A code number is transmitted for each level sampled in the modulating signal. If the exact number corresponding to the exact voltage were to be transmitted for every sample, an infinitely large number of different code symbols would be needed. Quantization has the effect of reducing this infinite number of levels to a relatively small number which can be coded without difficulty.

In the quantization process, the total range of the modulating signal is divided up into a number of small sub ranges. The number will depend on the nature of the modulating signal and will form as few as 8 to as many as 128 levels. A number that is an integer power of two is generally chosen because of the ease of generating binary codes. A new signal is generated by producing, for each sample, a voltage level corresponding to the midpoint level of the sub range in which the sample falls. Thus if a range of 0 to 5V were divided into 128, 5/128v sub ranges, and the signal sampled when it was 3V, the Quantizer would put a voltage of 2.96 V and hold that level

until the next sampling time. The result is a stepped waveform which follows the counter of the original modulating signal with each step synchronized to the sampling period.

Block diagram Description:

The block diagram of PCM modulation and Demodulation is shown ion front panel given in the circuit diagram.

Modulating signal:

A variable sinusoidal frequency generator is provided with frequency from 0 Hz to 500 Hz. To see the actual bits that are transmitted through the communication channel, a variable DC (-5V to +5V) source is provided on the panel.

PCM Encoding:

The modulating signal is applied to the input of Analog-to-Digital Converter which performs the two functions of Quantization and Encoding, Producing a 8-bit binary coded number. The signal is to be transmitted i.e, modulating signal is sampled at regular intervals. If the maximum amplitude +5V is represented by 8-bits the 1LSB corresponds to $Vx1/128 = 5/128=39mV$ and MSB represents the sign .So the values of the sampled signal at the output of Analog-to-Digital converter are 00000000, 00111111, 01111111, 00000000, 10111111, 11111111, 10111111, 00000000.

To transmit all the bits in one channel, actually it is often sent as binary number back to front by parallel to serial converter. i.e, 00000001, 11111100, 11111110 to make demodulating easier. A parallel to serial converter transmits the code bits in serial fashion.

PCM Decoding:

At the receiver end the received data will be in serial form. The serial data is converted back to parallel form by serial to parallel converter and passes the bits to a Digital- to- Analog converter for decoding which has in-built sample and hold amplifier which maintains the pulse level for the duration of the sampling period, recreating the pulse level for the duration of the sampling period, recreating the staircase waveform which is approximation of modulating signal. A low pass filter may be used to reduce the quantization noise and to yield the original modulating signal.

Circuit Diagram:
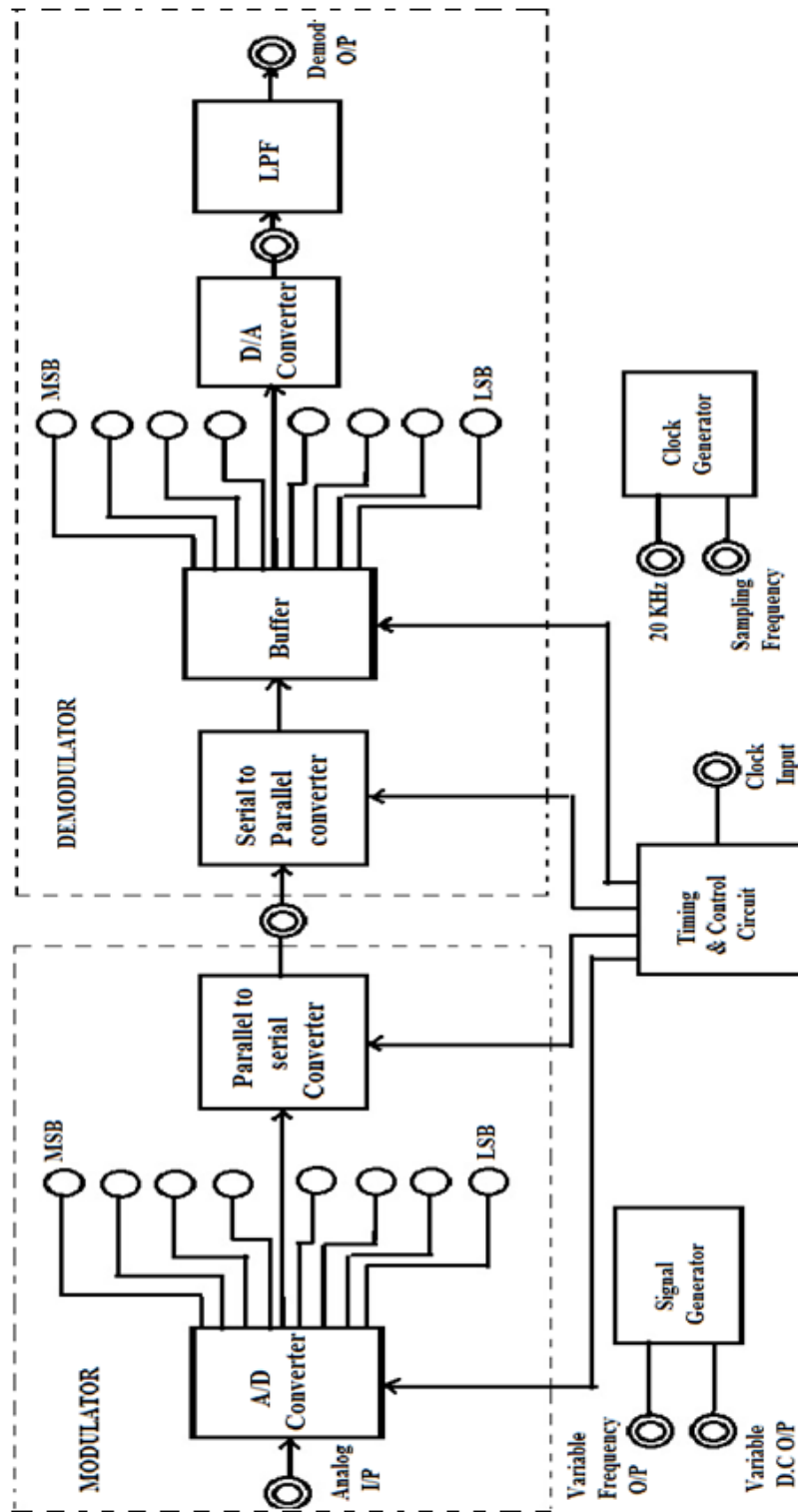
BLOCK DIAGRAM OF PCM MODULATOR AND DEMODULATOR

Model graphs:
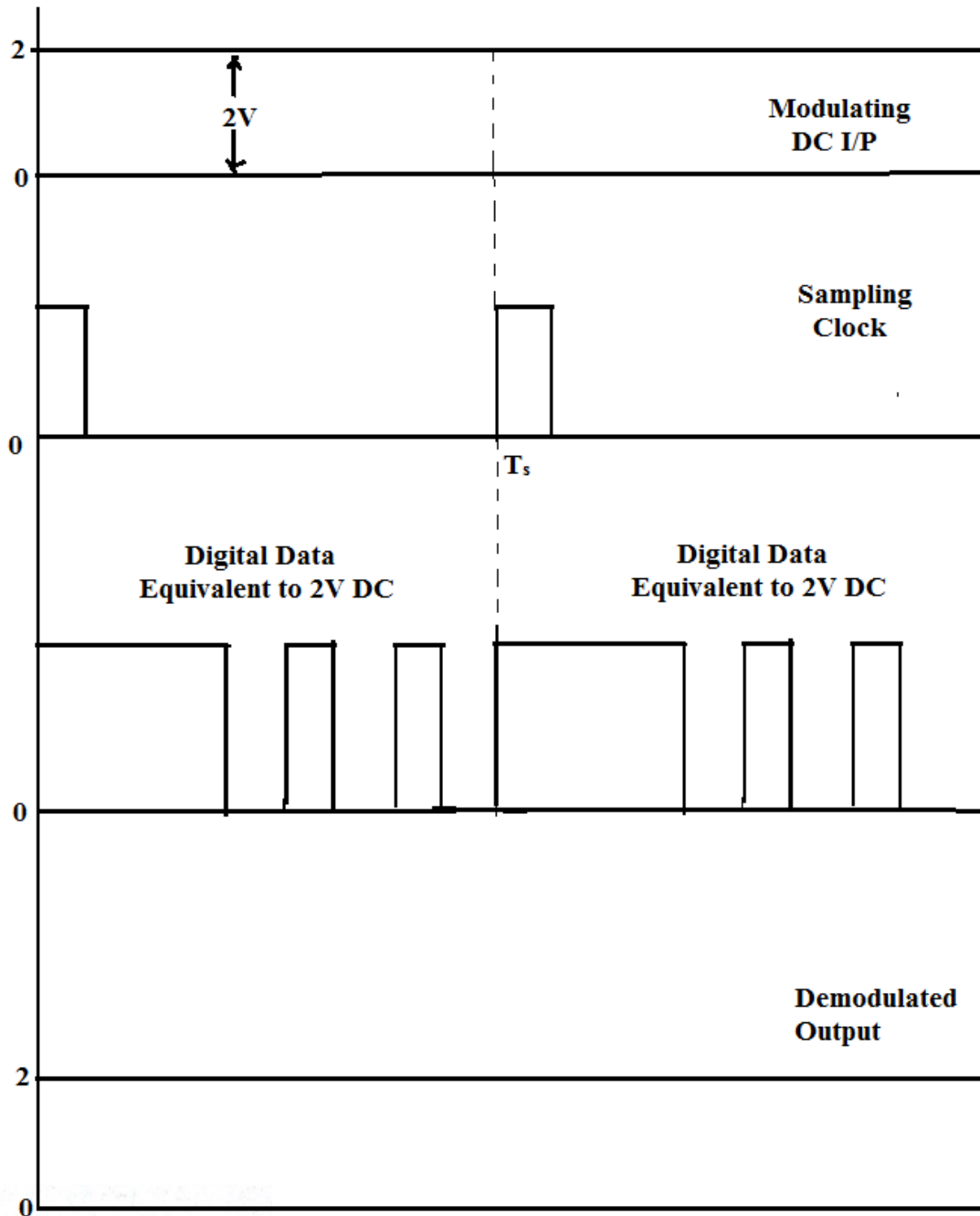
Model graphs of PCM

Experimental procedure:

1. Connect the AC Adapter to the mains and the other side to the Experimental Trainer. Power on the trainer kit.

2. Measure the Sampling Clock Frequency.

3. For visual convenience a DC Variable voltage is provided as Modulating signal. i.e. Variable DC Output is connected to the analog input. The LEDs of ADC glow according to the coded values of the strength of the DC signal.

4. LED 'ON' represents '1' & 'OFF' represents'0'.

5. As the DC voltage varies, the corresponding output data varies from 00000000 to 11111111. DMM is used to measure the DC voltage provided at the input. The readings are tabulated as given in the tabular column.

6. Now by applying Variable frequency DC output at analog input of the modulator the corresponding PCM modulated and demodulated signals can be observed and plotted.

Tabular form:

Sl. No	DC Variable input voltage (mV)	Digital Output	
		MSB bits	**LSB bits**
1	5	0000	0000

Calculations:

Practical values:

Weight of LSB   =

Weight of MSB   =

Dynamic Range   =

Theoretical values:

Weight of LSB   =

Weight of MSB   =

Precautions:

1. All connections must be done carefully.
2. Switch off power supply before making connections.

Result &Discussions: Thus the Pulse code modulation and demodulation is performed practically.

2. <u>DATA FORMATS</u>

Aim:

To study the various Data formats used in Line coding techniques.

Apparatus:

Sl. No	Name of the component	Specifications or range	Quantity
1	DCLT-005 Trainer kit	-------	1
2	CRO	20 MHz	1
3	Probes, connecting wires and Patch chords	----	As per required number

Theory:

In Digital Communications '1's and '0's can be represented in various formats in different levels and waveforms. The selection of coding technique depends on system band width, systems ability to pass dc level information, error checking facility.

We need to represent PCM binary digits by electrical pulses in order to transmit them through a Base Band channel. The most commonly used PCM popular Data formats are being realized here.

Different line coding Techniques are given as follows.

1. NRZ-L
2. NRZ-M
3. NRZ-S
4. RZ
5. Bi Phase-L

6. Bi Phase-M

7. Bi Phase-S

8. Differential Manchester.

9. RZ-AMI.

Model Graphs:
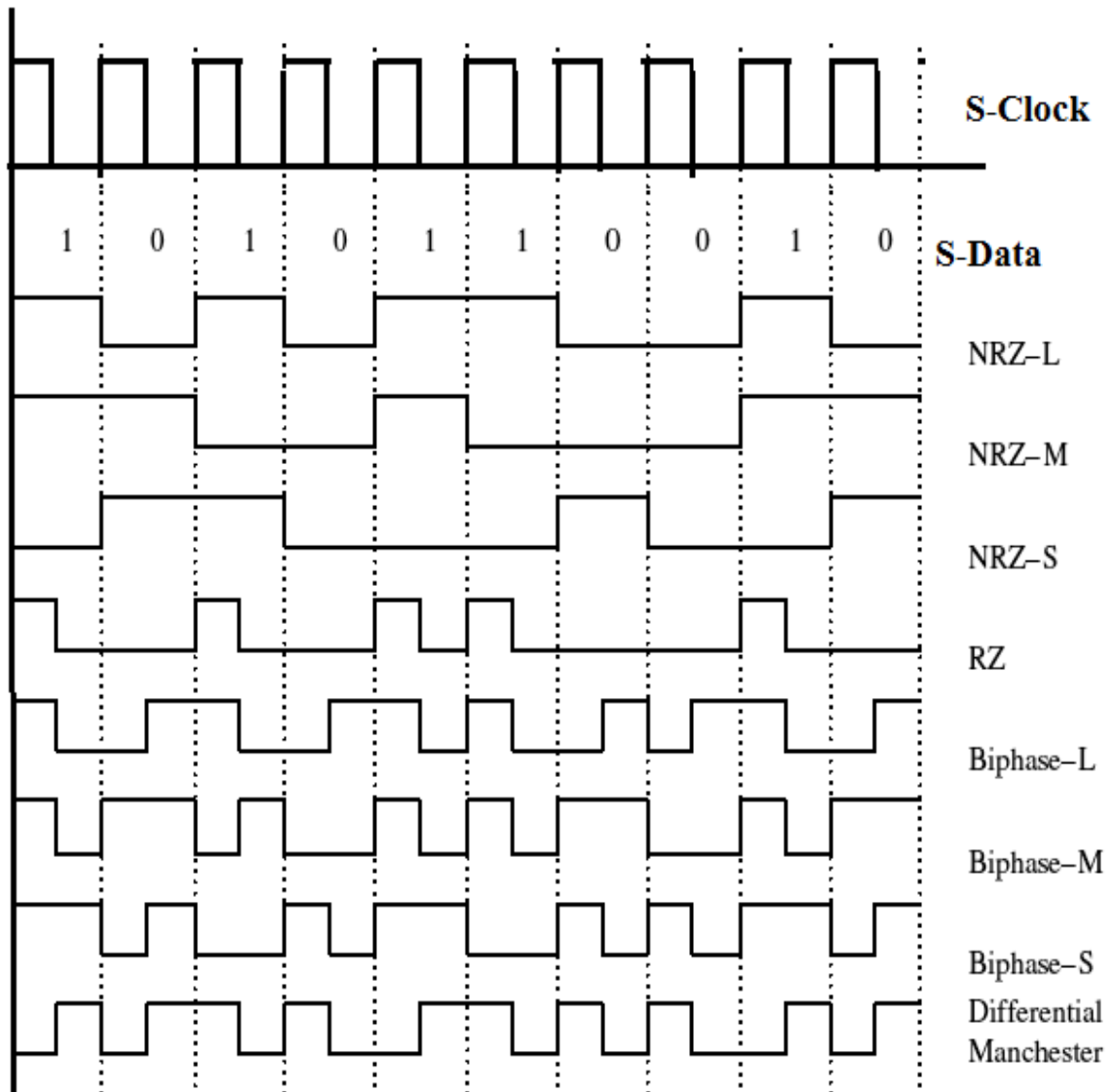
Waveforms of Data Formats

Experimental procedure:

1. Set up the DCLT-005 in standalone mode and prepare a list of waveforms that are to be observed in DCLT-005.
2. Connect the unit with the given power supply.
3. Connect s-clock to the Coding clock and observe the two signals.
4. Connect S-DATA to INPUT DATA and observe the two signals.
5. Connect one Channel-1 of the CRO to the S-DATA and Channel-2 to the CODED DATA.
6. Observe CODED DATA with respect to Clock signal for various S-DATA inputs.

Precautions:

1. All connections must be done carefully.
2. Switch off power supply before making connections.

Result &Discussions: Various Data formats are observed and the waveforms are plotted.

3. <u>LINEAR & ADAPTIVE DELTA MODULATION AND DEMODULATION</u>

Aim:

To study the operation of Delta Modulation and Demodulation.

Apparatus:

Sl. No	Name of the component	Specifications or range	Quantity
1	Delta Modulator trainer kit	-------	1
2	CRO	20MHz	1
3	Connecting wires, Probes and Patch chords.	----	As per required number

Theory:

Delta Modulation & Demodulation:

PCM codes each quantized sample into a binary code that is sent and decoded at the receiver. Another form of coded modulation is called Delta Modulation.

The main principle behind the Delta Modulation is to purposely over sampling the base band signal purposely to increase the correlation between adjacent samples of the signal, so as to permit the use of a sample quantizing strategy for constructing the encoded signal. Delta Modulation is a process of converting Analog signal into one bit code. In Delta Modulation only one bit is sent per sample. This bit indicates whether the signal is larger or smaller than the previous samples. The advantage of Delta Modulation is that the Modulator and Demodulator circuits are much simpler than those used in traditional PCM systems.

The purpose behind this form of Modulation is to minimize the effects of noise without increasing the number of bits being sent. This increases the Signal-to-Noise Ratio improving system performance. The idea behind delta modulation is to take samples close enough to each other so that each samples amplitude does not vary by more than signal step size. Then instead of sending a binary code representing the step size, a single bit is sent, signifying whether the sample size has increased or decreased by a single step.

This process can be illustrated by the following figure
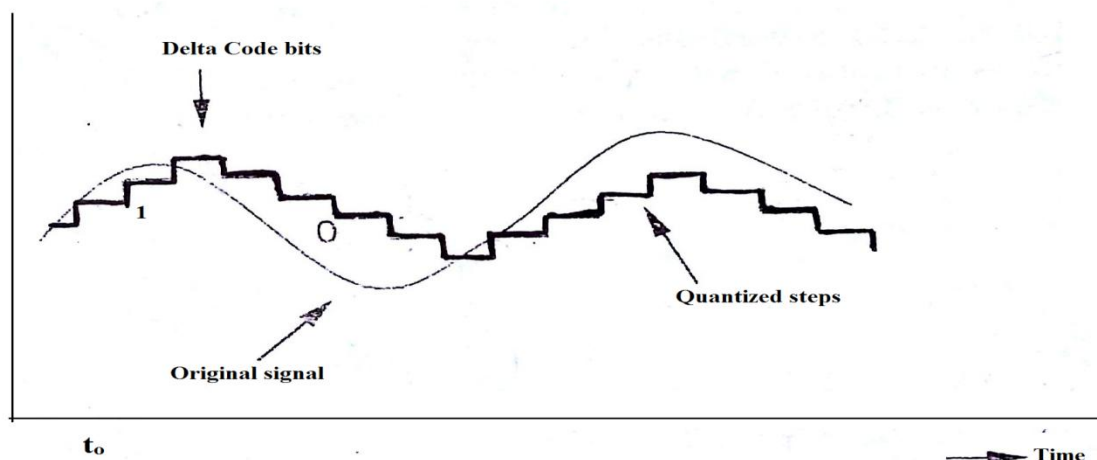
**Delta Encoding of Quantized Waveform**

The Original Signal is first transmitted and quantized as with PCM. If the sample currently being coded is above the previous sample, then a binary bit is set to logic '1' .If the sample is lower than the previous sample then the bit is set low.
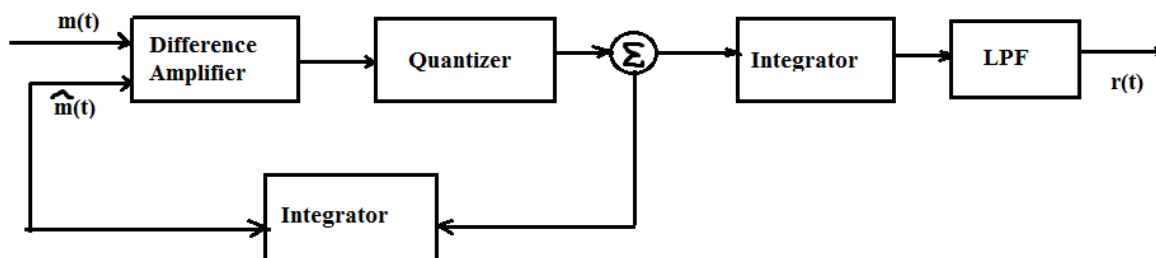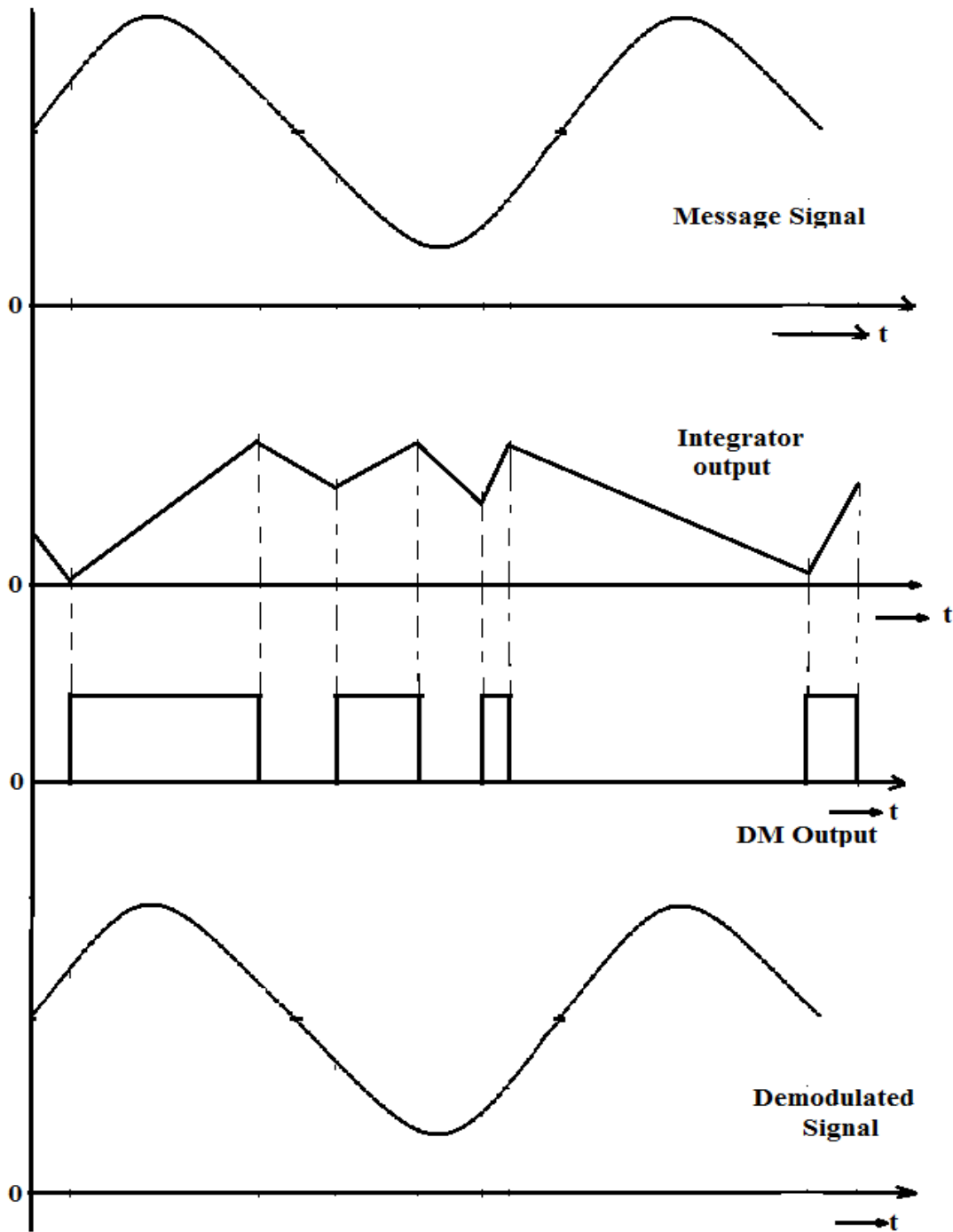

Block Diagram of Delta Modulation System

Circuit Diagram:

Model graphs:

Message Signal

Integrator output

DM Output
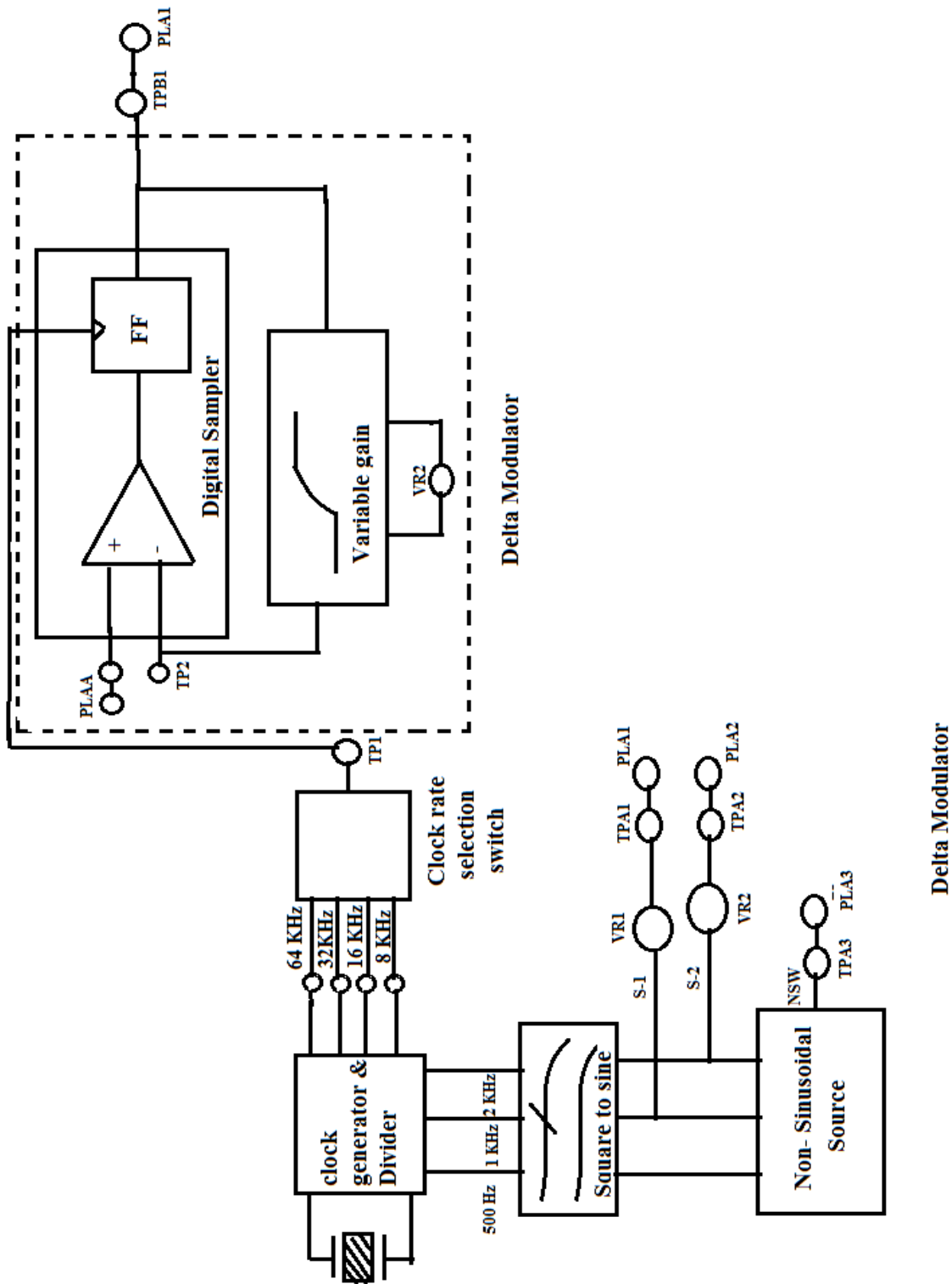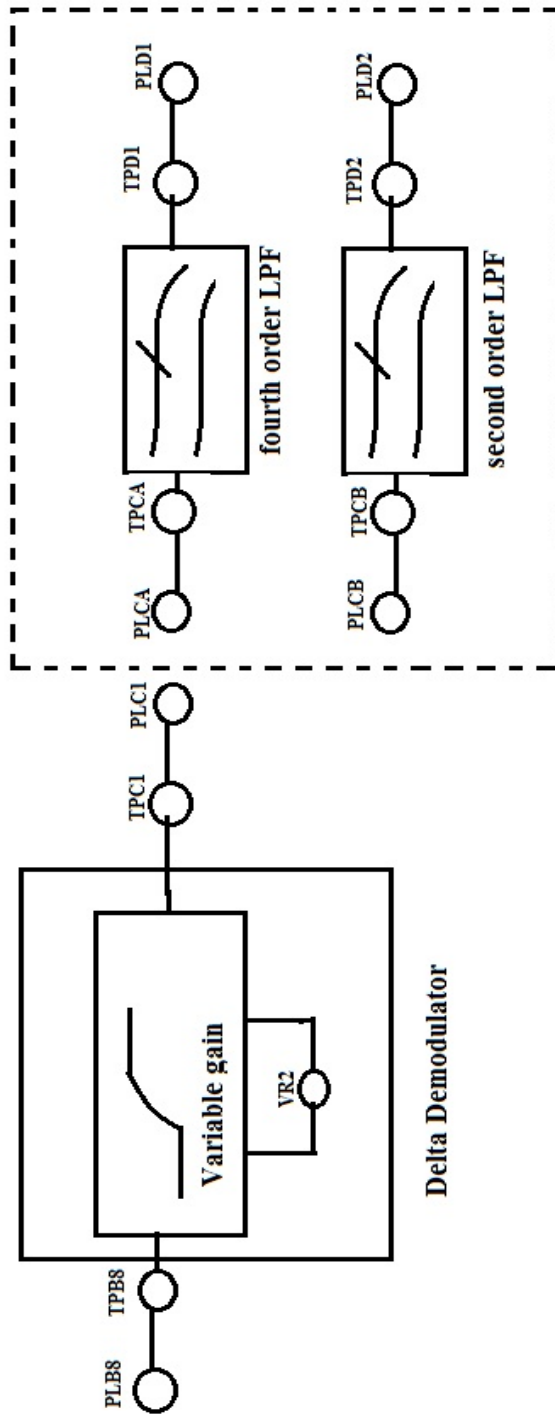
Demodulated Signal

Waveforms of Delta Modulation & Demodulation

Experimental procedure:

1. Connect PLA1 to PLAA.
2. Connect Channel-1 of CRO to TPA1/TPAA. Adjust VR_1 to minimum to get zero level signal.
3. Connect Channel-1 to TP2 and Channel-2 to TPB1and adjust VR2 to obtain square wave half the frequency of the clock rate selected (Output at TP1).
4. Connect Channel-1 to TP2 and set voltage/div of Channel 1 to mV range and observe a triangle waveform, which is output of integrator. It can be observed that as the clock rate is increased, amplitude of Triangle waveform decreases. This is called minimum step size (Clock rate can be changed by depressing SW1 switch).
5. Connect Channel-1 to TPA1/TPAA; adjust VR1 in order to obtain a 1 KHz sine wave of 500 mV Pk-Pk approximately.
6. Signal approximating 1 KHz is available at the integrator output (TP2). This signal is obtained by integrating the digital output resulting from Delta Modulation.
7. Connect Channel-1 to TP2 and Channel-2 to TPB1.It can be observed that the digital high makes the integrator output to go upwards and digital low makes the integrator output to go downwards.
8. With an Oscilloscope displaying three traces. It is possible to simultaneously observe the input signal of the modulation, the digital output of the modulator and the signal is obtained by the Integration from the modulator digital output.
9. Notice that, when the output is lower than the analog input the digital output is high, whenever it is low when the analog input is lower than the integrated output.
10. Increase the amplitude of 1 KHz sine wave by rotating VR1 1 V and high in the next case observe the changes in output signal. Repeat the same for different signal sources.

Precautions:

1. All connections must be done carefully.
2. Switch off power supply before making connections.

Result &Discussions: Thus the Delta modulation and demodulation is performed practically and the waveforms are plotted.

4. <u>ASK GENERATION & DETECTION</u>

Aim:

To generate ASK Modulated wave and To Demodulate the ASK signal.

Apparatus:

| Sl. No	Name of the component	Specifications or range	Quantity
1	ASK trainer kit	-------	1
2	CRO	20MHz	1
3	Connecting wires, Probes and Patch chords.	----	As per required number

Theory:

Amplitude Shift Keying:

When it is required to transmit digital signals of the sinusoidal carrier is varied in accordance with the incoming digital data since the digital data is in discrete steps, the modulation of band pass sinusoidal carrier is also done in discrete steps. Therefore, this type of modulation is called switching or signaling. If the amplitude of the carrier is switched depending on the incoming digital signal then it is called amplitude shift keying (ASK). This is similar to analog amplitude modulation.Amplitude shift keying (ASK) or ON-OFF keying is the simplest digital modulation technique. In this method, there is only one unit energy carrier and sit is switched on (or) off depending upon the input binary sequence. The ASK waveform can represented as $S(t) = \sqrt{2P_s} \cos(2\pi f_0 t)$, (to transmit '1'). To transmit symbol '0', the signal s(t) = 0 where P_s is power dissipated and fo is carrier frequency. The Original Signal is first transmitted and quantized as with PCM. If the sample currently being coded is above the previous sample, then a binary bit is set to logic '1' .If the sample is lower than the previous sample then the bit is set low.

Circuit Diagram:
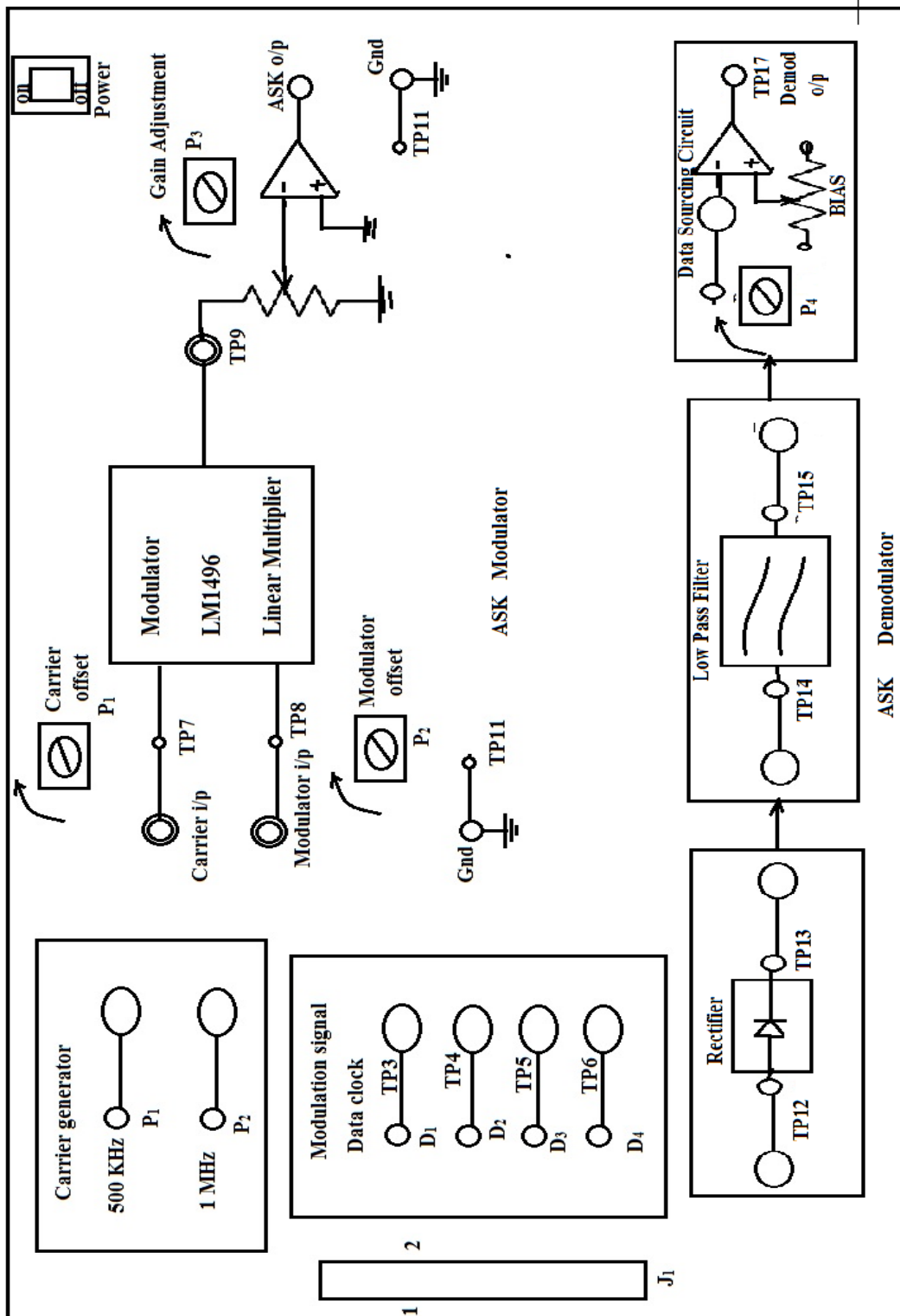
Model graphs:
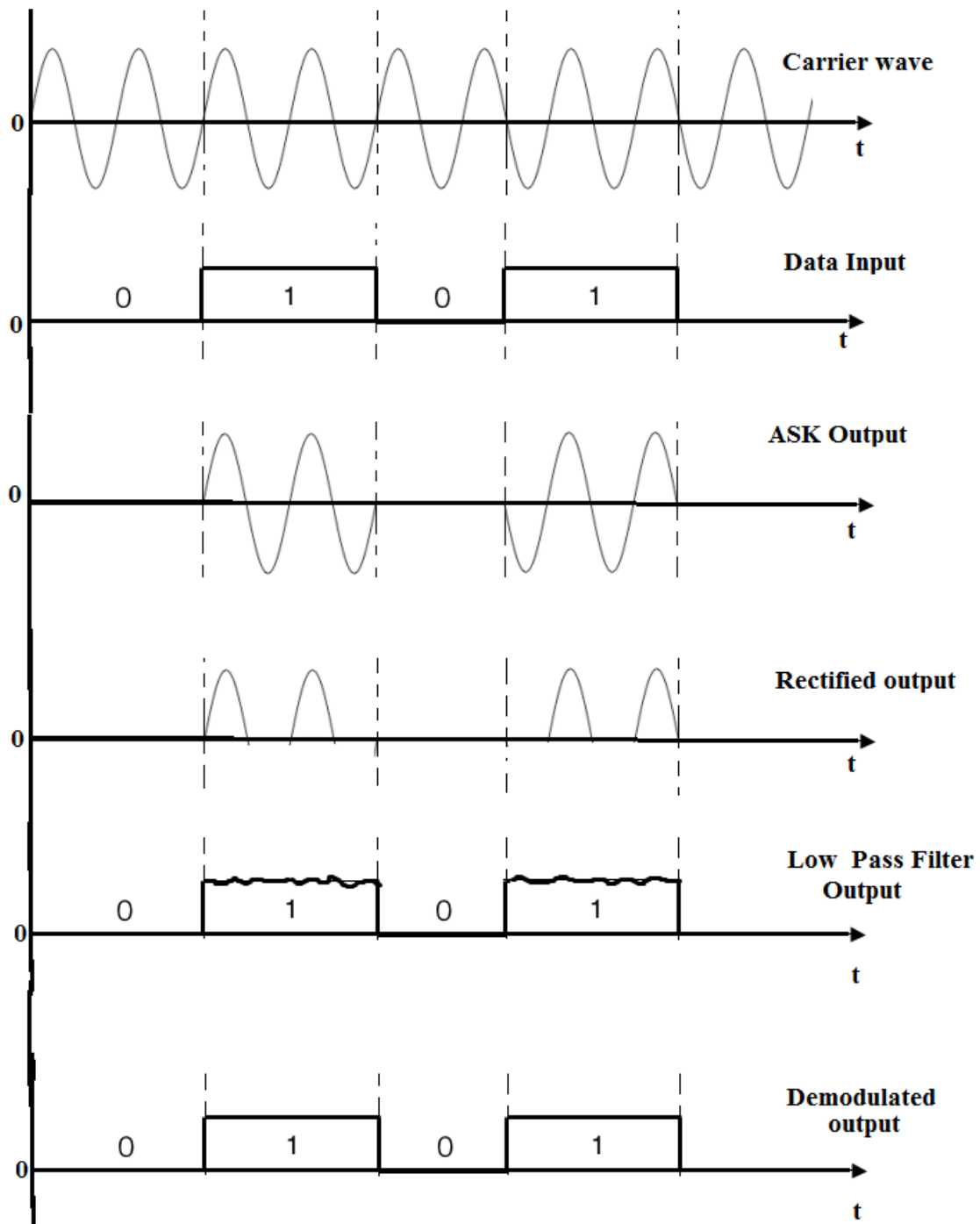
Waveforms of ASK Modulation & Demodulation

Experimental procedure:

Modulation:

1.   Switch on the power supply.

2.   The carrier frequency (sinusoid) is selected at carrier generation and is given to carrier input TP_{L1}.

3.   The data clock duty cycle is adjusted by the potentiometer P_1 and is given to the modulation input at TP_5. The data clock at TP_6 is observed and connected to TP_5.

4.   By applying carrier input and digital system stream input to the double balanced modulation the output ASK waveform is observed.

5.   The ASK output can be adjusted by the gain adjustment potentiometer TP_5.

Demodulation:

1.   The ASK input is given to the input of rectifier.

2.   This rectified signal is passed through low pass filter to remove carrier wave.

3.   This out coming waveform is given to the data squaring circuit which sets up a threshold. If the input to this circuit is greater than threshold it is set as +5V otherwise 0V.

4.   The demodulated output at $TP_{1\,8}$ is observed.

Precautions:

            1.   All connections must be done carefully.

            2.   Switch off power supply before making connections.

Result &Discussions: Thus the ASK modulation and demodulation is performed practically and the waveforms are plotted.

5. <u>FSK GENERATION AND DETECTION</u>

Aim:

1. To generate FSK modulated wave.
2. To generate Demodulated FSK signal.
3. To generate the NRZ-L signal.

Apparatus:

Sl. No	Name of the component	Specifications or range	Quantity
1	FSK trainer kit	-------	1
2	CRO	20MHz	1
3	Connecting wires, Probes and Patch chords.	----	As per required number

Theory:

Frequency Shift Keying:

When a digital signal is to be transmitted over a long distance, it needs continuous wave modulation.

A carrier of frequency 'fo' is used for modulation. Then the digital signal modulates some parameter like frequency, phase or amplitude of the carrier. The carrier 'fo' has some deviation in frequency. The deviation is called bandwidth of the channel. Thus the channel has to transmit some range of frequency. Hence such a type of transmission is called band pass transmission and the communication channel is called band pass channel.

When it is required to transmit digital signals on band pass channel the amplitude, frequency (or) phase of the sinusoidal carrier is varied in accordance with the incoming digital data. Since the

digital data is in discrete steps, the modulation of band pass sinusoidal carrier is also done in discrete steps. Hence this type of modulation is called switching or signaling. If the frequency of the sinusoidal carrier is switched on depending on the incoming digital signal, then it is called frequency shift keying (FSK). This is similar to analog frequency modulation.

In FSK the frequency of carrier is shifted according to binary symbol. That is there are 2 different frequency symbols according to binary symbols. Let there be a frequency shift by Ω, then we can write the following equations.
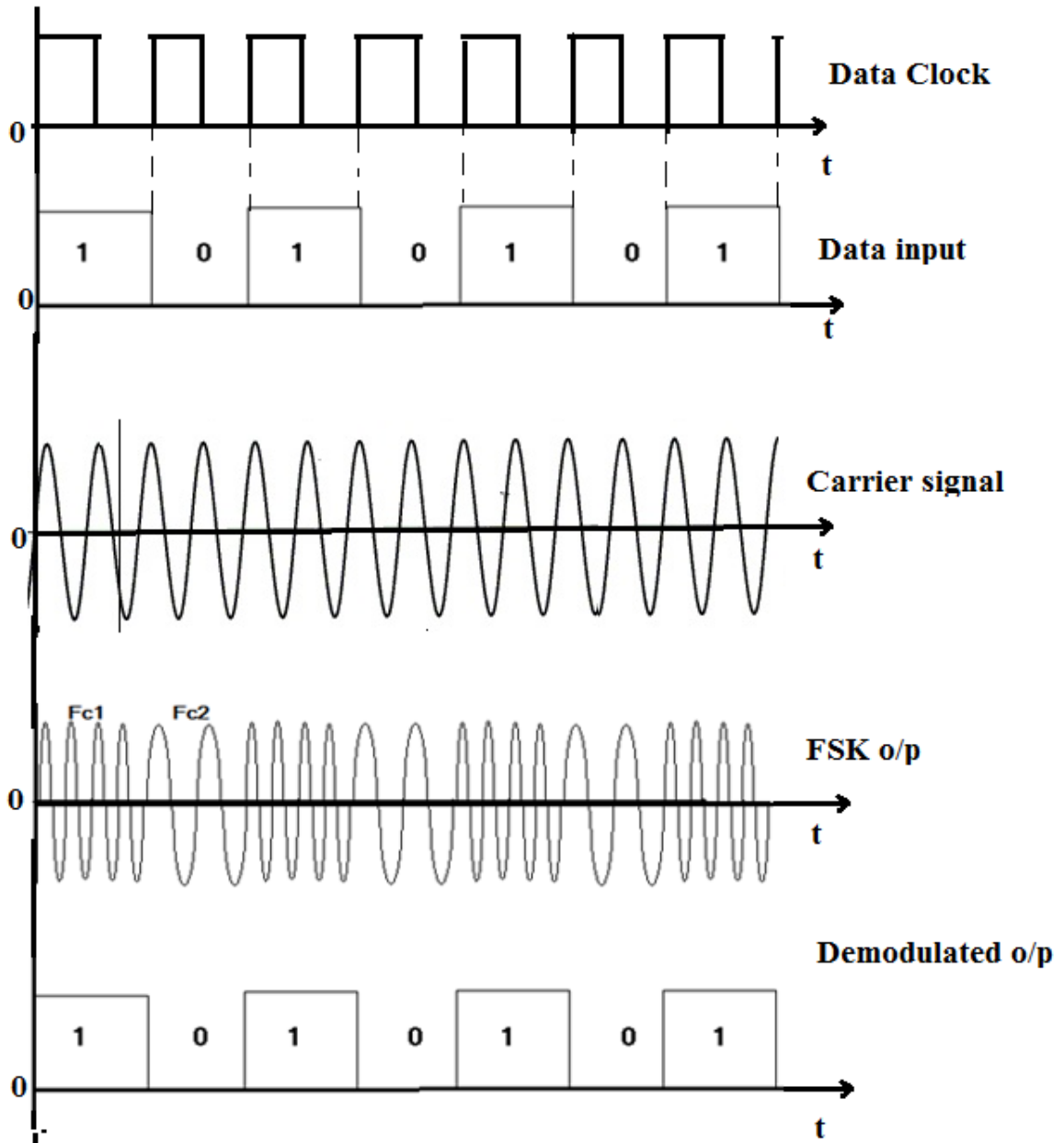
$$\text{If} \quad b(t) = 1, \quad s_H(t) = \sqrt{2Ps} \; \text{Cos} \; (2\pi f_o + \Omega) \, t$$

$$\text{If} \quad b(t) = 0, \quad s_L(t) = \sqrt{2Ps} \; \text{Cos} \; (2\pi f_o + \Omega) \, t$$

Circuit Diagram:
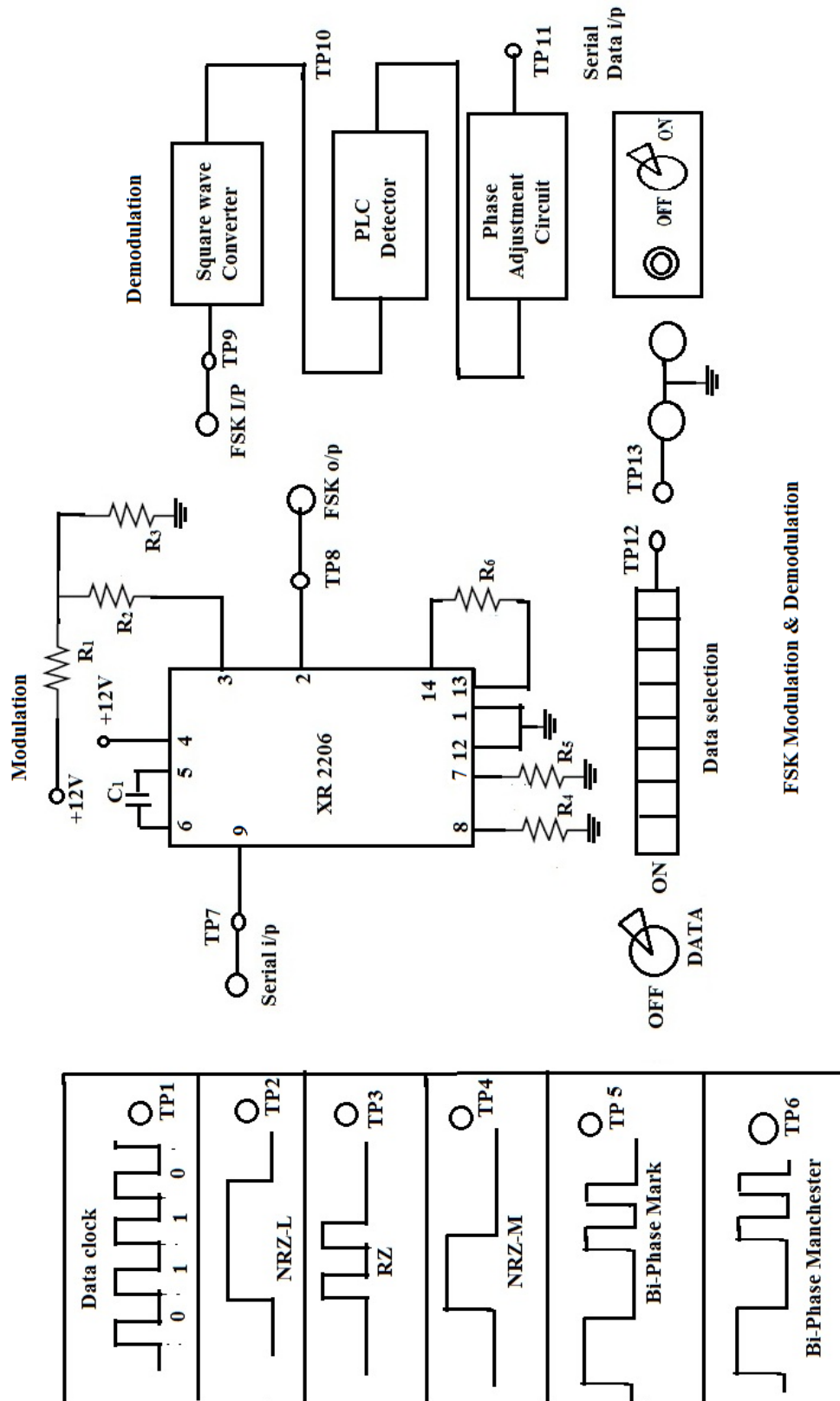
Model graphs:

Waveforms of FSK Modulation & Demodulation

Experimental procedure:

Modulation:

1. The power supply is switched ON and data selection switch is set to the desired code.

2. The switch is set (DATA ON-OFF) ON position. The 8 bit word pattern is observed on TP_{12}.

3. Observe the data clock at TP_1 and also observe NRZ (l) at TP_2, RZ at TP_3, and NRZ (M) at TP_4.

4. The patch cords are connected. The corresponding output (when data is logic '1' frequency is high) at TP_8.

5. Repeat the steps for other inputs and observe the corresponding FSK outputs.

6. The data selections are changed and repeat the steps 3 to 6 & observe corresponding FSK outputs.

Demodulation:

1. The patch chords are connected. The incoming FSK input is observed.

2. The output of square wave converter is available at TO_{10}. The serial output data is available at TP_{11}.

3. Repeat steps 1, 2 for other serial data inputs and outputs and the corresponding serial data is observed. The outputs are replica of the original inputs.

Precautions:

1. All connections must be done carefully.

2. Switch off power supply before making connections.

Result &Discussions: Thus the FSK modulation and demodulation is performed practically and the waveforms are plotted.

6. <u>A. PSK GENERATION AND DETECTION</u>

Aim:

To study the operation of phase shift keying modulation and demodulation

Apparatus:

Sl. No	Name of the component	Specifications or range	Quantity
1	PSK trainer kit-3210	-------	1
2	CRO	20MHz	1
3	Connecting wires, Probes and Patch chords.	----	As per required number

Theory:

Phase Shift Keying:

To transmit the Digital data from one place to another, we have to choose the Transmission medium. The simplest possible method to connect the Transmitter to the Receiver with a piece of wire. This works satisfactorily for short distances in some cases. But for long distance communication with the aircraft, ship, vehicle this is not feasible. Here we have to opt for the Radio Transmission.

It is not possible to send the digital data directly over the antenna because the antennae of practiced size works on very high frequencies, much higher than our data transmission rate. To be able to transmit the data over antennae, we have to modulate the signal i.e, phase, frequency or amplitude etc is varied in accordance with the digital data. At receiver we separate the signal from digital information by the process of demodulation. After this process we are left with high frequency signal (carrier signal) which we discard & the digital information, which we utilize. Modulation also allows different data streams to be transmitted over the same channel (Transmission medium). This process is called as 'Multiplexing' & result in a considerable

saving in Bandwidth no of channels to be used, Also it increases the channel efficiency. As variation of particular parameter variation of the carrier wave give rise to various modulation techniques. Some of the basic modulation techniques are ASK, FSK, PSK, DPSK &QPSK.

PSK is a form of angle modulated, constant amplitude digital modulation. Digital communication become important with the expansion of the use of computers and data processing and have continued to develop into a major industry providing the interconnection of computer peripherals and transmission of data between distant sites.

PSK is a relatively new system in which the carrier may have phase which is fixed for one level and is shifted by 180^0 for another level. PSK is similar to PSK in many aspects, as in PSK, frequency of carrier is shifted according to the modulating square wave.

Circuit Description:

In this trainer IC XR 2206 is a basic wave form generator which generates Sine, Square, and Triangle Waveforms. The sine wave generated by this XR 2206 IC is used as carrier signal to the system. This square wave is used as a clock input to a decade counter (IC 7490) which generates the modulating data outputs. The digital signal is applied to the modulation input for PSK generation is bipolar i.e., have equal positive and negative voltage levels. When the modulating input is negative the output of the modulator is a sine wave in phase with the carrier input. Whereas for the positive voltage levels, the modulator is a sine wave which is shifted out of phase by 180° from the carrier input compared to the differential data stream. This happens because the carrier input is now multiplied by the negative constant level. +Thus the output changes in phase when a change in polarity of the modulating signal results. The functional blocks of the PSK Modulator & Demodulator.
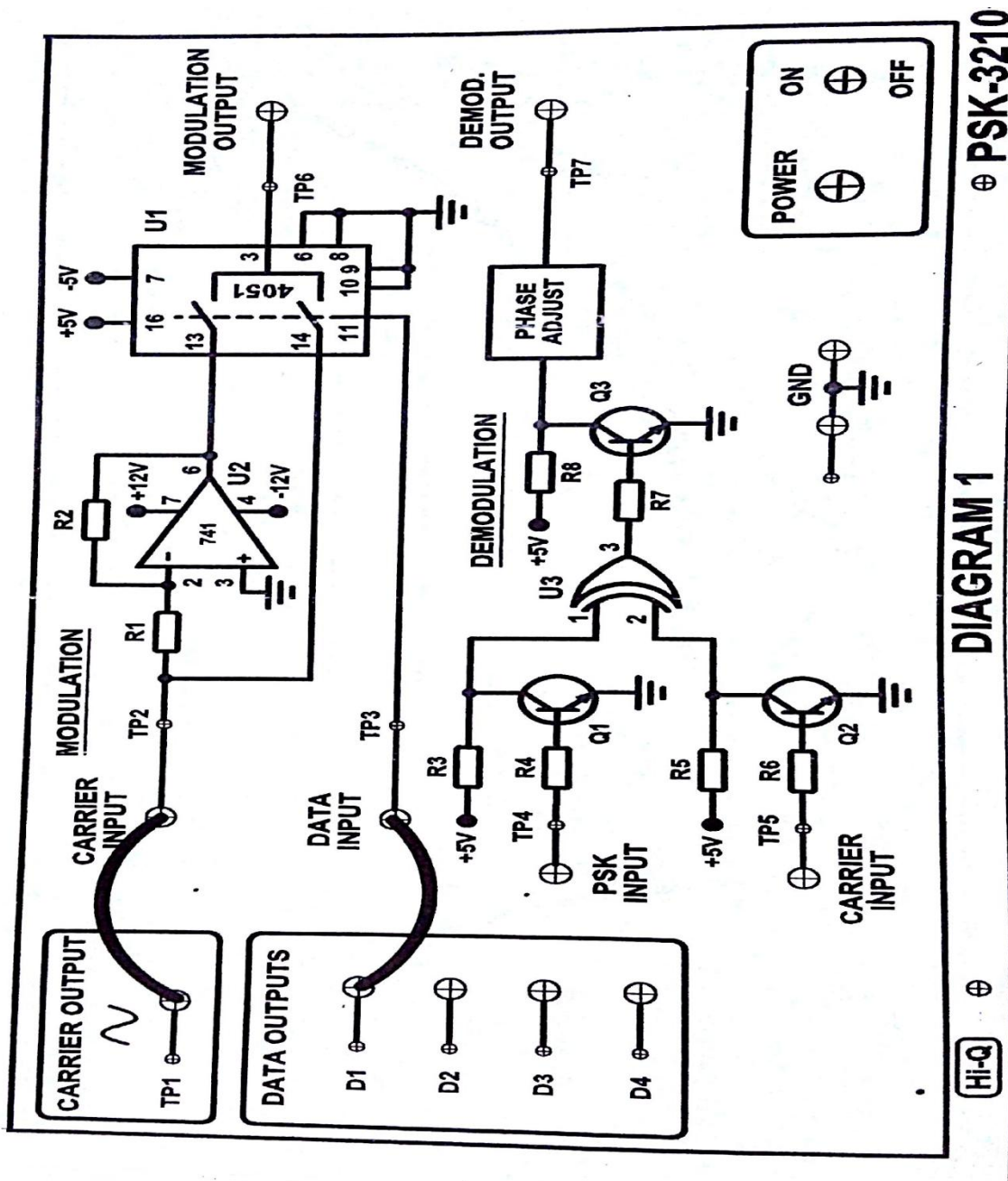
Modulation:

IC CD 4051 is an Analog multiplexer to which carrier is applied with and without 180° phase shift to the two multiplex inputs of the IC. Modulating data input is applied to its control input. Depending up on the level of the controlling signal, carrier signal applied with or without phase shift is steered to the output. The 180° phase shift to the carrier signal is carried by an operational amplifier using 741 IC.
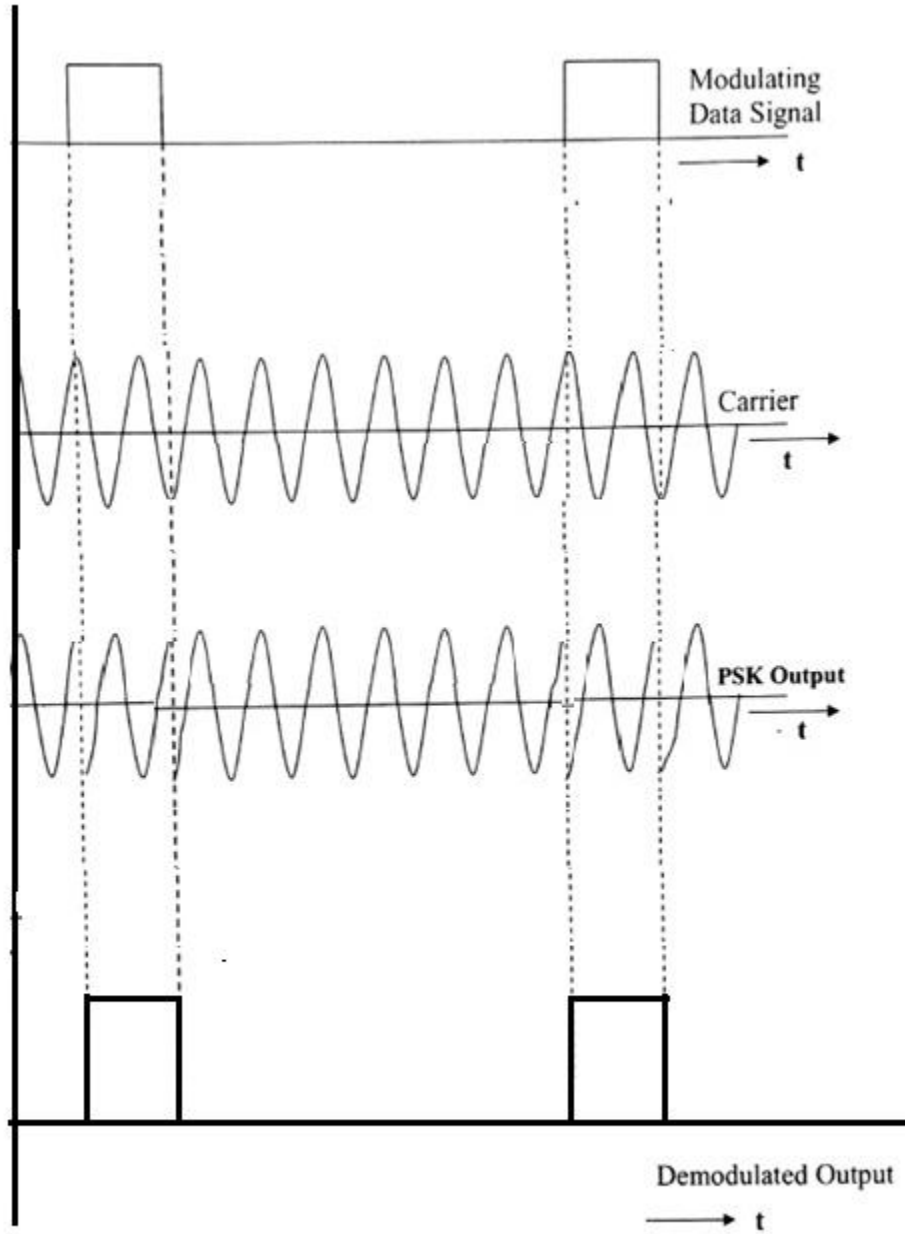
Demodulation:

During the demodulation the PSK signal is converted into a +5 volts Square wave signal using a transistor and is applied to one input of an EX-OR gate. To the second input of the gate

carrier signal is applied after conversion into a +5 volts signal. So the EX-OR gate output is equivalent to the modulating data signal.

Circuit Diagram:

Model graphs:

Waveforms of PSK Modulation and Demodulation

Experimental procedure:

Modulation:

1. The trainer is switched ON. The carrier signal is observed at TP1.

2. Data outputs (D_1, D_2, D_3, and D4) are observed.

3. Carrier output TP1 is connected to carrier input of PSK modulator at TP2 using patch chord.

4. Connect data input 'D_1' to input of PSK modulator at TP3. The PSK output waveform is observed on CRO on channel – 1 & corresponding data input on channel – 2.

5. These steps are repeated for D_2, D_3 & D_4 and the corresponding PSK output are observed.

Demodulation:

1. Connect the PSK modulation output TP6 to the PSK input of Demodulator at TP4.

2. Connect carrier output TP1 to the carrier input of PSK modulator at TP5.

3. Observe the PSK modulated output at TP7 on CRO at Channel-1 and corresponding data output on channel-2.

4. The demodulated output is true replica of data outputs D_2, D_3, and D_4.

Precautions:

1. All connections must be done carefully.
2. Switch off power supply before making connections.

Result &Discussions: Thus the PSK modulation and demodulation is performed practically and the waveforms are plotted.

6. B. QPSK GENERATION AND DETECTION

Aim:

To study the operation of Quadrature phase shift keying modulation and to plot QPSK modulated wave.

Apparatus:

| Sl. No	Name of the component	Specifications or range	Quantity
1	Physitech QPSK trainer kit	-------	1
2	CRO	20MHz	1
3	Connecting wires, Probes and Patch chords.	----	As per required number

Theory:

QPSK Modulation:

In QPSK, the phase of the carrier depends upon the pair of successive bits in the data stream. This there are four possible combinations of bit pair viz 00, 01, 10 & 11.   During each combination of bit pair, the carrier frequency fc is transmitted with Quadrature phase difference.

Bit Pair	Phase of Carrier
00	fc $<0^0$
01	fc $<180^0$

10	fc $<90^0$
11	fc $<270^0$

Circuit Diagram:
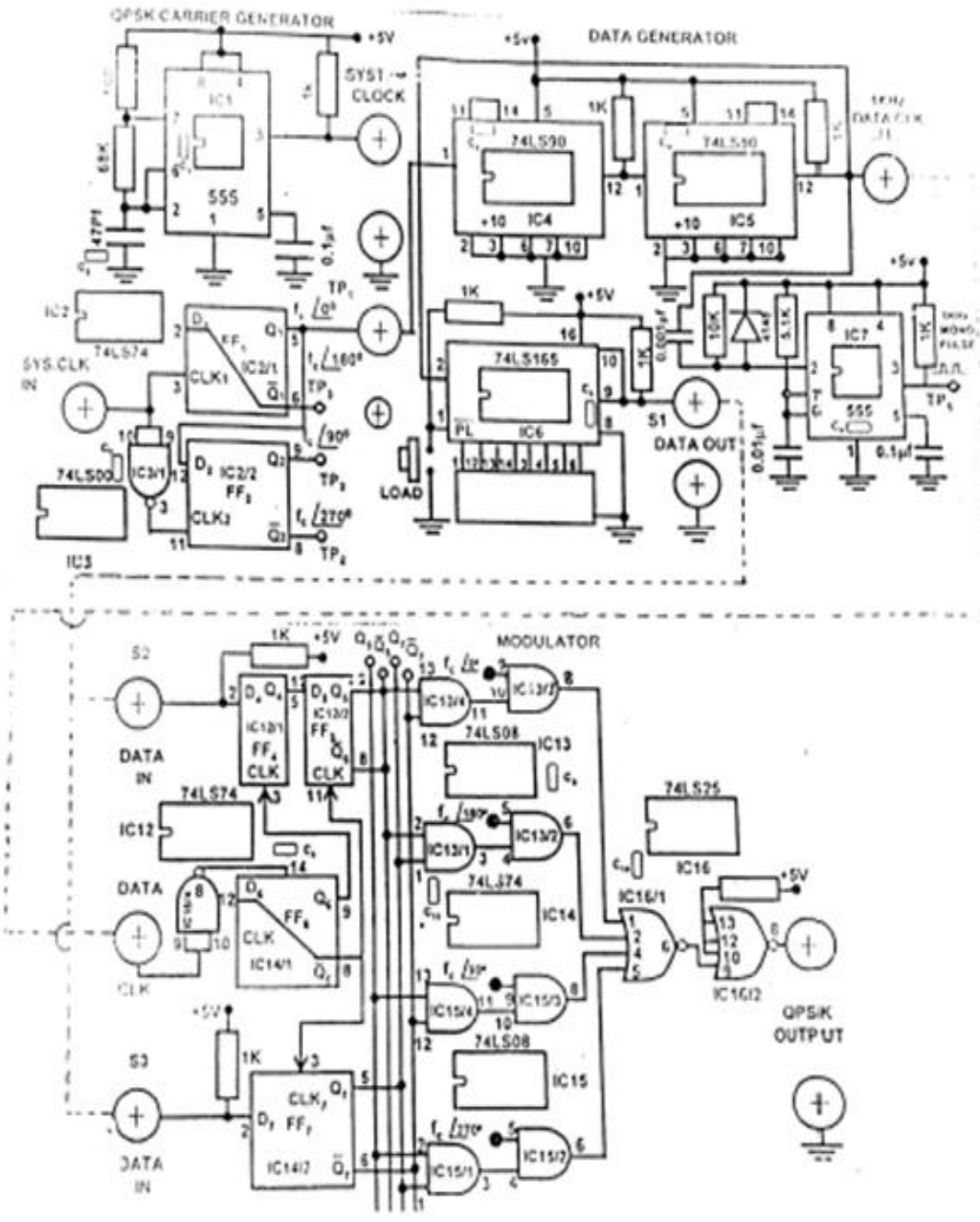
QPSK Modulator

QPSK Demodulator

Model graphs:

$f_c < 0^o$

$f_c < 180^o$

$f_c < 270^o$

$f_c < 90^o$
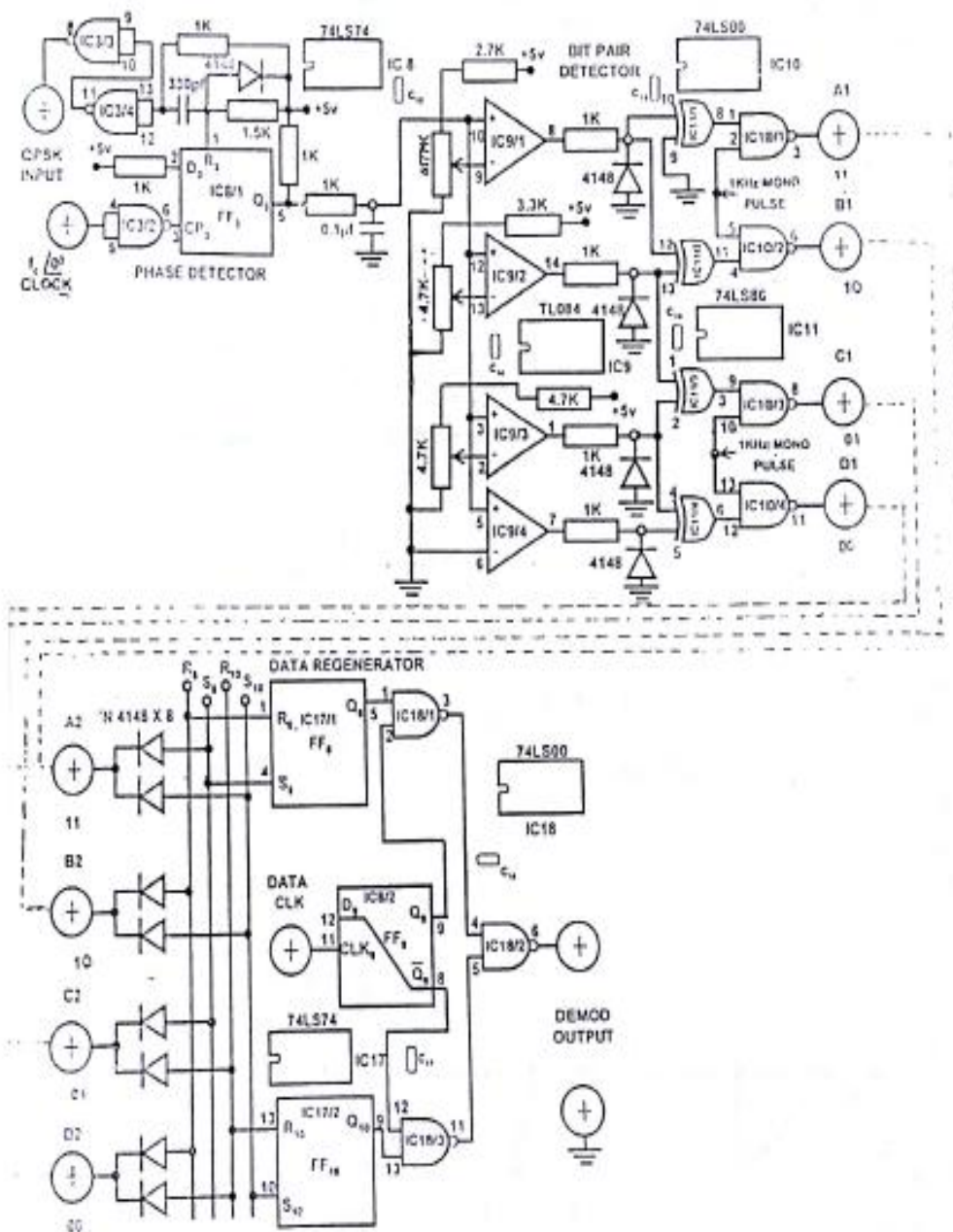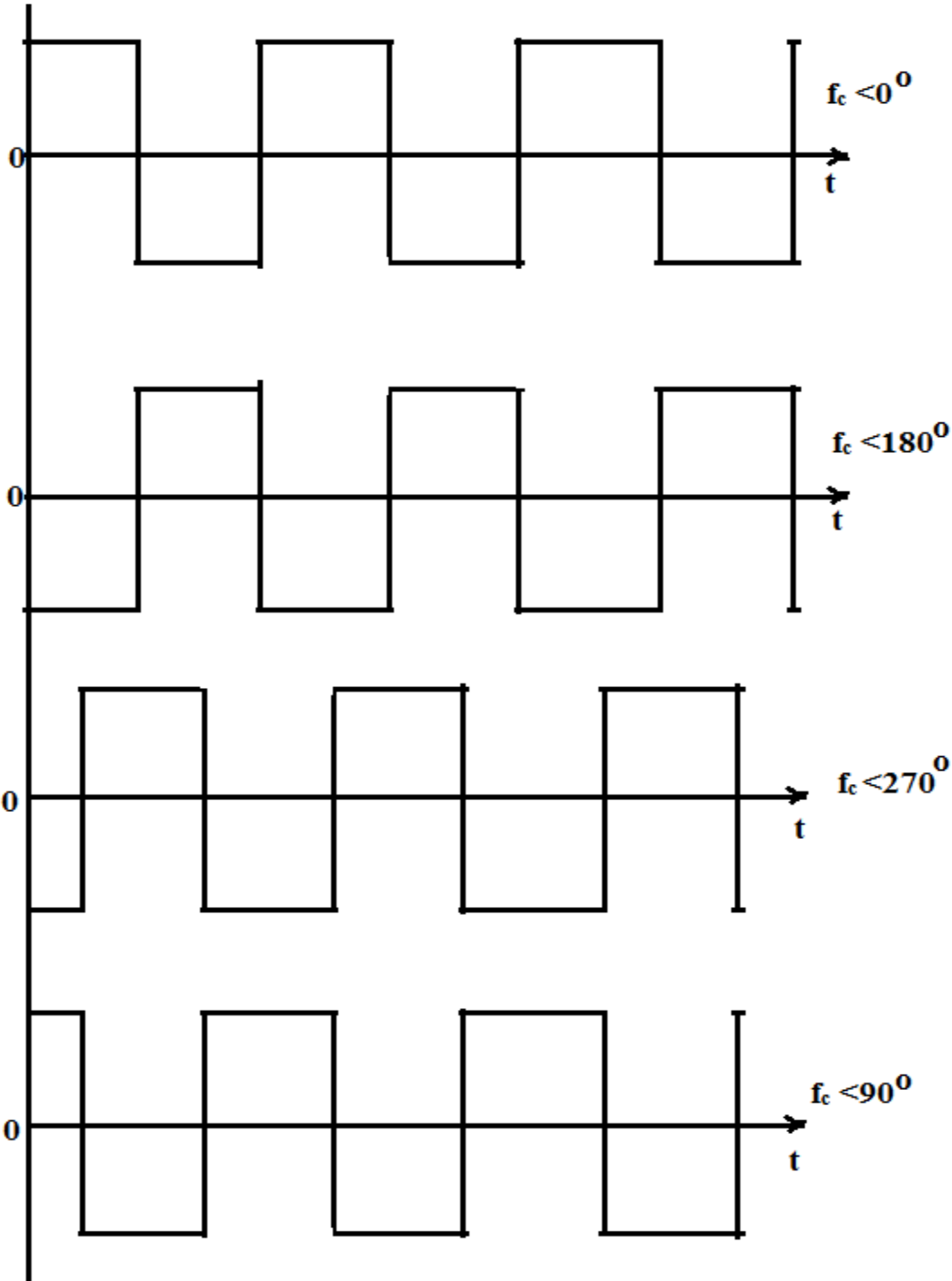
waveforms of Quadrature Phase carrier
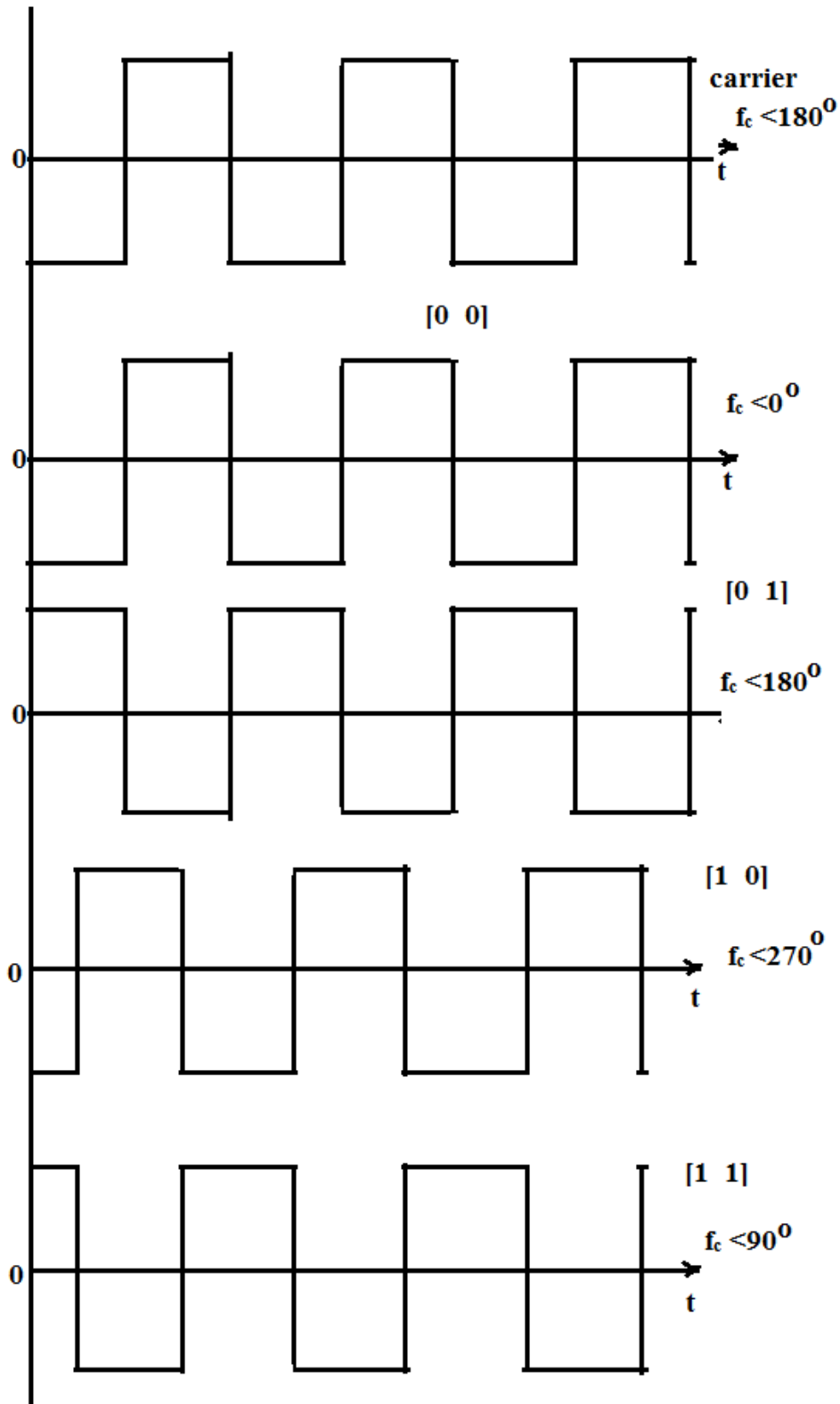
Waveforms of QPSK Modulation

Experimental procedure:

QPSK Modulation:

1. Connect the QPSK modulator to AC source and switch on the trainer.
2. Check the phase difference of the Quadrature phase carrier generated at the outputs of FF1 and FF2.
3. Connect the output at TP1 to Ch1 of oscilloscope and synchronize the scope with Ch1 and positive slope trigger.
4. Observe on Ch2 the phase shifted carriers at TP2, TP3 and TP4 w.r.t the carrier and TP1 and fill up the table.

Signal at pin	Phase angle with respect to carrier at TP1
TP1	$<0^o$
TP2	$<180^o$
TP3	$<90^o$
TP4	$<270^o$

5. Test the odd even bit separator for static bit levels. The logic levels at sockets S_2 and S_3 will determine the odd bit and even bit stream.

S3	S2	Outputs			
		00	01	10	11
Gnd	Gnd	H	L	L	L
Open	Gnd	L	L	H	L
Gnd	Open	L	H	L	L
Open	Open	L	L	L	H

6. Test the selection of carrier w.r.t the bit pattern generation. Observe on Channel-1 carrier $f_c < 180^o$ at TP1. Connect on Channel-2, the output of QPSK modulator. Observe the switched carrier as

Socket S2	Socket S3	Phase angle of QPSK O/P w.r.t fc $<180^o$ carrier
Gnd (0)	Gnd (0)	fc $<0^0$
Open (1)	Gnd (0)	fc $<90^0$
Gnd (0)	Open (1)	fc $<180^0$
Open (1)	Open (1)	fc $<270^0$

Precautions:

1. All connections must be done carefully.
2. Switch off power supply before making connections.

Result &Discussions: Thus QPSK modulation and demodulation is performed practically and graphs are plotted.

List of Experiments   **Page**

Communication Lab Using MATLAB

<u>**1. GENERATION & DETECTION OF ANALOG AND PULSE MODULATION TECHNIQUES BY USING MATLAB**</u>

Aim:

To Generate & to detect analog Modulation schemes like AM, FM and Pulse Modulation techniques like PAM, PWM and PPM using MATLAB.

Software required: MATLAB2010a

Program:

1. Amplitude Modulation:

```
clc;
clear all;
close all;
t=linspace(0,0.1,50000);  %defining time range
for the signal
fc=1000; %frequency of carrier signal
fm=500; %frequency of message signal
fs=100000;%samplingfrequency---fs>=2(fc+BW)
Am=5; %amplitude of the message signal
Ac=10; %amplitude of the carrier signal
m=Am/Ac %modulation index for the AM wave
wc=2*pi*fc*t; %carrier frequency in radians
wm=2*pi*fm*t; %message frequency in radians
ec=Ac*sin(wc); %carrier signal
em=Am*sin(wm); %message signal
y=ammod(em,fc,fs,0,Ac); %AM  signal
z=amdemod(y,fc,fs,0,Ac);%demodulated    AM
signal
l=50000;
subplot(4,1,1),plot(t(1:l),em(1:l))
xlabel('time(sec)');
ylabel('amplitude in volts(V)');
title('MODULATING SIGNAL');
subplot(4,1,2),plot(t(1:l/2),ec(1:l/2))
xlabel('time(sec)');
ylabel('amplitude in volts(V)');
title('CARRIER SIGNAL');
subplot(4,1,3),plot(t(1:l),y(1:l))
axis([0 0.02 -20 20]) %setting axis dimensions
xlabel('time(sec)');
ylabel('amplitude in volts(V)');
title('AMPLITUDE MODULATED SIGNAL');
subplot(4,1,4),plot(t(1:l),z(1:l))
xlabel('time(sec)');
ylabel('amplitude in volts(V)');
title(' AM DEMODULATED SIGNAL');
```

Output waveforms:
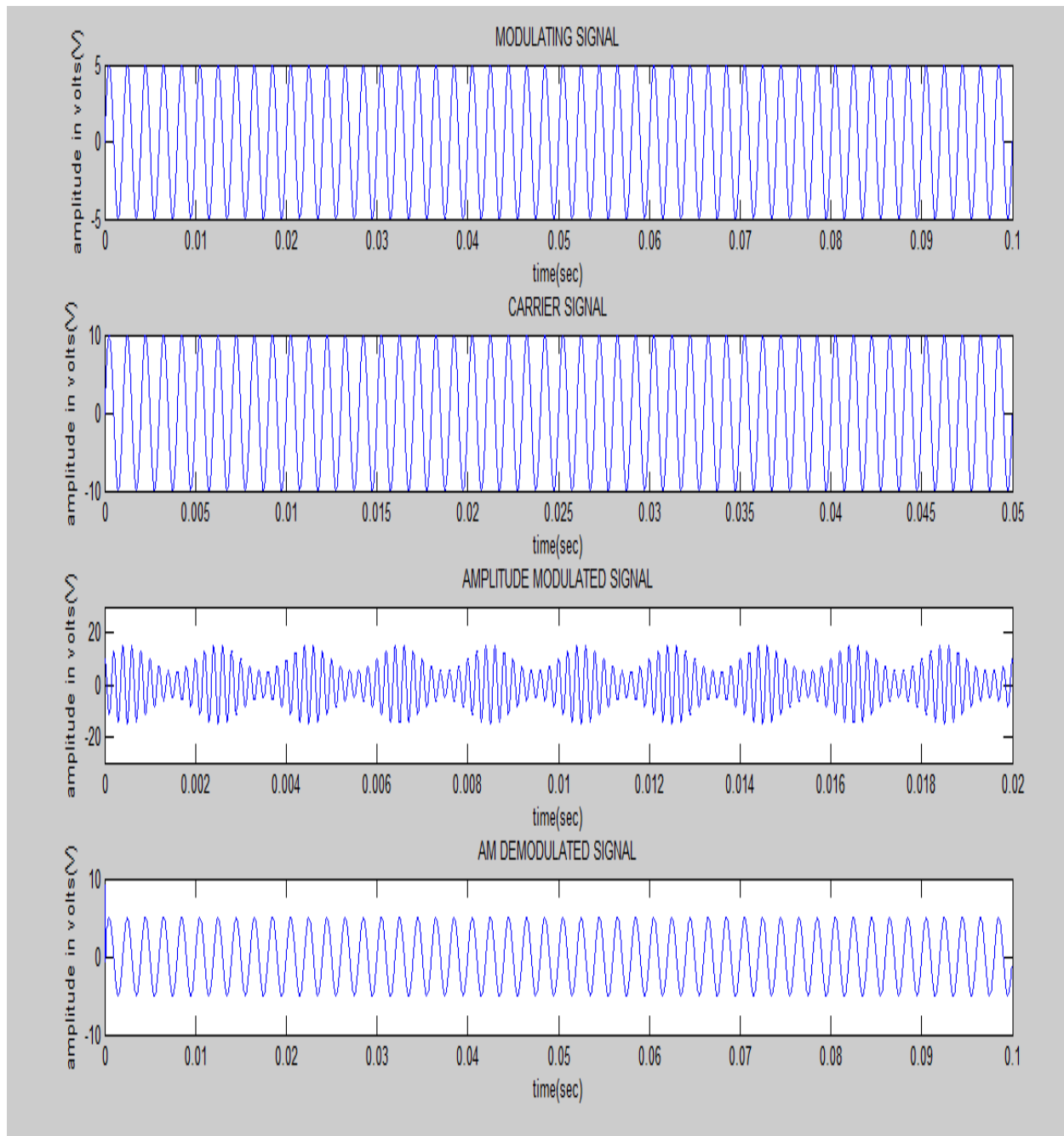
2. Frequency Modulation:

```
clc
clear all
close all
Fs = 8000; % Sampling rate of signal
Fc = 100; % Carrier frequency
t = linspace(0,1,10000); % Sampling times
x = sin(2*pi*10*t) % Channel 1
dev = 75; % Frequency deviation in modulated signal
y = fmmod(x,Fc,Fs,dev); % Modulate both channels.
z = fmdemod(y,Fc,Fs,dev); % Demodulate both channels.
subplot(411),plot(t,x)
xlabel('time(sec)');
ylabel('amplitude in volts(V)');
title('MODULATING SIGNAL');
subplot(412),plot(t,sin(2*pi*Fc*t))
xlabel('time(sec)');
ylabel('amplitude in volts(V)');
title('CARRIER SIGNAL');
subplot(413),plot(t,y)
xlabel('time(sec)');
ylabel('amplitude in volts(V)');
title('FREQUENCY MODULATED SIGNAL');
subplot(414),plot(t,z)
xlabel('time(sec)');
ylabel('amplitude in volts(V)');
title(' FM DEMODULATED SIGNAL');
```

Output waveforms:
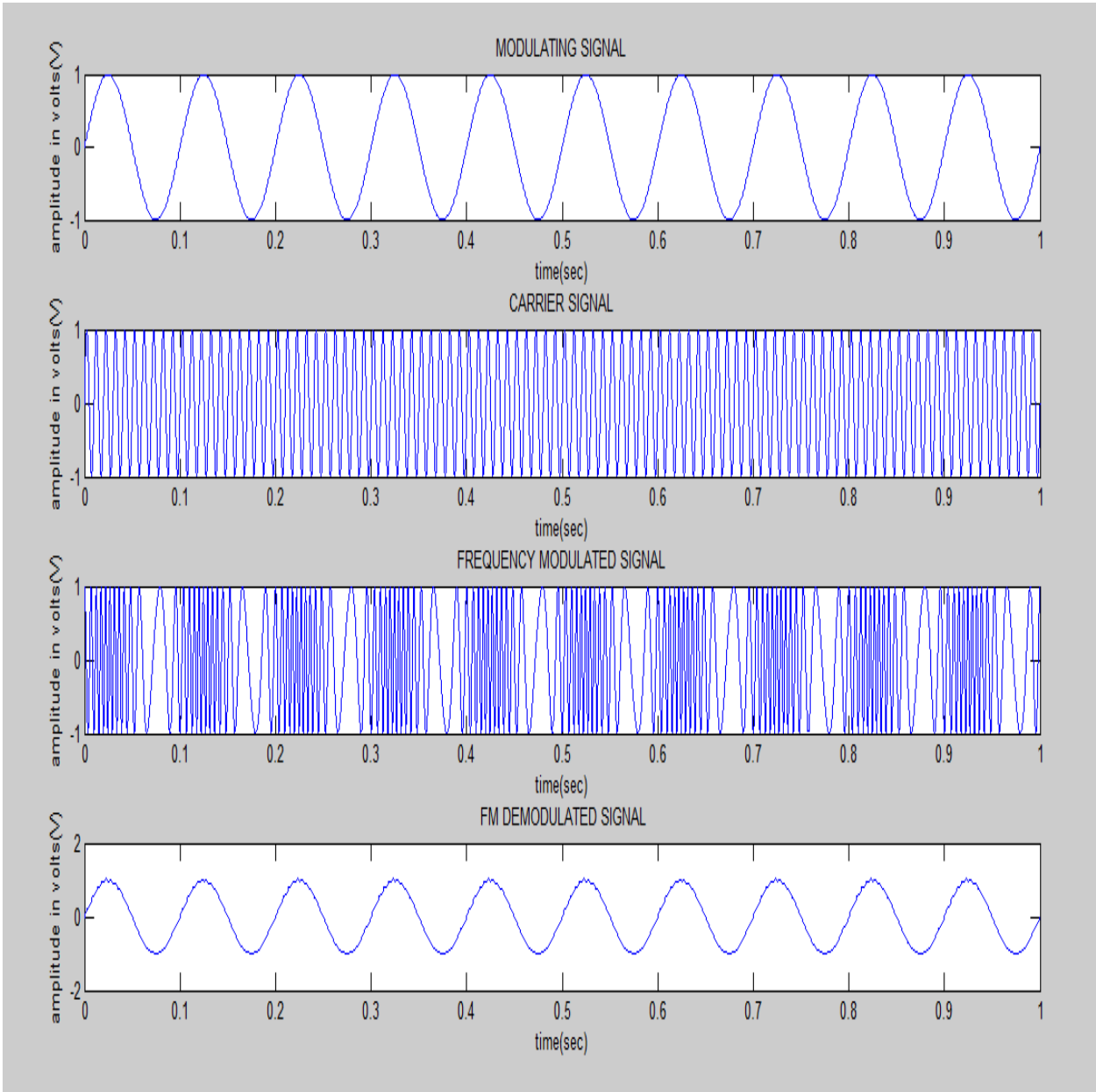
3. Pulse Width Modulation:

```
%PWM wave generation without functions
clc;
clear all;
close all;
t=0:0.001:2;
s=sawtooth(2*pi*20*t+pi);
m=0.75*sin(2*pi*1*t);
n=length(s);
for i=1:n
if (m(i)>=s(i))
pwm(i)=0;
elseif (m(i)<=s(i))
pwm(i)=1;
end
end
subplot(211),plot(t,m,'-r',t,s,'-b');axis([0 2 -1.5 1.5]);
title('message signal with sawtooth comparison')
xlabel('time(sec)');
ylabel('voltage(V)');
subplot(212),plot(t,pwm,'-k')
axis([0 2 -0.5 1.5]);
title('PWM wave');
xlabel('time(sec)');
ylabel('voltage(V)');
```
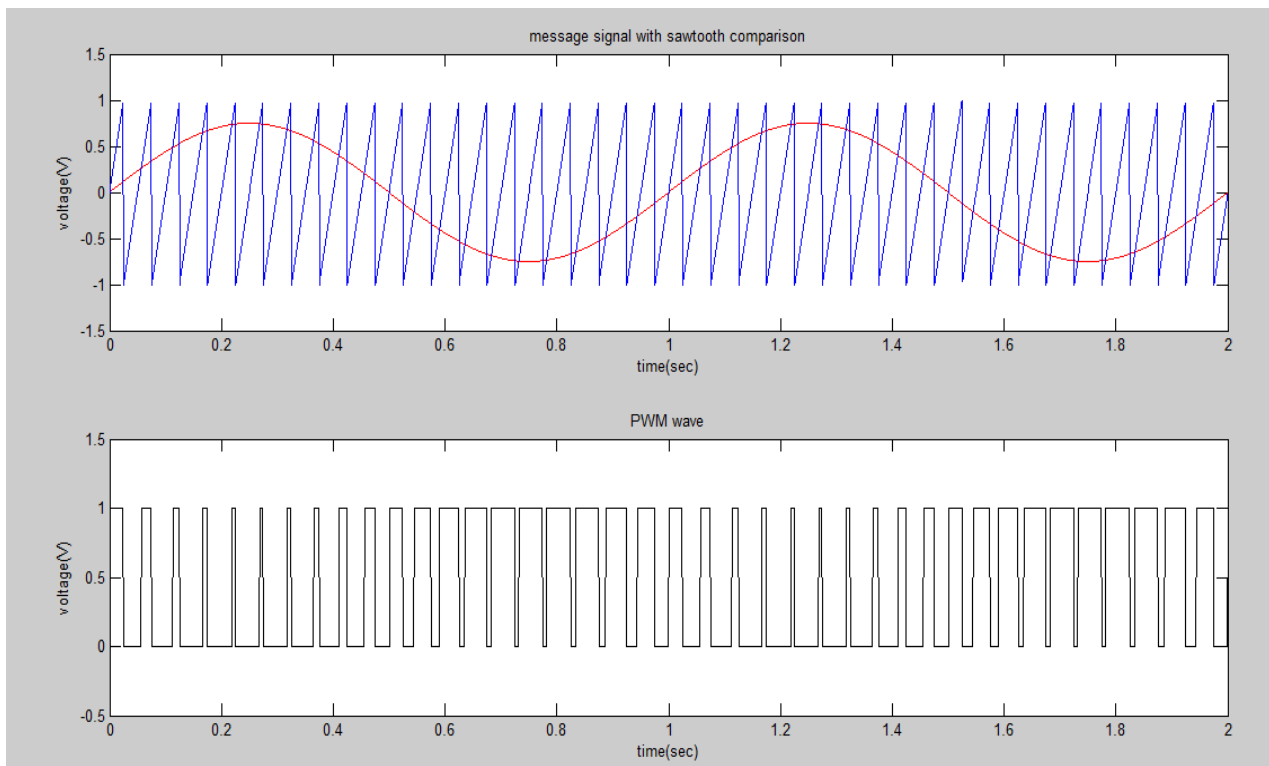
Output waveforms:

4. Pulse Position Modulation:

```
%PPM Modulation and Demodulation
clc;
clear all;
close all;
fc=4000;
fs=40000;
fm=1000;
t=0:1/fs:(2/fm-1/fs);
mt=0.4*sin(2*pi*fm*t)+0.5;
st=modulate(mt,fc,fs,'PPM');
dt=demod(st,fc,fs,'PPM');
figure
subplot(3,1,1);
plot(mt);
title('message signal');
xlabel('timeperiod');
ylabel('amplitude');
axis([0 50 0 1])
subplot(3,1,2);
plot(st);
title(' PPM signal');
xlabel('timeperiod');
ylabel('amplitude');
axis([0 500 -0.2 1.2])
subplot(3,1,3);
plot(dt);
title(' PPM demodulated signal');
xlabel('timeperiod');
ylabel('amplitude');axis([0 50 0 1])
```

Output waveforms:
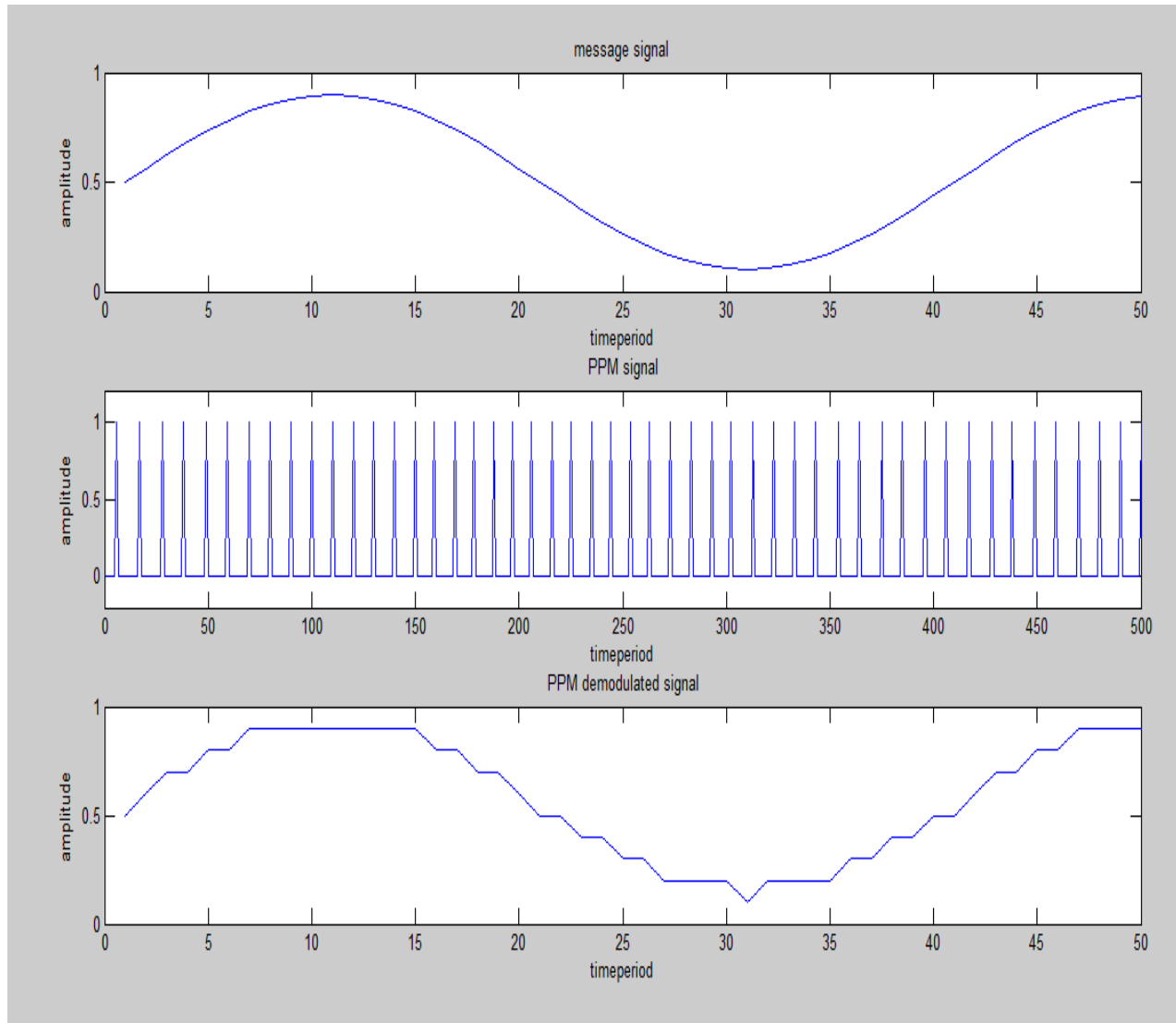
5. Pulse Amplitude Modulation:

```matlab
%Pulse Amplitude Modulation
clc;
clear all;
close all;
fc=100; fm=fc/10; fs=100*fc;
t=0:1/fs:4/fm;
mt=cos(2*pi*fm*t);
ct=0.5*square(2*pi*fc*t)+0.5;
st=mt.*ct;
tt=[ ];
%single sided PAM
for i=1:length(st);
if st(i)==0;
    tt=[tt,st(i)];
else
    tt=[tt,st(i)+2];
end
end
figure(1)
subplot(4,1,1);
plot(t,mt);
title('message signal');
xlabel('timeperiod');
ylabel('amplitude');
subplot(4,1,2);
plot(t,ct);
title('carrier signal');
xlabel('timeperiod');

ylabel('amplitude');
subplot(4,1,3); plot(t,st);
title('BIPOLAR PAM');
xlabel('timeperiod');
ylabel('amplitude');
subplot(4,1,4); plot(t,tt);
title('PAM');
xlabel('timeperiod');
ylabel('amplitude');
%demodulation
dt=st.*ct;
dt_frequency=fftshift(abs(fft(dt)));
filter=fir1(200,fm/fs,'low');
original_t_signal=conv(filter,dt);
original_f_signal=fftshift(abs(fft(original_t_signal)));
t1=0:1/(length(original_t_signal)-1):1;
f=-fs/2:fs/(length(original_f_signal)-1):fs/2;
figure(2)
subplot(2,1,1);
plot(t1,original_t_signal);
title('time domain signal');
xlabel('timeperiod');
ylabel('amplitude');
subplot(2,1,2);
plot(f,original_f_signal);
title('frequency domain signal');
xlabel('frequency');
ylabel('amplitude');
axis([-50 50 0 2000])
```

Output waveforms:
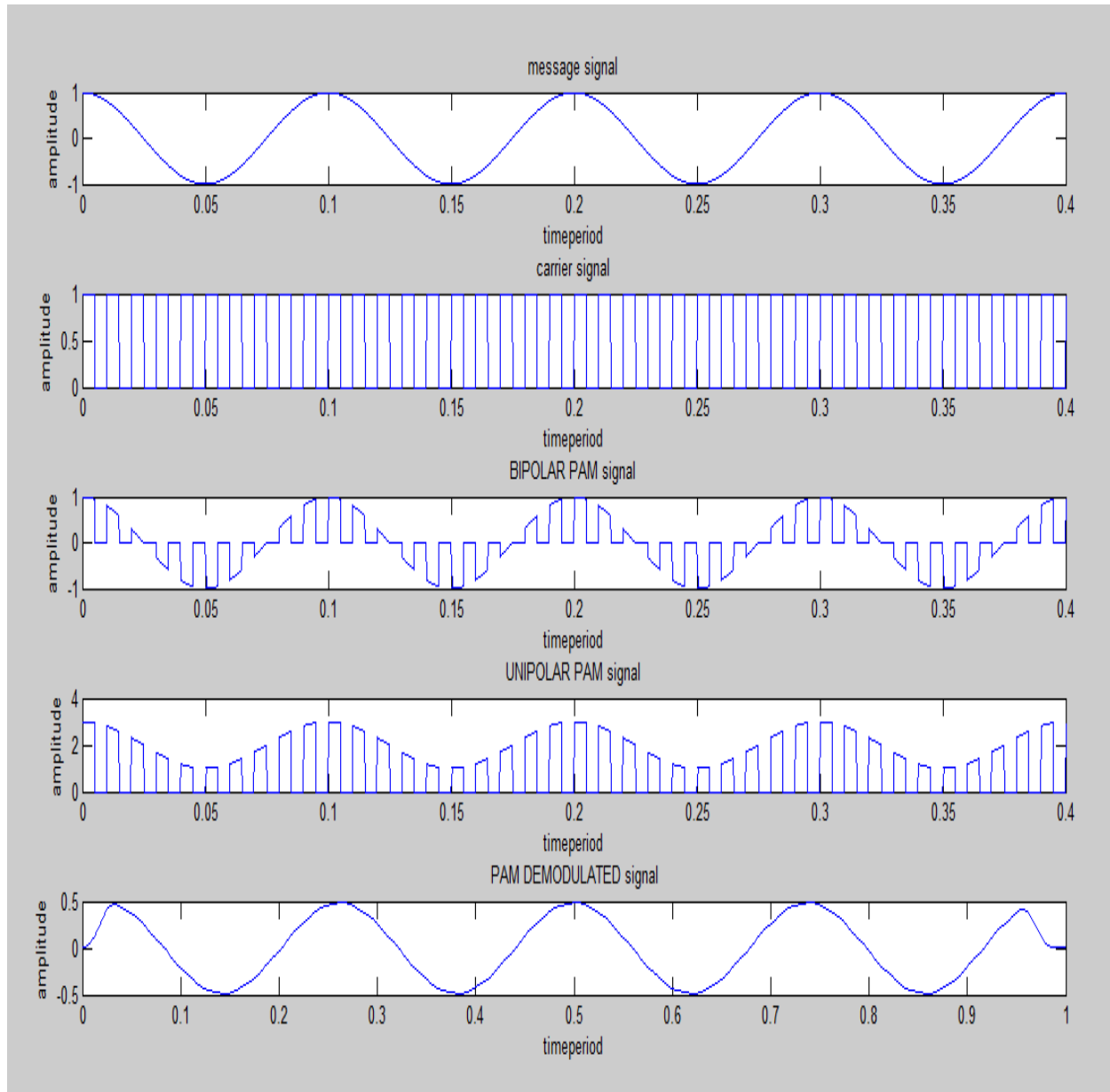
Result:

The generation and Detection of Analog Modulation schemes, Pulse Modulation schemes were observed using MATLAB.

2.GENERATION & DETECTION OF PCM, DELTA MODULATION & DIGITAL MODULATION SCHEMES (ASK, FSK, BPSK, QPSK) BY USING MATLAB

Aim:

To Generate & to detect Modulation schemes like PCM, DM and Digital Modulation schemes like ASK, FSK, BPSK, and QPSK using MATLAB.
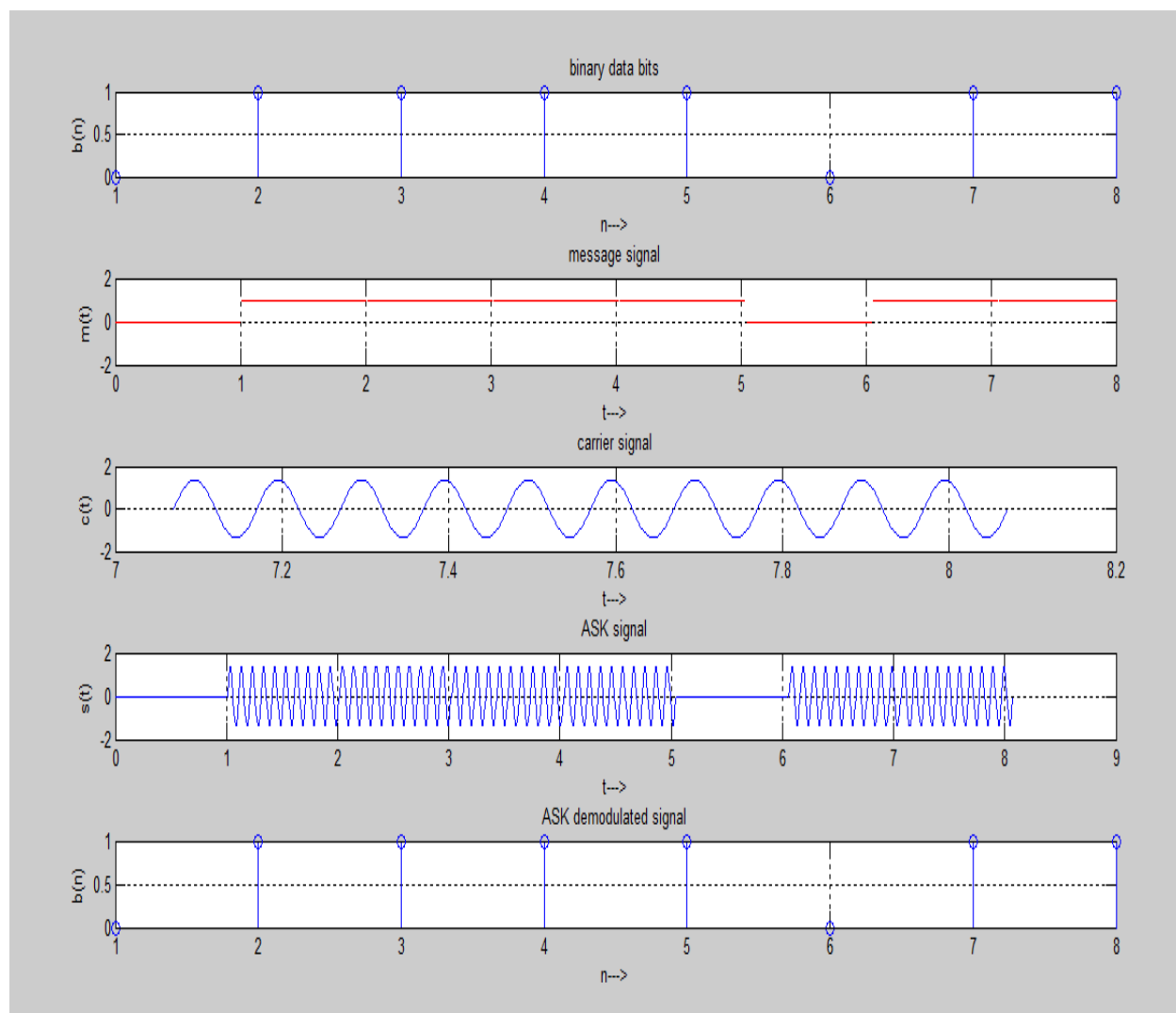
Software required: MATLAB2010a

Program:

1. ASK Modulation:

```
%ASK Modulation
clc;
clear all;
close all;
%GENERATE CARRIER SIGNAL
Tb=1; fc=10;
t=0:Tb/100:1;
c=sqrt(2/Tb)*sin(2*pi*fc*t);
%generate message signal
N=8;
m=rand(1,N);
t1=0;t2=Tb
for i=1:N
 t=[t1:.01:t2]
 if m(i)>0.5
 m(i)=1;
 m_s=ones(1,length(t));
 else
 m(i)=0;
```

```
m_s=zeros(1,length(t));
end
message(i,:)=m_s;
%product of carrier and message
ask_sig(i,:)=c.*m_s;
t1=t1+(Tb+.01);
t2=t2+(Tb+.01);
%plot the message and ASK signal
subplot(5,1,2);axis([0 N -2 2]);plot(t,message(i,:),'r');
title('message signal');xlabel('t--->');ylabel('m(t)');grid on
hold on
subplot(5,1,4);plot(t,ask_sig(i,:));
title('ASK signal');xlabel('t--->');ylabel('s(t)');grid on
hold on
end
hold off
%Plot the carrier signal and input binary data
subplot(5,1,3);plot(t,c);
title('carrier signal');xlabel('t--->');ylabel('c(t)');grid on
subplot(5,1,1);stem(m);
title('binary data bits');xlabel('n--->');ylabel('b(n)');grid on
 % ASK Demodulation
t1=0;t2=Tb
for i=1:N
t=[t1:Tb/100:t2]
%correlator
x=sum(c.*ask_sig(i,:));
%decision device
if x>0
demod(i)=1;
else
```

demod(i)=0;

end

t1=t1+(Tb+.01);

t2=t2+(Tb+.01);

end

%plot demodulated binary data bits

subplot(5,1,5);stem(demod);

title('ASK demodulated signal'); xlabel('n--->');ylabel('b(n)');grid on

Output waveforms:

2. PSK Modulation:

```
% PSK modulation
clc;
clear all;
close all;
%GENERATE CARRIER SIGNAL
Tb=1;
t=0:Tb/100:Tb;
fc=2;
c=sqrt(2/Tb)*sin(2*pi*fc*t);
%generate message signal
N=8;
m=rand(1,N);
t1=0;t2=Tb
for i=1:N
t=[t1:.01:t2]
if m(i)>0.5
m(i)=1;
m_s=ones(1,length(t));
else
m(i)=0;
m_s=-1*ones(1,length(t));
end
message(i,:)=m_s;
%product of carrier and message signal
bpsk_sig(i,:)=c.*m_s;
%Plot the message and BPSK modulated signal
subplot(5,1,2);axis([0 N -2 2]);plot(t,message(i,:),'r');
title('message signal(POLAR form)');xlabel('t--->');ylabel('m(t)');
grid on; hold on;
```

```matlab
subplot(5,1,4);plot(t,bpsk_sig(i,:));
title('BPSK signal');xlabel('t--->');ylabel('s(t)');
grid on; hold on;
t1=t1+1.01; t2=t2+1.01;
end
hold off
%plot the input binary data and carrier signal
subplot(5,1,1);stem(m);
title('binary data bits');xlabel('n--->');ylabel('b(n)');
grid on;
subplot(5,1,3);plot(t,c);
title('carrier signal');xlabel('t--->');ylabel('c(t)');grid on;
% PSK Demodulation
t1=0;t2=Tb
for i=1:N
t=[t1:.01:t2]
%correlator
x=sum(c.*bpsk_sig(i,:));
%decision device
if x>0
demod(i)=1;
else
demod(i)=0;
end
t1=t1+1.01;
t2=t2+1.01;
end
%plot the demodulated data bits
subplot(5,1,5);stem(demod);
title('demodulated data');xlabel('n--->');ylabel('b(n)');
grid on
```
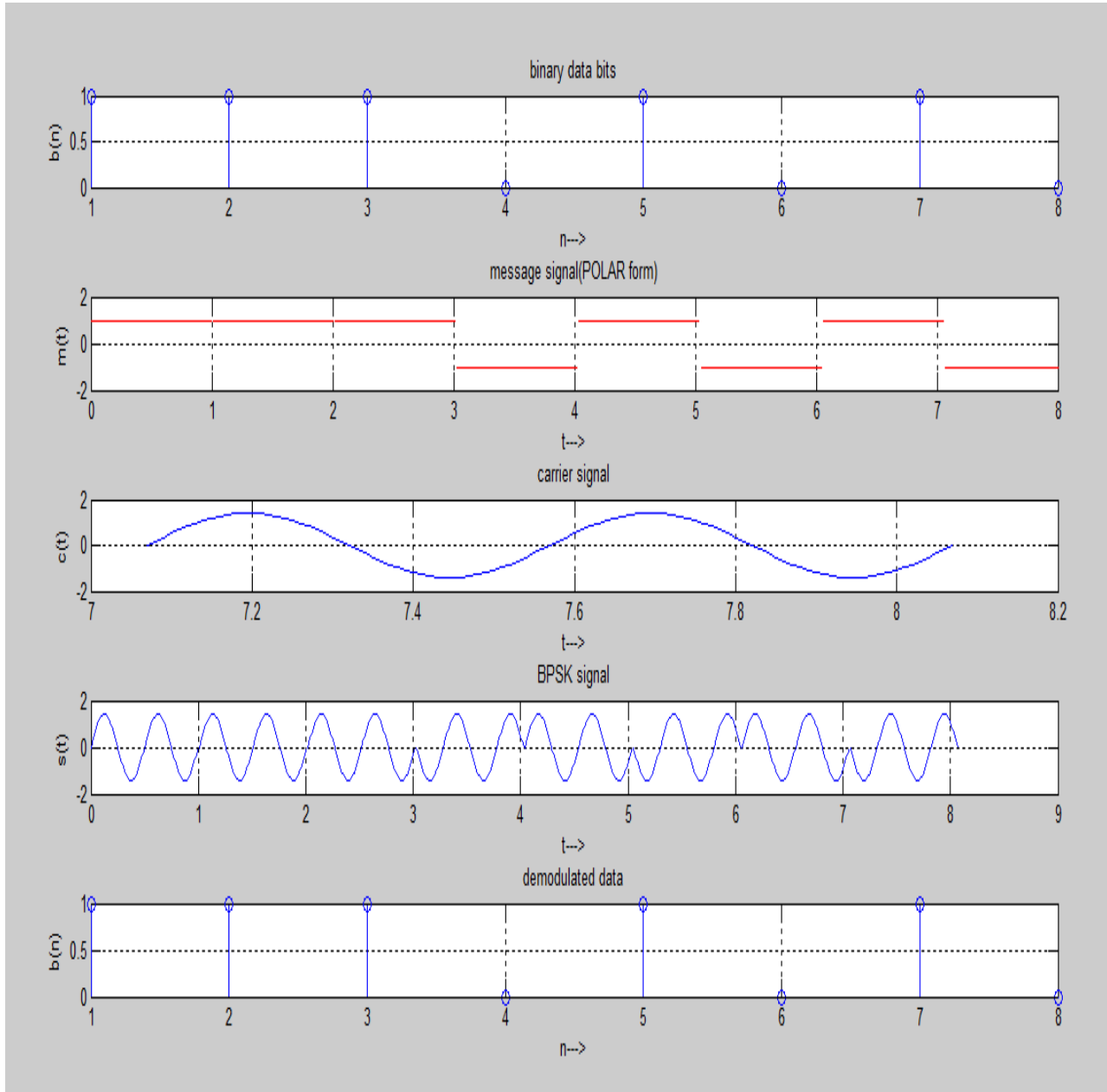
Output waveforms:

3. FSK Modulation:

```
% FSK Modulation
clc;
clear all;
close all;
%GENERATE CARRIER SIGNAL
Tb=1; fc1=2;fc2=5;
t=0:(Tb/100):Tb;
c1=sqrt(2/Tb)*sin(2*pi*fc1*t);
c2=sqrt(2/Tb)*sin(2*pi*fc2*t);
%generate message signal
N=10;
m=rand(1,N);
t1=0;t2=Tb
for i=1:N
t=[t1:(Tb/100):t2]
if m(i)>0.5
m(i)=1;
m_s=ones(1,length(t));
invm_s=zeros(1,length(t));
else
m(i)=0;
m_s=zeros(1,length(t));
invm_s=ones(1,length(t));
end
message(i,:)=m_s;
%Multiplier
fsk_sig1(i,:)=c1.*m_s;
fsk_sig2(i,:)=c2.*invm_s;
fsk=fsk_sig1+fsk_sig2;
```

```
%plotting the message signal and the modulated signal
subplot(3,2,2);axis([0 N -2 2]);plot(t,message(i,:),'r');
title('message signal');xlabel('t---->');ylabel('m(t)');grid on;hold on;
subplot(3,2,5);plot(t,fsk(i,:));
title('FSK signal');xlabel('t---->');ylabel('s(t)');grid on;hold on;
t1=t1+(Tb+.01); t2=t2+(Tb+.01);
end
hold off
%Plotting binary data bits and carrier signal
subplot(3,2,1);stem(m);
title('binary data');xlabel('n---->'); ylabel('b(n)');grid on;
subplot(3,2,3);plot(t,c1);
title('carrier signal-1');xlabel('t---->');ylabel('c1(t)');grid on;
subplot(3,2,4);plot(t,c2);
title('carrier signal-2');xlabel('t---->');ylabel('c2(t)');grid on;
13
% FSK Demodulation
t1=0;t2=Tb
for i=1:N
t=[t1:(Tb/100):t2]
%correlator
x1=sum(c1.*fsk_sig1(i,:));
x2=sum(c2.*fsk_sig2(i,:));
x=x1-x2;
%decision device
if x>0
demod(i)=1;
else
demod(i)=0;
end
t1=t1+(Tb+.01);
```

t2=t2+(Tb+.01);

end

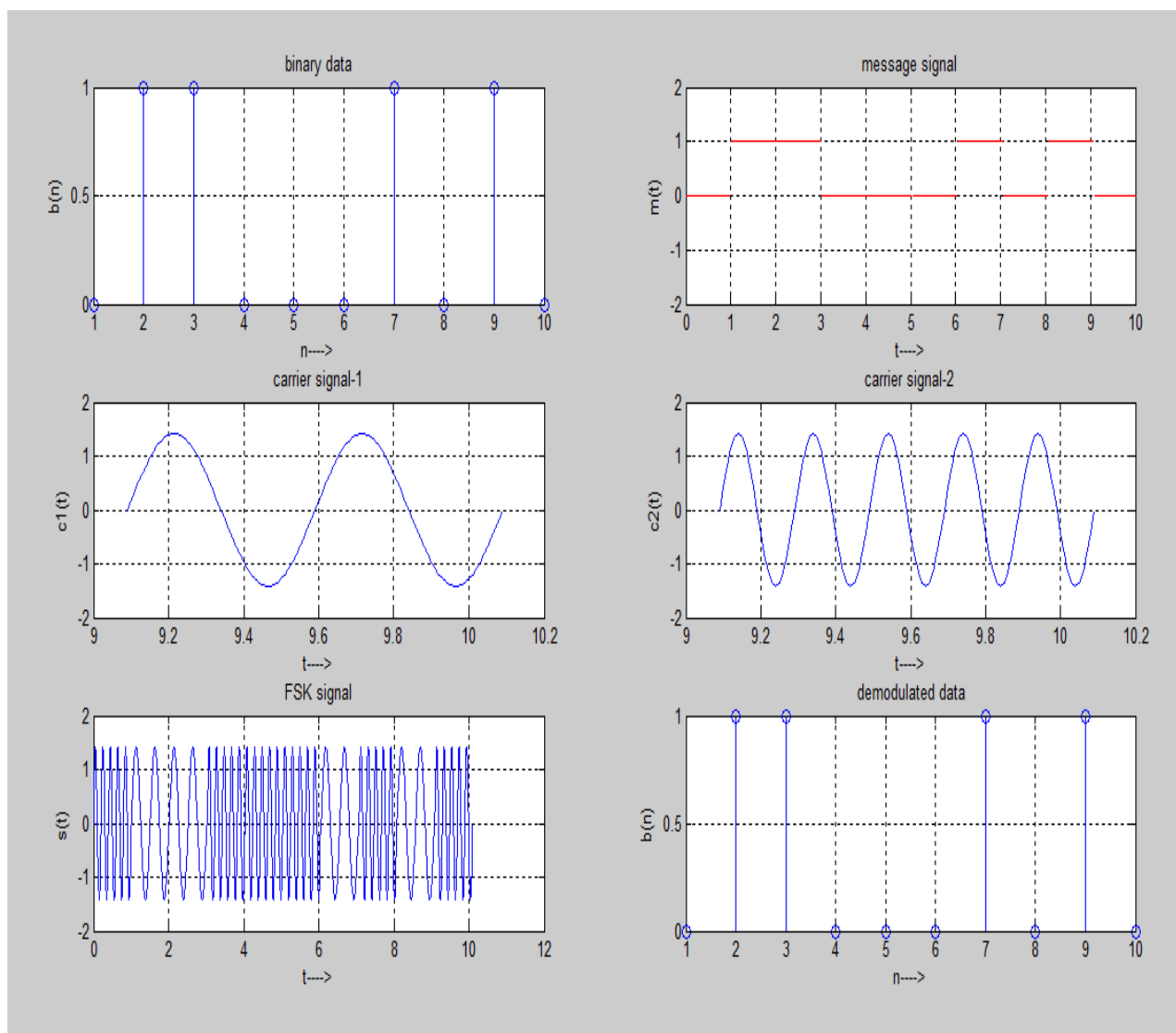%Plotting the demodulated data bits

subplot(3,2,6);stem(demod);

title(' demodulated data');xlabel('n---->');ylabel('b(n)'); grid on;

Output waveforms:

4. QPSK Modulation:

```
% QPSK Modulation
clc;
clear all;
close all;
%GENERATE QUADRATURE CARRIER SIGNAL
Tb=1;t=0:(Tb/100):Tb;fc=1;
c1=sqrt(2/Tb)*cos(2*pi*fc*t);
c2=sqrt(2/Tb)*sin(2*pi*fc*t);
%generate message signal
N=16;m=rand(1,N);
t1=0;t2=Tb
for i=1:2:(N-1)
t=[t1:(Tb/100):t2]
if m(i)>0.5
m(i)=1;
m_s=ones(1,length(t));
else
m(i)=0;
m_s=-1*ones(1,length(t));
end
%odd bits modulated signal
odd_sig(i,:)=c1.*m_s;
if m(i+1)>0.5
18
m(i+1)=1;
m_s=ones(1,length(t));
else
m(i+1)=0;
m_s=-1*ones(1,length(t));
```

```
end
%even bits modulated signal
even_sig(i,:)=c2.*m_s;
%qpsk signal
qpsk=odd_sig+even_sig;
%Plot the QPSK modulated signal
subplot(3,2,4);plot(t,qpsk(i,:));
title('QPSK signal');xlabel('t---->');ylabel('s(t)');grid on; hold on;
t1=t1+(Tb+.01); t2=t2+(Tb+.01);
end
hold off
%Plot the binary data bits and carrier signal
subplot(3,2,1);stem(m);
title('binary data bits');xlabel('n---->');ylabel('b(n)');grid on;
subplot(3,2,2);plot(t,c1);
title('carrier signal-1');xlabel('t---->');ylabel('c1(t)');grid on;
subplot(3,2,3);plot(t,c2);
title('carrier signal-2');xlabel('t---->');ylabel('c2(t)');grid on;
% QPSK Demodulation
t1=0;t2=Tb
for i=1:N-1
t=[t1:(Tb/100):t2]
%correlator
x1=sum(c1.*qpsk(i,:));
x2=sum(c2.*qpsk(i,:));
%decision device
if (x1>0&&x2>0)
demod(i)=1;
demod(i+1)=1;
elseif (x1>0&&x2<0)
demod(i)=1;
```

```
demod(i+1)=0;
elseif (x1<0&&x2<0)
demod(i)=0;
demod(i+1)=0;
elseif (x1<0&&x2>0)
demod(i)=0;
demod(i+1)=1;
end
t1=t1+(Tb+.01); t2=t2+(Tb+.01);
end
subplot(3,2,5);stem(demod);
title('qpsk demodulated bits');xlabel('n---->');ylabel('b(n)');grid on;
```
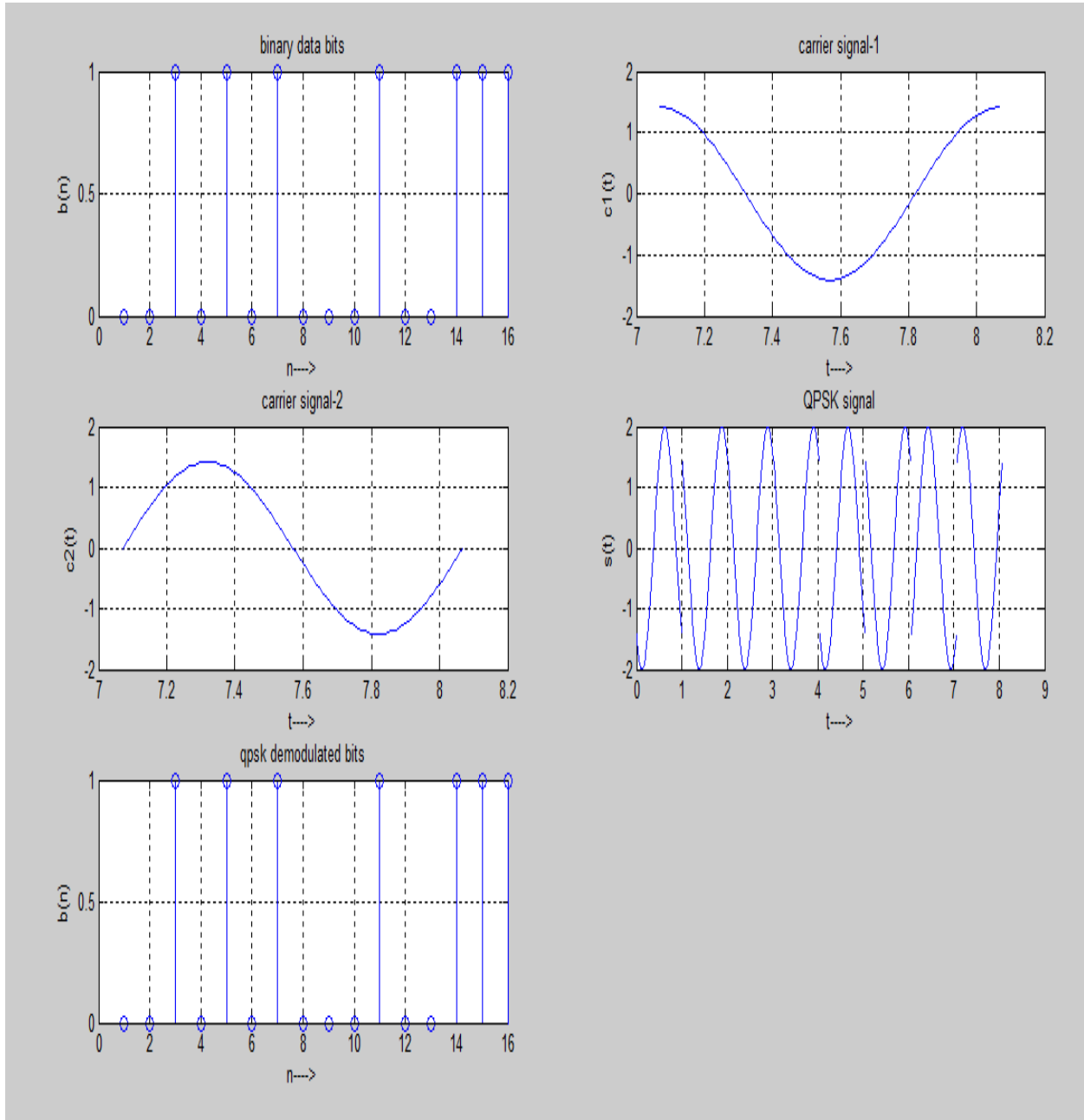
Output waveforms:

5. Pulse Code Modulation:

```
clc;
clear all;
t = 0:0.005:20;
partition = -1:0.2:2;
codebook = -1:0.2:2.2;
x = sin(t);
[index,quants] = quantiz(x,partition,codebook);
subplot(3,1,1);
plot(t,x);
title('Message Signal');
xlabel('Time(s) ---->')
ylabel('Amplitude(V) ---->')
subplot(3,1,2);
plot(t,quants);
title('Quantized Signal');
xlabel('Time(s) ---->')
ylabel('Amplitude(V) ---->')
y = uencode(quants,3);
subplot(3,1,3);
plot(t,y);
title('PCM Signal');
xlabel('Time(s) ---->');
ylabel('Amplitude(V) ---->')
```

Output waveforms:
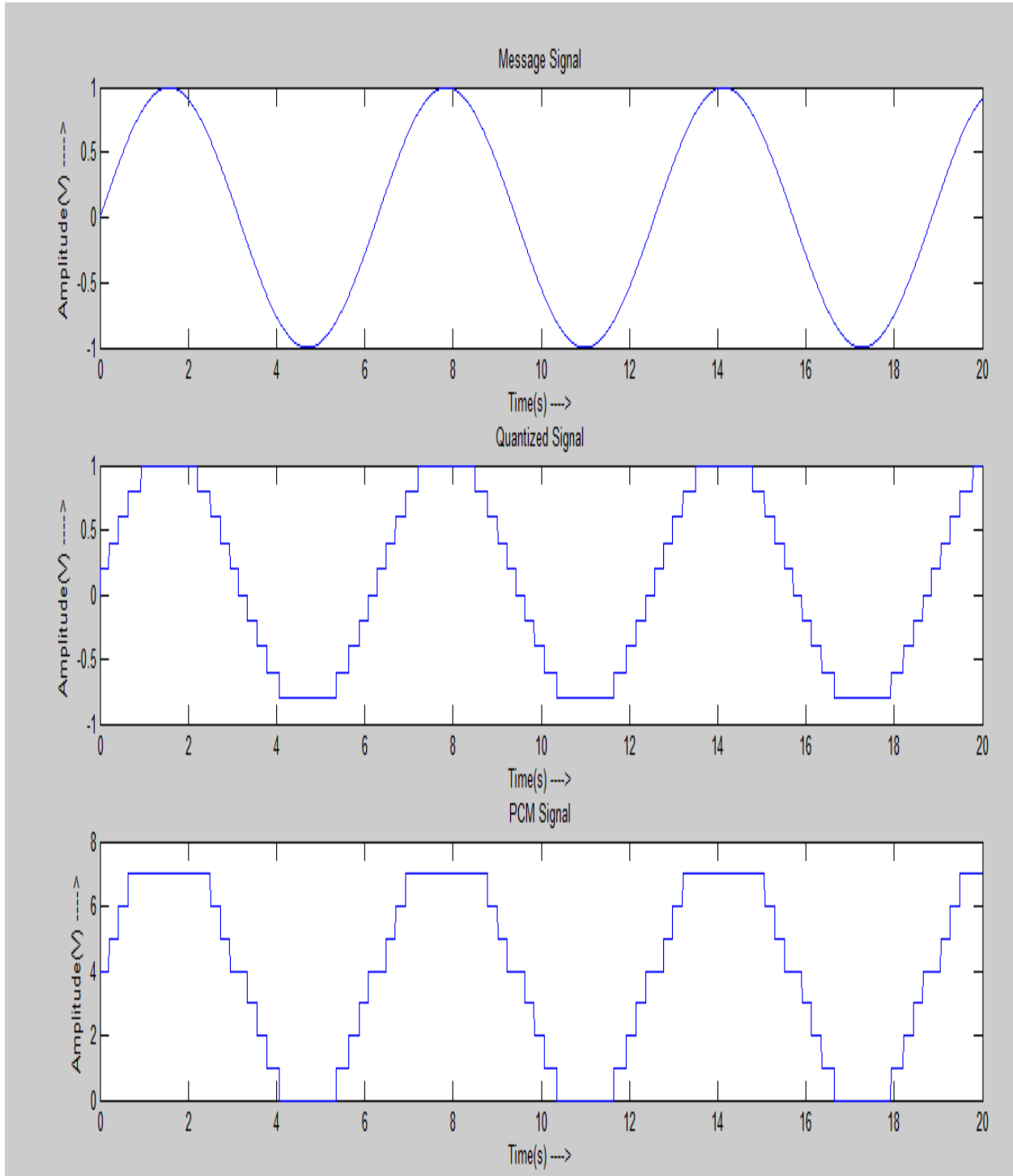
5. Delta Modulation:

t=[0:0.01:1]   %t is the time we are considering for our calculation. Even signal time period is 1 second

m=sinc(2*pi*t) %genrates the sinc pulse with the time period of t

subplot(211) %opens the figure window and splits it into two parts horizontally

hold on   %all the graphs drawn after this command will be plotted on the first part of the figure

plot(m,'*black') %plotting the sinc pulse with the *'s

title('sinc pulse') %putting the title for the graph drawn earlier

xlabel('time')%specifies the xlabel for our graph

ylabel('amplitude')%specifies the ylabel for our figure

d=2*pi/100 %d is the step size we are dividing the total time period into 100 parts of same size

%Logic to calculate the delta modulation signal

%We have total 100 samples over the time period of t

%When the delta modulation we consider error signal is same as the sampled version of the incoming signal

%and we will quantize the error signal

%mq is the star case approximates signal and is is equal to the previous time frame step approximation plus the quantized error signal for the current sample

for n=1:1:100

  if n==1

    e(n)=m(n)

    eq(n)=d*sign(e(n))

    mq(n)=eq(n)

  else

    e(n)=m(n)-mq(n-1)

    eq(n)=d*sign(e(n))

    mq(n)=mq(n-1)+eq(n)

  end

end

```matlab
%draw the quantized version of the signal on the graph of original signal
stairs(mq,'red')
hleg=legend('original signal','stair case approximated signal')
hold off


%Deltma Modulation of Sine wave
subplot(212)
hold on
m1=sin(2*pi*t)
plot(m1,'red')
title('sin wave')
xlabel('time')
ylabel('amplitude')
d=2*pi/100
for n=1:1:100
    if n==1
        e1(n)=m1(n)
        eq1(n)=d*sign(e1(n))
        mq1(n)=eq1(n)
    else
        e1(n)=m1(n)-mq1(n-1)
        eq1(n)=d*sign(e1(n))
        mq1(n)=mq1(n-1)+eq1(n)
    end
end
stairs(mq1,'blue')
hleg=legend('original signal','stair case approximated signal')
hold off
```
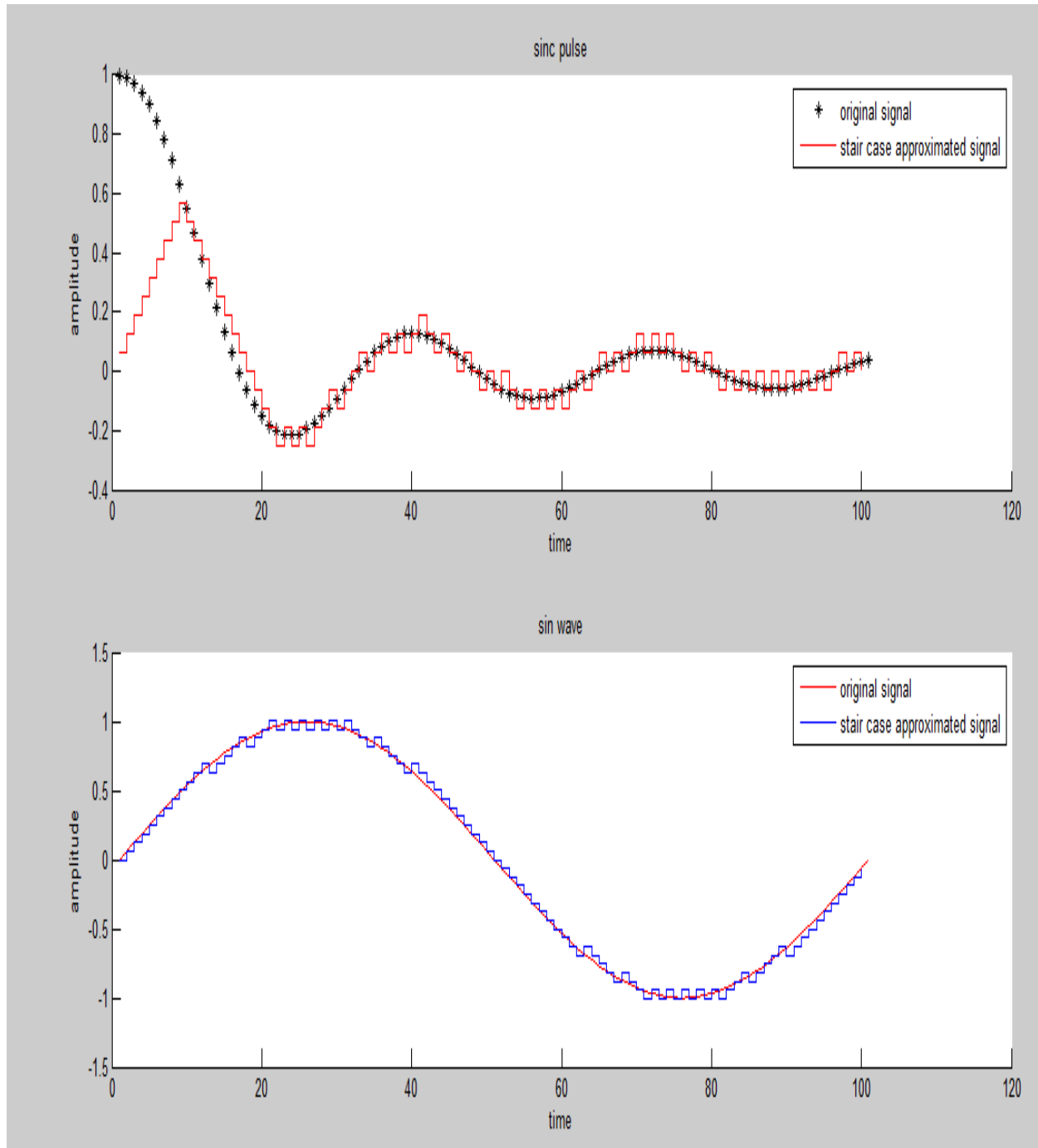
Output waveforms:

Result:

To Generation and Detection of Modulation schemes like PCM, DM and Digital Modulation schemes like ASK, FSK, BPSK, and QPSK using MATLAB.

APPENDIX

LABORATORY COURSE ASSESSMENT GUIDELINES

i.   The number of experiments in each laboratory course shall be as per the curriculum in the scheme of instructions provided by OU. Mostly the number of experiments is 10 in each laboratory course under semester scheme and 18 under year wise scheme.

ii.   The students will maintain a separate note book for observations in each laboratory course.

iii. In each session the students will conduct the allotted experiment and enter the data in the observation table.

iv.   The students will then complete the calculations and obtain the results. The course coordinator will certify the result in the same session.

v.   The students will submit the record in the next class. The evaluation will be continuous and not cycle-wise or at semester end.

vi.   The internal marks of 25 are awarded in the following manner:
   a. Laboratory record   -   Maximum Marks 15
   b. Test and Viva Voce   -   Maximum Marks 10

vii. Laboratory Record: Each experimental record is evaluated for a score of 50. **The rubric parameters are as follows:**
   a. Write up format   -   Maximum Score 15
   b. Experimentation Observations & Calculations -   Maximum Score 20
   c. Results and Graphs   -   Maximum Score 10
   d. Discussion of results   -   Maximum Score 5

While (a), (c) and (d) are assessed at the time of record submission, (b) is assessed during the session based on the observations and calculations. Hence if a student is absent for an experiment but completes it in another session and subsequently submits the record, it shall be evaluated for a score of 30 and not 50.

viii. The experiment evaluation rubric is therefore as follows:

Parameter	Max Score	Outstanding	Accomplished	Developing	Beginner	Points
Observations and Calculations	20					
Write up format	15					
Results and graphs	10					
Discussion of Results	5					

LABORATORY EXPERIMENT EVALUATION RUBRIC

CATEGORY	OUTSTANDING (Up to 100%)	ACCOMPLISHED (Up to 75%)	DEVELOPING (Up to 50%)	BEGINNER (Up to 25%)
Write up format	Aim, Apparatus, material requirement, theoretical basis, procedure of experiment, sketch of the experimental setup etc. is demarcated and presented in clearly labeled and neatly organized sections.	The write up follows the specified format but a couple of the specified parameters are missing.	The report follows the specified format but a few of the formats are missing and the experimental sketch is not included in the report	The write up does not follow the specified format and the presentation is shabby.
Observations and Calculations	The experimental observations and calculations are recorded in neatly prepared table with correct units and significant figures. One sample calculation is explained by substitution of values	The experimental observations and calculations are recorded in neatly prepared table with correct units and significant figures but sample calculation is not shown	The experimental observations and calculations are recorded neatly but correct units and significant figures are not used. Sample calculation is also not shown	The experimental observations and results are recorded carelessly. Correct units significant figures are not followed and sample calculations not shown
Results and Graphs	Results obtained are correct within reasonable limits. Graphs are drawn neatly with labeling of the axes. Relevant calculations are performed from the graphs. Equations are obtained by regression analysis or curve fitting if relevant	Results obtained are correct within reasonable limits. Graphs are drawn neatly with labeling of the axes. Relevant calculations from the graphs are incomplete and equations are not obtained by regression analysis or curve fitting	Results obtained are correct within reasonable limits. Graphs are not drawn neatly and or labeling is not proper. No calculations are done from the graphs and equations are not obtained by regression analysis or curve fitting	Results obtained are not correct within reasonable limits. Graphs are not drawn neatly and or labeling is not proper. No calculations are done from the graphs and equations are not obtained by regression analysis or curve fitting
Discussion of results	All relevant points of the result are discussed and justified in light of theoretical expectations. Reasons for divergent results are identified and corrective measures discussed.	Results are discussed but no theoretical reference is mentioned. Divergent results are identified but no satisfactory reasoning is given for the same.	Discussion of results is incomplete and divergent results are not identified.	Neither relevant points of the results are discussed nor divergent results identified

ix.   The first page of the record will contain the following title sheet:

SAMPLE ASSESSMENT SHEET

NAME: **ROLL NO.**

Exp. No.	Date conducted	Date Submitted	Observations &Calculations (Max 20)	Write up (Max 15)	Results and Graphs (Max 10)	Discussion of Results (Max 5)	Total Score (Max 50)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

x.   The 15 marks of laboratory record will be scaled down from the TOTAL of the assessment sheet.
xi.   The test and viva voce will be scored for 10 marks as follows:
        Internal Test   -   6 marks
        Viva Voce / Quiz   -   4 marks
xii.   Each laboratory course shall have 5 course outcomes.

The proposed course outcomes are as follows:

On successful completion of the course, the student will acquire the ability to:

1. Conduct experiments, take measurements and analyze the data through hands-on experience in order to demonstrate understanding of the theoretical concepts of _____, while working in small groups.

2. Demonstrate writing skills through clear laboratory reports.

3. Employ graphics packages for drawing of graphs and use computational software for statistical analysis of data.

4. Compare the experimental results with those introduced in lecture, draw relevant conclusions and substantiate them satisfactorily.

5. Transfer group experience to individual performance of experiments and demonstrate effective oral communication skills.

xiii. The Course coordinators would prepare the assessment matrix in accordance with the guidelines provided above for the five course outcomes. The scores to be entered against each of the course outcome would be the sum of the following as obtained from the assessment sheet in the record:

   a. Course Outcome 1: Sum of the scores under 'Observations and Calculations'.
   b. Course Outcome 2: Sum of the scores under 'Write up'.
   c. Course Outcome 3: Sum of the scores under 'Results and Graphs'.
   d. Course Outcome 4: Sum of the scores under 'Discussion of Results'.
   e. Course Outcome 5: Marks for 'Internal Test and Viva voce'.

xiv. Soft copy of the assessment matrix would be provided to the course coordinators.

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

Program Outcomes of B.E (ECE) Program:

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: Problem analysis: Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: 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 limitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: 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.

PO11: Project management and finance: Demonstrate knowledge and understanding of the 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.

PO 12: Life-long learning: Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs) of ECE Department, MJCET

PSO1: The ECE Graduates will acquire state of art analysis and design skills in the areas of digital and analog VLSI Design using modern CAD tools.

PSO2: The ECE Graduates will develop preliminary skills and capabilities necessary for embedded system design and demonstrate understanding of its societal impact.

PSO3: The ECE Graduates will obtain the knowledge of the working principles of modern communication systems and be able to develop simulation models of components of a communication system.

PSO4: The ECE Graduates will develop soft skills, aptitude and programming skills to be employable in IT sector.