INSTITUTE OF AERONAUTICAL ENGINEERING
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Lab Manual:

ANALOG AND DIGITAL COMMUNICATIONS LABORATORY (AECC14)

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April 4, 2022

Contents

INTRODUCTION

1.1 Introduction

This course is intended to enhance the learning experience of the student in topics encountered in AECC14. In this lab, students are expected to gain experience in analyzing the operation of various blocks of communication system like modulator, demodulator, automatic gain control, mixer, phase locked loop frequency synthesizer and spectrum analyzer; hands-on experience on spectrum analyzer; current hardware topics related to communication system are also simulated using MATLAB software. How the student performs in the lab depends on his/her preparation, participation, and teamwork. Each team member must participate in all aspects of the lab to insure a thorough understanding of the equipment and concepts. The student, lab teaching assistant, and faculty coordinator all have certain responsibilities toward successful completion of the lab's goals and objectives and communication engineering is the field of study concerned with the transmission of information either in analog or digital form. The objective of this course provides a platform to the students to understand the basics of analog and digital communication systems, modulation techniques, data transmission and multiplexing etc.The applications include digital signal processors in secured communication systems,multimedia and data storage applications.

1.1.1 Student Responsibilities

The student is expected to be prepared for each lab. Lab preparation includes reading the lab experiment and related textbook material. If you have questions or problems with the preparation, contact your Laboratory teaching Faculty (LTF), but in a timely manner. Do not wait until an hour or two before the lab and then expect the LTF to be immediately available.

A large portion of the student's grade is determined in the comprehensive final exam, resulting in a requirement of understanding the concepts and procedure of each lab experiment for the successful completion of the lab class. The student should remain alert and use common sense while performing a lab experiment. They are also responsible for keeping a professional and accurate record of the lab experiments in the lab manual wherever tables are provided. Students should report any errors in the lab manual to the teaching Faculty.
The student responsibilities are:

1. Students are required to attend all labs.
2. Students should work individually in the hardware and software laboratories.
3. Students have to bring the lab worksheet whenever they come for lab work.
4. Should take only the lab worksheet, calculator (if needed) and a pen or pencil to the work area.
5. Should learn the prelab questions. Read through the lab experiment to familiarize themselves with the components and assembly sequence.

6. Should utilize 3 hour's time properly to perform the experiment and to record the readings. Do the calculations, draw the graphs and take signature from the faculty.

7. If the experiment is not completed in the stipulated time, the pending work has to be carried out in the leisure hours or extended hours.

8. For practical subjects there shall be a continuous evaluation during the semester for 30 sessional marks and 70 end examination marks.

9. Out of 30 internal marks, 20 marks shall be awarded for day-to-day work and 10 marks to be awarded by conducting an internal laboratory test.

1.1.2 Responsibilities of Faculty Teaching the Lab Course

The Faculty shall be completely familiar with each labprior to the laboratory. He/She shall provide the students with details regarding the syllabus and safety review during the first week.Lab experiments should be checked in advance to make sure that everything is in working order.The Faculty should demonstrate and explain the experiment and answer any questions posed by the students.Faculty have to supervise the students while they perform the lab experiments. The Faculty is expected to evaluate the lab worksheets and grade them based on their practical skills and understanding of the experiment by taking Viva Voce. Evaluation of work sheets has to be done in a fair and timely manner to enable the students, for uploading them online through their CMS login within the stipulated time.

1.1.3 Laboratory In-charge Responsibilities

The Laboratory In-charge should ensure that the laboratory is properly equipped, i.e., the Faculty teaching the lab receive any equipment/components necessary to perform the experiments.He/She is responsible for ensuring that all the necessary equipment for the lab is available and in working condition. The Laboratory In-charge is responsible for resolving any problems that are identified by the teaching Faculty or the students.

1.1.4 Course Coordinator Responsibilities

The course coordinator is responsible for making any necessary corrections in Course Description and lab manual. He/She has to ensure that it is continually updated and available to the students in the CMS learning Portal.

1.2 Lab Policy and Grading

The student should understand the following policy:

ATTENDANCE: Attendance is mandatory as per the academic regulations.

LAB RECORD's: The student must:

1. Write the work sheets for the allotted experiment and keep them ready before the beginning of each lab.

2. Keep all work in preparation of and obtained during lab.

3. Perform the experiment and record the observations in the worksheets.

4. Analyze the results and get the work sheets evaluated by the faculty.

5. Upload the evaluated reports online from CMS LOGIN within the stipulated time.

Grading Policy:

The final grade of this course is awarded using the criterion detailed in the academic regulations. A large portion of the student's grade is determined in the comprehensive final exam of the Laboratory course (SEE PRACTICALS),resulting in a requirement of understanding the concepts and procedure of each lab experiment for successful completion of the lab course.

Pre-Requistes and Co-Requisties:

Co-Requisites for this lab is analog communication course and pre-requisites are probability theory and stochastic process course. Students are required to have completed both the courses with better grade in each.

1.3 Course Goals and Objectives

The Analog and Digital Communication Laboratory is designed to provide the student with the knowledge of communication system blocks and basic MATLAB programming and techniques with proficiency. These techniques are designed to complement the concepts introduced in AECC14. In addition, the student should learn how to record experimental results effectively and present these results in a written report. More explicitly, the class objectives are:
The class objectives are to learn:

More explicitly, the class objectives are:

- To write and simulate the MATLAB code to study the amplitude and frequency modulation techniques and to analyze their frequency spectrum.
- To enhance understanding the theory of Analog and Digital Communication concepts including:
  - Amplitude modulation and demodulation,
  - Frequency modulation and demodulation,
  - Pulse position modulation and demodulation,
  - Pulse code modulation and demodulation,
  - Pulse width modulation and demodulation ,
  - Differential pulse code modulation,
  - Time division multiplexing,
  - Delta modulation,
  - Differential phase shift keying generation and detection,
  - Amplitude shift keying generation and detection,
  - Binary phase shift keying generation and detection.
- To develop communication skills through:
  - Verbal interchanges with the Faculty and other students.
  - Preparation of succinct but complete laboratory reports.
  - Maintenance of laboratory worksheets as permanent, written descriptions of procedures, analysis and results.
- To compare theoretical predictions with experimental results and to determine the source of any apparent errors.

1.4 Use of Laboratory Instruments

One of the major goals of this lab is to familiarize the student with the proper equipment and techniques for programming in MATLAB. Some understanding of the lab instruments is necessary to avoid personal or equipment damage. By understanding the device's purpose and following a few simple rules, costly mistakes can be avoided. You have already, learned these rules, but they are repeated for convenience and emphasis below. In general, all devices have physical limits. These limits are specified by the device manufacturer and are referred to as the device rating. The ratings are usually expressed in terms of voltage limits, current limits, or power limits. It is up to the engineer to make sure that in device operation, these ratings (limit values) are not exceeded. The following rules provide a guideline for instrument protection.

1.4.1 Instrument Protection Rules

1. Set instrument scales to the highest range before turning on the power/source.
2. Be sure instrument grounds are connected properly. Avoid accidental grounding of "hot" leads, i.e., those that are above ground potential.
3. Check polarity markings and connections of instruments carefully before connecting power.
4. Do not exceed the voltage and current ratings of instruments or other circuit elements.
5. Switch on the power supply after checking connection.
6. Handle the Trainer kit carefully.
7. Switch of Trainer kit after completing the experiment.
8. Setup MATLAB software in personal computer.
9. Be sure the MATLAB software is installed properly.
10. Open the MATLAB and create a new script.
11. Write the MATLAB code using basic commands and simulate the code

1.5 Data Recording and Reports

1.5.1 The Laboratory Worksheets

Students must record their experimental values in the provided tables in this laboratory manual and reproduce them in the lab worksheets. Worksheets are integral to recording the methodology and results of an experiment. Make plots of data and sketches when these are appropriate in the recording and analysis of observations. Note that the data collected will be an accurate and permanent record of the data obtained during the experiment and the analysis of the results.

1.5.2 The Laboratory Files/Reports

Reports are the primary means of communicating your experience and conclusions to other professionals. In this course you will use the lab report to inform your faculty about what you did and what you have learned from the experience. Engineering results are meaningless unless they can be communicated to others. You will be directed by your faculty to prepare a lab report on a few selected lab experiments during the semester. Your assignment might be different from your lab partner's assignment.
Your laboratory report should be clear and concise. The lab report shall be scanned and upload

to lab faculty through CMS login. Use tables, circuit diagrams and model waveforms as necessary also write the MATLAB program to show what you did, what was observed, and what conclusions you can observe from this. Even though you work with one or more lab partners your report will be the result of your individual effort in order to provide you with practice in technical communication.

1.5.3 Order of Lab Report Components

Cover page - Cover page must include lab name and number, your name and the date the lab was performed.
Objective - Clearly state the experiment objective in your own words.
Prelab: Indicate the required knowledge for performing the concerned experiment
Equipment used - Indicate which equipment was used in performing the experiment.
For each part of the lab:

- Write the lab's part number and title in bold font.
- Firstly, describe the problem that you studied in this part, give an introduction of the theory, and explain why you did this experiment. Do not lift the text from the lab manual; use your own words.
- Check polarity markings and connections of instruments carefully before connecting power.
- Do not exceed the voltage and current ratings of instruments or other circuit elements.
- Secondly, describe the experimental setup and procedures. Do not follow the lab manual in listing out individual pieces of equipment and MATLAB code . That is not relevant information in a lab report! Instead, explain the program. Your description should take the form of a narrative, and include information not present in the manual, such as descriptions of what happened during intermediate steps of the experiment.
- Thirdly, explain your findings. This is the most important part of your report, because here, you show that you understand the experiment beyond the simple level of completing it. Explain (compare expected results with those obtained). Analyze (analyze experimental error). Interpret (explain your results in terms of theoretical issues and relate to your experimental objectives). All the results should be presented even if there is any inconsistency with the theory.
- Finally, provide a summary of what was learned from this part of the laboratory experiment. If the results seem unexpected or unreliable, discuss them and give possible explanations.
- Setup MATLAB software in personal computer.
- Be sure the MATLAB software is installed properly.
- Open the MATLAB and create a new script.
- Write the MATLAB code using basic commands and simulate the code

Conclusions - The conclusion section should provide a take-home message summing up what has been learned from the experiment:

- Briefly restate the purpose of the experiment (the question it was seeking to answer)
- Identify the main findings (answer to the research question)

- Note the main limitations that are relevant to the interpretation of the results
- Summarize what the experiment has contributed to your understanding of the problem.

Probing further experiments - Questions pertaining to this lab must be answered at end of laboratory report

LAB-1 ORIENTATION

2.1 Introduction

In the first lab period, the students should become familiar with the location of equipment and components in the lab, the course requirements, and the teaching instructor. Students should also make sure that they have all of the co-requisites and pre-requisites for the course at this time.

2.2 Objective

To familiarize the students with the lab facilities, equipment, standard operating procedures, lab safety, and the course requirement.

2.3 Prelab Preparation:

Read the Introduction and Appendix D, of this manual. Download and install the MATLAB software on your personal computer, available here.

2.4 Equipment needed

2.4.1 Hardware Requirements:

1. Digital oscilloscope
2. Function generator
3. Multimeter
4. personal computer
5. Connecting wires and CRO probes

2.4.2 Software Requirements:

1. MATLAB software

2.5 Procedure

1. During the first laboratory period, the instructor will provide the students with a general idea of what is expected from them in this course. Each student will receive a copy of the syllabus, stating the instructor's contact information. In addition, the instructor will review the safety concepts of the course.

2. During this period, the instructor will briefly review the equipment which will be used throughout the semester. The location of instruments, equipment, and components (e.g. Trainer kits, digital oscilloscopes, Function Generators, Multi meters, CRO probes and Patch cords) will be indicated. The guidelines for instrument use will be reviewed.

2.6 Further Probing Experiments

LAB-2 AMPLITUDE MODULATION AND DEMODULATION

3.1 Introduction

The purpose of this experiment is to acquaint the student with the concept of amplitude modulation and de modulation. In amplitude modulation, the amplitude (signal strength) of the carrier wave is varied in proportion to that of the message signal, such as an audio signal. From these characteristics, you will determine modulation index and also can observe the differences between the under, over and critical modulation. Amplitude modulation technique is used in electronic communication, most commonly for transmitting messages with a radio wave.

3.2 Objective

3.2.1 Educational

- Learn to measure output voltage.
- Learn to differentiate the over, under and critical modulation.
- Gain experience in operation of modulator and de modulator.

3.2.2 Experimental

- Generation of amplitude modulated wave and determine the percentage of modulation.
- Demodulation of the amplitude modulated wave using envelope detector.
- Compare theoretical and practical values of modulation index.
- Draw the input and output waveforms.
- Simulation of MATLAB code to generate and detect amplitude modulated waveforms.

3.3 Prelab Preparation:

3.3.1 Reading

- Read and study the Background section of this Laboratory.
- Read Appendix A, B, C and D Voltage Measurement of an oscilloscope with two vertical inputs.

3.3.2 Written

- Prior to coming to lab class, complete Part 0 of the Procedure.

3.4 Equipment needed

3.4.1 Hardware Requirements:

1. Amplitude Modulation and demodulation trainer kit.
2. Digital oscilloscope.
3. Function generator
4. PC
5. CRO probes and Connecting Wires.

3.4.2 Software Requirements:

1. MATLAB Software.

3.5 Circuit Diagram:

Modulator

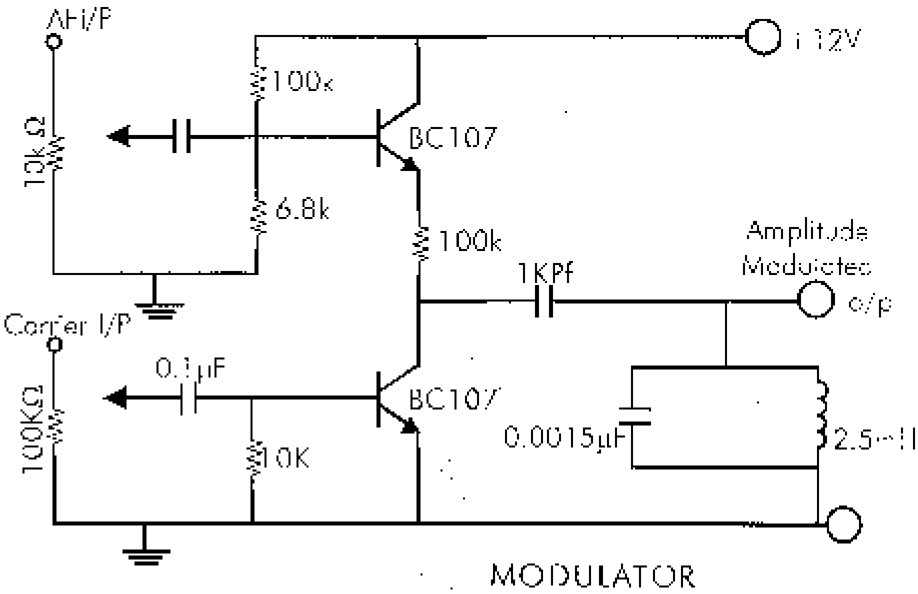


Figure 3.1: Amplitude Modulator

De-Modulator

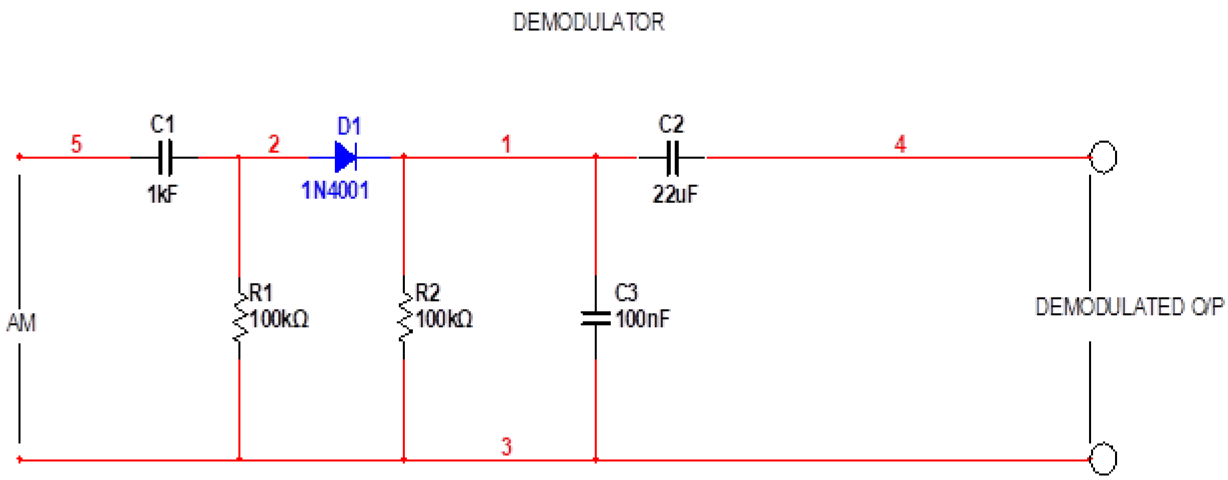


Figure 3.2: Amplitude De-Modulator

3.6 Background:

An Amplitude Modulated signal is composed of both low frequency and high frequency components. The amplitude of the high frequency (carrier) of the signal is controlled by the low frequency (modulating) signal. The envelope of the signal is created by the low frequency signal. If the modulating signal is sinusoidal, then the envelope of the modulated Radio Frequency (RF) signal will also be sinusoidal. This would be the case in a common AM radio. The low frequency signal would be an audio signal and the high frequency would be the transmitting frequency of the AM radio station. Shown in Figure 4.3 is an example of an AM signal in the time domain.

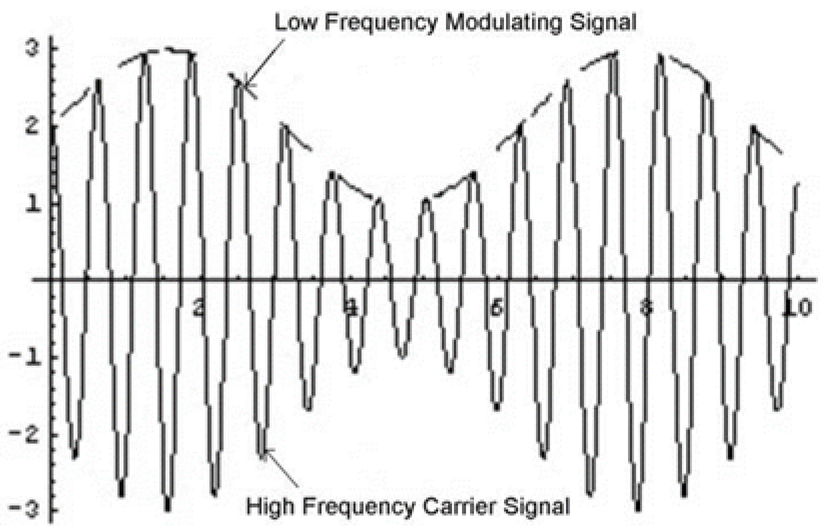


Figure 3.3: Amplitude Modulated Waveform

The mathematical representation for this waveform is as follows:

$$fAM(t) = A[1 + \mu\cos(\omega mt)]cos(\omega ct)$$

where,
A= DC value of the waveform
µ= modulation index
ωm= modulation frequency (rad/s)
ωc= carrier frequency (rad/s)
Figure 4.4 shows the physical interpretation of the mathematical equation given above. In this diagram, the quantities A and mp are indicated.

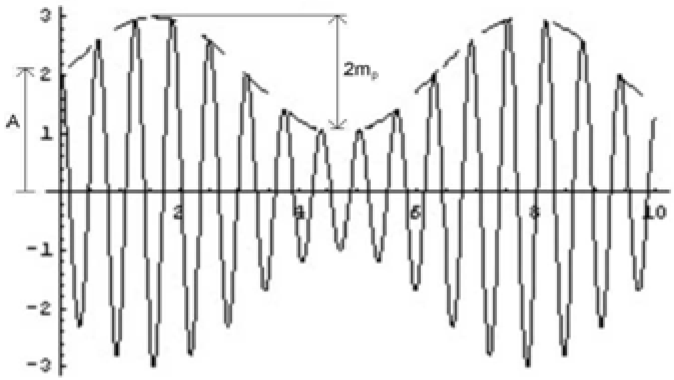


Figure 3.4: AM Modulated Signal Showing Values

The circuit for generating an AM modulated waveform must produce the product of the carrier and the modulating signal. This can be achieve in many ways, but often is done by biasing a transistor for nonlinear operation (creating the product term) and filtering the output with a tank circuit to remove the higher harmonics introduced. This type of modulator is shown in Figure 3-5. For class B operation, the transistor is biased such that when both the carrier and modulating signals are zero, the DC voltage at the transistor base will be 0.7 V (i.e., the knee voltage of the base emitter junction). If a carrier is added via the coupling capacitor C1 while the modulating signal remains zero the transistor will be turned off for the negative half cycle of the carrier, producing only positive current pulses in the collector. The tank circuit will have large impedance at the carrier frequency, also the fundamental frequency of the current pulses, and low impedance at the higher harmonics of the current pulses. Thus, the voltage produced at the output will be a sinusoid of the carrier frequency. When the modulating signal is added via the coupling capacitor C5 the emitter voltage of the transistor will follow the modulating signal, causing the cutoff voltage of the transistor and also the collector current pulse amplitude to vary with the modulating signal. The collector current waveform has the shape of the positive half of the waveform shown in Figure 4.4; the tank circuit attenuates the higher harmonics to produce an output voltage with the waveform of Figure 4.4.
The modulation index, µ, can be found with the following equation:

$$\mu = \frac{mp}{A}$$

After receiving an AM signal, it can be demodulated to recover the low frequency signal. One of the simplest types of AM demodulating circuits is the envelope detector. In order to accurately recover the low frequency signal the envelope detector must satisfy an important condition; the time constant of the envelope detector network must be much longer than the period of the high frequency signal but much shorter than the period of the low frequency signal. Once the signal is demodulated, the high frequency signal is eliminated and what remains is the low frequency component. Figure 4.5 shows the general idea of the envelope detection method to regain the low frequency signal.

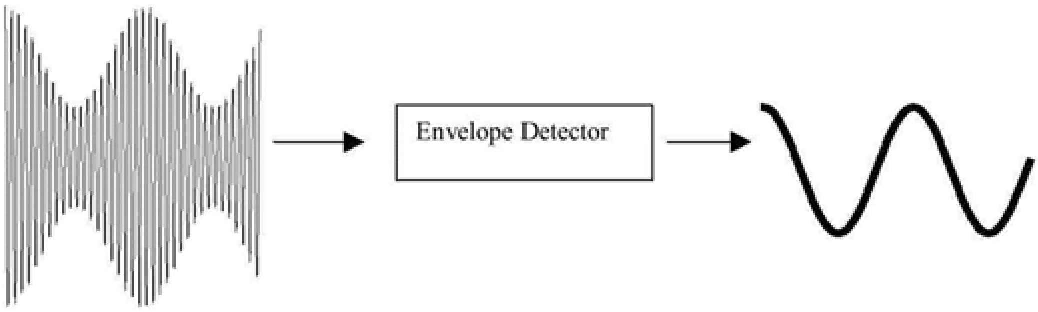


Figure 3.5: Demodulation of an AM Signal

A typical circuit used for an envelope detector is shown in Figure 4.6. It is composed of a resistor, capacitor, and diode. The time constant set by the values of the resistor and capacitor needs to be much less than the period of the audio signal but much greater than the period of the RF (high frequency) signal.

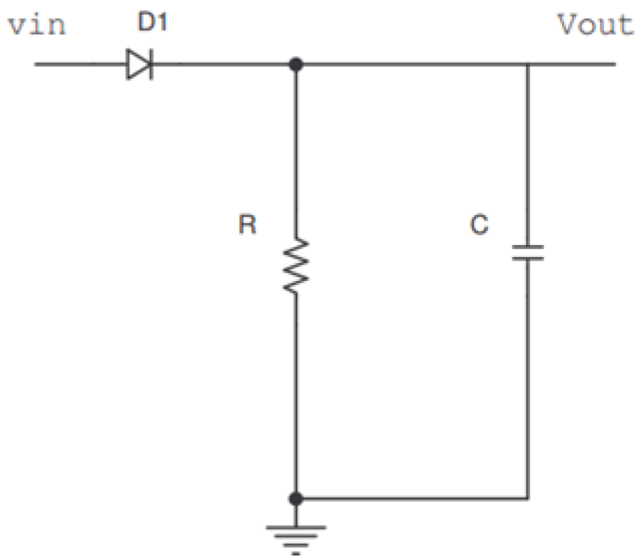


Figure 3.6: Envelop Detector

3.7 Procedure

Part (0) After answering the following questions, review the laboratory exercise procedures and plan how you will use the experience gained in these calculations to find the values sought. **Hardware:**

Step 1: Switch on the trainer kit and check the o/p of carrier generator on oscilloscope.

Step 2: Apply the 1KHz (2vp-p) A.F modulating signal to the AM modulation at AF i/p terminal.

Step 3: Connect the carrier signal (RF) at the carrier i/p of the modulator.

Step 4: Connect the modulating (AF) signal to CH 1 and modulated signal (i.e, o/p of AM modulator) to CH 2 of a dual trace oscilloscope. Observe the o/p.

Step 5: Calculate the maxima and minima points of modulated wave (o/p) on the CRO and the calculate the depth of modulation using the formula.

$$ModulationIndex(\mu) = \frac{Vmax - Vmin}{Vmax + Vmin}$$

$$\%ModulationIndex(\mu) = \frac{Vmax - Vmin}{Vmax + Vmin} X100$$

Step 6: Vary the modulating frequency and amplitude and observe the effects of the o/p modulated waveform.

Step 7: The depth of modulation can be varied by varying the potentiometer provided at AF input.

Step 8: Repeat step 5 for 100% modulation, under modulation over modulation.

Step 9: Connect the o/p of the modulation circuit to the i/p of demodulator circuit and observe the o/p.

Step 10: Connect the modulated signal (i/p demodulator) to CH 1 and (o/p of demodulator) to CH 2. Observe the waveforms.

3.8 Expected wave forms:

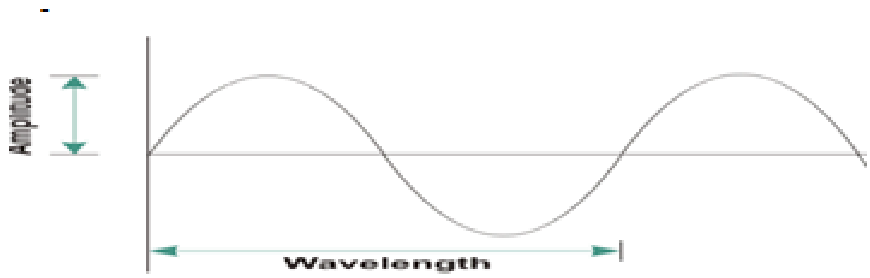


Figure 3.7: Message Signal

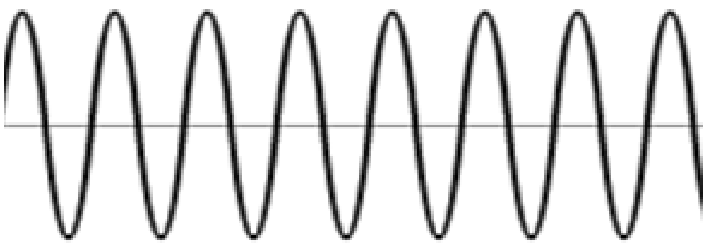


Figure 3.8: Carrier Wave

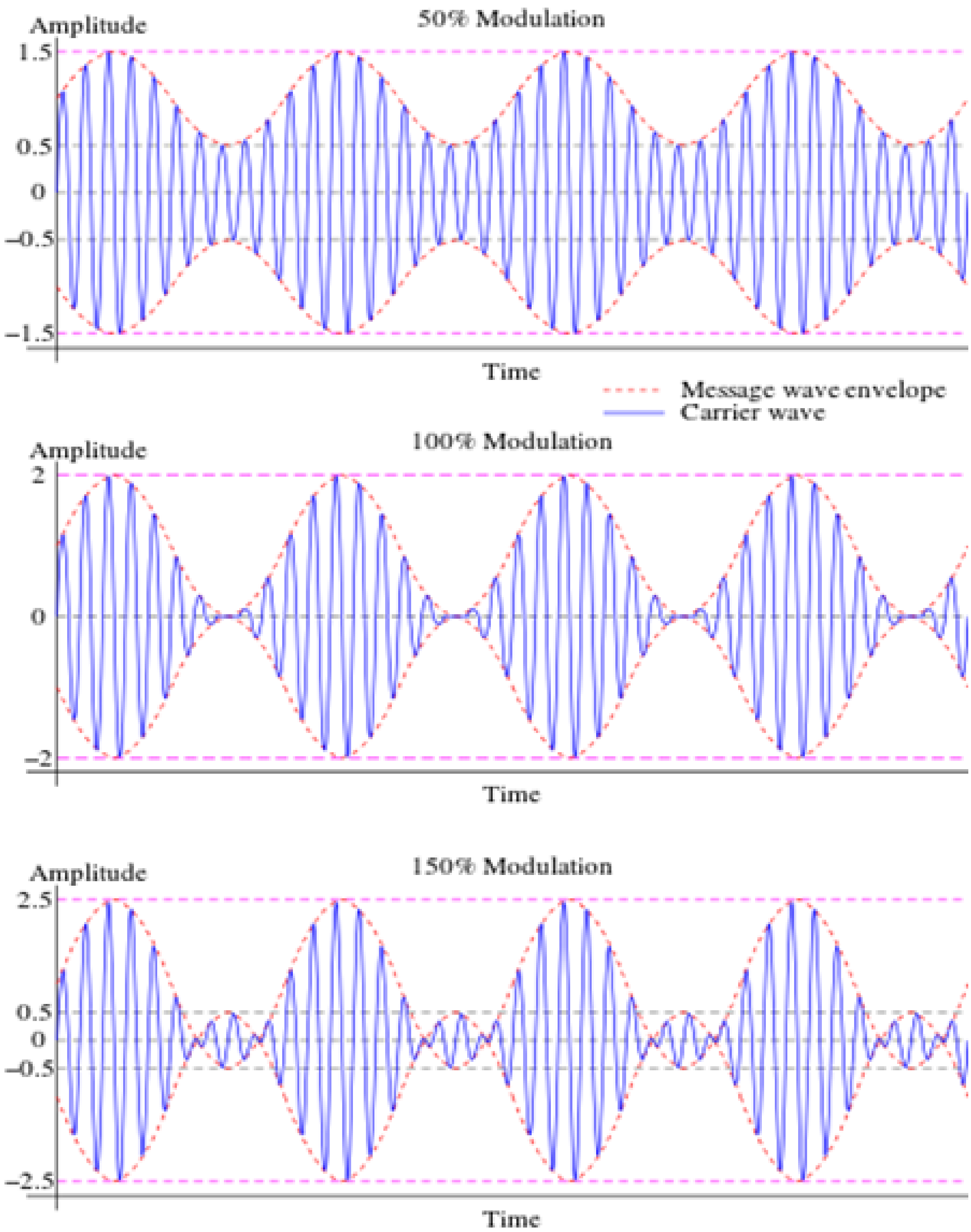


Figure 3.9: Types of Amplitude Modulated Wave Forms

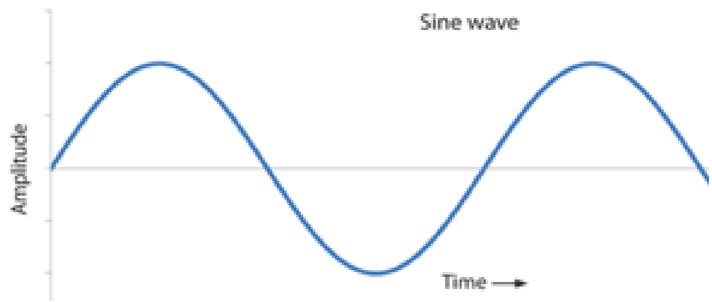


Figure 3.10: Demodulated signal

Table 3.1: **TabularColumn:**

S. No.	**Vmax (Volts)**	**Vmin (Volts)**	**Theoretical** $\mu = \frac{Vm}{Vc}$	$\mu = \frac{Vmax-Vmin}{Vmax+Vmin}$

3.9 MATLAB program

```
clc;
clear all;
close all;
t=[0:0.001:2];
f1=5;
m=sin(2*pi*f1*t);
subplot(6,2,[1,2]);
plot(t,m);
title('mesage');
f2=50;
c=sin(2*pi*f2*t);
subplot(6,2,[3,4]);
plot(t,c);
title('carrier');
m1=0.5;
s1=(1+(m1*m)).*c;
subplot(6,2,[5,6]);
plot(t,s1);
title('under modulation');
m2=1;
s2=(1+(m2*m)).*c;
subplot(6,2,[7,8]);
plot(t,s2);
title('100%modulation');
m3=1.5;
s3=(1+(m3*m)).*c;
subplot(6,2,[9,10]);
plot(t,s3);
title('over modulation');
```

```
s5=s2.*c;
[b,a]=butter(5,0.1);
s4=filter(b,a,s5);
subplot(6,2,[11,12]);
plot(t,s4);
title('demodulation' );
```

3.10 Procedure For MATLAB Software:

1. Click on the MATLAB Icon on the desktop.
2. MATLAB window open.
3. Click on the ‘FILE’ Menu on menu bar.
4. Click on NEW M-File from the file Menu.
5. An editor window open, start typing commands.
6. Now SAVE the file in directory.
7. Then Click on DEBUG from Menu bar and Click Run.

3.11 Expected Waveforms

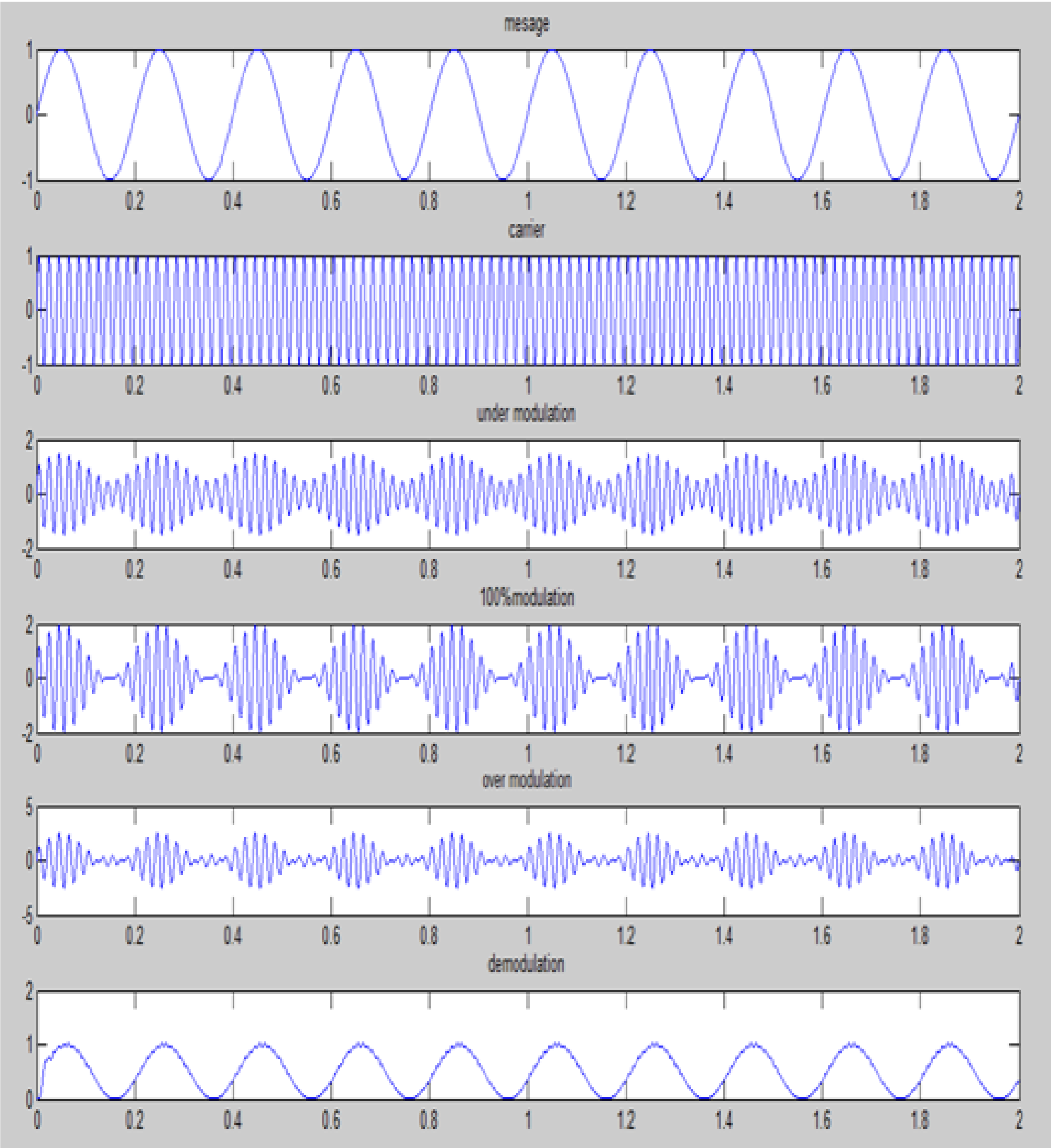


Figure 3.11: Simulation Result

3.12 Precautions

1. Always turn off power to the trainer kit when making the connections to the circuit.
2. Failure to turn off power when making circuit changes is a major reason for blowing fuses in the equipment, thereby rendering the equipment unusable and wasting your time and that of others. Please carefully check circuit wiring, frequency and voltage settings in function generator before applying power to the circuits.
3. Only reapply power after verifying that the circuit is properly wired and that the voltage to be applied is at or below the required value.

3.13 Further Probing Experiments

Q1. 1. What happens to the modulation index of an AM signal if the carrier level remains constant and the sideband level increases?

Q2. An AM signal, depth of modulation 100%.from a single tone message, has a peak-to-peak amplitude of 4 volts. What would an RMS voltmeter read if connected to this signal?

LAB-3 DSB-SC MODULATOR DETECTOR

4.1 Introduction

The buzzer is interfaced to Port P3.6 of the microcontroller and switch is interfaced to Port P1.4. The simple ON/OFF program is written as an example using delay in between them. Whenever switch is pressed the buzzer will give sound and whenever it is released buzzer will OFF. One can also use the switch concept to control the ON/OFF operation of buzzer. Here, switch is connected to Port P3.6 pin and Debouncing concept is applied.

4.2 Objective

4.2.1 Educational

• Learn to measure output voltage.
• Learn about the operation of balanced modulator and synchronous detector.
• Learn to suppress the carrier from amplitude modulated waveforms

4.2.2 Experimental

• Generation of DSBSC modulated wave using balance modulator.
• Demodulation of the amplitude modulated wave using synchronous detector.
• Draw the input and output waveforms.
• Simulation of MATLAB code to generate and detect DSBSC modulated waveforms.

4.3 Prelab Preparation:

4.3.1 Reading

• Read and study the Background section of this Laboratory.
• Read Appendix A, B, C and D Voltage Measurement of an oscilloscope with two vertical inputs.

4.3.2 Written

• Prior to coming to lab class, complete Part 0 of the Procedure.

4.4 Equipment needed

4.4.1 Hardware Requirements:

1. Balanced modulator trainer kit 2. Synchronous detector Trainer kit 3. Function Generator (0-1) MHz 4. C.R.O. (0-20) MHz 5. PC
6. CRO probes and Connecting Wires.

4.4.2 Software Requirements:

1. MATLAB Software.

4.5 Circuit Diagram:

Modulator

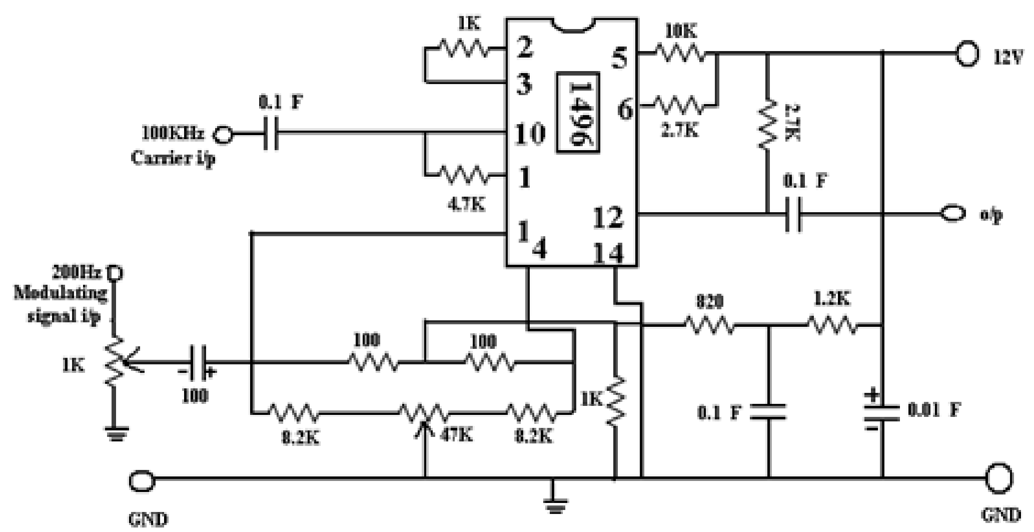


Figure 4.1: Balance Modulator

De-Modulator

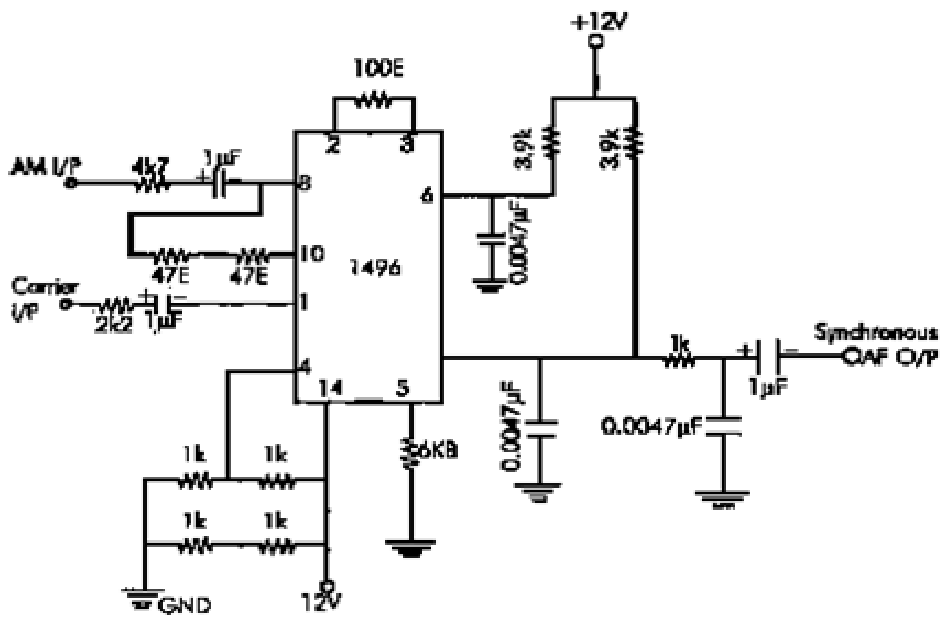


Figure 4.2: Synchronous De-Modulator

4.6 Background:

The carrier of amplitude modulation wave does not convey any information. It is obvious from the fact that the carrier component remains constant in amplitude and frequency. Nomatter what the modulating signal does. It is thus, seen that no information is conveyed by the carrier. If the carrier is suppressed, only the side bands remains and a saving of two third powers can achieve at 100% modulation such suppression of carrier doesn't affect the massage signal in any way. This idea has resulted in the evolution of suppressed carrier modulation. Thus, the short coming of the conventional AM in regard of power wastage is overcome by suppressing the carrier from the modulated wave resulting in double side band suppressed carrier modulation. A balanced is used to generate DSBSC wave. A DSBSC signal is basically the product of the base band signal and the carrier wave.

S(t) = m(t) *c(t)

Where m(t) is base band signal

C(t) is carrier signal

C(t) = A_c cos $2\pi f_c$ t

The modulated wave under goes a phase reversal when ever base band signal m(t) crosses zero. Spectrum of base band signal

$S(f) = \frac{A_c}{2}[(M(f - f_c) + M(f + f_c))]$

Where M (f) is the fourier trans form of m(t)

Ac is carrier amplitude And

fc is frequency of the carrier.

The band width of DSBSC signal is same as that of conventional AM i.e., 2W. The base band signal m(t) can be uniquely recovered from a DSB-SC wave S(t) by first multiplying s(t) with a locally generated sinusoidal wave and then low-pass filtering the product, as in fig. below. It is assumed that the local oscillator signal is exactly coherent or synchronized, in both frequency and phase, with the carrier wave C(t) used in the product modulator to generate S(t). This method of demodulation is known as Coherent or Synchronous demodulation.

4.7 Procedure

Part (0) After answering the following questions, review the laboratory exercise procedures and plan how you will use the experience gained in these calculations to find the values sought. **Balance Modulator:**

1. Switch on the balanced modulator trainer kit
2. Connect 200 Hz sine wave, and 100 KHz square wave from the function generators. Adjust R1 (1K linear pot). Connect oscilloscope to the output.
3. Vary R_1 (1K) both clockwise and counter clockwise .Observe the output.
4. Disconnect the sine input to R_1(1K) . The output should now be close to zero.
5. Increase the oscilloscope's vertical input sensitivity to measure the output voltage, E out carrier only.

6. Set the vertical input control to 1V /cm .Connect the sine input to R_1 (1K) and adjust R1 for maximum output without producing clipping. Measure the peak side band output voltage E_{pk} side bands = ————————-
7. Calculate the carrier suppression in db.
8. Suppression (db) = -20 log (E_{pk} sideband/E_{out} carrier only)

Synchronous Detector:

1. Observe the carrier signal at the terminal provided on the kit. Set it to 100KHz
2. Connect 200 Hz AF signal externally from the signal generator to the AF input terminal provided on the kit. Adjust the amplitude pot of signal generator such that should observe an AM output terminal.
3. Connect the carrier output to the carrier input of Synchronous circuit.
4. Connect the AM output to the AM input of the Synchronous circuit.
5. Observe the synchronous detector AF output on the oscilloscope.

4.8 Expected wave forms:

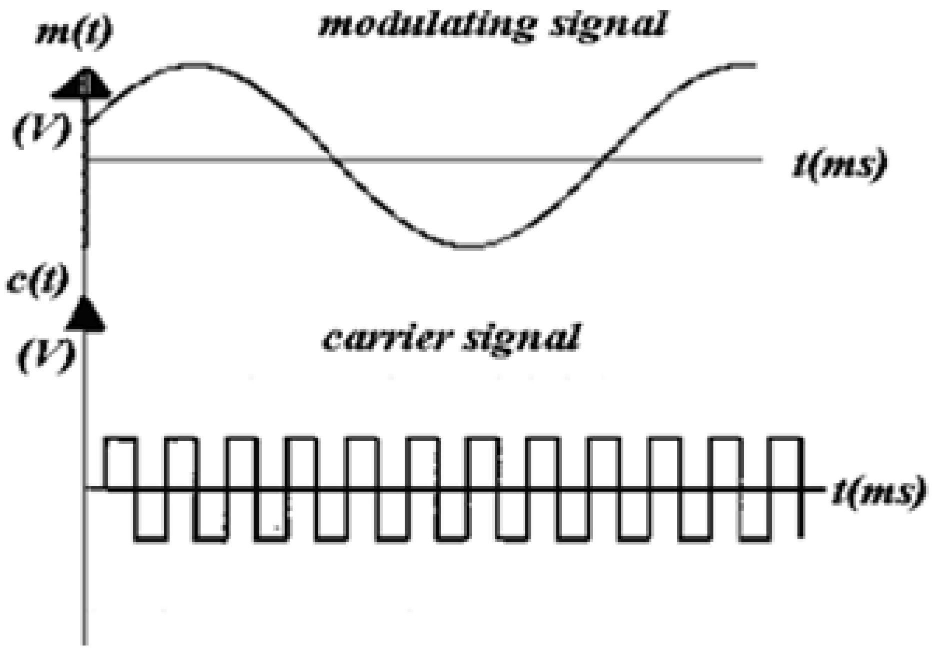


Figure 4.3: Message And Carrier Waveforms

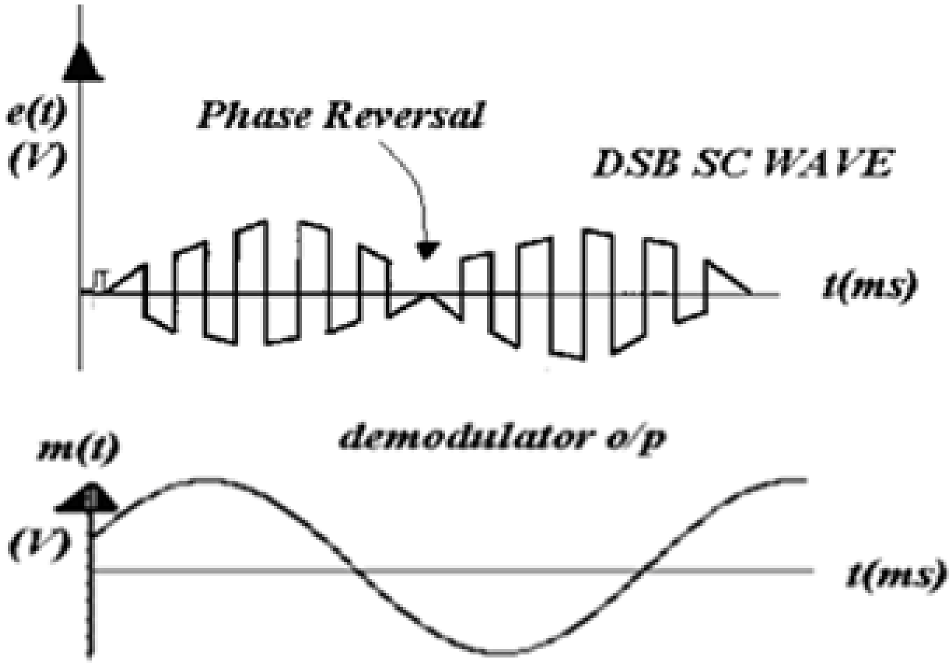


Figure 4.4: DSBSC Modulated and Demodulated Waveforms

Table 4.1: **TabularColumn:**

S.No.	**Modulating Signal Voltage E_{min}$ V**	**De Modulated signal Voltage** E_{min} **V**	**Modulating Frequency** F_m **Hz**	**De modulated Frequency** F_m **Hz**

4.9 MATLAB program

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

```
s1=s.*c;
[b,a]=butter(5,0.1);
s2=filter(b,a,s1);
subplot(4,2,[7,8]);
plot(t,s2);
title('demodulation');
```

4.10 Procedure For MATLAB Software:

1. Click on the MATLAB Icon on the desktop.
2. MATLAB window open.
3. Click on the 'FILE' Menu on menu bar.
4. Click on NEW M-File from the file Menu.
5. An editor window open, start typing commands.
6. Now SAVE the file in directory.
7. Then Click on DEBUG from Menu bar and Click Run.

4.11 Expected Waveforms

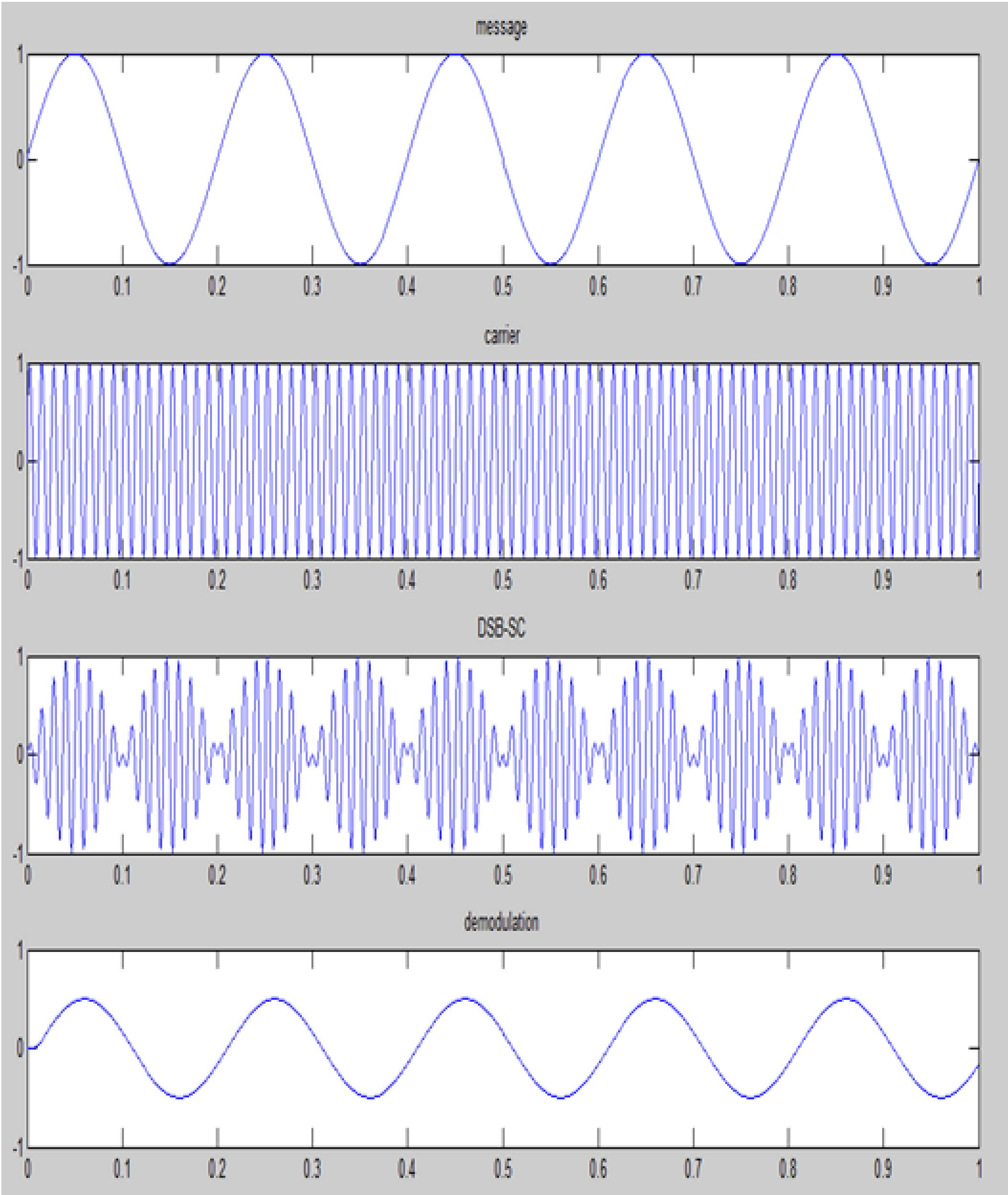


Figure 4.5: Simulation Result

4.12 Precautions

1. Always turn off power to the trainer kit when making the connections to the circuit.
2. Failure to turn off power when making circuit changes is a major reason for blowing fuses in the equipment, thereby rendering the equipment unusable and wasting your time and that of others. Please carefully check circuit wiring, frequency and voltage settings in function generator before applying power to the circuits.
3. Only reapply power after verifying that the circuit is properly wired and that the voltage to be applied is at or below the required value.

4.13 Further Probing Experiments

Q1. What is the percentage of power saving for DSBSC when compared with AM having 100% depth of modulation?

Q2. A 1500Hz signal which has amplitude of 25V amplitude modulates a 50 MHz carrier which when unmodulated has amplitude of 75V. What frequencies would show up in the spectrum of AM wave?

Q3. A commercial AM station is broadcasting with an average transmitted carrier power of 10kW; the modulation index is 0.707 for a sinusoidal message signal. Find the transmission power and efficiency.

LAB-4 FREQUENCY MODULATION AND DEMODULATION

5.1 Introduction

Frequency Modulation is a modulation in which the frequency of the carrier wave is altered in accordance with the instantaneous amplitude of the modulating signal, keeping phase and amplitude constant. Modification of carrier wave frequency is performed for the purpose of sending data or information over small distances. FM technology is widely used in the fields of computing, telecommunications, and signal processing.

5.2 Objective

5.2.1 Educational

• Learn to measure output voltage.
• Learn about the concept of frequency modulation and demodulation.
• Learn to measure the frequency deviation of the carrier waveform.

5.2.2 Experimental

• Generation of frequency modulated wave.
• Demodulation of the frequency modulated signal using FM detector.
• Determination the modulation index and bandwidth for various values of amplitude and frequency of modulating signal.
• Draw the input and output waveforms.
• Simulation of MATLAB code to generate and detect frequency modulated waveforms.

5.3 Prelab Preparation:

5.3.1 Reading

• Read and study the Background section of this Laboratory.
• Read Appendix A, B, C and D Voltage Measurement of an oscilloscope with two vertical inputs.

5.3.2 Written

• Prior to coming to lab class, complete Part 0 of the Procedure.

5.4 Equipment needed

5.4.1 Hardware Requirements:

1. Frequency modulation and demodulation trainer kit
2. Function Generator (0-1) MHz

3. C.R.O. (0-20) MHz
4. PC
5. CRO probes and Connecting Wires.

5.4.2 Software Requirements:

1. MATLAB Software.

5.5 Circuit Diagram:

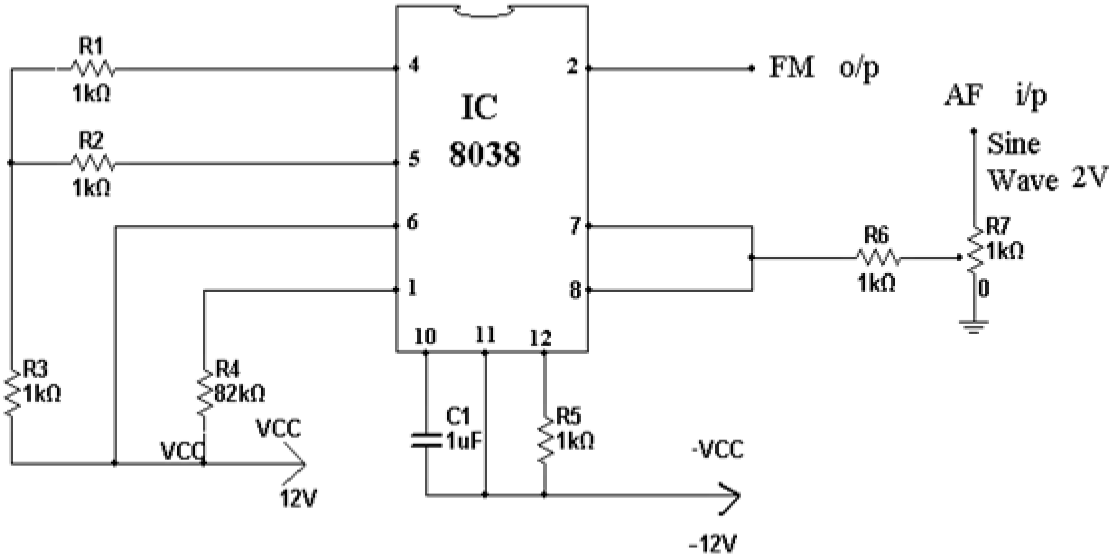


Figure 5.1: Frequency Modulator

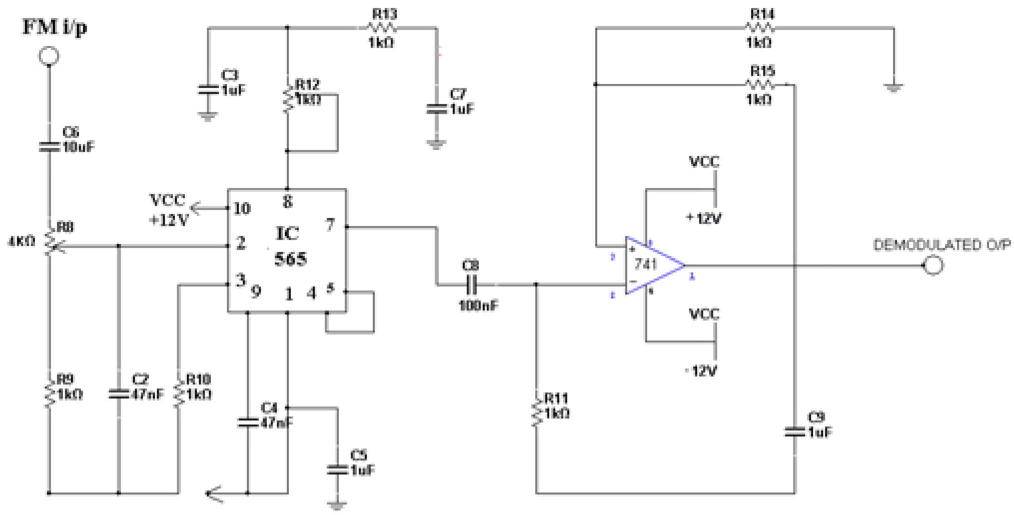


Figure 5.2: Frequency De Modulator

5.6 Background:

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

$$ModulationIndex = \frac{\triangle f}{f_m}$$

5.7 Procedure

Part (0) After answering the following questions, review the laboratory exercise procedures and plan how you will use the experience gained in these calculations to find the values sought. **Modulation:**

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

Demodulation:

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

5.8 Expected wave forms:

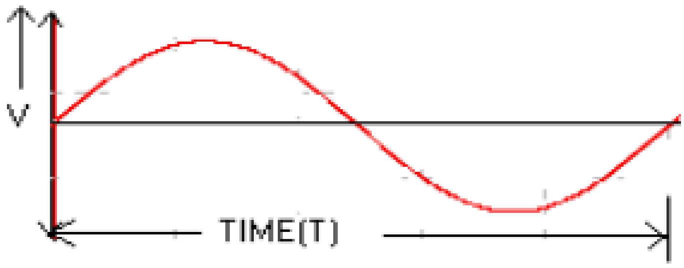


Figure 5.3: Message Signal

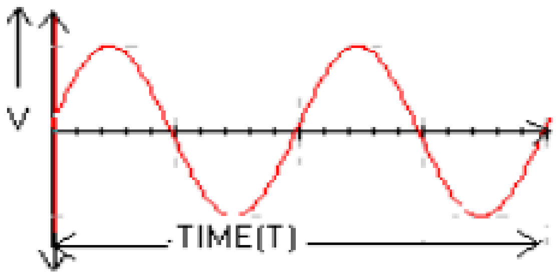


Figure 5.4: Carrier Waveforms

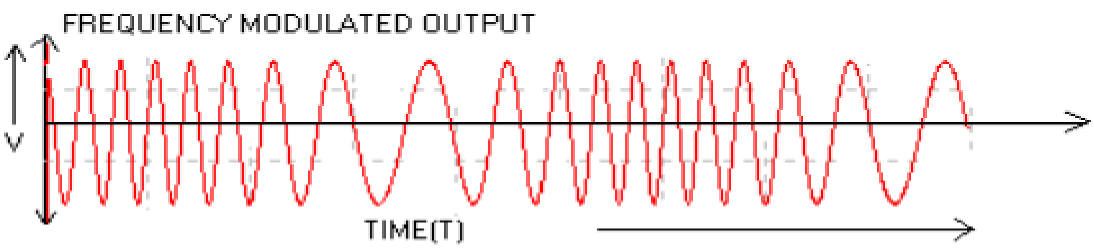


Figure 5.5: Frequency Modulated Waveform

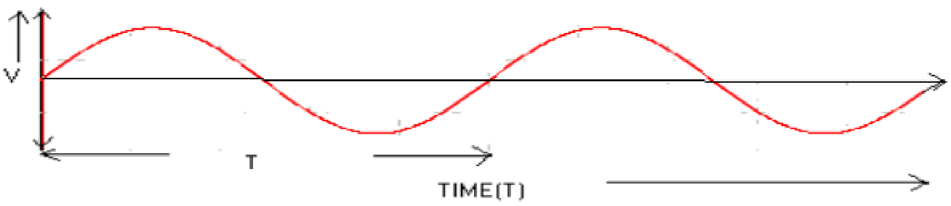


Figure 5.6: Frequency De modulated Waveform

Table 5.1: **TabularColumn: Frequency Modulation**

S.No.	Modulating Signal Voltage (V)	Carrier Frequency (KHz)	Change in Frequency (KHz)	Frequency Deviation (KHz)	$M_f = \frac{FrequencyDeviation}{f_m}$

Table 5.2: **TabularColumn: FM De Modulation**

S.No.	Modulating Signal Voltage (mV)	Modulating Frequency (KHz)	De Modulated Signal Voltage (V)	De Modulated Signal Frequency (KHz)

5.9 MATLAB program

```
clc;
clear all;
close all;
t=[0:0.001:4];f1=1;
m=cos(2*pi*f1*t);
subplot(4,2,[1,2]);
plot(t,m);
title('message');
f2=30;
c=sin(2*pi*f2*t);
subplot(4,2,[3,4]);
plot(t,c);
title('carrier');
mf=20;
s=sin((2*pi*f2*t)+(mf*sin(2*pi*f1*t)));
subplot(4,2,[5,6]);
plot(t,s);
title('fm');
syms t1;
x=diff(s);
y=abs(x);
[b,a]=butter(10,0.033);
s1=filter(b,a,y);
subplot(6,2,[11,12]);
plot(s1);
title('demodulation');
```

5.10 Procedure For MATLAB Software:

1. Click on the MATLAB Icon on the desktop.
2. MATLAB window open.
3. Click on the 'FILE' Menu on menu bar.
4. Click on NEW M-File from the file Menu.
5. An editor window open, start typing commands.
6. Now SAVE the file in directory.
7. Then Click on DEBUG from Menu bar and Click Run.

5.11 Expected Waveforms

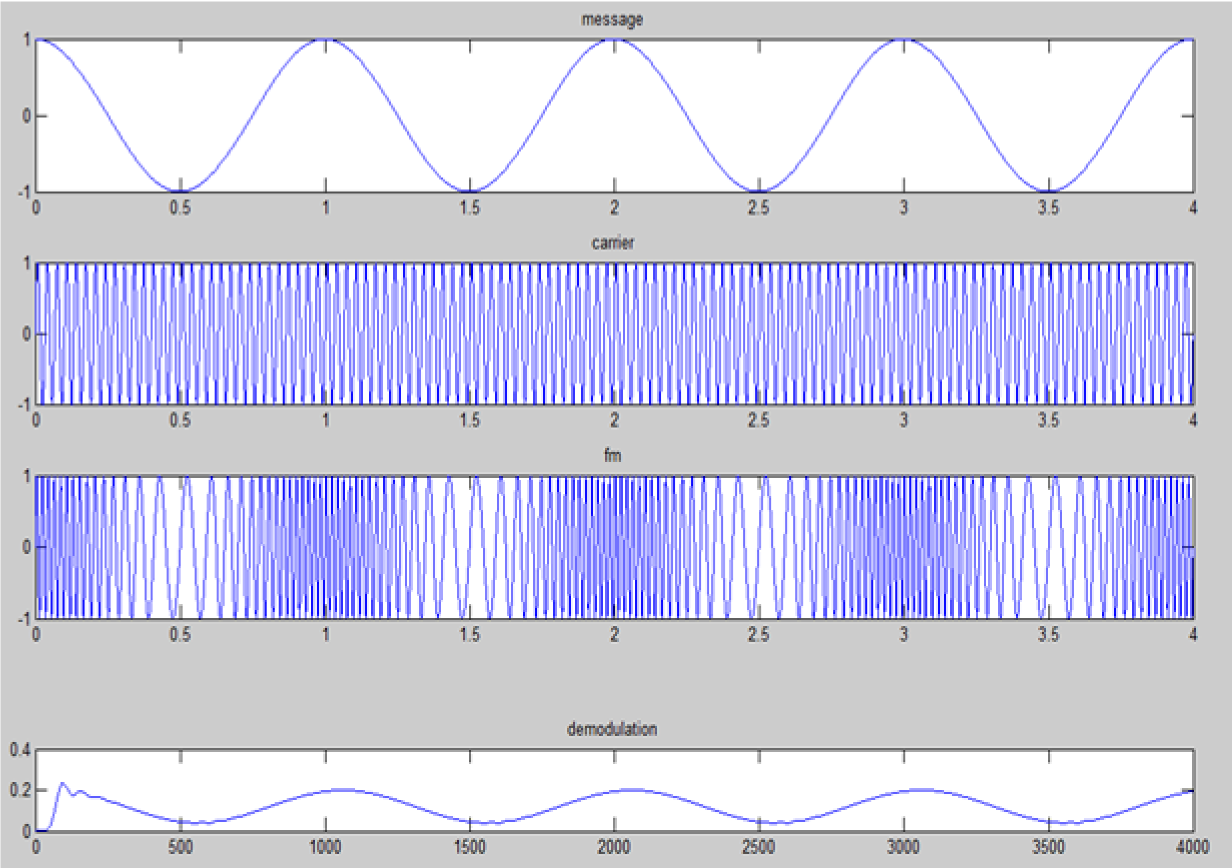


Figure 5.7: Simulation Result

5.12 Precautions

1. Always turn off power to the trainer kit when making the connections to the circuit.
2. Failure to turn off power when making circuit changes is a major reason for blowing fuses in the equipment, thereby rendering the equipment unusable and wasting your time and that of others. Please carefully check circuit wiring, frequency and voltage settings in function generator before applying power to the circuits.

3. Only reapply power after verifying that the circuit is properly wired and that the voltage to be applied is at or below the required value.

5.13 Further Probing Experiments

Q1. Generate PM output using Frequency modulation?

Q2. Observe the spectrum and calculate BW?

Q3. When the amplitude of modulating signal increases then the effect on freq deviation?

LAB-5 SAMPLING THEOREM- VERIFICATION

6.1 Introduction

The purpose of this experiment is to set up sampling and reconstruction circuits to study the sampling theorem and to plot waveforms for different sampling rates. All of these terms are used in analog to digital signal conversions. Students will examine conversion of continuous time signal to discrete time signal.

6.2 Objective

After the completion of this experiment, students will have good knowledge about sampling, effect of sampling rate, method of sampling and reconstruction of signals.

6.3 Prelab Preparation:

Theoretical background of signals and system in analog communication.

6.4 Equipment needed

1. Sampling Theorem Trainer Kit-1
2. Function Generator (0-2) MHz-1
3. C.R.O (0-30) MHz-1
4. Connecting wires
5. BNC Probes.

6.5 Background

Sampling theorem states that if the sampling rate in any pulse modulation system exceeds twice the maximum signal frequency the original signal can be reconstructed in the receiver with minimum distortion. Let m (t) is a signal whose highest frequency component is fm. Let the value of m(t) be obtained at regular intervals separated by time T far less than (1/2 fm). The sampling is thus periodically done at each TS seconds. Now the samples m (nTS) where n is an integer which determines the signals uniquely. The signal can be reconstructed from these samples without distortion. Time Ts is called the sampling time. The minimum sampling rate is called nyquist rate. The validity of sampling theorem requires rapid sampling rate such that at least two samples are obtained during the course of the interval corresponding to the highest frequency of the signal under analysis. Let us consider an example of a pulse modulated signal, containing speech information, as is used in telephony. Over standard telephone channels the frequency range of A.F. is from 300 Hz to 3400 Hz. For this application the sampling rate taken is 8000 samples per second. This is an International standard. We can observe that the pulse rate is more than twice the highest audio frequency used in this system. Hence the sampling theorem is satisfied and the resulting signal is free from sampling error.

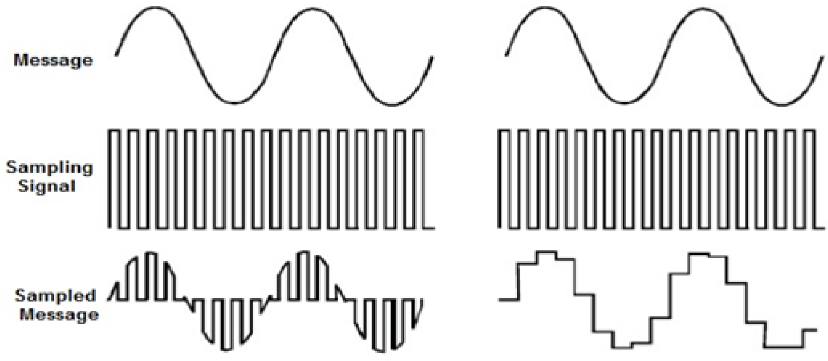
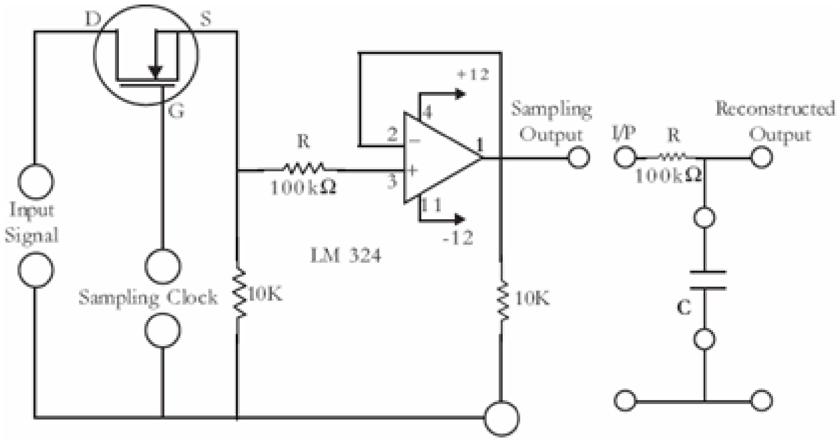


Figure 1(a) Figure 1(b)

6.6 Procedure



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

6.6.1 Observation Table

Parameter	Analog Input Signal	Sampling Clock	Sampled Output
Amplitude(V)			
Frequency(Hz)			

6.7 Further Probing Experiment

1. Observe the Sampling output for Triangular wave as Analog Input Signal.
2. Observe the reconstruction waveform for fs eqal 2fm and justify aliasing effect.

LAB-6 PULSE WIDTH MODULATION AND DEMODULATION

7.1 Introduction

The purpose of this experiment is to identify width of a carrier pulse train is varied in accordance with the instantaneous level of the modulating signal. All of these terms are used in pulse analog modulation systems. You will find that most of these parameters are depend on the modulation process.

7.2 Objective

After the completion of this experiment, students will have good knowledge with the generation and detection of pulse width modulation. You will verify where the width of the pulses in a carrier pulse train is made proportional to the instantaneous amplitude of the modulating signal

7.3 Prelab Preparation:

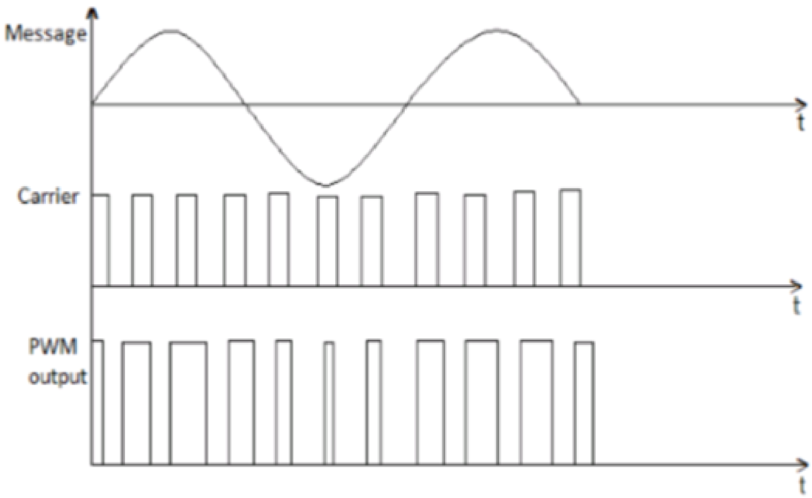
Theoretical background of signals and system, modulation in communication

7.4 Equipment needed

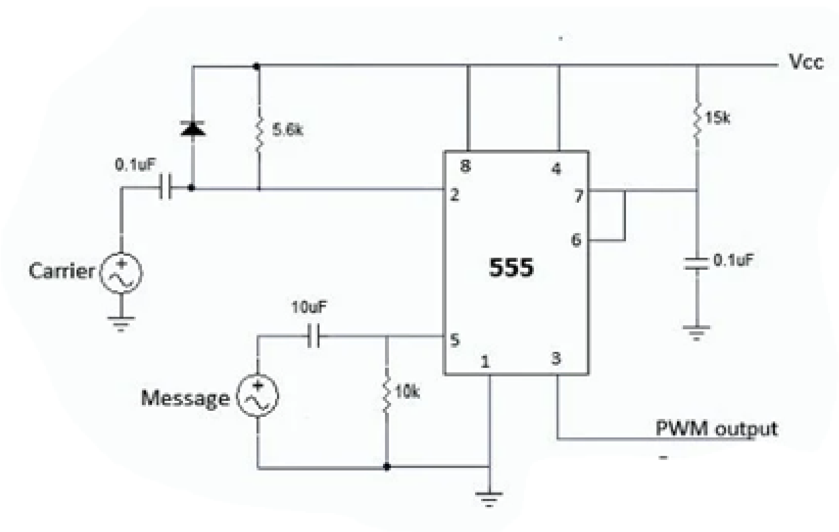
1. Pulse width modulation trainer (PHY-60)
2. Function Generator (0-2) MHz-1
3. C.R.O (0-30) MHz-1
4. Connecting wires
5. BNC Probes.

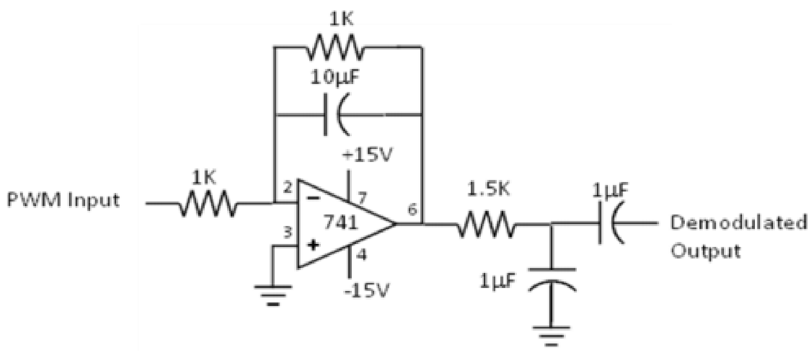
7.5 Background

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 waveforms may be reconstituted from the information regarding the samples. The pulse Width Modulation of the PTM is also called as the Pulse Duration Modulation (PDM) and less often Pulse length Modulation (PLM). In pulse Width Modulation method, we have fixed and starting time of each pulse, but the width of each pulse is made proportional to the amplitude of the signal at that instant. This method converts amplitude varying message signal into a square wave with constant amplitude and frequency, but which changes duty cycle to correspond to the strength of the message signal. Pulse-Width modulation has the disadvantage, that its pulses are of varying width and therefore of varying power content. This means that the transmitter must be powerful enough to handle the maximum-width pulses. But PWM still works if synchronization between transmitter and receiver fails, whereas pulse-position modulation does not. Pulse-Width modulation may be generated by applying trigger pulses to control the starting time of pulses from a mono stable multivibrator, and feeding in the signal to be sampled to control the duration of these pulses. When the PWM signals arrive at its destination, the recovery circuit used to decode the original signal is a sample integrator (LPF). Modulation: - The PWM circuit uses the 555 IC (U1) in monostable mode. The Modulating signal input is applied to pin no.5 of 555IC, and there Pulse input is applied to pin no.2. The output of PWM is taken at the pin no.3 of 555IC i.e., TP3. Demodulation: - The demodulation section comprises of a fourth order low pass filter and an AC amplifier. The TL074 (U5) is used as a low pass filter and an AC amplifier. The output of the modulator is given as the input to the low pass filter. The low pass filter output is obviously less and it is feed to the AC amplifier which comprises of a single op amp and whose output is amplified.



7.6 Procedure





1. Switch on pulse width modulation and Demodulation trainer kit
2. Connect the Clk O/P to the clk I/P terminal of PWM modulation.
3. Connect the AF O/P to AF I/P terminal of PWM modulation.
4. Observe the PWM O/P at pin 3 of 555 IC on CRO.
5. By varying frequency and amplitude of the modulating signal, observe the corresponding change in the width of the output pulses.
6. During demodulation, connect the PWM O/P of PWM modulation to the PWM I/P of PWM demodulation.
7. Observe the demodulated output at AF O/P of PWM demodulation on CRO.

7.7 Observation Table

Parameter	Modulating Signal	Input Pulse	PWM signal	Reconstructed Signal
Amplitude(V)				
Frequency(Hz)				

7.8 Further Probing Experiments

Q1.Clock frequency in a PWM system is 2.5 kHz and modulating signal frequency is 500Hz how many pulses per cycle of signal occur in PWM output? Draw the PWM signal?

Q2. Draw a TDM signal which is handling three different signals using PWM?

LAB-7 PULSE POSITION MODULATION AND DEMODULATION

8.1 Introduction

The purpose of this experiment is to identify position of a carrier pulse train is varied in accordance with the instantaneous level of the modulating signal. All of these terms are used in pulse analog modulation systems. You will find that most of these parameters are depend on the modulation process.

8.2 Objective

After the completion of this experiment, students will have good knowledge with the generation and detection of pulse position modulation. You will verify where the position of the pulses in a carrier pulse train is made proportional to the instantaneous amplitude of the modulating signal

8.3 Prelab

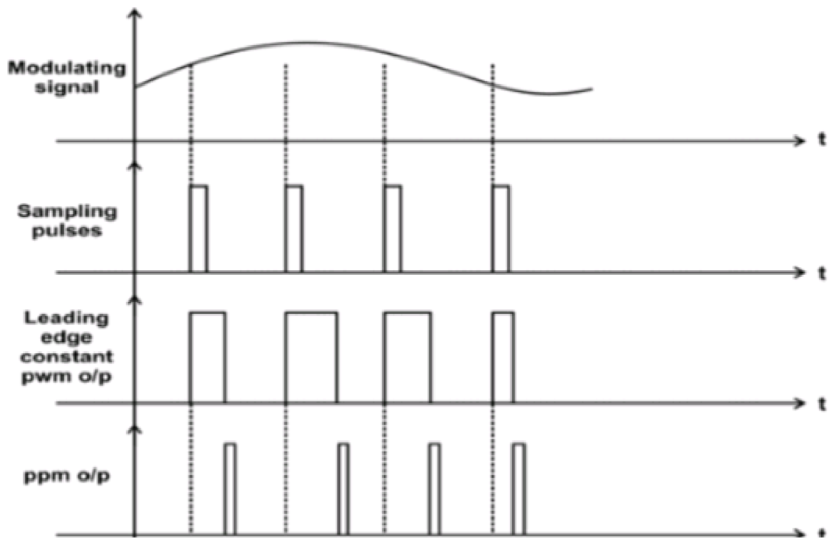
Theoretical background of signals and system, modulation in communication

8.4 Equipment needed

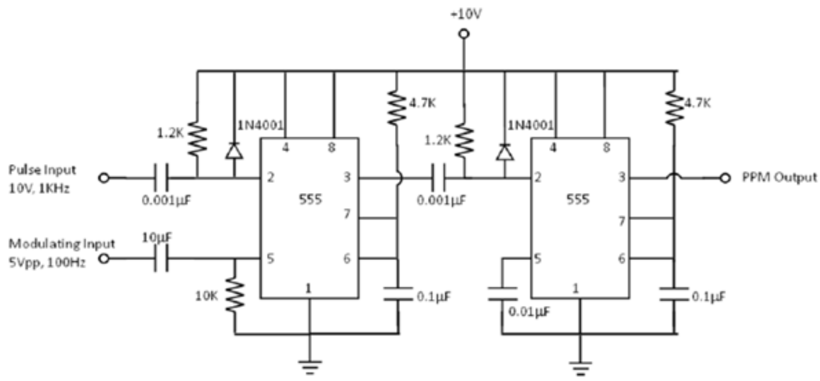
1. Pulse width modulation trainer
2. Function Generator(0-1) MHz-1
3. C.R.O (0-30) MHz-1
4. Connecting wires
5. BNC Probes.

8.5 Background

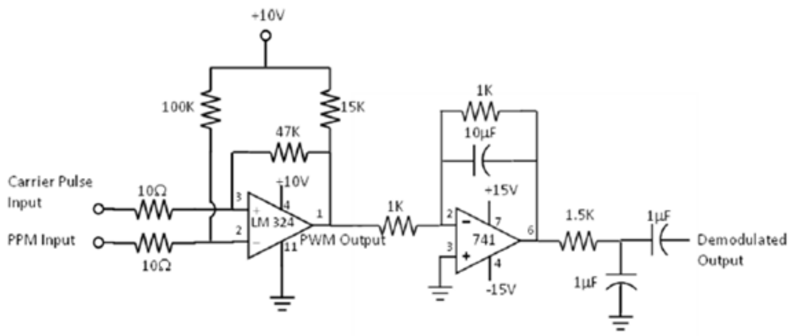
Pulse Modulation is used to transmit analog information in this system continuous wave forms are sampled at regular intervals. Information regarding the signal is transmitted only at the sampling times together with synchronizing signals. At the receiving end, the original waveforms may be reconstituted from the information regarding the samples. Pulse modulation may be subdivided in to two types analog and digital. In analog the indication of sample amplitude is the nearest variable. In digital the information is a code. 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. Pulse-Position modulation has the advantage of requiring constant transmitter power output, but the disadvantage of depending on transmitter receiver synchronization. Pulse-position modulation may be obtained very simply from PWM. A pulse position modulator made up of IC 555 is shown in figure. Both the 555s are working in monostable mode. The first monostabe generates a PWM signal and this PWM output is used as the trigger input of the second monostable. Since the monastable triggers at the trailing edge of the PWM signal, the position of the resulting pulses will have position shift compared to the input pulse train. The PPM demodulator is set up using an Op Amp SR flip flop, an integrator and a low pass filter. The flip flop is set by the carrier pulses and reset by the PPM pulses. The resulting output is a PWM signal. This PWM signal is then demodulated using the integrator-low pass filter combination.



8.6 Procedure



Modulator



Demodulator

1. Test all the components and probes.
2. Set up the circuit as shown in the figure on the bread board. Switch on the power supplies.
3. Feed the 10Vpp, 1 KHz, 0.2 duty cycle carrier pulse train and the 5Vpp, 100Hz modulating signal (Sine wave) at the trigger and control inputs of the first 555 respectively.
4. Make sure that the PWM signal is available at pin 3 of the first 555. Vary the amplitude of the modulating signal to get a proper PWM output if needed.
5. Observe the waveforms of the input pulse train, modulating input, PWM output and PPM output on the CRO.
6. Observe the following waveforms in pairs on both the channels of the CRO; a) Modulating input and PWM output b) PWM output and PPM output c) Modulating input and PPM output
7. Plot the waveforms.
8. Set up the demodulator circuit as shown in figure. Switch on the power supply.
9. Feed the PPM signal input and the carrier pulse input as shown in figure. Observe the waveforms at various points on CRO and plot.

8.6.1 Observation Table

Parameter	Modulating Signal	Input Pulse	PPM signal	Reconstructed Signal
Amplitude(V)				
Frequency(Hz)				

8.7 Further Probing Experiments

Q1.Shift in the position of each pulse of PPM depends on what?

Q2. What is the main advantage of PPM over PAM and PWM?

LAB-8 PULSE CODE MODULATION AND DEMODULATION

9.1 Introduction

The purpose of this experiment is to identify Pulse Code Modulation. It is a digital modulation technique by which an analog signal is converted to an equivalent sequence of binary codes. The analog signal is first sampled at regular intervals and these samples are then quantized to predefined levels. An analog to digital convertor converts these quantized symbols to their corresponding binary code words. You will find sampled, quantized, encoded signals.

9.2 Objective

After the completion of this experiment, students will have good knowledge with the generation and detection of pulse code modulation. You will verify how the analog signal is converted into digital signal.

9.3 Prelab Preparation:

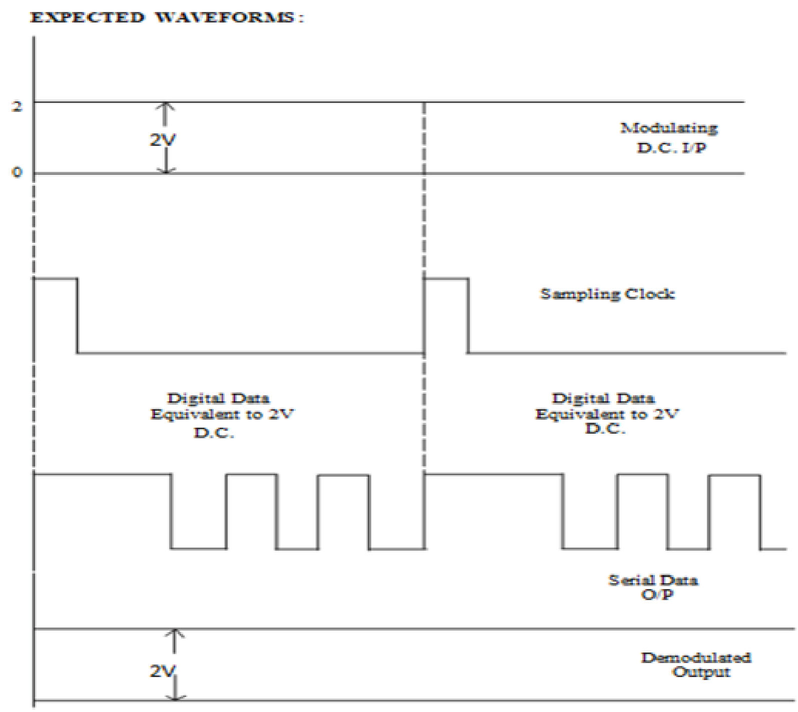
Theoretical background of signals and system, modulation in communication

9.4 Equipment needed

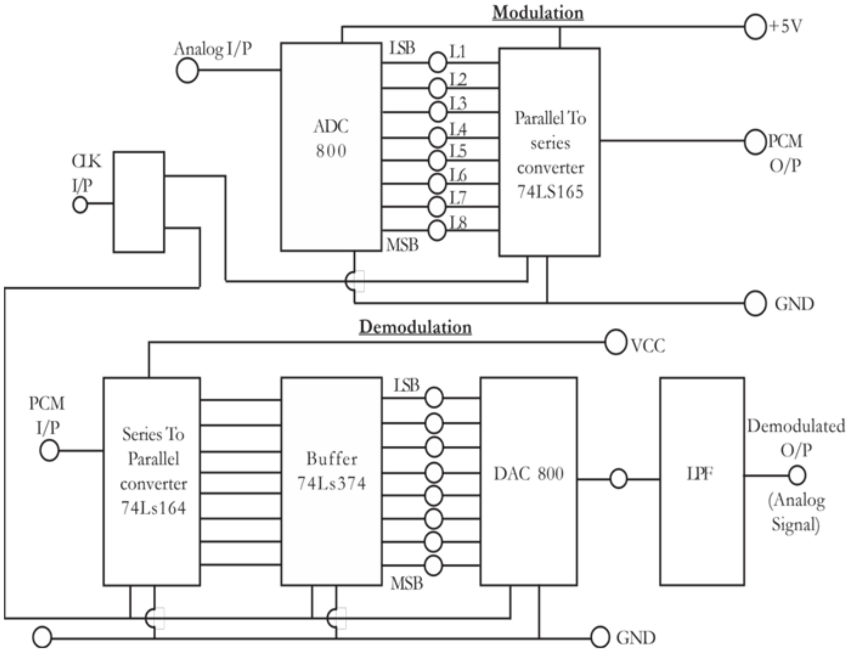
1. Pulse Code Modulation and Demodulation Trainer Kit
2. Function Generator (0-2) MHz-1
3. C.R.O (0-30) MHz-1
4. Volt Meter-1
5. Connecting wires
6. BNC Probes.

9.5 Background

In pulse code modulation (PCM), a message signal is represented by a sequence of coded pulses, which is accomplished by representing the signal in discrete from in both time and amplitude. The basic operations performed in the transmitter of a PCM system are sampling, quantizing and encoding. The Low pass filter prior to sampling is included to pre vent aliasing of the message signal. The incoming message signal is sampled with a train of narrow rectangular pulses so as to closely approximate the instantaneous sampling process. To ensure perfect reconstruction of the message signal at the receiver, the sampling rate must be greater than twice the highest frequency component W of the message signal in accordance with the sampling theorem. The quantizing and encoding operations are usually performed in the same circuit, which is called an analog-to-digital converter. The same circuit, which is called an analog-to-digital converter. The sampled version of the message signal is then quantized, thereby providing a new representation of the signal that is discrete in both time and amplitude. In combining the process of sampling and quantization, the specification of a continuous message (baseband) signal becomes limited to a discrete set of values, but not in the form best suited to transmission. To exploit the advantages of sampling and quantizing for the purpose of making the transmitted signal more robust to noise, interference and other channel impairments, we require the use of an encoding process to translate the discrete set of sample values to a more appropriate form of signal. The equalizer shapes the received pulses so as to compensate for the effects of amplitude and phase distortions produced by the non ideal transmission characteristics of the channel. The timing circuitry provides a periodic pulse train, derived from the received pulses, for sampling the equalized pulses at the instants of time where the signal-to-noise ratio is maximum. The final operation in the receiver is to recover the message signal by passing the decoder output through a low -pass reconstruction filter whose cutoff frequency is equal to the message bandwidth W. Assuming that the transmission path is error free, the recovered signal includes no noise with the exception of the initial distortion introduced by the quantization process.



9.6 Procedure



1. Test all the components and probes.
2. Set up the circuit as shown in figure on a bread board.
3. Feed 2Vpp, 100Hz unipolar sine wave as the analog input (Set dc level at 2V to obtain a signal that varies between +1V and +3V). Make sure that the input peak voltage never exceeds the peak DAC output.
4. Use the dc offset knob on the function generator to add dc offset to make unipolar sine wave.
5. Use 4Vpp, 500Hz square wave with 20 percentage duty cycle as sampling clock (clock 1) and 5V, 5 KHz square wave as the clock input of the counter (clock 2).
6. Observe the input sine wave, sampled output and the PCM output (DAC output; staircase waveform) on CRO. Vary the analog input and clock 1 input amplitudes to obtain the optimum result, if needed.

9.7 Observation Table

Parameter	Input	Clock signal	PCM signal	Reconstructed Signal
Amplitude(V)				
Frequency(Hz)				

9.8 Conversion Table

Input Voltage	LED								Output Voltage (256 V)
	L1	L2	L3	L4	L5	L6	L7	L8	
+5V									
+4V									
+3V									
+2V									
+1V									
-1V									
-2V									
-3V									
-4V									
-5V									
	$2^0=1$	$2^1=2$	$2^2=4$	$2^3=8$	$2^4=16$	$2^5=32$	$2^6=64$	$2^7=128$	

9.9 Further Probing Experiments

LAB-9 DIFFERENTIAL PULSE CODE MODULATION AND DEMODULATION

10.1 Introduction

The purpose of this experiment is to identify Differential Pulse Code Modulation. It is a digital modulation technique by which an analog signal is converted to an equivalent sequence of binary codes. The analog signal is first sampled at regular intervals and these samples are then quantized to predefined levels. An analog to digital convertor converts these quantized symbols to their corresponding binary code words. You will find sampled, quantized, encoded signals.

10.2 Objective

After the completion of this experiment, students will have good knowledge with the generation and detection of differential pulse code modulation with lower bandwidth. You will verify how the analog signal is converted into digital signal. To reduce Redundancy occurs in pulse code modulation.

10.3 Prelab Preparation:

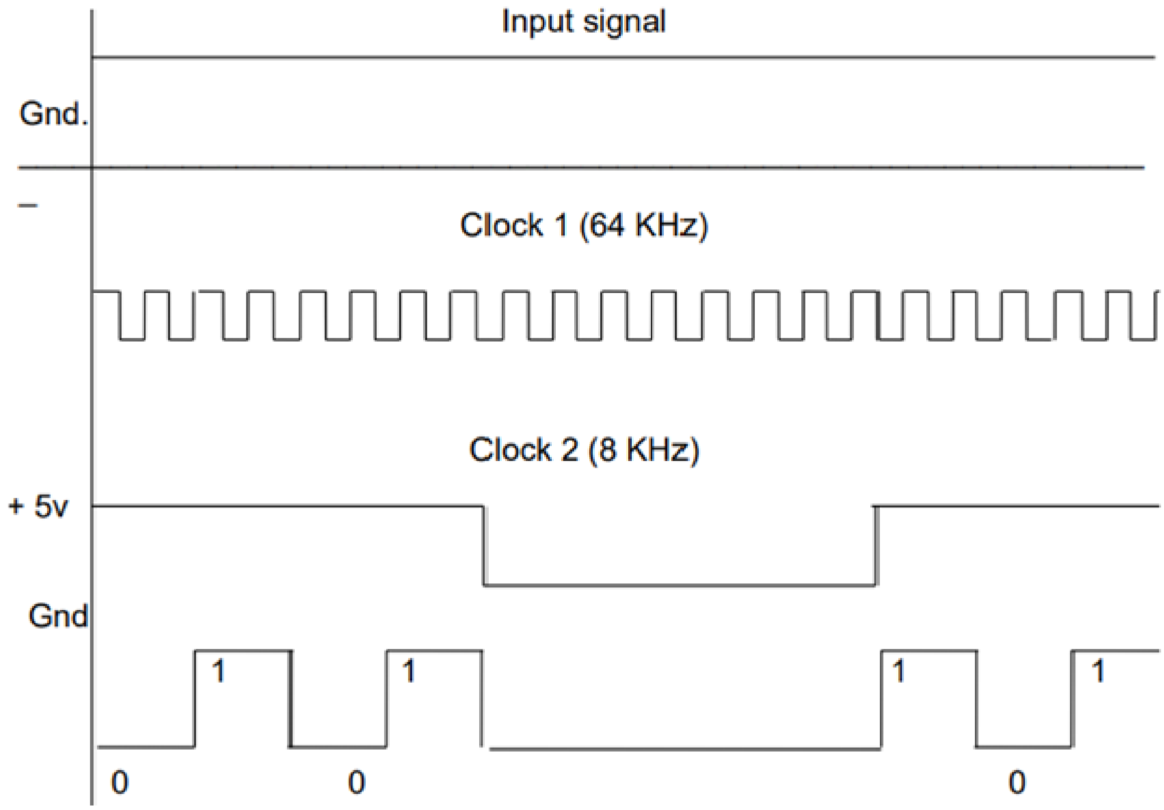
Theoretical background of signals and system, modulation in communication.

10.4 Equipment needed

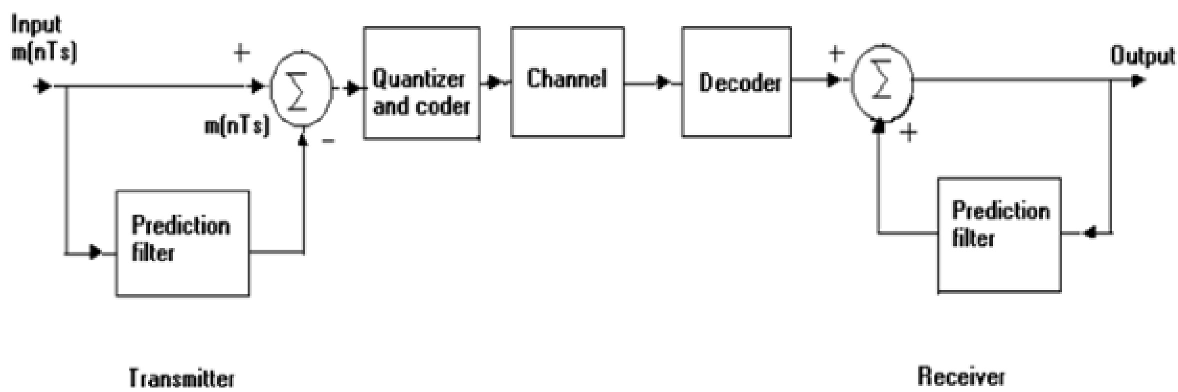
1. Differential Pulse Code Modulation and Demodulation Trainer Kit
2. Function Generator (0-2) MHz-1
3. C.R.O (0-30) MHz-1
4. Connecting wires
5. BNC Probes.

10.5 Background

Differential PCM is quite similar to ordinary PCM. However, each word in this system indicates the difference in amplitude, positive or negative, between this sample and the previous sample. Thus the relative value of each sample is indicated rather than, the absolute value as in normal PCM. For the samples that are highly correlated, when encoded by PCM technique, leave redundant information behind. To process this redundant information and to have a better output, it is a wise decision to take a predicted sampled value, assumed from its previous output and summarize them with the quantized values. Such a process is called as Differential PCM (DPCM) technique.



10.6 Procedure



DPCM Operation (with DC input): Modulation:

1. Keep CRO in dual mode. Connect one channel to 8 KHz signal (one which is connected to the Shift register) and another channel to the DPCM output.

2. Observe the DPCM output with respect to the 8 KHz signal and sketch the Waveforms. Note: Form this waveform you can observe that the LSB bit enters the output First. **Demodulation:**

3. Connect DPCM signal to the demodulator (S-P register) from the DPCM modulator with the help of coaxial cable (supplied with the trainer).

4. Connect clock signal (64 KHz) from the transmitter to the receiver using coaxial cable.

5. Connect transmitter clock to the timing circuit.

6. 4
7. 5
8. 6

10.7 Further Probing Experiments

LAB-10 DELTA MODULATION

11.1 Introduction

A delta modulation is an analog-to-digital and digital-to-analog signal conversion technique used for transmission of voice information where quality is not of primary importance. In delta modulation, the transmitted data are reduced to a 1-bit data stream. The one bit quantizer can gives either 0 or 1 to the samples based on voltage levels. You will find sampled, quantized, encoded staircase signals.

11.2 Objective

After the completion of this experiment, students will have good knowledge with the generation and detection of delta modulation. Will be able verify how the staircase signal can be increased and decreased based upon present and previous samples to transmit one bit per sample .How to increase transmission speed delta modulation and know the slope over load and granular noises.

11.2.1 Educational

- Learn the concept of digital modulation.
- Learn the purpose of modulation.

11.2.2 Equipment needed

- Delta Modulation and Demodulation Trainer Kit
- Function Generator (0-2) MHz-1
- C.R.O (0-30) MHz-1
- Connecting wires
- BNC Probes.

11.3 Prelab Preparation:

Theoretical background of digital communication system, no. of bits per sample transmission in PCM and bandwidth requirements.

11.3.1 Reading

- Read and study the Background section of this Laboratory.
- Read Appendix A, B, C and D Voltage Measurement of an oscilloscope with two vertical inputs.

11.3.2 Written

- Prior to coming to lab class, complete Part 0 of the Procedure.

11.4 Equipment needed

11.4.1 Hardware Requirements:

1. Receiver trainer kit.
2. CRO.
3. Function generator
4. Connecting Wires.

11.4.2 Software Requirements:

1. MATLAB Software

11.5 Circuit Diagram:

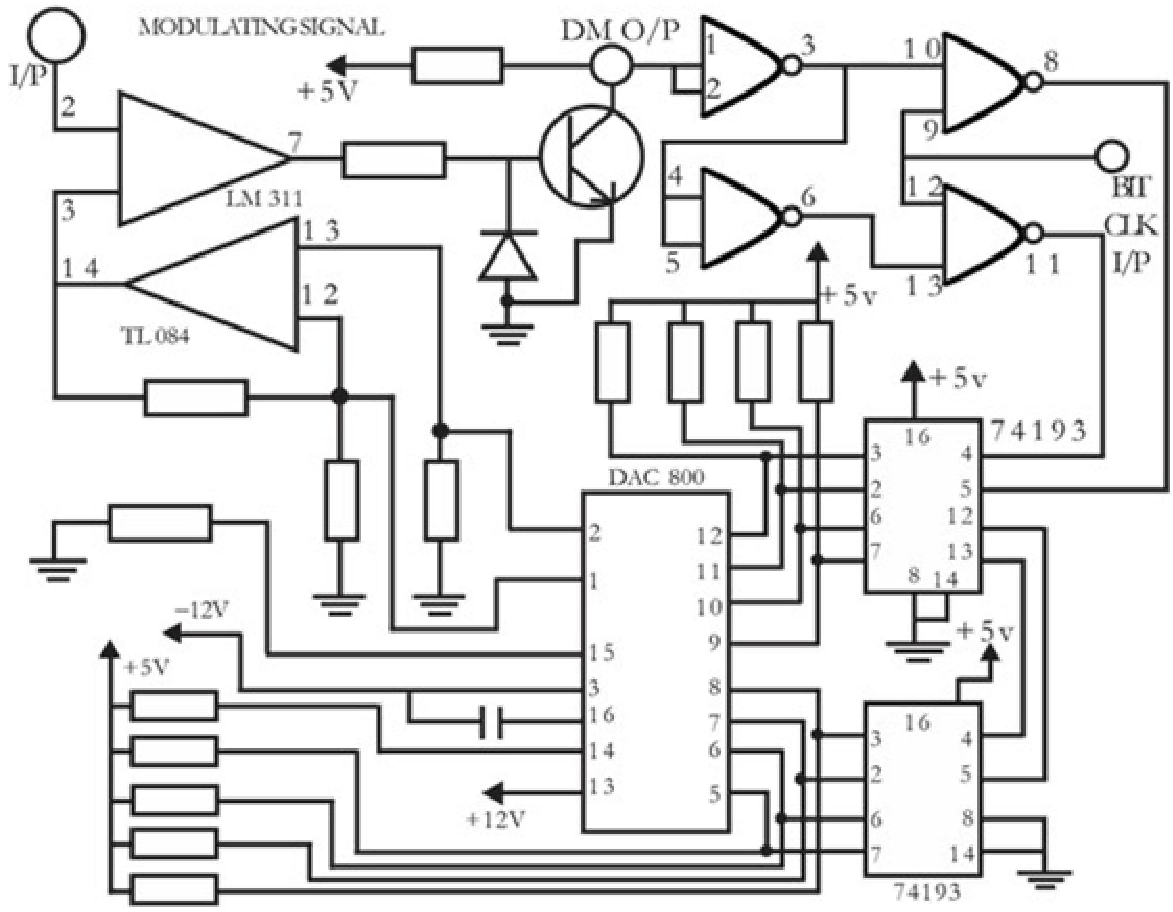


Figure 11.1:

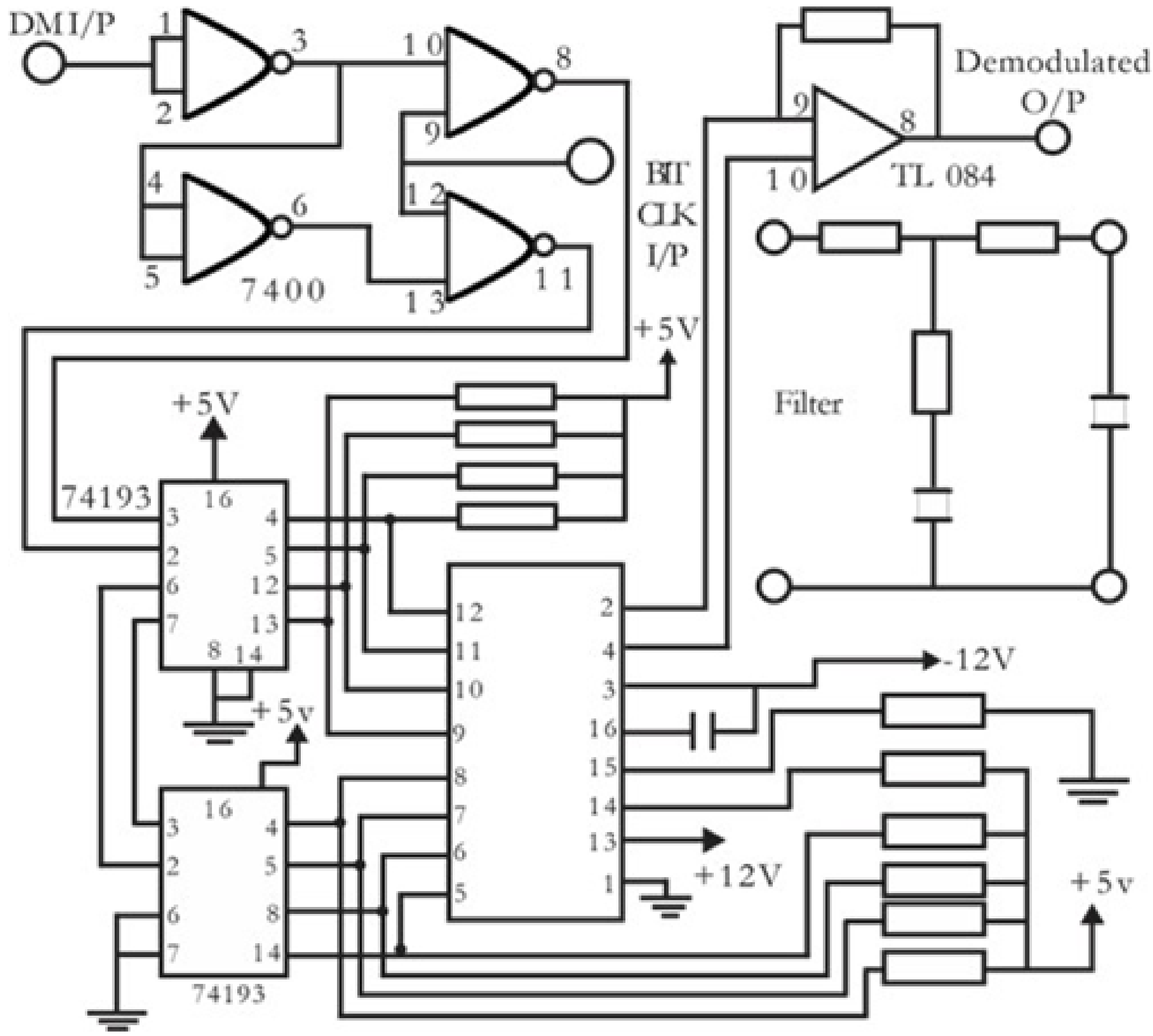


Figure 11.2:

11.6 Background

The difference between the input and the approximation is quantized into only two levels namely, +1, corresponding to positive and negative differences. Thus if the approximation falls below the signal at any sampling epoch, it is increased by 1. Or if the approximation lies above the signal, it is diminished by ˆe. Provided that the signal does not change too rapidly from sample to samples we find that the staircase approximation remains within +1 of the input signal. At the sampling instant nTs, the accumulator increments the approximation by a step ˆe in a positive or negative direction depending on the algebra IC sign of the error sample e(n).If the input sample m(n) is greater than the most recent approximation mq(n), a positive increment+1 is applied to the approximation. If the input sample is smaller, a negative increment –1 is applied to the approximation.

In the Receiver, the staircase approximation is reconstructed by passing the sequence of positive and negative pulses, produced at the decoder output, through an accumulator in a manner similar to that used in the transmitter. Low pass filter is used to reject the out- of- band quantization noise in the high frequency staircase waveform, with a bandwidth equal to the original message bandwidth. In modulator section, the comparator compares the input signal m(t) and reconstructed signal r(t). If m(t) greater than r(t) a logic 1 is generated at the output of the comparator, otherwise logic 0 is generated.

The value of logic 1 or logic 0 turned as I(t) is held for the bit duration by the sample and hold current to generate the Delta modulated output. During demodulation, the delta modulated output is fed to the 8 bit binary up/ down counter to control its count direction. Logic 1 at the mode control input increases the count value by one and a logic 0 decrements the count value by one. All the 8 outputs of the counter are given to DAC to reconstruct the original signal. In essence the counter and decoder form the Delta modulator in the feedback loop of the comparator. Thus, if the input signal is higher than the reconstructed signal the counter increments at each step so as to enable the DAC output to reach to the input signal values. Similarly if the input signal m(t) is lower than the reconstructed signal r(t), the counter decrements at each step, and the DAC output gets reduced to reach a value to that of m(t).

11.7 Procedure

1. Switch on the experimental board.
2. Connect the clock signal of Bit clock generator to the bit clock input of Delta modulator circuit.
3. Connect modulating signal of the modulating signal generator to the modulating signal input of the Delta modulator.
4. Observe the modulating signal on Channel 1 of CRO.
5. Observe the Delta modulator output on channel 2 of CRO.
6. Connect the DM o/p of modulator to the DM I/P of Demodulator circuit.
7. Connect the clock signal to the Bit clock I/P of Demodulator circuit.
8. Observe the demodulated o/p on channel 2 of CRO.
9. Connect the demodulated o/p to the filter input of demodulator circuit
10. Observe the demodulated o/p with filter on CRO

Observation Table

Parameter	Input Signal	Clock Signal	DM Signal	Reconstructed Signal

11.8 Expected Waveforms (Hardware)

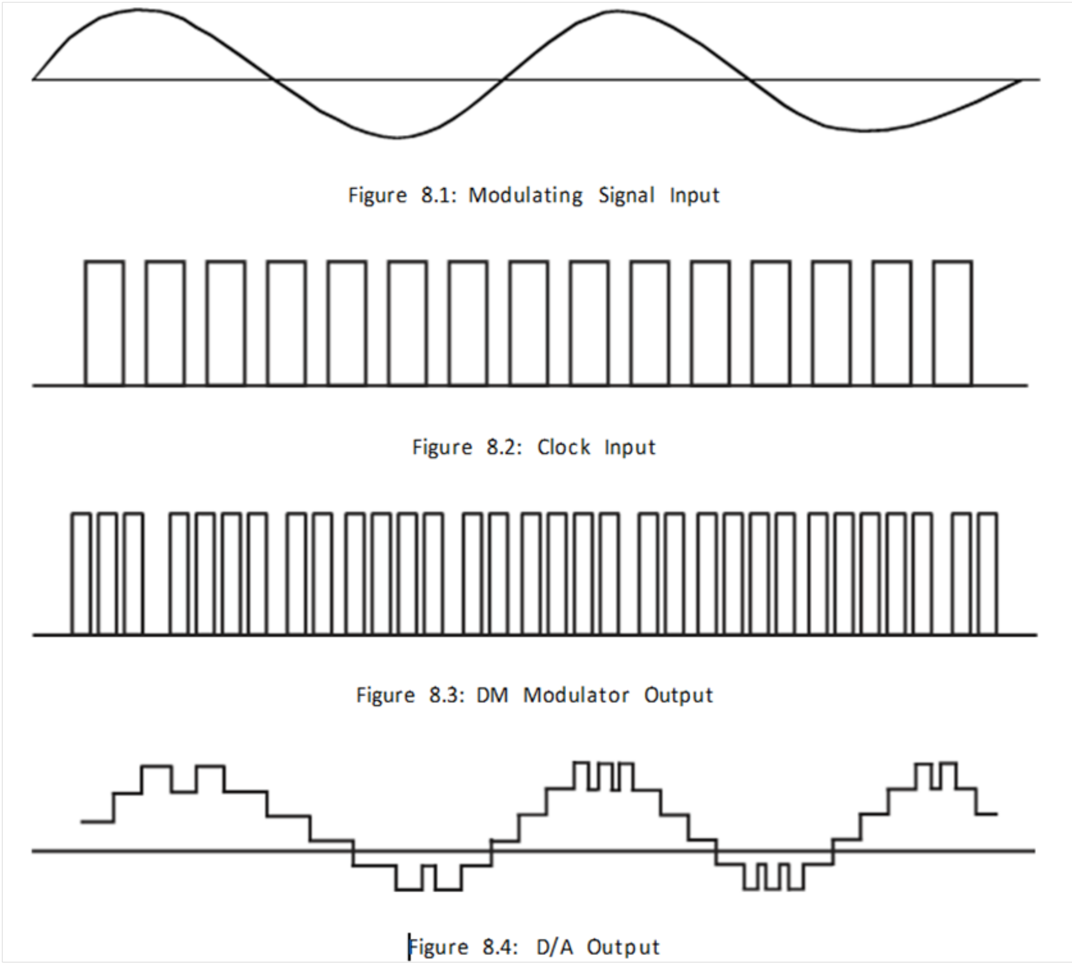


Figure 11.3:

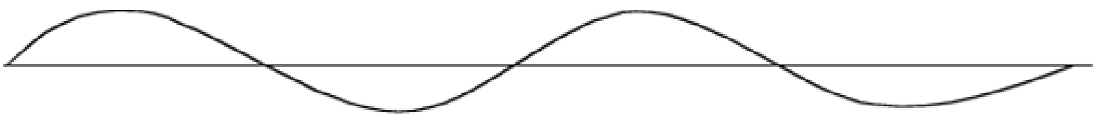


Figure 11.4:

11.9 Further Probing Experiments

1. 1. Design a delta modulator if the ramp signal x(t) = a(t) is applied to a delta modulator that operates with a sampling period Ts and step size $\Delta = 2\delta$. Show slope overload distortion occurs is $\delta \leq$ aTs. Sketch the modulator outputut of the following values of the step sizes. i)$\delta = 0.75$aTs. ii)$\delta =$ aTs.

LAB-11 TIME DIVISION MULTIPLEXING AND DEMULTIPLEXING

12.1 Introduction

Time-division multiplexing (TDM) is a method of transmitting and receiving independent signals over a common signal path by means of synchronized switches at each end of the transmission line so that each signal appears on the line only a fraction of time in an alternating pattern. This method transmits two or more digital signals or analog signals over a common channel. It can be used when the bit rate of the transmission medium exceeds that of the signal to be transmitted.

12.2 Objective

12.2.1 Educational

• Learn the concept of multiplexing.
• Learn to transmit more than one signal through a channel using time division multiplexing.
• Learn to extract the individual signals from the time division multiplexed signal using demultiplexer.

12.2.2 Experimental

• To perform the time division multiplexing and de multiplexing.
• Draw the input and output waveforms.
• Simulation of MATLAB code to generate the time division multiplexed and de multiplexed waveforms.

12.3 Prelab Preparation:

12.3.1 Reading

• Read and study the Background section of this Laboratory.
• Read Appendix A, B, C and D Voltage Measurement of an oscilloscope with two vertical inputs.

12.3.2 Written

• Prior to coming to lab class, complete Part 0 of the Procedure.

12.4 Equipment needed

12.4.1 Hardware Requirements:

1. Time Division Multiplexing and De multiplexing trainer Kit
2. C.R.O. (0-20) MHz
3. PC
4. CRO probes and Connecting Wires.

12.4.2 Software Requirements:

1. MATLAB Software.

12.5 Circuit Diagram:

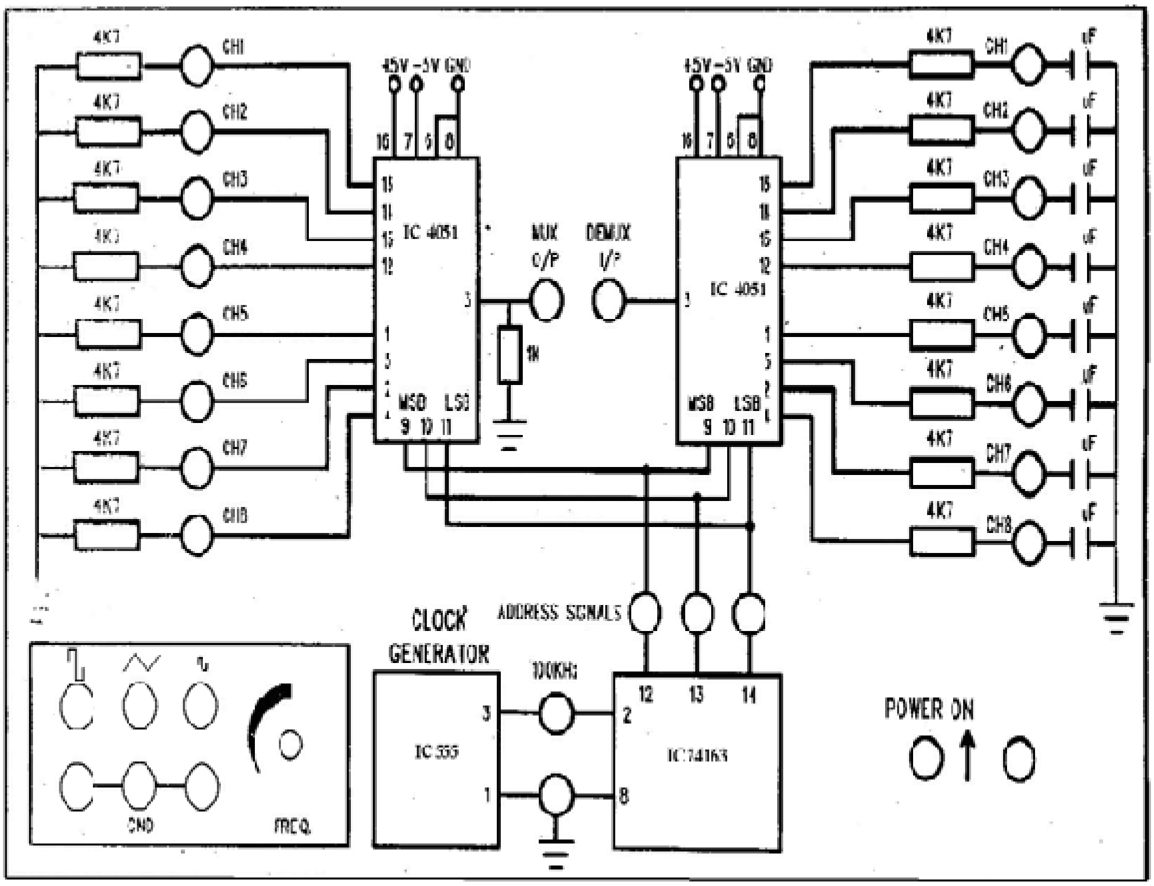


Figure 12.1: Time Division Multiplexing And De Multiplexing Circuit

12.6 Background:

The TDM system is highly sensitive to dispersion in the common channel, that is, to variations of amplitude with frequency or lack of proportionality of phase with frequency. Accordingly, accurate equalization of both magnitude and phase response of the channel is necessary to ensure a satisfactory operation of the system.
The primary advantage of TDM is that several channels of information can be transmitted

simultaneously over a single cable. In the CIRCUIT DIAGRAM the 555 timer is used as a clock generator. This timer is a highly stable device for generating accurate time delays. In this circuit this timer generates clock signal, which is of 100 KHz frequency (approximately). This clock signal is connected to the 74163 IC. 74163 IC is a synchronous preset-able binary counter. It divides the clock signal frequency into three parts and those are used as selection lines for multiplexer and Demultiplexer. In built signal generator is provided with sine, square and triangle outputs with variable frequency. These three signals can be used as inputs to the multiplexer. IC 4051 is a 8 to 1 analog multiplexer. It selects one-of eight signal sources as a result of a unique three-bit binary code at the select inputs. Again IC 4051 is wired as 1 to 8 Demultiplexer. Demux input receives the data source and transmits the data signals on different channels.

12.7 Procedure

Part (0) After answering the following questions, review the laboratory exercise procedures and plan how you will use the experience gained in these calculations to find the values sought.

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

12.8 Expected wave forms:

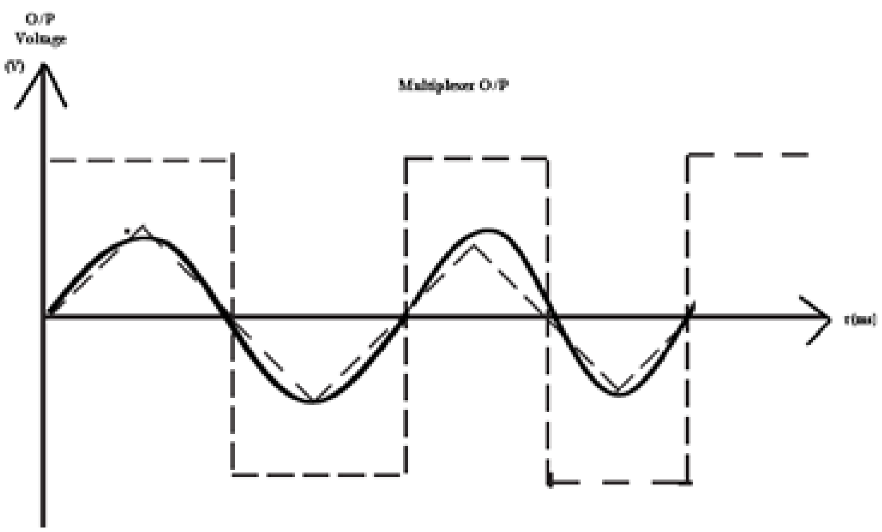


Figure 12.2: Multiplexed o/p:

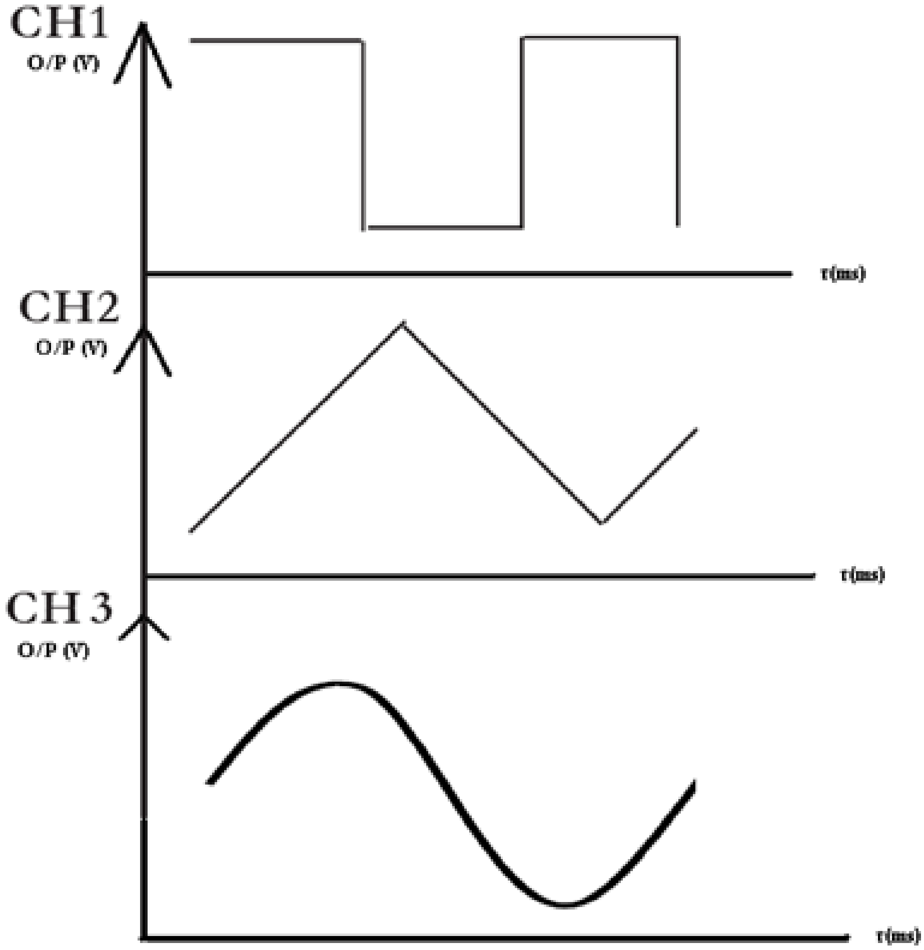


Figure 12.3: De Multiplexed o/p:

12.9 MATLAB program

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

```
% Display of Both Sampled Signal
subplot(2,2,3);
stem(sig1);
title('Sampled Sinusoidal Signal');
ylabel('Amplitude--->');
xlabel('Time--->');
subplot(2,2,4);
stem(sig2);
title('Sampled Triangular Signal');
ylabel('Amplitude--->');
xlabel('Time--->');
l1=length(sig1);
l2=length(sig2);
for i=1:l1
sig(1,i)=sig1(i); % Making Both row vector to a matrix
sig(2,i)=sig2(i);
end
% TDM of both quantize signal
tdmsig=reshape(sig,1,2*l1);
% Display of TDM Signal
figure
stem(tdmsig);
title('TDM Signal');
ylabel('Amplitude--->');
xlabel('Time--->');
% Demultiplexing of TDM Signal
demux=reshape(tdmsig,2,l1);
for i=1:l1
sig3(i)=demux(1,i); % Converting The matrix into row vectors
sig4(i)=demux(2,i);
end
% display of demultiplexed signal
figure
subplot(2,1,1)
plot(sig3);
title('Recovered Sinusoidal Signal'); ylabel('Amplitude--->');
xlabel('Time--->');
subplot(2,1,2)
plot(sig4);
title('Recovered Triangular Signal'); ylabel('Amplitude--->');
xlabel('Time--->');
```

12.10 Procedure For MATLAB Software:

1. Click on the MATLAB Icon on the desktop.
2. MATLAB window open.
3. Click on the 'FILE' Menu on menu bar.
4. Click on NEW M-File from the file Menu.
5. An editor window open, start typing commands.

6. Now SAVE the file in directory.
7. Then Click on DEBUG from Menu bar and Click Run.

12.11 Expected Waveforms

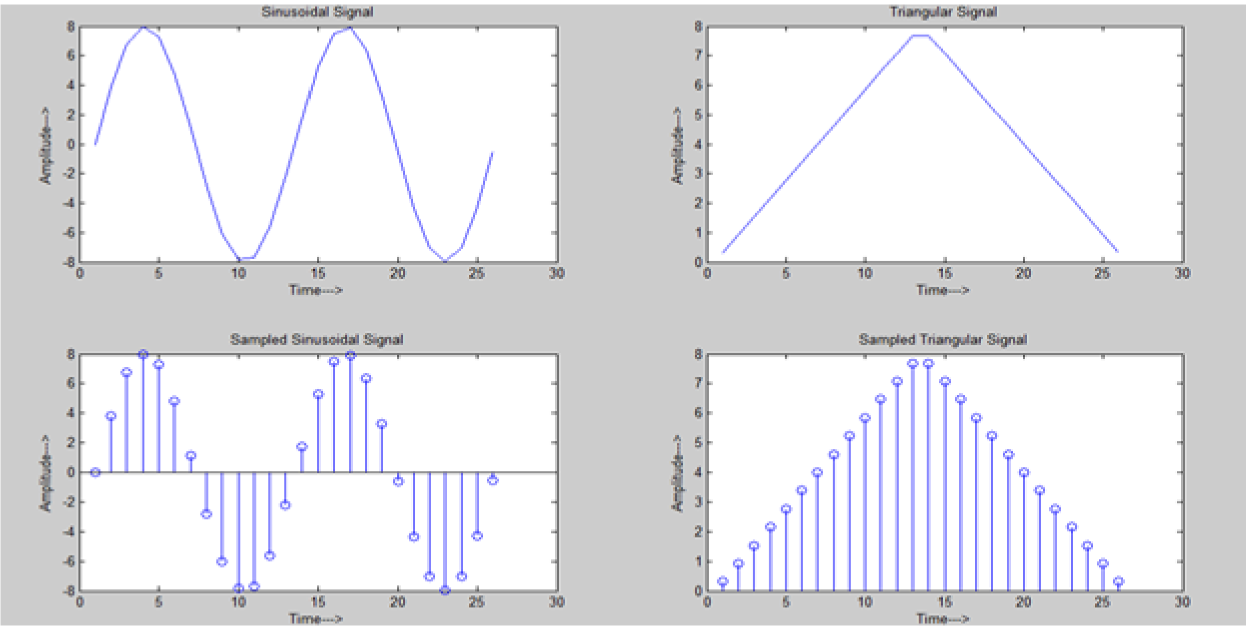


Figure 12.4: Simulation Result

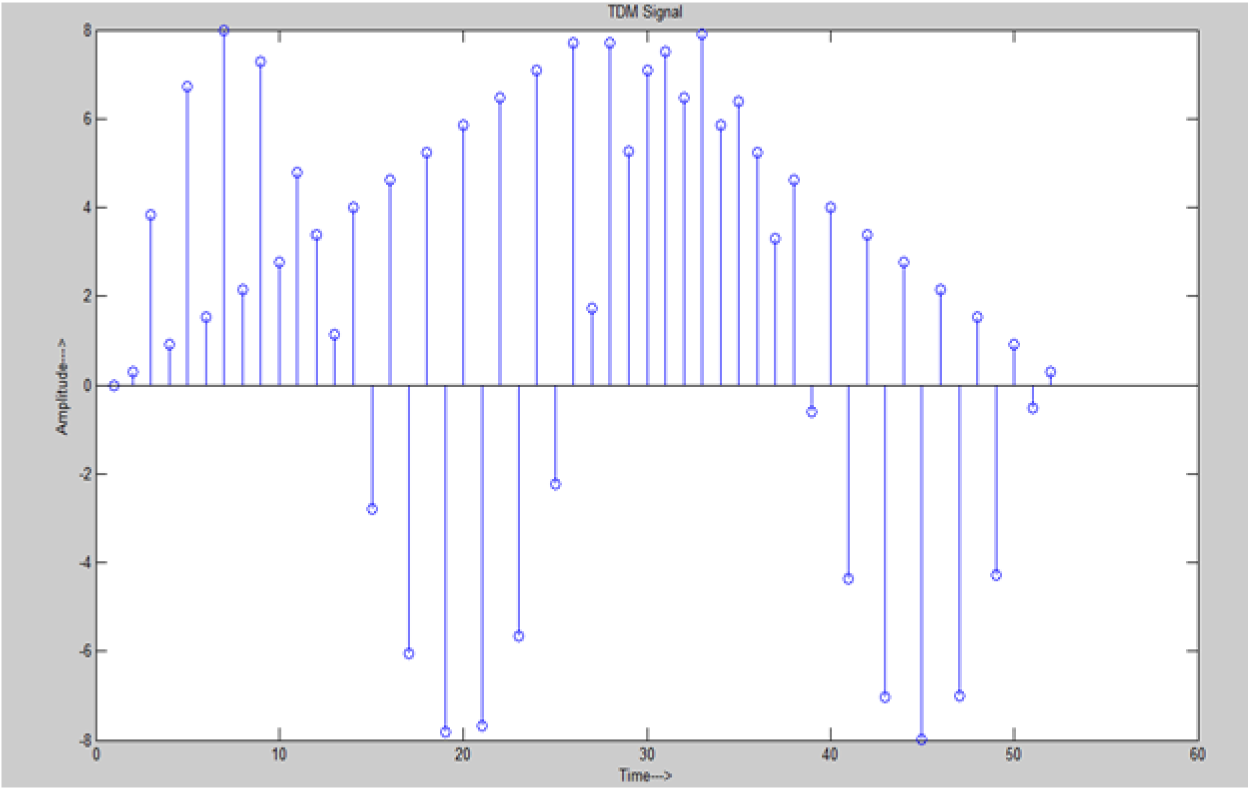


Figure 12.5: Simulation Result

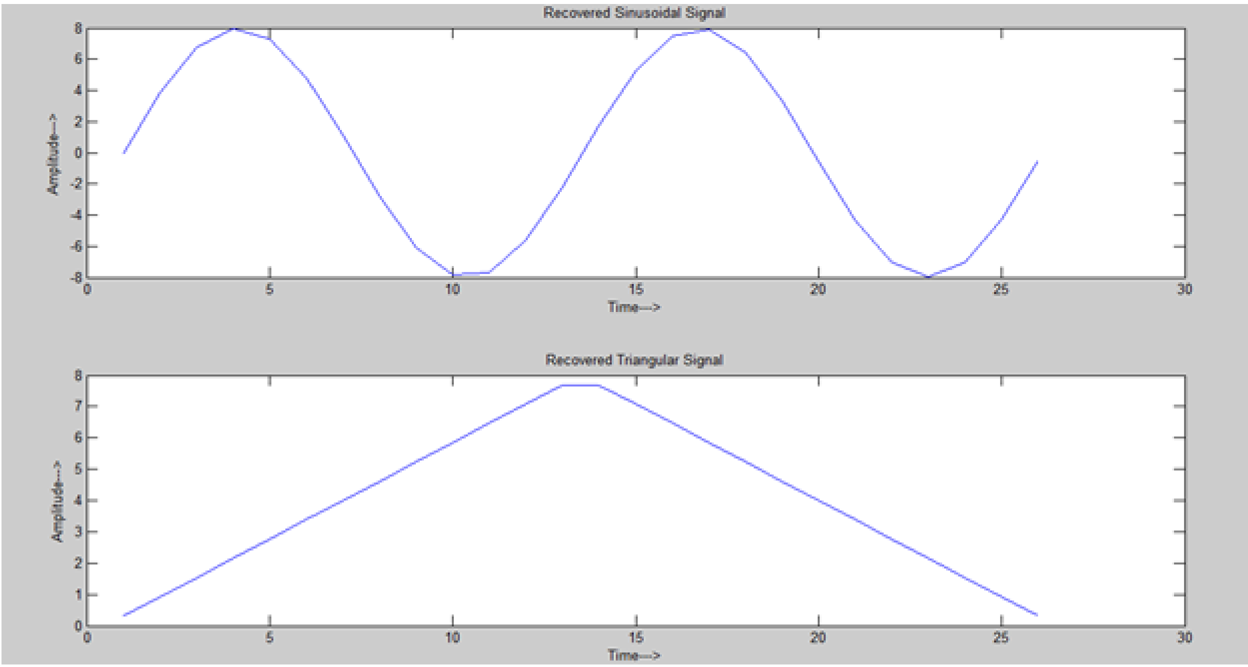


Figure 12.6: Simulation Result

12.12 Precautions

1. Always turn off power to the trainer kit when making the connections to the circuit.
2. Failure to turn off power when making circuit changes is a major reason for blowing fuses in the equipment, thereby rendering the equipment unusable and wasting your time and that of others. Please carefully check circuit wiring, frequency and voltage settings in function generator before applying power to the circuits.
3. Only reapply power after verifying that the circuit is properly wired and that the voltage to be applied is at or below the required value.

12.13 Further Probing Experiments

Q1. Observe TDM output at different channels?

Q2. Observe TDM output for 3 inputs using mat lab code

LAB-12 FREQUENCY SHIFT KEYING GENERATION AND DETECTION

13.1 Introduction

The purpose of this experiment is to identify frequency deviation. It is a digital modulation technique in which the nominal frequency provides frequency shift. The digital binary signal is given as input and continuous time signal as a carrier. The frequency drift can be occurred based on 1 and 0 as input. You will find data input, Carrier signals and frequency shift keying signals.

13.2 Objective

After the completion of this experiment, students will be able to perform generation and detection of frequency shift keying. Verify how the high and low frequency shifting can be occurred based on input binary signal and also find the frequency drift and band width spectrum of frequency shift keying

13.3 Prelab Preparation:

Theoretical background of pulse digital modulation techniques, characteristics of a signal and frequency swing between 1 and 0.

13.4 Equipment needed

13.4.1 Hardware Requirements:

1. Frequency synthesizer Trainer kit.
2. Function Generator
3. C.R.O. (0-20) MHz
4. PC
5. CRO probes and Connecting Wires.

13.5 Background:

In Frequency shift keying, the carrier frequency is shifted (i.e. from one frequency to another) corresponding to the digital modulating signal. If the higher frequency is used to represent a data 1 and lower frequency a data 0, the resulting FSK waveform appears. Thus Data =1 High Frequency Data =0 Low Frequency. It is also represented as a sum of two ASK signals. The two carriers have different frequencies and the digital data is inverted. The demodulation of

FSK can be carried out by a PLL. As known, The FSK generator is formed by using a 555 as an astable multi vibrator whose frequency is controlled by the transistor of Q1. The output frequency of the FSK generator depends on the logic state of the digital data input. 150Hz is one of the standard frequencies at which the data are commonly transmitted.
When the input is logic 1, transistor Q1 is off. Under these conditions, the 555 works in its normal mode as an astable multi vibrator; that is capacitor C charges through R and R to 2/3 VCC and discharges through R to 1/3VCC. Thus capacitor C charges and discharges alternately between 2/3 VCC and 1/3 VCC as long as the input is at logic 1 state. When the input signal is logic 0, Q1 is on (Saturated), which intern connects the resistance RC across Ra. This action reduces the charging time of the capacitor and increases the output frequency.
The output of the 555 FSK generators is then applied to the 565 FSK demodulator. Capacitive coupling is used at the input to remove a dc level. As the signal appears at the input of the 565, the loop locks to the input frequency and tracks it between the two frequencies with a corresponding dc shift at the output. Resistor R1 and capacitor C1 determine the free-running frequency of the VCO, while C2 is a loop filter capacitor that establishes the dynamic characteristics of the demodulator. Here C2 must be chosen smaller than usual to eliminate overshoot on the output pulse. A three stage RC ladder (Low-pass) filter is used to remove the carrier component from the output. The high cutoff frequency (fh=1/2 RC) of the ladder filter is chosen to be approximately half way between the maximum keying rate of 150Hz and twice the input frequency. The output signal of 150Hz can be made logic compatible by connecting a voltage comparator between the output of the ladder filter and pin 6 of the PLL. The VCO frequency is adjusted with R1, So that a slightly positive voltage is obtained at the output.

13.6 Procedure

Part (0) After answering the following questions, review the laboratory exercise procedures and plan how you will use the experience gained in these calculations to find the values sought.

1. Connect the trainer kit to the mains and switch on the power supply
2. Check internal RPS voltage (it should be 12V) and logic source voltage for logic one (it should be 12V).
3. Observe the data signal using oscilloscope. Note down the value. (Amplitude and Time Period).
4. Connect the output of the logic source to data input of the FSK modulator.
5. Set the output frequency of the FSK modulator as 1.2 KHz using control F0 (this represents logic 0). Then set another frequency as 2.4 KHz using control F1 (this represents logic 1) using multimeter
6. Connect the data input of the FSK modulator to the output of the data signal generator. Observe the signal that comes out of FSK modulator and note down the readings
7. Connect the FSK modulator output to the input of the FSK demodulator. Observe the waveform of FSK demodulator output using CRO and note down the readings

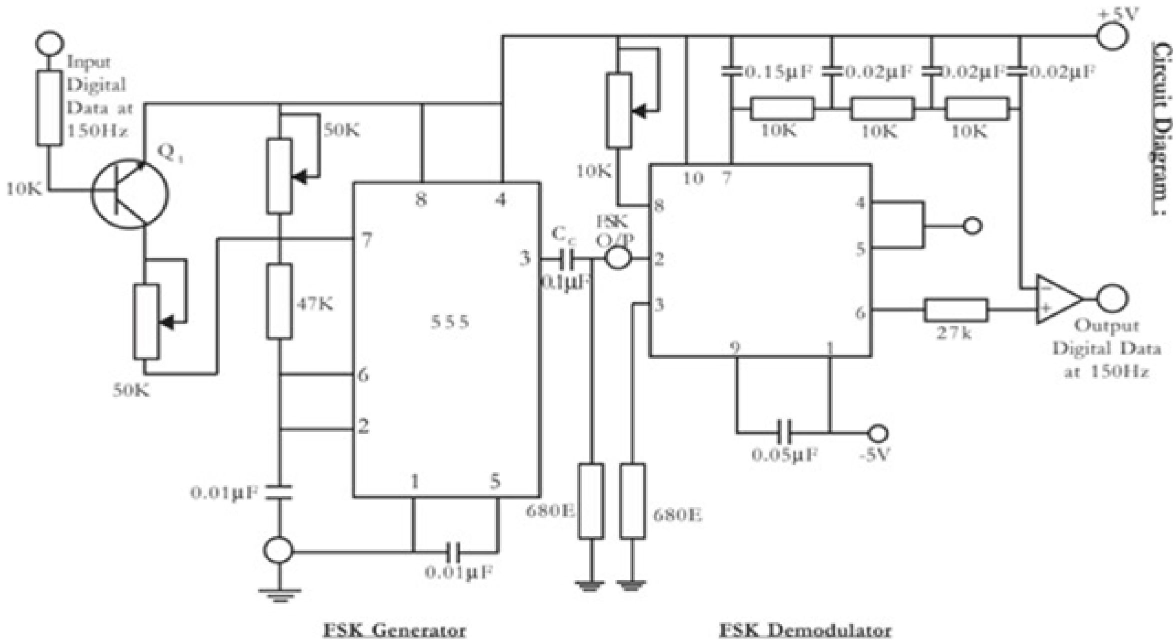


Figure 13.1: Frequency Synthesized Output

Table 13.1: **TabularColumn:**

Parameter	Binary Signal	High Carrier	FSK Signal	Reconstructed Signal

13.7 Expected Waveforms

13.8 Expected Waveforms

13.9 Precautions

1. Always turn off power to the trainer kit when making the connections to the circuit.

2. Failure to turn off power when making circuit changes is a major reason for blowing fuses in the equipment, thereby rendering the equipment unusable and wasting your time and that of others. Please carefully check circuit wiring, frequency and voltage settings in function generator before applying power to the circuits.

3. Only reapply power after verifying that the circuit is properly wired and that the voltage to be applied is at or below the required value.

13.10 Further Probing Experiments

1. Analysis of the spectrum of an FM signal (an example of non-linear modulation) is not trivial. For the case where the FSK signal can be looked upon as the sum of two ASK signals (example of linear modulation).

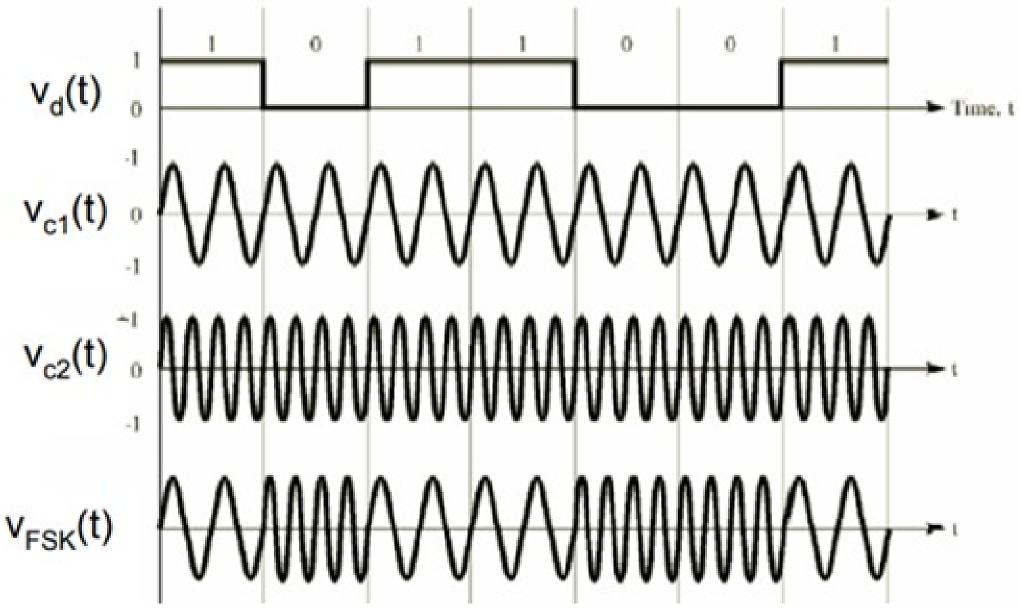


Figure 13.2: Simulation Result

LAB-13 BINARY PHASE SHIFT KEYING GENERATION AND DETECTION

14.1 Introduction

The purpose of this experiment is to identify Phase shift between 0 and 1. It is a digital modulation technique in which, a zero binary input, the phase will be 0 and for a high input, the phase reversal is of 180. The output sine wave of the modulator will be the direct input carrier or the inverted 180 phase shifted input carrier, which is a function of the data signal. You will find data input, Carrier signal and phase shift keying signals.

14.2 Objective

14.2.1 Educational

After the completion of this experiment, students will be able to perform generation and detection of phase shift keying. To identify how 00 and 1800 phase shifted signal can be changed based on input binary signal.

14.3 Prelab Preparation:

14.3.1 Reading

•Theoretical background of pulse digital modulation techniques, phase shift between 1 and 0

14.3.2 Written

• Prior to coming to lab class, complete Part 0 of the Procedure.

14.4 Equipment needed

14.4.1 Hardware Requirements:

1. Binary phase shift Trainer kit
2. Digital oscilloscope (0-20MHz).
3. Function generator
4. Personal Computer
5. CRO probes and Connecting Wires.

14.4.2 Software Requirements:

1. MATLAB Software.

14.5 Circuit Diagram:

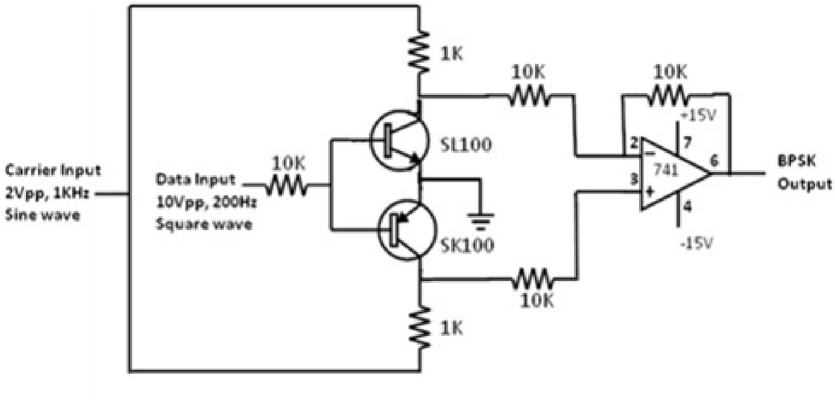
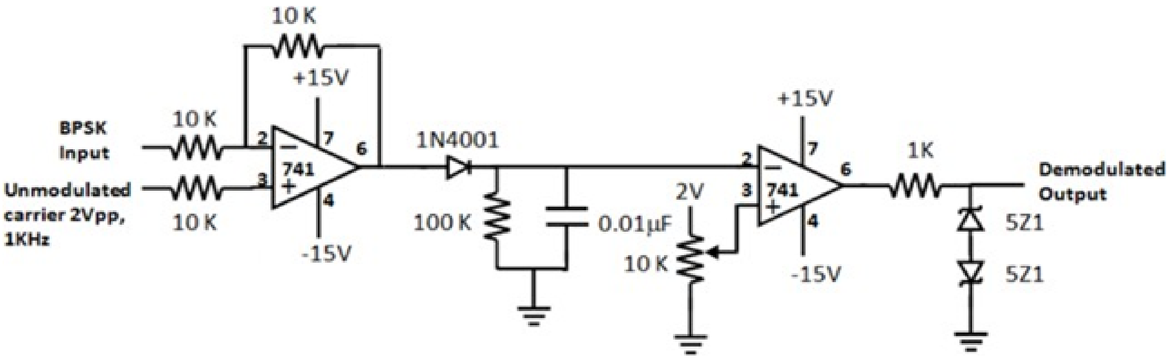


Figure 14.1: BPSK Modulator

14.6 Background:

Binary Phase Shift Keying (BPSK) is digital transmission scheme where the binary data is transmitted using out of phase signals. During logic 0 a preset number of cycles of a sinusoidal carrier signal is transmitted and during logic 1 the same number of cycles of the carrier signal is transmitted but with 180 degrees phase shift. Modulator A simple BPSK modulator circuit using an NPN-PNP transistor pair and an Op amp is shown in figure. The transistors work as switches and the Op amp works as inverting or inverting amplifier. The carrier signal is fed to the collectors and the message signal is fed to the bases of the two transistors simultaneously. The emitters of the transistors are grounded. When the message signal is at logic 1 (+5V), the NPN transistor is ON and works as a closed switch. The PNP transistor is OFF and works as an open switch.

The Op amp now works as a no inverting amplifier with the carrier signal fed to its non-inverting input. The carrier signal reaches the output without any phase shift. When the message signal is at logic '0' (-5V), the NPN transistor is OFF and the PNP transistor ON. The Op amp works as an inverting amplifier with the carrier signal fed to its inverting pin. The carrier signal now reaches the output with 180o phase shift. Thus the carrier signal switches its phase as the message signal switches between '0' and '1'. The resulting output is BPSK modulated. Demodulator The BPSK demodulator circuit shown in figure consists of an Op Amp difference amplifier, a rectifier, an envelope detector and a comparator. The difference amplifier which is fed with the unmodulated carrier signal at the non-inverting input and the BPSK modulated signal at the inverting input passes only the phase shifted signal to the output. The in phase signals get subtracted completely. The envelope detector removes the carrier content and recovers the data information. The comparator inverts and level limits the signal to regain the correct logic level.



14.7 Procedure

Part (0) After answering the following questions, review the laboratory exercise procedures and plan how you will use the experience gained in these calculations to find the values sought.

1. Test all the components and probes.
2. Set up the circuits on the bread board as shown in figure.
3. Feed 2Vpp, 1 KHz sine wave as carrier input and 10Vpp, 200Hz square wave signal as the message input.
4. Observe the BPSK output on CRO and plot the waveforms.
5. Feed this BPSK modulated signal to the inverting input of the demodulator. Also feed the unmodulated carrier signal (2Vpp, 1KHz) to the non-inverting input.
6. Observe waveforms on CRO. Adjust the potentiometer to obtain the correct output (if needed).
7. Plot the waveforms

Table 14.1: **TabularColumn:**

Parameter	Binary Signal	High Carrier	FSK Signal	Reconstructed Signal

14.8 Expected wave forms:

14.9 Precautions

1. Always turn off power to the trainer kit when making the connections to the circuit.
2. Failure to turn off power when making circuit changes is a major reason for blowing fuses in the equipment, thereby rendering the equipment unusable and wasting your time and that of others. Please carefully check circuit wiring, frequency and voltage settings in function generator before applying power to the circuits.
3. Only reapply power after verifying that the circuit is properly wired and that the voltage to be applied is at or below the required value.

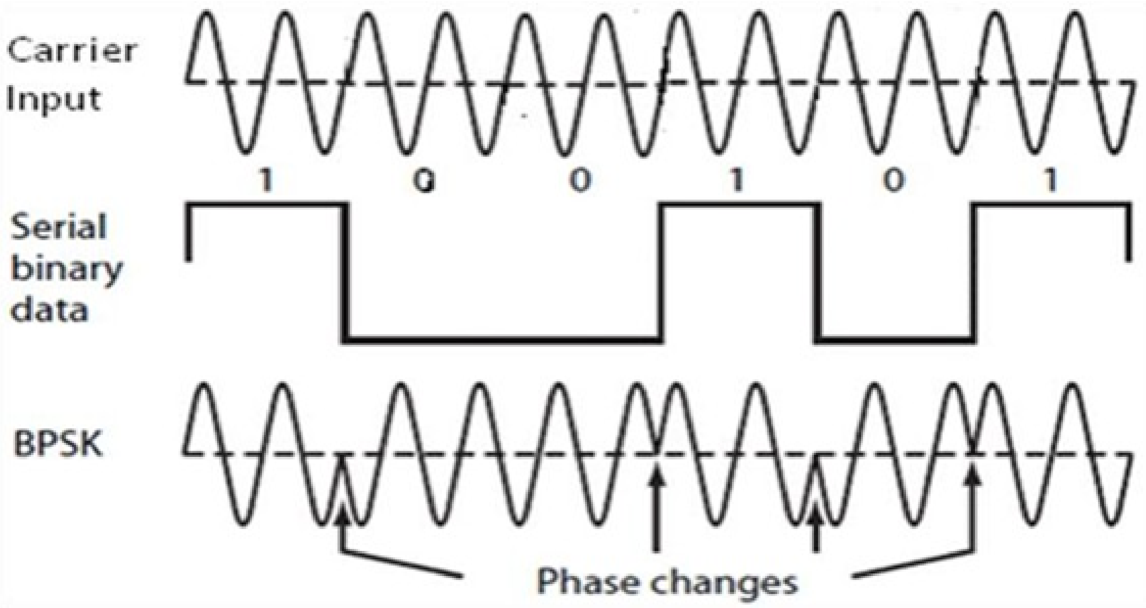


Figure 14.2: BPSK Output

14.10 Further Probing Experiments

Q1. 1. Design phase shift keying for ramp signal for the bit stream 10110011 and plot the graph for encoded sequence

LAB-14 DIFFERENTIAL PHASE SHIFT KEYING GENERATION AND DETECTION

15.1 Introduction

The purpose of this experiment is to identify Differential Phase shift between 0 and 1. It is a digital modulation technique in which, an arbitrary sequence gives a delayed data and it can be given to XOR logic gate. The logic gate provides differential encoded data at output, based on differential data the phase will be 0 for low input and for a high input, the phase reversal is of 180. The phase shifted output of the modulator will be the function of differential data. You will find data input, arbitrary sequence, Carrier signal and differential phase shift keying signals.

15.2 Objective

15.2.1 Educational

After the completion of this experiment, students will have good knowledge with the generation and detection of Differential phase shift keying. Will be able to identify how 00 and 1080 phase shifted signal can be changed based on arbitrary differential signal and also they are able to find how to reduce ambiguity in phase shift keying modulator.

15.2.2 Experimental

- Understand the differential Phase shift between 0 and 1.
- generation of Shifted signal.
- Draw the input and output wave forms.

15.3 Prelab Preparation:

Theoretical background of signals and system, modulation in communication.

15.4 Equipment needed

1. Differential phase shift keying Trainer kit
2. Digital oscilloscope (0-20MHz).
3. Function generator
4. Personal Computer
5. CRO probes and Connecting Wires.

15.5 Introduction:

The differentially phase shift keying makes use of a technique designed to get around the need for a coherent reference signal at the receiver. In differential phase shift keying scheme, the phase reference for the demodulation is derived from the phase of the carrier during the preceding signaling interval and the receiver decodes the digital informations based on the differential phase. If the channel perturbations and other disturbances are slowly varying compared to the bit rate than the phase of the RF pulse are affected by the same manner, thus preserving the information contained in the phase difference. If the digital information had been differentially encoded in the carrier phase the transmitter the decoding at the receiver can be accomplished without a coherent load oscillator signal.
In modulation, the differential signal to the modulating signal is generated using an Exclusive OR gate and 1-bit delay circuit (It is shown in figure). CD4051 is an analog multiplexer to which carrier is applied with and without180 degree phase shift (created by using an operational amplifier connected in inverting amplifier mode) to the two inputs of the ICTL084. Differential signal generated by Ex-OR gate (IC7486) is given to the multiplier's control signal input. Depending upon the level of control signal, carrier signal applied with or without phase shift is steered to the output.1- bit delay generation of differential signal to the input is created by using a D- flip-flop (IC7474).
In demodulation, the DPSK signal is converted into a +5V Square Wave signal using a transistor and is applied to one input of an EX-OR gate. So the EX-OR gate output is equivalent to the differential signal of the modulating data. This differential data is applied to one input of an EX-OR gate and to the second input, after 1-bit delay the same signal is given. So the output of this Ex-OR gate is modulating signal..

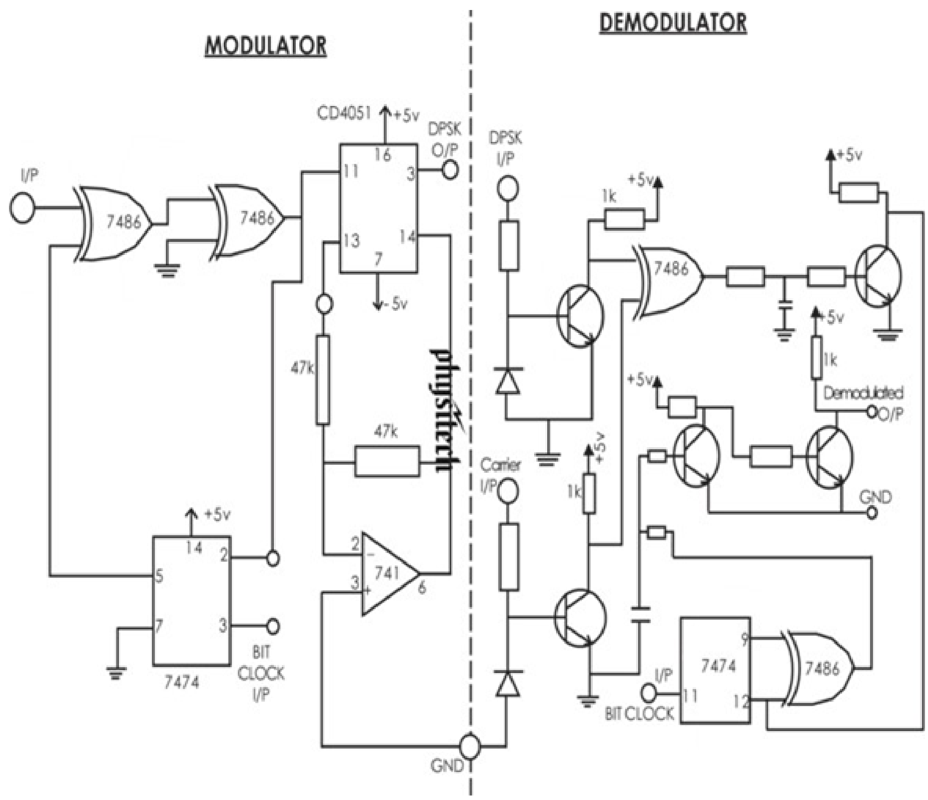


Figure 15.1: Circuit Diagrams

15.6 Procedure

Part (0) After answering the following questions, review the laboratory exercise procedures and plan how you will use the experience gained in these calculations to find the values sought.

1. Test all the components and probes.
2. Set up the circuits on the bread board as shown in figure.
3. Feed 2Vpp, 1 KHz sine wave as carrier input and 10Vpp, 200Hz square wave signal as the message input.
4. Feed this DPSK modulated signal to the inverting input of the demodulator. Also feed the unmodulated carrier signal (2Vpp, 1KHz) to the non-inverting input
5. Observe waveforms on CRO. Adjust the potentiometer to obtain the correct output (if needed).
6. Plot the waveforms

Table 15.1: **TabularColumn:**

Parameter	Binary Signal	High Carrier	DPSK Signal	Reconstructed Signal

15.7 Expected wave forms:

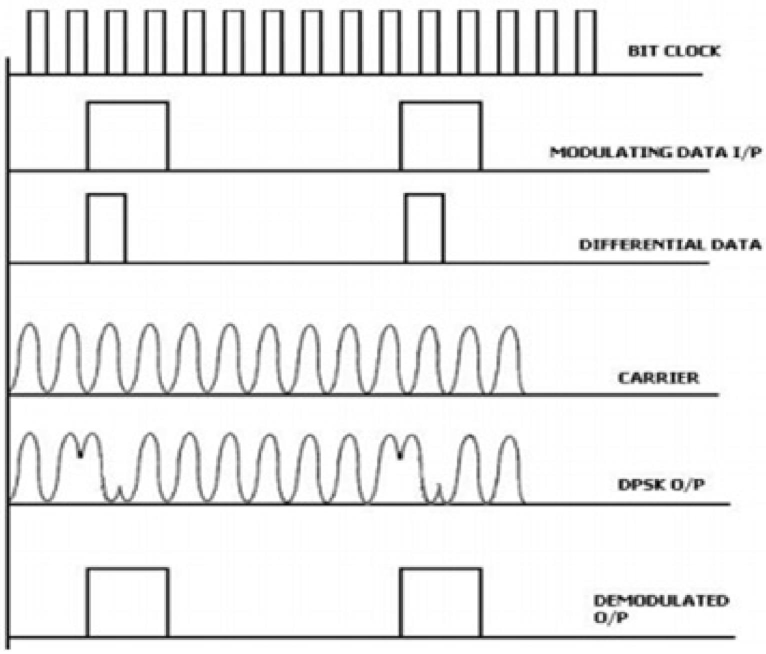


Figure 15.2: Expected wave forms

15.8 Precautions

1. Always turn off power to the trainer kit when making the connections to the circuit.
2. Failure to turn off power when making circuit changes is a major reason for blowing fuses in the equipment, thereby rendering the equipment unusable and wasting your time and that of others. Please carefully check circuit wiring, frequency and voltage settings in function generator before applying power to the circuits.
3. Only reapply power after verifying that the circuit is properly wired and that the voltage to be applied is at or below the required value.

15.9 Further Probing Experiments

Q1. Design differential shift keying for ramp signal for the bit stream 100101011 and plot the graph for encoded sequence

LAB-15 AMPLITUDE SHIFT KEYING GENERATION AND DETECTION

16.1 Introduction

The purpose of this experiment is to identify Amplitude Shift Keying between 0 and 1. It is a digital modulation technique in which, the sequence of 1's and 0's gives amplitude shifted waveform output. The carrier signal amplitude is present at output when '1'is at input and carrier is absent when '0' is at input. The amplitude shifted output of the modulator will be the function of binary data. You will find data input, Carrier signal and Amplitude shift keying signals.

16.2 Objective

16.2.1 Educational

After the completion of this experiment, students will have good knowledge with the generation and detection of Amplitude shift keying. Will be able to identify how carrier signal amplitude can be changed based on binary input signal and also they are able to find how amplitude shift keying modulator works as a on off switch.

16.2.2 Experimental

- Understand the operation of Amplitude Shift Keying.
- generation of Amplitude Shift Keying spectrum.
- Draw the input and output wave forms.

16.3 Prelab Preparation:

Theoretical background of signals and system, modulation in communication

16.4 Equipment needed

1. Function Generator (0-2) MHz-1 3.
2. Modulation and Demodulator kit.
3. CRO probes and Connecting Wires.
4. Amplitude shift keying Trainer Kit
5. BNC Probes.

16.5 Introduction:

Amplitude Shift Keying (ASK) is a type of Amplitude Modulation which represents the binary data in the form of variations in the amplitude of a signal. Any modulated signal has a high frequency carrier. The binary signal when ASK modulated, gives a zero value for Low input while it gives the carrier output for High input. The carrier generator sends a continuous high-frequency carrier. The binary sequence from the message signal makes the unipolar input to be either High or Low.
The high signal closes the switch, allowing a carrier wave. Hence, the output will be the carrier signal at high input. When there is low input, the switch opens, allowing no voltage to appear. Hence, the output will be low. The band-limiting filter shapes the pulse depending upon the amplitude and phase characteristics of the band-limiting filter or the pulse-shaping filter. The modulated ASK signal is given to the half-wave rectifier, which delivers a positive half output. The low pass filter suppresses the higher frequencies and gives an envelope detected output from which the comparator delivers a digital output.

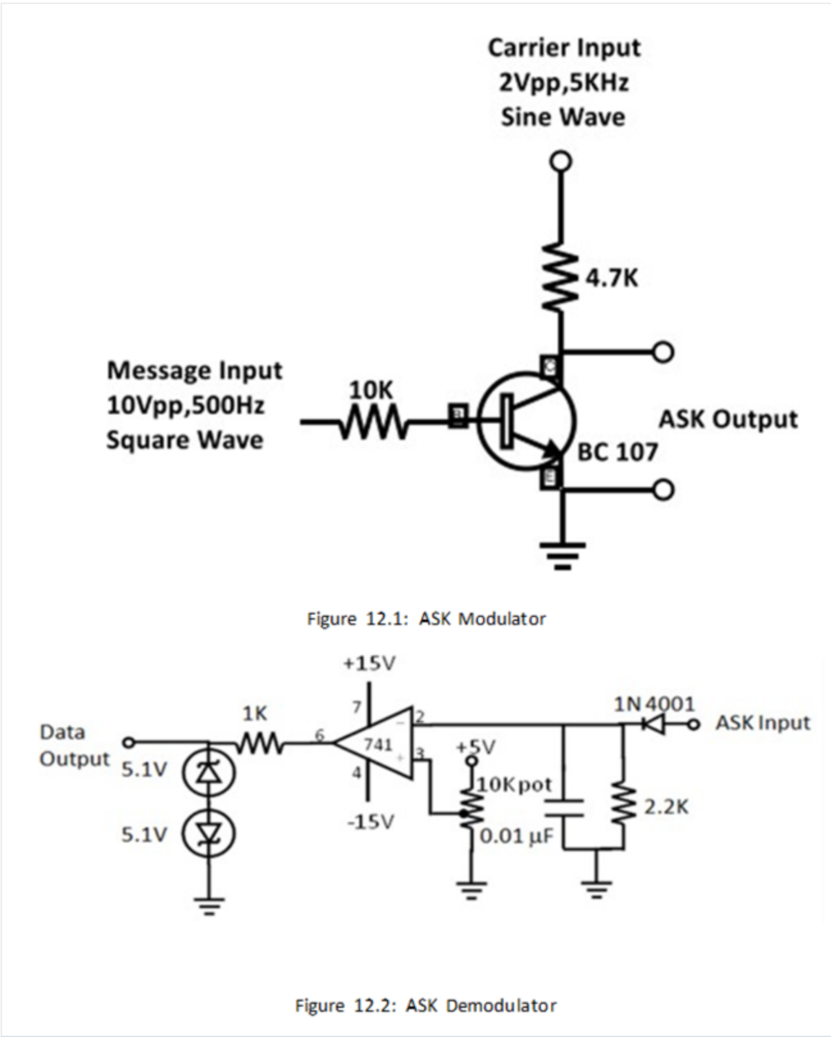


Figure 16.1: Modulator ans Demodulator

16.6 Procedure

Part (0) After answering the following questions, review the laboratory exercise procedures and plan how you will use the experience gained in these calculations to find the values sought.

1. Test all the components and probes.
2. Set up the circuits on the bread board as shown in figure.
3. Feed 2Vpp, 1 KHz sine wave as carrier input and 10Vpp, 200Hz square wave signal as the message input.
4. Feed this DPSK modulated signal to the inverting input of the demodulator. Also feed the unmodulated carrier signal (2Vpp, 1KHz) to the non-inverting input
5. Observe waveforms on CRO. Adjust the potentiometer to obtain the correct output (if needed).
6. Plot the waveforms

Table 16.1: **TabularColumn:**

Parameter	Binary Signal	High Carrier	ASK Signal	Reconstructed Signal

16.7 Expected wave forms:

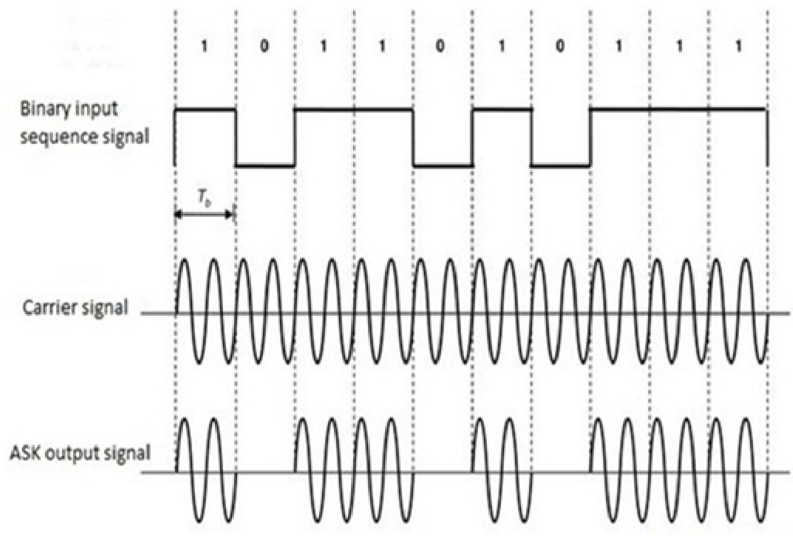


Figure 16.2: Expected wave forms

16.8 Precautions

1. Always turn off power to the trainer kit when making the connections to the circuit.
2. Failure to turn off power when making circuit changes is a major reason for blowing fuses in the equipment, thereby rendering the equipment unusable and wasting your time and that of others. Please carefully check circuit wiring, frequency and voltage settings in function generator before applying power to the circuits.
3. Only reapply power after verifying that the circuit is properly wired and that the voltage to be applied is at or below the required value.

16.9 Further Probing Experiments

Q1. Design Amplitude shift keying for ramp signal for the bit stream 10111111 and plot the graph for encoded sequence.

Appendix A - Safety

Electricity, when improperly used, is very dangerous to people and to equipment. This is especially true in an industrial environment where large amounts of power is used, and where high voltages are present [1]; in environments where people are especially susceptible to electric shock such as maintenance of a high voltage system (while in operation) or in hospitals where electrical equipment is used to test or control physiological functions [2, 3]; and in an experimental or teaching laboratory where inexperienced personnel may use electrical equipment in experimental or nonstandard configuration.

Engineers play a vital role in eliminating or alleviating the danger in all three types of environments mentioned above. For conditions where standard equipment is used in standard configurations, govern- mental agencies and insurance underwriters impose strict laws and regulations on the operation and use of electrical equipment including switchgear, power lines, safety devices, etc. As a result, corporations and other organizations in turn impose strict rules and methods of operation on their employees and contractors. Engineers who are involved in using electrical equipment, in supervising others who use it, and in designing such systems, have a great responsibility to learn safety rules and practices, to observe them, and to see that a safe environment is maintained for those they supervise. In any working environment there is always pressure to "get the job done" and take short cuts. The engineer, as one who is capable of recognizing hazardous conditions, is in a responsible position both as an engineer and as a supervisor or manager and must maintain conditions to protect personnel and avoid damage to equipment.

Because of their non-standard activities, experimental laboratories are exempt from many of these rules and regulations. This puts more responsibility on the engineer in this environment to know and enforce the safest working procedures.

The knowledge and habit-forming experience to work safely around electrical equipment and the ability to design safe electrical equipment begins with the first student laboratory experience and con- tinues through life. This includes learning the types of electrical injuries and damage, how they can be prevented, the physiology of electrical injuries, and steps to take when accidents.

Physiology of Electrical Injuries

There are three main types of electrical injuries: electrical shock, electrical burns, and falls caused by electrical shock. A fourth type, 'sunburned' eyes from looking at electric arcs, such as arc-welding, is very painful and may cause loss of work time but is usually of a temporary nature. Other injuries may be indirectly caused by electrical accidents, e.g., burns from exploding oil-immersed switch gear or transformers.

Although electric shock is normally associated with high-voltage AC contact, under some circum- stances death can occur from voltages from substantially less than the nominal 120 Volts AC found in residential systems. Electric shock is caused by an electric current passing through a part of the human body. The human body normally has a high resistance to electric currents so that a high voltage is usually required to cause lethal currents. This resistance is almost all in the skin, but when the skin is wet its resistance is much lower. When a person is hot and sweaty or is standing in water, contact with 120 Volts or less is likely to cause a fatal shock.

Electric shock is not a single phenomenon but is a disturbance of the nerves that is caused by electric current. A current through a part of the body such as the arm or leg will cause pain and muscle contraction. If a victim receives an electric shock from grasping a live conductor, a current of greater than 15 to 30 mA through the arm will cause muscle contractions so severe that the victim cannot let go. Similar currents through leg muscles may cause sudden contractions causing the victim to jump or fall, resulting in possible injuries or death. It is also possible for a prolonged period of contact of more than a minute or so to cause chest muscles to be contracted, preventing breathing and resulting in suffocation or brain damage from lack of oxygen.

The predominant cause of death by electric shock is generally attributed to ventricular fibrillation, which is an uncontrolled twitching or beating of the heart that produces no pumping action and therefore no blood circulation. Unless corrective action is taken, death follows quickly from lack of oxygen to the brain. While the amount of current that will cause fibrillation depends on several variables, 0.5 to 5A through the body will normally cause the very small current through the heart that causes fibrillation in most people. Larger currents than this through the heart causes contraction or clamping of the heart muscle and resulting death unless corrective action is taken. Prolonged contact of more than a minute or so may cause chest muscles to contract, preventing breathing and resulting in suffocation or brain damage from lack of oxygen.

Death by electric shock is most often attributed to ventricular fibrillation, which is an uncontrolled twitching or beating of the heart that produces no pumping action and therefore no blood circulation. Unless corrective action is taken, death follows quickly from lack of oxygen to the brain. While the amount of current that will cause fibrillation depends on several variables, 0.5 to 5 amperes through the body will normally cause the very small current (approximately 1 mA) through the heart that is sufficient to cause fibrillation in most people. Larger currents than this through the heart cause contraction or clamping of the heart muscle, resulting in death unless corrective action is taken.

Electric burns may be caused by electric currents flowing in or near parts of the body. Such burns are similar to burns from ordinary heat sources, except that those caused by high-frequency currents are generally deeper and take longer to heal the other burns. Electrocution will often leave severe burns at the points where the current entered and left the body.

Source of Electric Shock

Since electric shock is caused by an electric current through a part of the body, it is prevented by not allowing the body to become part of any electric circuit. From this viewpoint, electric circuits may be classified as either grounded or ungrounded.

Electric circuits may be classified as either grounded or ungrounded. Grounded circuits are safer for most conditions, since they result in known voltages at other points in the circuit and provide easier and better protection against faulty conditions in the circuit. The disadvantage is that a person standing on a non-insulated floor can receive a shock by touching only one conductor.

Almost all electric power generation, transmission, and distribution systems are grounded to pro- tect people and equipment against fall conditions caused by windstorms, lightning, etc. Residential, commercial, and industrial systems such as lighting and heating are always grounded for greater safety. Communication, computer, and similar systems are grounded for safety reasons and to prevent or reduce noise, crosstalk, static, etc. Many electronic equipment or instruments are grounded for safety and noise prevention, also. Common examples are DC power supplies, oscilloscopes, oscillators, and analog and digital multimeters.

Ungrounded circuits are used in systems where isolation from other systems is necessary, where low voltages and low power are used, and in other instances where obtaining a ground connection is difficult or impractical. In the ungrounded circuit, contact with two points in the circuit that are at different potentials is required to produce an electrical shock. The hazard is that with no known ground, a hidden fault can occur, causing some unknown point to be grounded, in which case, touching a supposedly safe conductor while standing on the ground could result in an electric shock.

Protecting People and Equipment in the Laboratory

Prevention of electric shock to individuals and damage to equipment in the laboratory can be done by strict adherence to several common-sense rules summarized below:

Protecting People

1. When hooking up a circuit, connect to the power source last, while power is off.
2. Before making changes in a circuit, turn off or disconnect the power first, if possible.
3. Never work alone where the potential of electric shock exists.
4. When changing an energized connection, use only one hand. Never touch two points in the circuit that are at different potentials.
5. Know that the circuit and connections are correct before applying power to the circuit.
6. Avoid touching capacitors that may have a residual charge. The stored energy can cause a severe shock even after a long period of time.
7. Insulate yourself from ground by standing on an insulating mat where available.

The above rules and the additional rules given below also serve to protect instruments and other circuits from damage.

Protecting Equipment

1. Set the scales of measurement instrument to the highest range before applying power.
2. Before making changes in a circuit, turn off or disconnect the power first, if possible.
3. When using an oscilloscope, do not leave a bright spot or trace on the screen for long periods of time. Doing so can burn the image into the screen.
4. Be sure instrument grounds are connected properly. Avoid ground loops and accidental grounding of "hot" leads.
5. Check polarity markings and connections of instruments carefully before connecting power.
6. Never connect an ammeter across a voltage source, but only in series with a load.
7. Do not exceed the voltage or current ratings of circuit elements or instruments. This particularly applies to wattmeters, since the current or voltage rating may be exceeded with the needle still reading on the scale.
8. Be sure any fuses and circuit breakers are of suitable value.

When connecting electrical elements to make up a network in the laboratory, it easy to lose track of various points in the network and accidentally connect a wire to the wrong place. One procedure to help avoid this problem is to connect first the main series loop of the circuit, then go back and add the elements in parallel.

Types of Equipment Damage Excessive currents and voltages can damage instruments and other circuit elements. A large over- current for a short time or a smaller over-current for a longer time will cause overheating, resulting in insulation scorching and equipment failure.

Blown fuses are the most common equipment failure mode in this laboratory. The principal causes for these failures include:

- incorrectly wired circuits;
- accidental shorts;
- switching resistance settings while power is applied to the circuit;
- changing the circuit while power is applied;
- using the wrong scale on ammeter;
- connecting an ammeter across a voltage source;
- using a low-power resistor box (limit 1/2 amp) when high power is required;
- turning on an auto-transformer at too high a setting.

All of these causes are the result of carelessness by the experimenter.

Some type of insulating material, such as paper, cloth, plastic, or ceramic, separates conductors that are at different potentials in electrical devices. The voltage difference that this material can withstand is determined by design (type, thickness, moisture content, temperature, etc.). Exceeding the voltage rating of a device by an appreciable amount can cause arcing or corona, resulting insulation breakdown, and failure.

Some electrical devices can also be damaged mechanically by excessive currents. An example is the D'Arsonval meter, the indicator in most analog metering instruments. A large pulse of over current will provide mechanical torque that can cause the needle to wrap around the pin at the top of the scale, thereby causing permanent damage even though the current may not have been on long enough to cause failure due to overheating.

After Accident Action

Since accidents do happen despite all efforts to prevent them, plans for appropriate reaction to an accident can save time and lives. Such a plan should include immediate availability of first aid material suitable for minor injuries or for injuries that are likely because of the nature of the work. Knowledge of how to obtain trained assistance such as Emergency Medical Services (EMS) should be readily available for everyone.

Treating victims for electrical shock includes four basic steps that should be taken immediately. Step two requires qualification in CPR and step three requires knowledge of mouth-to-mouth resuscitation. Everyone who works around voltages that can cause dangerous electrical shock should take advantage of the many opportunities available to become qualified in CPR and artificial respiration.

Immediate Steps After Electric Shock

1. Shut off all power and remove victim from the electric circuit. If the power cannot be shut off immediately,use an insulator of some sort, such as a wooden pole, to remove victim from the circuit. Attempts to pull the victim from the circuit with your hands will almost always result in your joining the victim in the electric shock.

2. If you are qualified in CPR, check for ventricular fibrillation or cardiac arrest. If either is detected, external cardiac massage should be started at once. Whether you are qualified in CPR or not, notify EMS and the ECE Department at once, using the telephone numbers listed below.

3. Check for respiratory failure and take appropriate action. This may have resulted from physical paralysis of respiratory muscles or from a head injury. Sometimes many hours pass before normal respiration returns. Artificial respiration should be continued until trained EMS assistance arrives.

4. Check for and treat other injuries such as fractures from a fall or burns from current entry and exit sites. Investigations are always after accidents. As an engineer you will be involved as a part of the investigating team or in providing information to an investigator. Information obtained and notes written immediately after the emergency will aid this investigation and assist in preventing future accidents of a similar nature.

Investigations are always made after accidents. As an engineer, you will be involved as a part of the investigating team or in providing information to an investigator. Information obtained and notes written immediately after the emergency will aid the investigation and assist in preventing future accidents of a similar nature.

Emergency Numbers

Fire / EMS: 911 or (864) 656-2222
Student Health Center: (864) 656-2233
ECE Department Office: (864) 656-5650

Appendix A References

1. 1. D. Roy Chowdhury, “Linear Integrated Circuits”, New age international (p) Ltd, 2nd Edition,2003

2. Ramakanth A. Gayakwad, “Op-Amps linear ICs”, PHI, 3rdEdition,2003.

3. John F. Wakerly, “Digital Design Principles and Practices”, Prentice Hall, 3rdEdition,2005.

4. Salivahanan, “Linear Integrated Circuits and Applications”, TMH, 1st Edition, 2008.

Appendix B - Instruments for Electrical Measurements

Electrical engineers measure and use a wide variety of electrical circuit variables, such as voltage, current, frequency, power, and energy, as well as electrical circuit parameters, such as resistance, capacitance, and inductance. Many instruments can be used to make such measurements, but the proper use of the instruments and interpretation of the measurements depend on a fundamental understanding of how the instruments work, their capabilities, and their limitations.

This appendix provides a brief overview of the fundamentals of the electrical equipment and instru- ments that you will use in this and other laboratory courses. As you encounter more and varied types of electrical equipment and instruments in this and subsequent courses, you will find several books, in addition to your textbook, useful in developing your understanding and measurement skills. In addition, many commercial instrument manufacturers publish handbooks and application notes that provide more information on specific measurement techniques.

Digital Multimeter

A multimeter is an electronic device that measures a multitude of electrical values, usually including at least AC and DC voltage and current, as well as resistance. Analog multimeters have an analog display and digital multimeter (DMM) have a digital display. The DMM in this laboratory is used to measure voltage (DC and AC), current (DC and AC), resistance, capacitance. Additionally it may be used for diode tests and audible continuity tests. For capacitance and inductance measurements you must make connections to the DMM/Impedance Analyzer on the prototyping board. For all other measurements make connections to the DMM banana jacks on the workstation.

Dual-Beam Oscilloscope

The oscilloscope is a tool to allow engineers to look at the shape of an electrical voltage versus time or versus a second signal. Until relatively recently, oscilloscopes used a cathode ray tube (CRT) to draw the waveforms onto a screen, just like an image on a television. Televisions and computer monitors also used cathode ray tubes until the advent of the new flat screens. Most engineers refer to the instrument as a "scope".

The Dual-Beam Oscilloscope has two vertical ("y") input channels and one horizontal ("x") channel. The horizontal channel can be connected either to an external AC voltage signal or to an internal time- base generator (x = time). You should become familiar with the scale options on the y input channels, the x input channel, and the time base, since you will be using these to obtain values for voltage and time. The y inputs can be either direct (1X) or through a 10X probe. Figure shows the equivalent input circuit for a direct input and Figure shows an equivalent circuit for the 10X probe input. Note that in both configurations one side of the input is grounded, which means that care must be used in connecting the ground clip of the probe or connector used to assure that these are not connected to a "hot" (V ¿ 0) part of the circuit. (See the section "Oscilloscope Grounding Errors".) The calibrated time base is useful when measuring the phase difference between two waveforms (on the y1 and y2 inputs) by carefully lining up the zero levels for both y inputs and then using in the ac-couple mode to observe the time difference between zero crossings of the two waveforms.

textbfDigital Storage Oscilloscope The digital storage oscilloscope (DSO) is now the preferred type of oscilloscope for most industrial applications, although analog oscilloscopes are still widely used. The DSO uses digital memory to store data as long as required without degradation. The digital storage allows use of an enormous array of sophisticated digital signal processing tools for the analysis of complex waveforms in today's circuitry.

The digital storage oscilloscopes of the Analog Discovery 2 are dual-beam oscilloscopes with two vertical inputs, as described above. The vertical input on the oscilloscope, instead of driving a vertical amplifier, is digitized by an analog-to-digital (A-to-D) converter to create a data set that is stored in the memory of a microprocessor. The data set is processed and then sent to the display. The data set can be written to a flash drive or sent over a LAN or a WAN for processing or archiving. The screen image can be directly recorded on paper by means of an attached printer or plotter, without the need for an oscilloscope camera. The scope's own signal analysis software can extract many useful time- domain features (e.g. rise time, pulse width, amplitude), frequency spectra, histograms and statistics, persistence maps, and a large number of parameters meaningful to engineers in specialized fields such as telecommunications, disk drive analysis, and power electronics.

Digital oscilloscopes are limited principally by the performance of the analog input circuitry and the sampling frequency. In general, the sampling frequency should be at least the Nyquist rate – double the frequency of the highest-frequency component of the observed signal – to avoid aliasing.

Appendix C - Operating Instructions for a Typical Oscilloscope

The oscilloscope is an instrument for the analysis of electrical circuits by observation of voltage and current waves. It may be used to study frequency, phase angle, and time, and to compare the relation between two variables directly on the display screen. Perhaps the greatest advantage of the oscilloscope is its ability to display the periodic waveforms being studied.

Until recently, oscilloscopes used a cathode-ray tube to display the signals of interest. A cathode ray tube (CRT) contains an electron gun that directs a high-velocity beam of electrons onto a fluorescent screen. The beam is controlled by a pair of horizontal and a pair of vertical deflecting plates. When the voltage on the deflection plates is equal to zero, the beam produces a spot of light in the center of the screen. Any potential applied to the plates creates an electric field that deflects the electron beam proportionally to the applied voltage.

The basic components of the traditional oscilloscope are cathode-ray tube, amplifiers, sweep or tim ing oscillator, and power supply. A voltage to be observed is applied to the vertical deflection plates. This signal may be amplified by the vertical amplifier in order to obtain a satisfactory vertical deflection. Meanwhile, a sweep oscillator moves the beam horizontally at a uniform rate. The simultaneous horizontal and vertical sweep of the beam across the CRT screen displays the waveform of the voltage applied to the vertical plates. The sweep oscillator blanks the CRT electron gun during its reverse sweep across the screen to switch off the electron beam.

If several voltage waveforms are to be studied and must maintain their relative phase positions, the sweep generator must be synchronized to the same voltage during the entire test. In this case, one voltage is applied to the oscilloscope as an external trigger.

An independent voltage may be applied to the horizontal input in place of the sweep oscillator voltage. In this case, two independent input voltages are displayed against one another. If the horizontal frequency is a submultiple of the vertical frequency, the trace will form a stationary pattern on the screen.

The traditional CRT oscilloscopes are rapidly being replaced with digital oscilloscopes that have flat-panel liquid crystal displays (LCDs), some with color displays. Instead of directly applying the incoming voltages to deflection plates, the digital oscilloscopes capture the voltage information and store it in computer memory as digital signals, which are then analyzed and displayed on the LCD. While the new digital scopes handle the incoming signal differently from the CRT-based scopes, the basic purpose and many of the operational controls remain the same. Therefore, the discussion that follows applies, for the most part, to both types of oscilloscopes. Avoiding Grounding Errors with Oscilloscope The shield or ground wire on the oscilloscope's signal input is connected to the oscilloscope's chassis ground, and therefore to the ground lead on the instrument's electrical power connection. This fact creates the possibility of grounding errors when making connections to circuits, especially when trying to measure voltages across ungrounded components.

The problem is illustrated in the following diagram. Suppose one wants to measure the voltage across resistor R1. Because the circuit and the oscilloscope both have the same ground, connecting the oscilloscope's input leads directly across R1, as indicated, will create a short across R2. Besides giving an incorrect reading, such a connection might damage either the oscilloscope or the circuit under test.

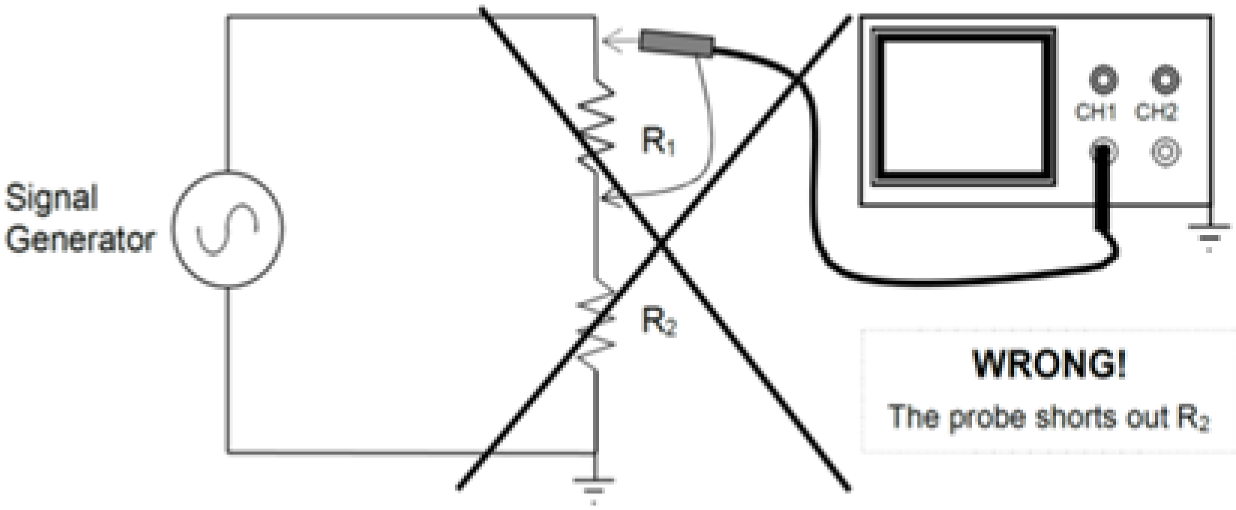


Figure C.1: Grounding error

Waveform Observation

After the initial adjustments are made, the oscilloscope is ready for operation. To observe the waveform of any periodic signal, apply the signal to the vertical input terminals. Use DC coupling if the input is DC or very low in frequency or if you want to capture any DC offset. Now the signal from an oscillator, signal generator, or some component of an electrical circuit may be observed on the screen. The best resolution of the waveform is obtained when the time scale is adjusted so one or two cycles appear on the screen and when the vertical scale is adjusted so the amplitude occupies most of the graticule. If the waveform will not stabilize, adjust the SYNC or TRIGGER just enough to cause the pattern to stop. Whenever possible, connect the oscilloscope ground to the common ground of the circuit. Exercise great care when making measurements with both terminals above ground potential, as there may be a difference in potential between two instrument cases, causing ground loop currents, faulty readings, and damaged equipment.

Voltage Measurement (AC and DC)

The oscilloscope has advantages as a voltmeter: a very high input impedance compared to an analog voltmeter; the ability to measure voltages over a very wide frequency range; and the ability to indicate magnitude regardless of waveform. Also, scopes measure peak-to-peak values of AC voltages, whereas standard AC voltmeters measure rms values of sine wave voltages.

To use the oscilloscope as an AC voltmeter, apply the signal to the vertical input terminals, and adjust the calibrated VERTICAL SENSITIVITY (or VOLTS/DIV) so the amplitude is of suitable magnitude on the graticule. The peak-to-peak value is then the distance indicated multiplied by the vertical calibration. For example, assume that a sine wave generator is set to 1000 Hz and adjusted for maximum output voltage. A peak-to-peak value of 60V is observed on the oscilloscope. The output of the generator at 1000 Hz, therefore, is approximately 60V peak-to-peak, and 21.2 Vrms.

For DC measurements, apply the voltage to the vertical input terminals, again suitably adjusting the VERTICAL SENSITIVITY. A straight line is produced with the horizontal sweep functioning. With no horizontal voltage applied, a spot will appear on the screen. In measuring DC voltages, it is necessary to remember where the trace was with 0V applied to the vertical

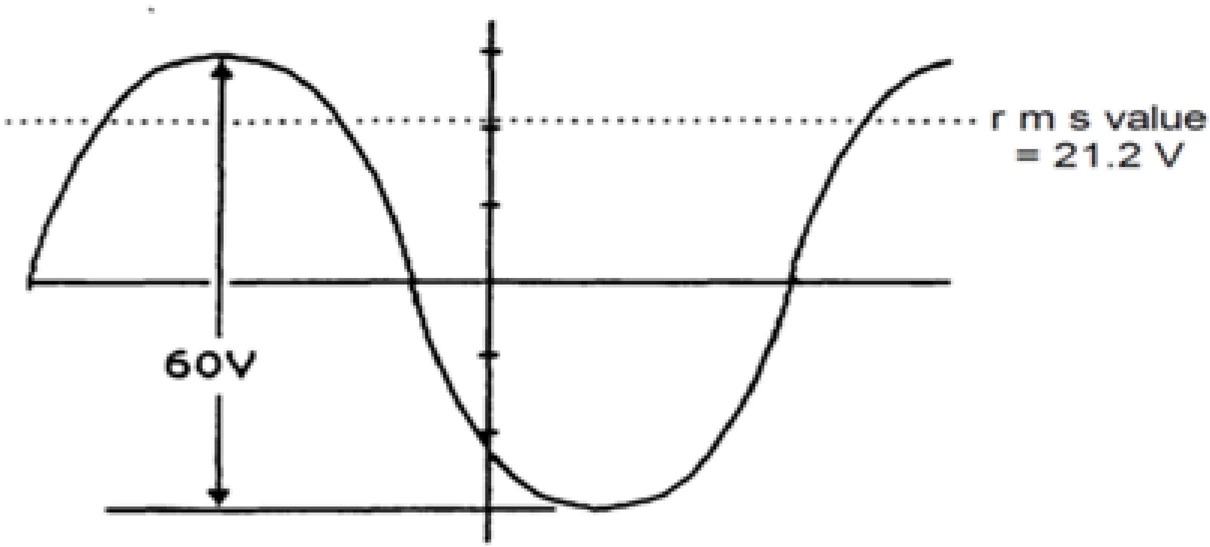


Figure C.2: Sinusoidal waveform

input.
Frequency Measurement
The frequency of an unknown signal may be calculated from the oscilloscope very easily. The period of the waveform is the product of the distance along the x-axis covered by one cycle and the horizontal sweep setting. As an example, a sine-wave generator is set to 1000 Hz with the voltage applied to the oscilloscope vertical. One cycle covers 9.95 cm, with a sweep speed of 100 µsec/cm. The period is T = (9.95)•(100x106)sec. The measured frequency is f = 1/T = 1005 Hz.

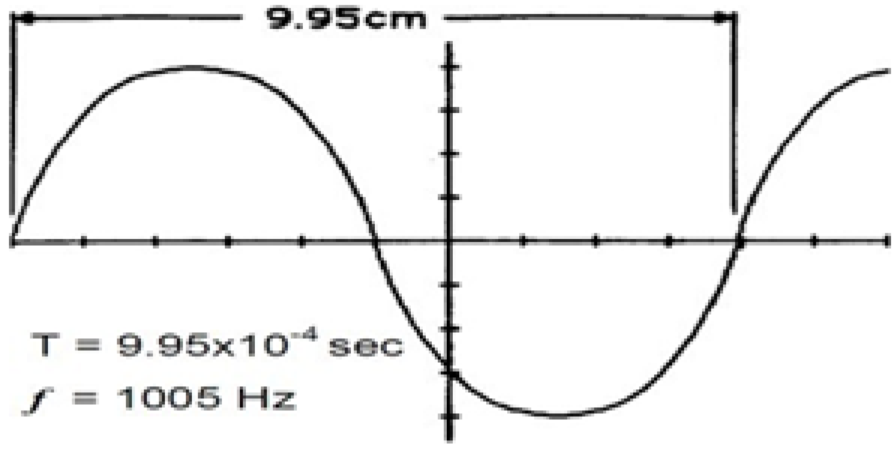


Figure C.3: Frequency measurement

Phase-Angle Measurement
The difference in phase angle between two waveforms may be measured directly on the oscilloscope with little difficulty. For an oscilloscope with only one vertical input: One wave is chosen as the reverence and applied to the vertical input terminals. This same wave is applied to the external trigger input of the scope. Next, a convenient point on the wave is selected as a time reference, such as where the wave is zero and about to swing positive. Then, this waveform is removed from the vertical input and a second waveform is applied. The voltage of this wave

at the time reference is observed. The ratio of voltage at the time reference to the maximum voltage is equal to the sine of the phase difference between the two waves.

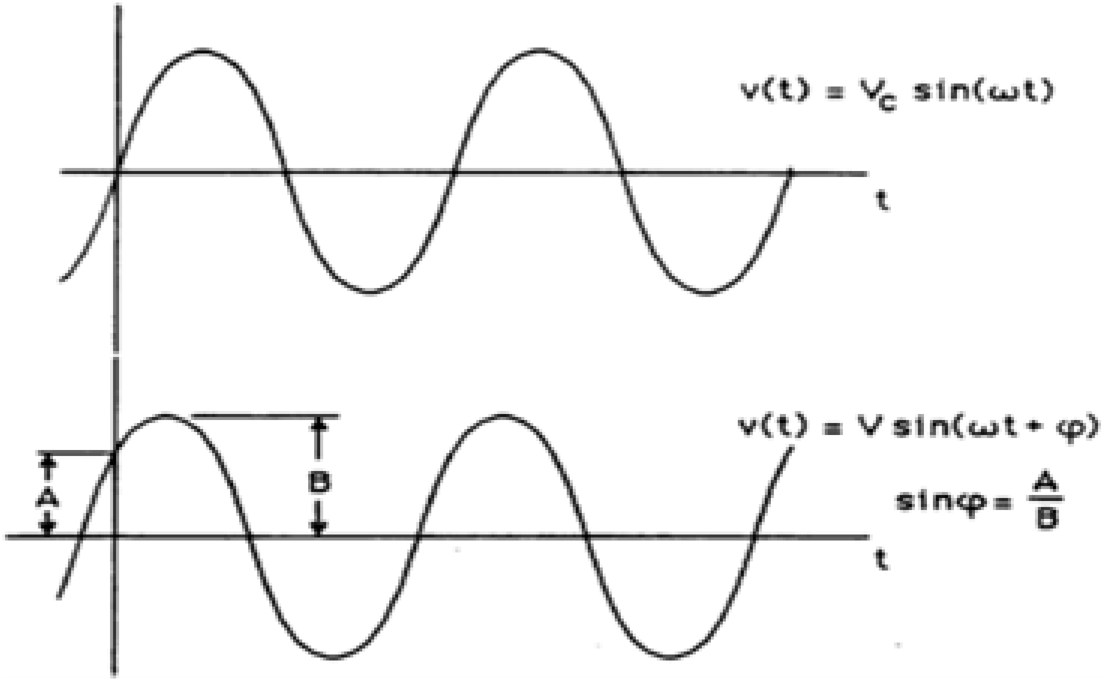


Figure C.4: Phase measurement

For an oscilloscope with two vertical inputs:
Connect the reference voltage to Channel 1 of the oscilloscope and connect the second voltage to Channel 2. Adjust the amplitudes so the overlapping signals look something like the figure below, where the solid curve is Channel 1 (the reference) and the dashed curve is Channel 2. (In this figure, the dashed curve is lagging the solid curve; if the dashed curve were shifted to the left so it "started" before the solid curve, then the dashed curve would be leading the solid curve.) The phase shift in degrees can be calculated by the following formula: where is the phase shift, f is the frequency, and t is the time difference between the two waveforms. Many new digital scopes have cursors that allow directly marking, calculating, and displaying the time difference and perhaps even the phase shift.

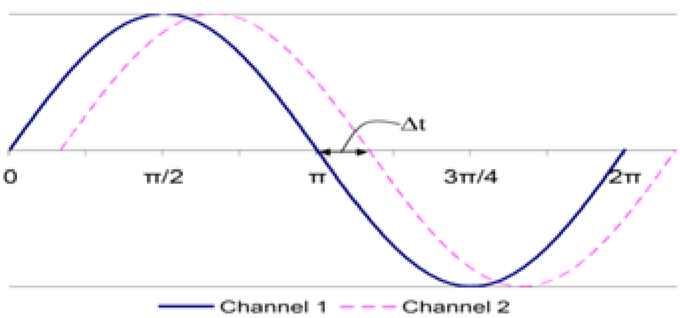


Figure C.5: Frequency measurement

Appendix D - Introduction to MATLAB

D.0.1 MATLAB (Matrix labaratory)

MATLAB is a software package for high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include the following

.Math and computation

.Algorithm development

.Data acquisition

.Modeling, simulation, and prototyping

.Data analysis, exploration, and visualization

.Scientific and engineering graphics

.Application development, including graphical user interface building
At its core ,MATLAB is essentially a set (a "toolbox") of routines (called "m files" or "mix files") that sit on your computer and a window that allows you to create new variables with names (e.g. voltage and time) and process those variables with any of those routines (e.g. plot voltage against time, find the largest voltage, etc). It also allows you to put a list of your processing requests together in a file and save that combined list with a name so that you can run all of those commands in the same order at some later time. Furthermore, it allows you to run such lists of commands such that you pass in data and/or get data back out (i.e. the list of commands is like a function in most programming languages). Once you save a function, it becomes part of your toolbox (i.e. it now looks to you as if it were part of the basic toolbox that you started with). For those with computer programming backgrounds: Note that MATLAB runs as an interpretive language (like the old BASIC). That is, it does not need to be compiled. It simply reads through each line of the function, executes it, and then goes on to the next line. (In practice, a form of compilation occurs when you first run a function, so that it can run faster the next time you run it.)
The name MATLAB stands for matrix laboratory. MATLAB was originally written to provide easy access to matrix software developed by the LINPACK and EISPACK projects. Today, MATLAB engines incorporate the LAPACK and BLAS libraries, embedding the state of the art in software for matrix computation. MATLAB has evolved over a period of years with input from many users. In university environments, it is the standard instructional tool for introductory and advanced courses in mathematics, engineering, and science. In industry, MATLAB is

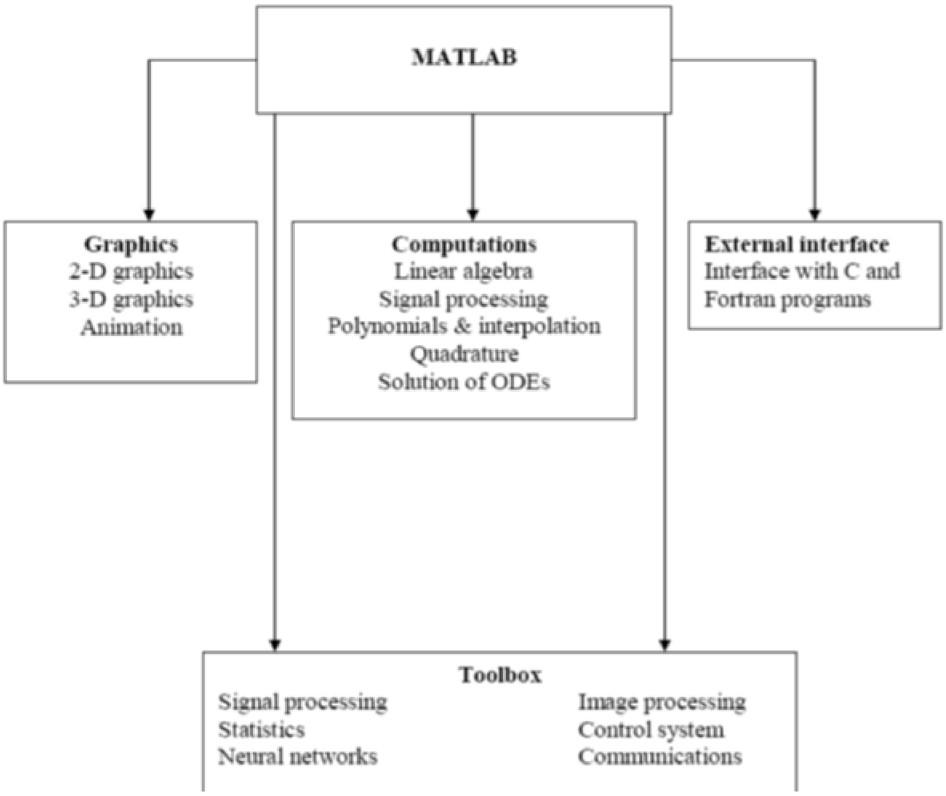


Figure D.1: matlab

the tool of choice for high-productivity research, development, and analysis.

MATLAB features a family of add-on application-specific solutions called toolboxes. Very important to most users of MATLAB, toolboxes allow learning and applying specialized technology. Toolboxes are comprehensive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available include Image processing, signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, and many others.

D.0.2 Main features of MATLAB

Advance algorithm for high performance numerical computation, especially in the Field matrix algebra

A large collection of predefined mathematical functions and the ability to define one's own functions.

Two-and three dimensional graphics for plotting and displaying data

complete online help system

Powerful, matrix or vector oriented high level programming language for individual applications.

Toolboxes available for solving advanced problems in several application areas

D.0.3 MATLAB WINDOW

MATLAB works with through three basic windows

D.0.4 command WINDOW

This is the main window .it is characterized by MATLAB command prompt ¿¿ when you launch the application program MATLAB puts you in this window all commands including those for user-written programs ,are typed in this window at the MATLAB prompt

D.0.5 GRAPHICS WINDOW

The output of all graphics commands typed in the command window are flushed to the graphics or figure window, a separate gray window with white background color the user can create as many windows as the system memory will allow.

D.0.6 EDIT WINDOW

This is where you write edit, create and save your own programs in files called M files.

D.0.7 INPUT-OUTPUT

MATLAB supports interactive computation taking the input from the screen and flushing, the output to the screen. In addition it can read input files and write output files.

D.0.8 DATA TYPE

The fundamental data –type in MATLAB is the array. It encompasses several distinct data objects- integers, real numbers, matrices, character strings, structures and cells. There is no need to declare variables as real or complex, MATLAB automatically sets the variable to be real.

D.0.9 How to Invoke MATLAB

Double Click on the MATLAB icon on the desktop.

You will find a Command window where in which you can type the commands and see the output. For example if you type PWD in the command window, it will print current working directory.

If you want to create a directory type mkdir mydir in the command window, It will create a directory called pes.

If you want delete a directory type rmdir mydir in the command window.

D.0.10 How to open a MATLAB

Go to File -¿New-¿M-File and click

Then type the program in the file and save the file with an extension of .m. While giving file name we should make sure that given file name should not be a command. It is better to the file name as myconvlution

D.0.11 How to Run a MATLAB

Go to Debug-¿run and click

D.0.12 Where to work in MATLAB

All programs and commands can be entered either in the a)Command window b) As an M file using Mat lab editor
Note: Save all M files in the folder 'work' in the current directory. Otherwise you have to locate the file during compiling. Typing quit in the command prompt¿¿ quit, will close MATLAB Mat lab Development Environment. For any clarification regarding plot etc, which are built in functions type help topic i.e. help plot.

D.0.13 Basic Instruction in MATLAB

= 0: 1:10 This instruction indicates a vector T which as initial value 0 and final value 10 with an increment of 1 Therefore T = [0 1 2 3 4 5 6 7 8 9 10]

F= 20: 1: 100 Therefore F = [20 21 22 23 24 .... 100]

T= 0:1/pi: 1 Therefore T= [0, 0.3183, 0.6366, 0.9549]

zeros (1, 3) The above instruction creates a vector of one row and three columns whose values are zero Output= [0 0 0]

zeros(2,4) Output = 0 0 0 0 0 0 0 0

ones (5,2) instruction creates a vector of five rows and two columns
Output = 1 1
1 1
1 1
1 1
1 1

a = [1 2 3] b = [4 5 6]

a.*b = [4 10 18]

8 if c= [2 2 2]

b.*c results in [8 10 12]

plot (t, x)
If x = [6 7 8 9] t = [1 2 3 4] this instruction will display a figure window which indicates the plot of x versus t.

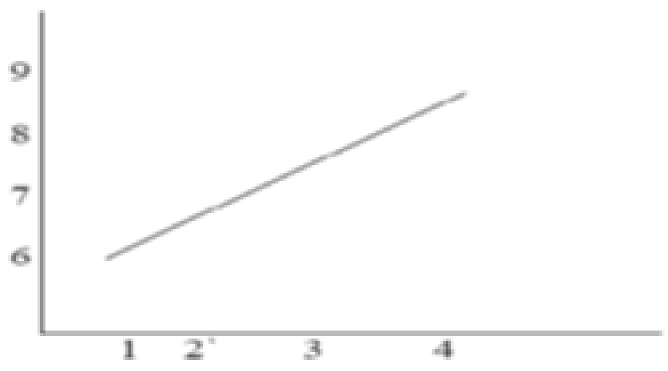


Figure D.2: plot

stem (t,x) :- This instruction will display a figure window as shown

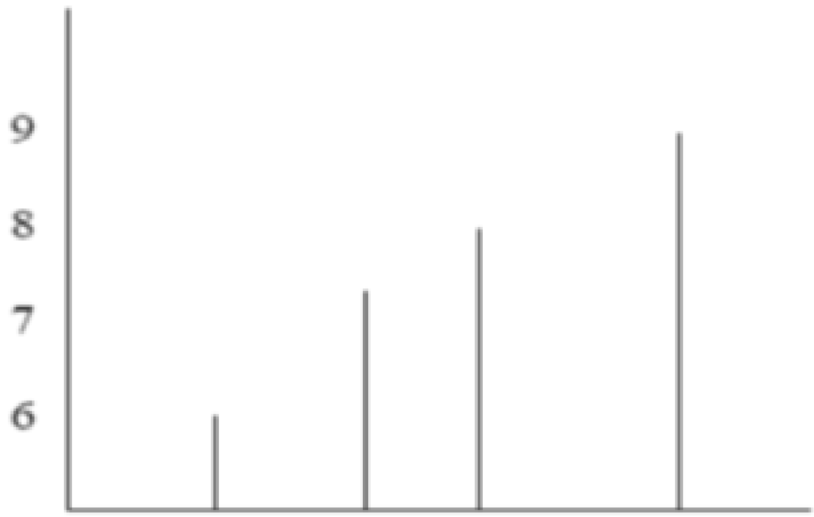


Figure D.3: stem

D.0.14 subplot

This function divides the figure window into rows and columns. Subplot (2 2 1) divides the figure window into 2 rows and 2 columns 1 represent number of the figure

Subplot (3 1 2) divides the figure window into 3 rows and 1 column 2 represent number of the figure

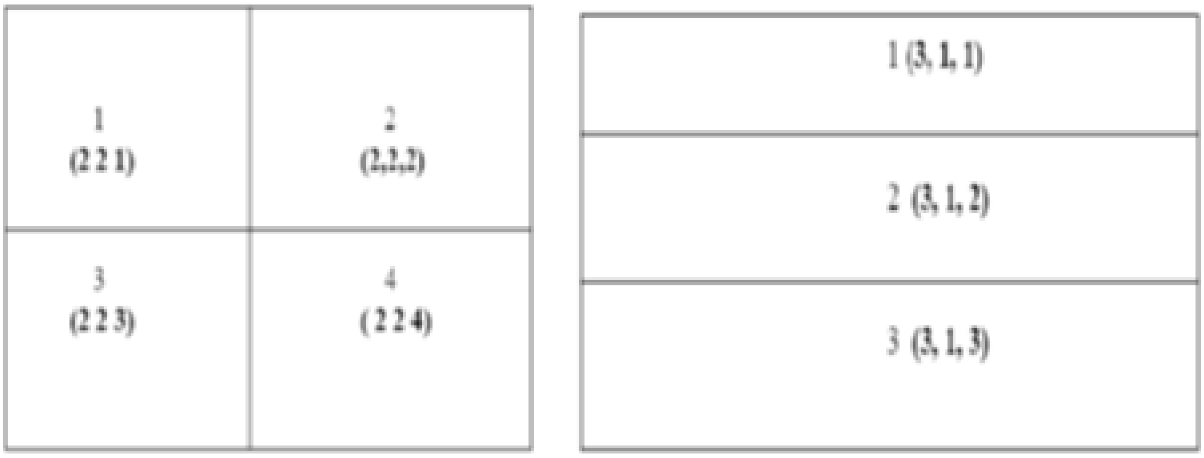


Figure D.4: subplot

conv Syntax: w = conv(u,v) Description: w = conv(u,v) convolves vectors u and v. Algebraically, convolution is the same operation as multiplying the polynomials whose coefficients are the elements of u and v.

disp Syntax: disp(X) Description: disp(X) displays an array, without printing the array name. If X contains a text string, the string is displayed.
Another way to display an array on the screen is to type its name, but this prints a leading "X=," which is not always desirable.Note that disp does not display empty arrays.

xlabel Syntax: xlabel('string') Description: xlabel('string') labels the x-axis of the current axes.

ylabel Syntax : ylabel('string')
Description: ylabel('string') labels the y-axis of the current axes.

title Syntax : title('string') Description: title('string') outputs the string at the top and in the center of the current axes.

grid on Syntax : grid on Description: grid on adds major grid lines to the current axes.

FFT Discrete Fourier transform. FFT(X) is the discrete Fourier transform (DFT) of vector X. For matrices, the FFT operation is applied to each column. For N-D arrays, the FFT operation operates on the first non-singleton dimension. FFT(X,N) is the N-point FFT, padded with zeros if X has less than N points and truncated if it has more.

abs Absolute value. abs(X) is the absolute value of the elements of X. When X is complex, abs(X) is the complex modulus (magnitude) of the elements of X.

angle Phase angle. angle(H) returns the phase angles, in radians, of a matrix with complex elements.

interp Resample data at a higher rate using lowpass interpolation. y = interp(x,L) resamples the sequence in vector X at L times the original sample rate. The resulting resampled vector Y is L times longer, Length(y) = L*Length(x).

decimate Resample data at a lower rate after lowpass filtering.

y = decimate(x,M) resample's the sequence in vector X at 1/M times the original sample rate. The resulting resample vector Y is M times shorter,
i.e., Length(Y) = Ceil(Length(x)/M).
By default, Decimate filters the data with an 8th order Chebyshev Type I lowpass filter with cutoff frequency .
8*(Fs/2)/R, before resampling.