Analog Communications Lab/EC351 R20

III/IV B.TECH – I SEM

LABORATORY MANUAL

PREPARED BY

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DEPARTMENT OF E.C.E

DEPARTMENT OF
ELECTRONICS AND COMMUNICATION ENGINEERING

BAPATLA WOMEN'S ENGINEERING COLLEGE::BAPATLA

(AFFILIATED TO ACHARYA NAGARJUNA UNIVERSITY,GUNTUR)

BAPATLA DISTRICT, ANDHRA PRADESH, INDIA PIN: 522101

COLLEGE VISION AND MISSION

COLLEGE VISION:

BWEC has been established with forethought to organize the growing needs of higher technical education for WOMEN, to provide them a competitive edge and a unique niche in the society. We at BWEC are determined to create a conductive environment with updated technological inputs and latest information to facilitate the students with a pleasant feel in acquiring knowledge and skills required to make them globally competitive technocrats.

COLLEGE MISSION:

Our mission is to impart the quality education on par with global standards to the students from all over India, and particularly those from local and rural areas. We continuously try to maintain high standards to make them technologically competent and ethically strong individuals who shall be able to improve the quality of life and economy of our country.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

VISION

To produce highly professional and socially responsible women engineers through world class quality technical education and research to meet industry and Society needs in thefield of Electronics and Communication Engineering.

MISSION

M1- To inculcate quality education for women through innovative learningpractices with the use of modern tools.

M2- To impart professional ethics and moral values through co-curricular andExtra-curricular activities as individual and team member.

M3- Empowering graduates through industrial trainings/on-job training in collaboration with industries with-a-view to life-long learning.

PROGRAM EDUCATIONAL OBJECTIVES (PEO's)

PEO1: To develop and implementation of Electronics and Communication systems by imparting technical knowledge, professional leadership and communication skills as an individual and team in a multi-disciplinary stream.

PEO2: To train Graduates in solving complex problems, analyzing, designing and imparting research-based knowledge by using modern scientific tools to develop least cost-effective and innovative products.

PEO3: To produce women graduates through life-long learning, who ensure ethical and moral behaviuor.

PROGRAM SPECIFIC OUTCOMES (PSO's)

PSO1: To understand and analyze basic concepts of electronics and communication in various areas like signal processing, VLSI, embedded systems, communications, digital and analog devices.

PSO2: Ability to design and develop computing systems using concepts of mathematics, electronics engineering and other related inter disciplines to asses and resolve societal, environmental, health safety and cultural issues with professional ethics.

PROGRAMME OUTCOMES (PO'S)

- **PO1: Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- **PO2: Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- **PO3: Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- **PO4: Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- **PO5: Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools prediction and modelling to complex engineering activities with an understanding of the limitations.
- **PO6: The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice
- **PO7: Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and the need for sustainable development.
- **PO8: Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- **PO9: Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- **PO10: Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and receive clear instructions.
- **PO11: Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in team, to manage projects and in multidisciplinary environments.
- **PO12: Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

EC351 R20 –Analog Communications Laboratory **2022-2023 (ODD)**

SYLLABUS

EC351 R20	**ANALOG COMMUNICATIONS LABORATORY**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**1.5**

OBJECTIVES:

- ✓ To understand the Concept of modulation and demodulation
- ✓ To understand how the pre Emphasis and De Emphasis takes place
- ✓ To learn about PAM, PPM and PWM.
- ✓ To understand the Multiplexing Techniques.

LIST OF EXPERIMENTS

1. Amplitude Modulation and Demodulation
2. DSB SC Modulation and Demodulation
3. SSB SC Modulation and Demodulation
4. Frequency Modulation and Demodulation
5. Pre Emphasis - De Emphasis Circuits
6. Verification of Sampling Theorem
7. PAM and Reconstruction.
8. PWM and PPM: Generation and Reconstruction
9. Effect of Noise on the Communication Channel
10. Time Division Multiplexing & amp; De multiplexing
11. Frequency Synthesizer.
12. AGC Characteristics.
13. PLL as FM Demodulator.
14. Spectrum analyzer and analysis of AM & amp; FM signals
15. Frequency Division Multiplexing & amp; De multiplexing

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

EC351 R20 –Analog Communications Laboratory **2022-2023 (ODD)**

LIST OF EXPERIMENTS

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8. PWM and PPM: Generation and Reconstruction
9. Time Division Multiplexing & amp; De multiplexing
10. Frequency Division Multiplexing & amp; De multiplexing

EXPERIMENT(S) BEYOND THE SYLLABUS

1. Design of Mixer

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

COURSE OUTCOMES (CO's):

After the completion of the subject/course, the student should able to learn

Co No.	Course Outcome	Bloom's TaxonomyLevel
C351.1	**Demonstrate** Analog and Pulse Analog Modulation and DemodulationTechniques	**Apply**
C351.2	**Interpret** Frequency response of Pre-emphasis and De-emphasis Circuits	**Understand**
C351.3	**Apply** Basic Multiplexing Techniques	**Apply**
C351.4	**Verify** Sampling Theorem	**Evaluate**

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C351.1	3	3	3	2	-	-	-	-	-	-	-	2	3	3
C351.2	2	2	2	-	-	-	-	-	-	-	-	1	2	1
C351.3	3	3	3	2	-	-	-	-	-	-	-	2	3	3
C351.4	3	2	3	2	-	-	-	-	-	-	-	2	3	2
Avg	2.75	2.5	2.75	1.5	-	-	-	-	-	-	-	1.75	2.75	2.25

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) - : No Correlation

EC351 R20 –Analog Communications Laboratory

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7	PAM and Reconstruction	39
8	PWM and PPM: Generation and Reconstruction	45
9	Time Division Multiplexing & amp; De multiplexing	59
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EXPERIMENT(S) BEYOND SYLLABUS		
1	Design of Mixer	75

1. Amplitude Modulation & Demodulation

Aim: To study the process of amplitude modulation & demodulation and to calculate the depth of modulation.

Apparatus:

1. Hi-Q Test Equipment Pvt Ltd amplitude modulation and demodulation trainer kit
2. CRO-20 MHZ dual channel
3. Patch Chords

Theory:

Amplitude modulation is defined as a process in which amplitude of a carrier signal is varied in accordance with the amplitude of the message signal.

The standard form of amplitude modulated wave is given by

$$s(t)=Ac[1+k_a\, m(t)]\cos 2\pi f_c t$$

where k_a=amplitude sensitivity of the modulator.

m(t)= message signal
s(t)= envelope of AM wave

In amplitude modulated wave information contained in the message signal is super imposed upon the carrier signal. This time varying amplitude multiplied by cos $2\pi f_c t$ is called envelope of AM wave S(t).
The numerator circuit shown in fig (1) generates the envelope of AM wave s(t)

The demodulator circuit at the receiver side shown in fig (2) is used to recover the message signal from the incoming AM wave.

An envelope detector is a highly effective device that is well suited for the demodulation of AM.

The modulation is calculated using the formula.

$$\%\ m= v_{max}\text{-}v_{min/(}v_{max+}v_{min)}$$

Where V_{max}=maximum amplitude of envelope

V_{min}=minimum amplitude of envelope

Circuit Description:-

Modulating and Carrier Signal generator:

The IC XR2206 is used to generate a sine wave and is used to drive the circuit. XR-2206 is a16-pin monolithic function generator integrated circuit. It is capable of producing high quality sine, square, triangle, ramp and pulse waveforms of high –stability and accuracy. The output waveforms can be both amplitude and frequency modulated by an external voltage.

Applications of XR-2206 include waveform generator, sweep generator, AM/FM generator, V/F conversion, FSK generator, Phase locked loop (VCO)

For amplitude modulation, The modulating signal or message signal is applied at pin1 of XR-2206 and DC bias voltage of 12v is applied at pin4.The internal impedance at pin 1 is approximately 100kohm.Output amplitude modulated wave is collected at pin2.

Circuit Diagram:-

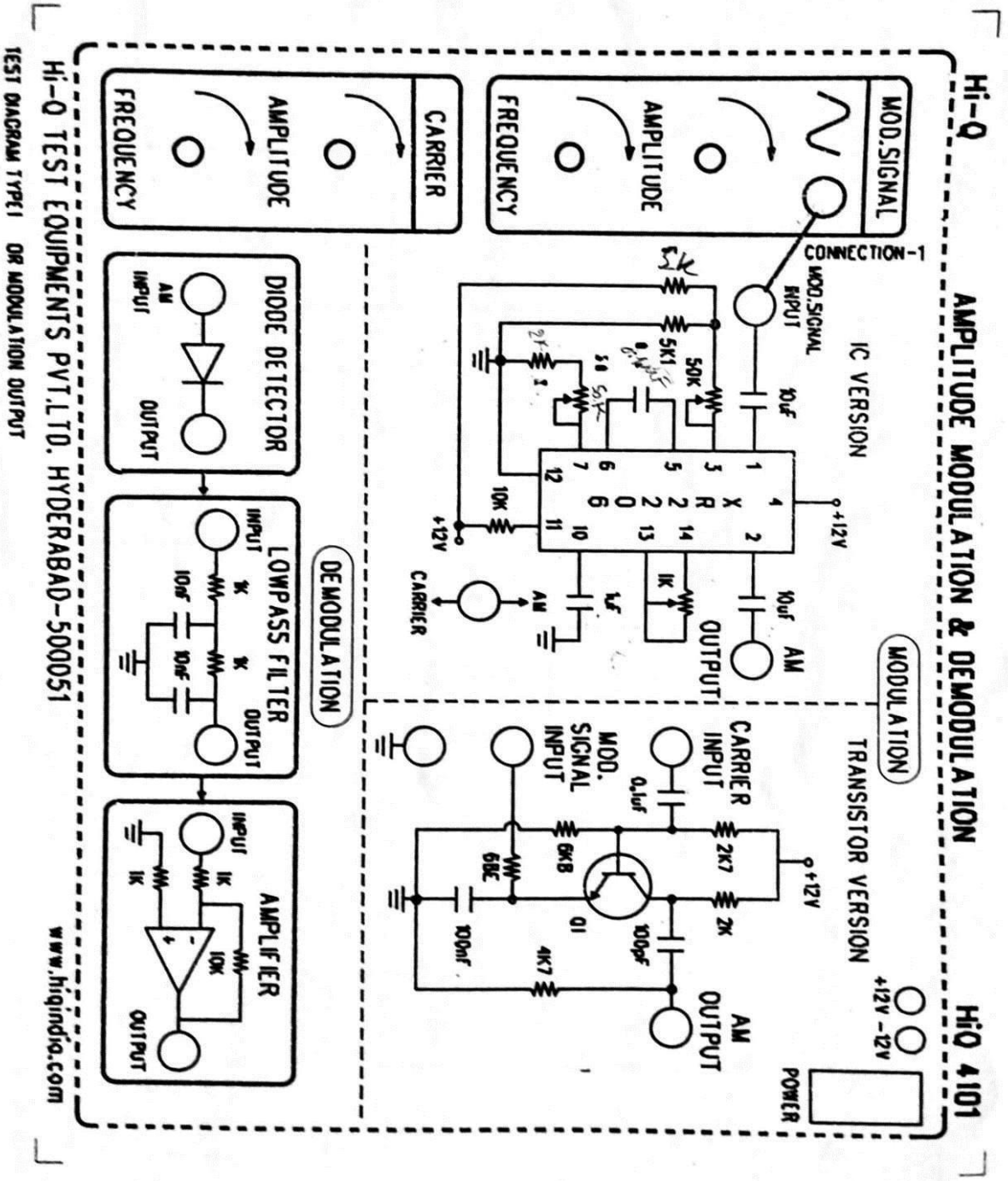
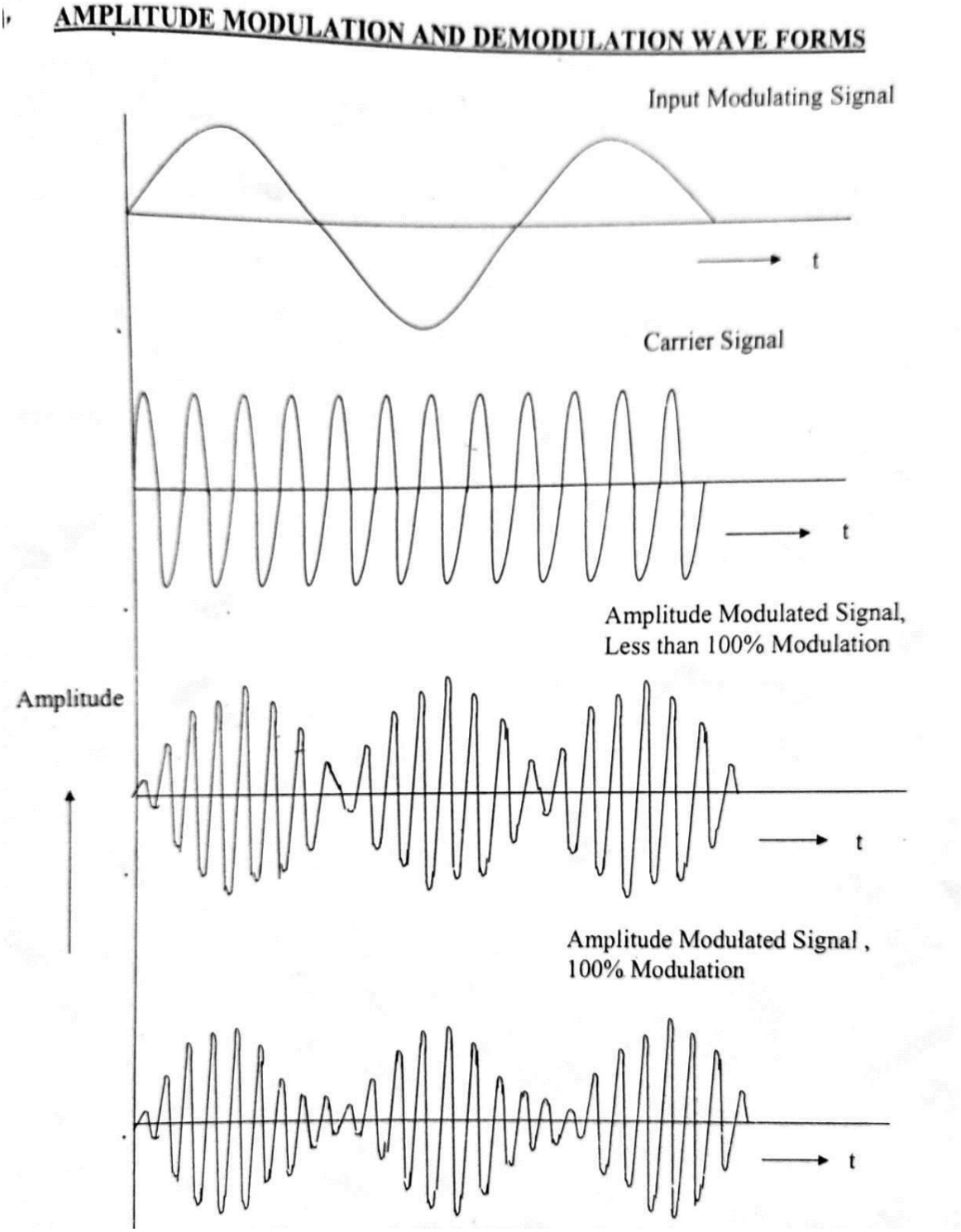
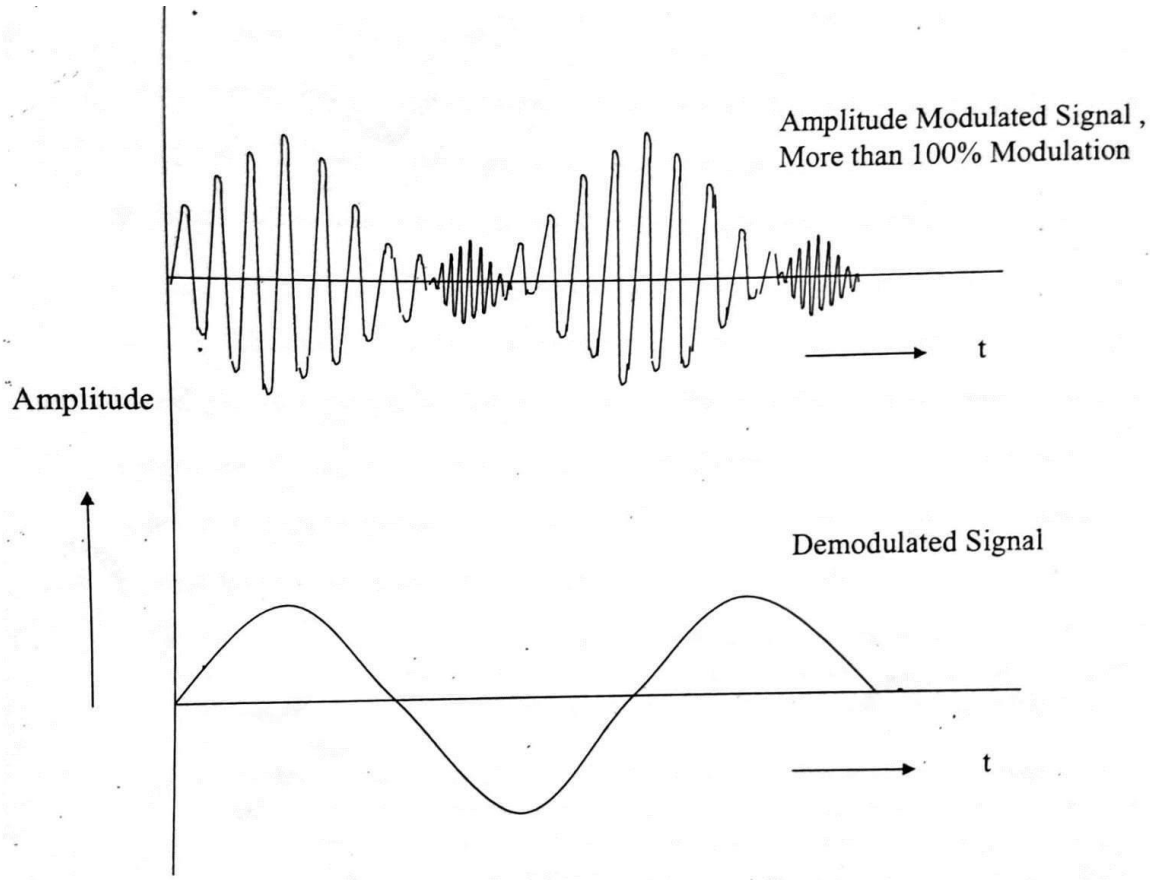


Fig. 1.1

Waveforms


AMPLITUDE MODULATION AND DEMODULATION WAVE FORMS
Input Modulating Signal
t
Carrier Signal
t
Amplitude Modulated Signal,
Less than 100% Modulation
Amplitude
t
Amplitude Modulated Signal ,
100% Modulation
t



Procedure:

Modulation:-

1. Connect the Circuit as shown in test diagram Type 1. For Modulation output, Switch on the power supply.
    a. Output of modulating signal generator to modulating signal input and keep the frequency to 500 Hz pot.
    b. Set carrier frequency 180 KHz.
2. Observe the amplitude modulated output on CRO at 50%, 100% and over modulation.
3. Now change modulating signal generator to 1 KHz and observe the output at CRO.
4. Observe the amplitude modulated output on CRO at 50%, 100% and over modulation.

Demodulation:-

1. Connect the Circuit as shown in test diagram Type 1. For de- Modulation output,
   a. Output of modulating signal generator to modulating signal input and keep the frequency to 500 Hz pot.
   b. Amplitude modulation output from to input of Diode Detector.

Precautions:

1. Check the connections before giving the supply.

2. Observations should be done carefully.

VIVA-VOCE QUESTIONS:

1. Define AM?
2. Give the significance of modulation index?
3. What are the different degrees of modulation?\
4. Explain how AM wave is detected?

2. DSB SC MODULATION AND DEMODULATION

Aim:- To study the process of double side band modulation and demodulation

Apparatus:

1. Hi-Q Test Equipment Pvt Ltd Double side band suppressed carrier trainer kit
2. CRO-20MHZ dual channel
3. Patch Chords

Theory:

Balanced modulator is used for generating DSB-SC signal .A Balanced modulator consists of two standard amplitude modulator arranged in a balanced configuration, so as to suppress the carrier wave. The two modulators are identical except the reversal of sign of the modulating signal applied to them.

Circuit Diagram:-

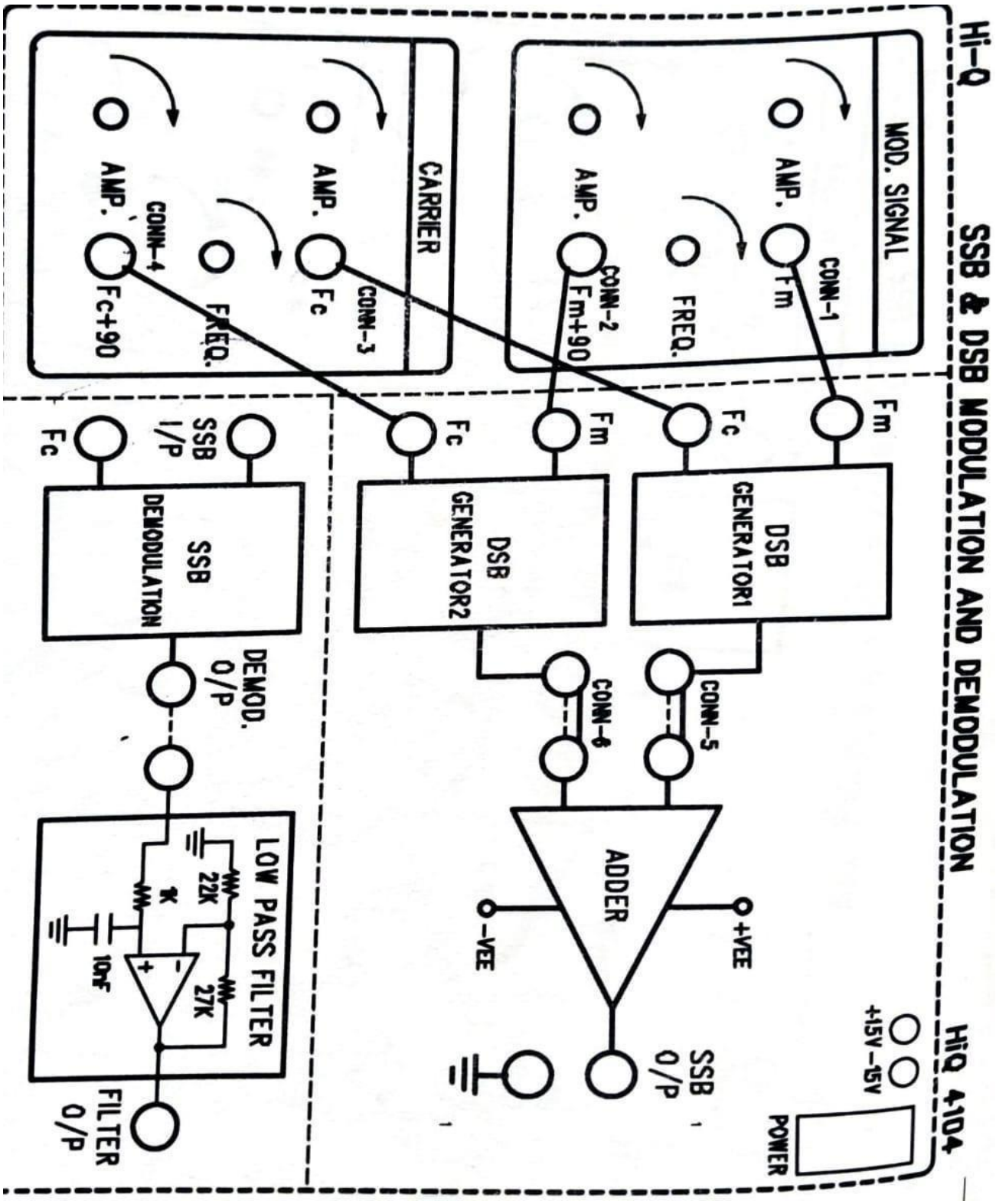


Fig.2.1

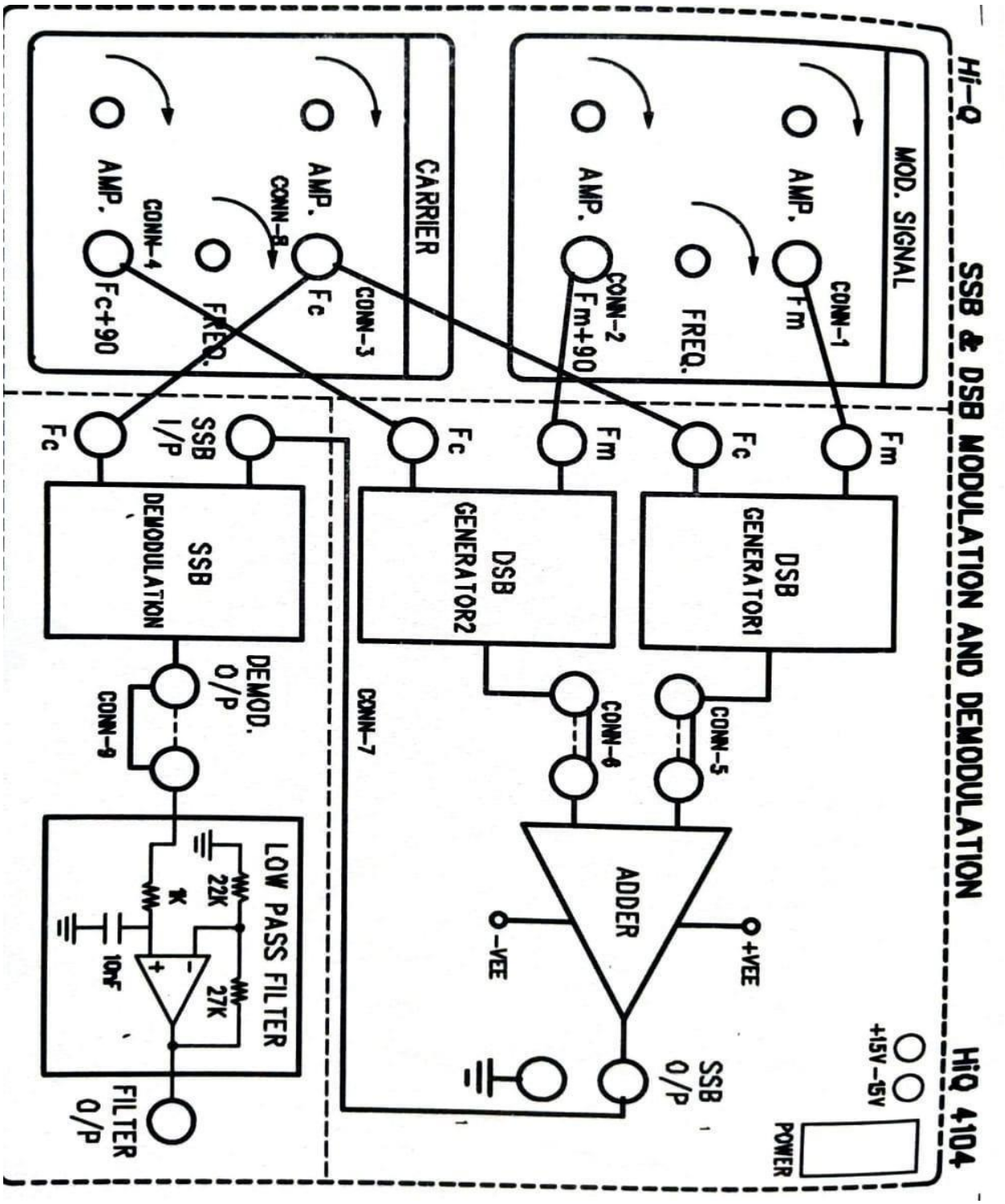
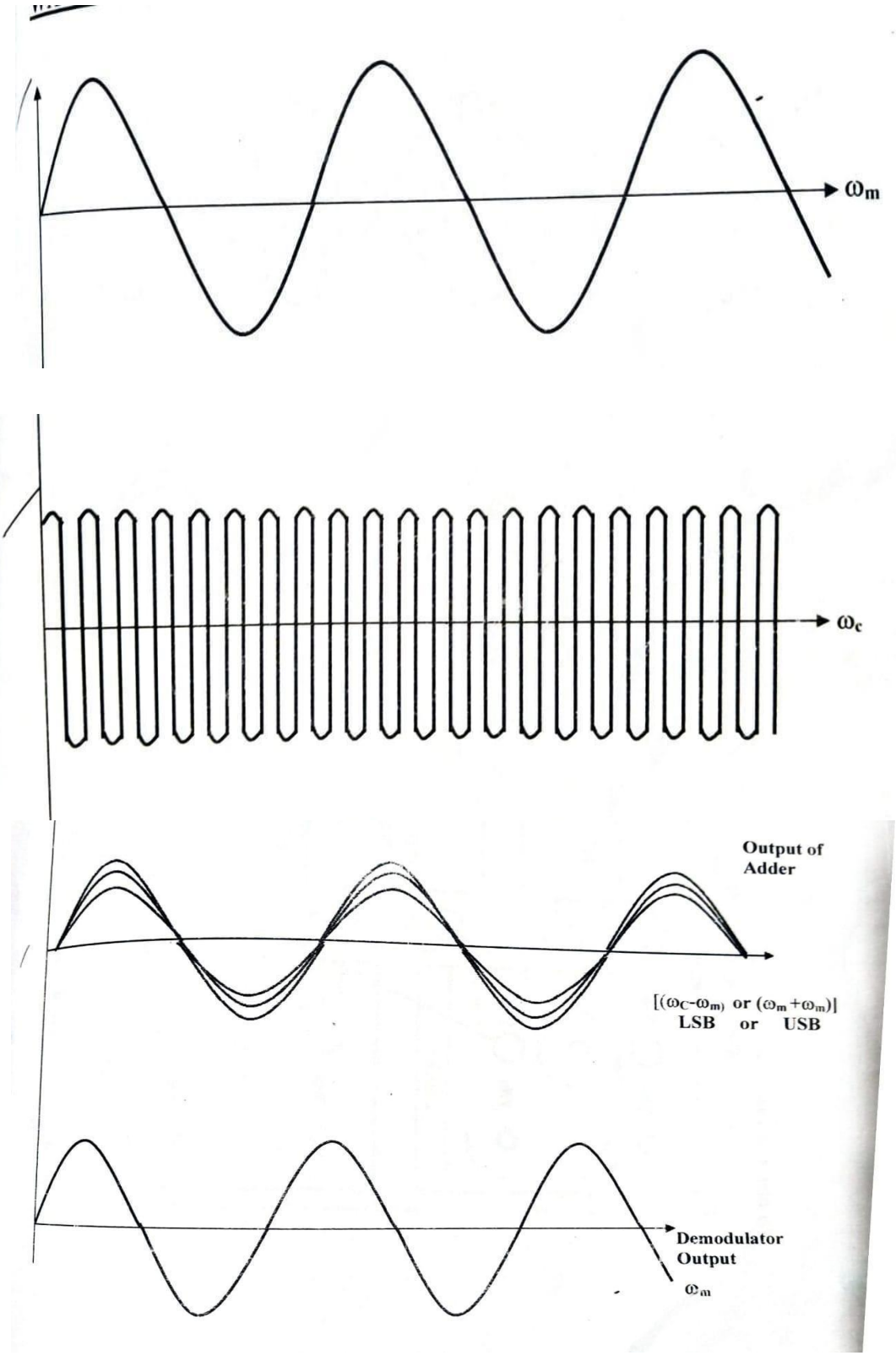

Hi-Q
SSB & DSB MODULATION AND DEMODULATION
HiQ 4104
MOD. SIGNAL
AMP.
FREQ.
CONN-1
Fm
CONN-2
Fm+90
CARRIER
CONN-3
Fc
CONN-4
Fc+90
CONN-8
DSB GENERATOR1
DSB GENERATOR2
SSB DEMODULATION
SSB I/P
DEMOD. O/P
CONN-9
CONN-5
CONN-6
CONN-7
ADDER
+VEE
-VEE
SSB O/P
LOW PASS FILTER
22K
27K
10nF
FILTER O/P
+15V -15V
POWER

Fig.2.2

Waveforms:


ωm
ωc
Output of
Adder
[(ωC-ωm) or (ωm+ωm)]
LSB or USB
Demodulator
Output
ωm

Procedure:

Modulation:

1. Connect the circuit diagram as shown in Fig.
2. Connect modulation of carrier signals to input of DSB generator.
3. Observe the DSB of GEN-1 balanced modulator o/p on CRO

Demodulation:

1. For demodulation connect DSB o/p to the DSB modulator i/p and also connect fc to DSB-SC modulation of f_c and observed its o/p.
2. Connect the DSB demodulation to i/p of low pass filter. And observe filter output as smooth modulating signal.
3. Switch OFF the power supply.

Precautions:

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

VIVA-VOCE QUESTIONS:

1. What are the two ways of generating DSB_SC?
2. What are the applications of balanced modulator?
3. What are the advantages of balanced modulator?
4. Write the expression for the output voltage of a balanced modulator?
5. What are the advantages of suppressing the carrier?

3. SSB SC Modulation & Demodulation

Aim:-

To study the process of double side band modulation and demodulation.

Apparatus:-

1. Hi-Q Test Equipment Pvt Ltd Single side band suppressed carrier trainer kit
2. CRO-20MHZ dual channel
3. Patch Chords

Theory:-

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

Circuit Diagram:

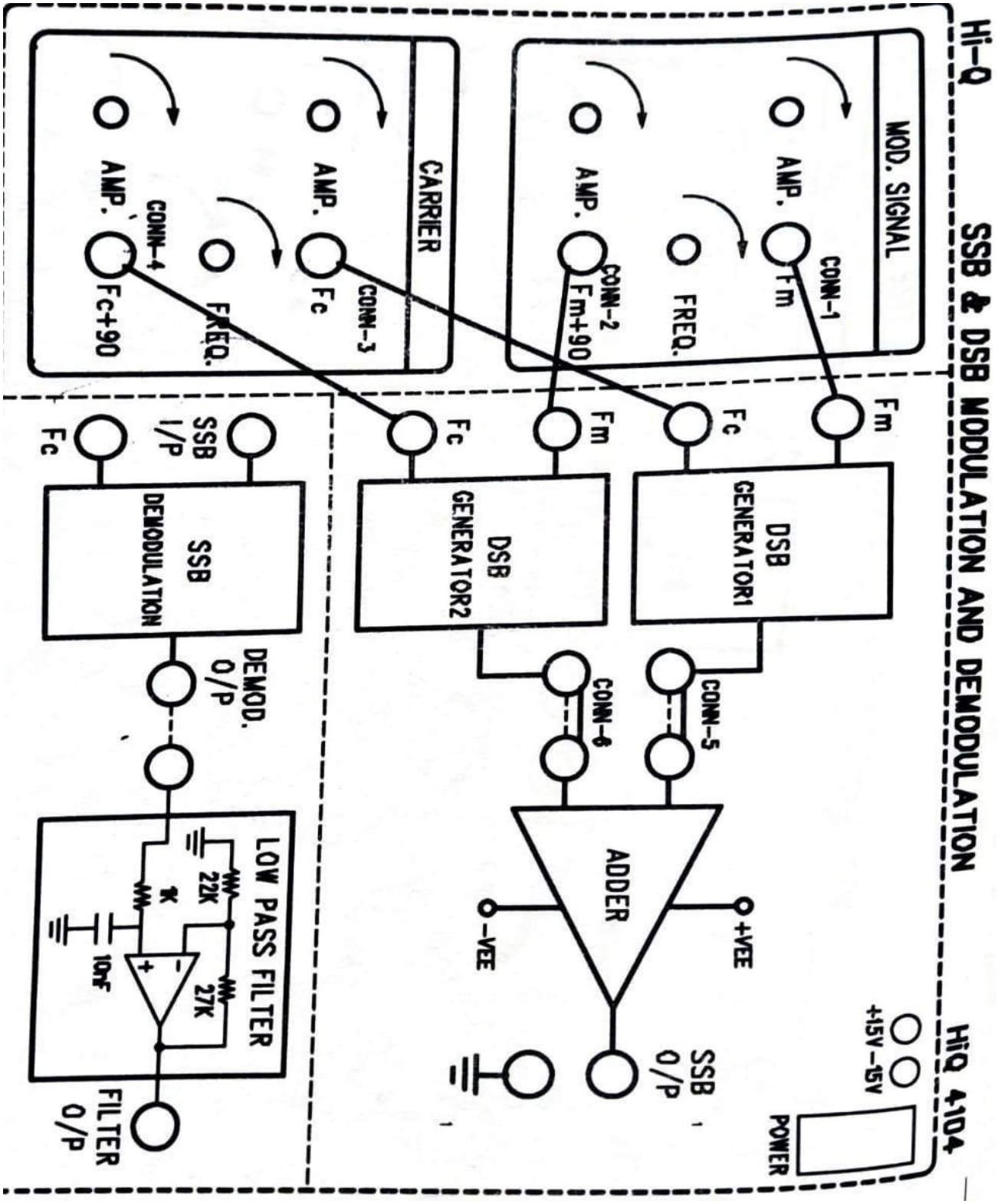


Fig.3.1

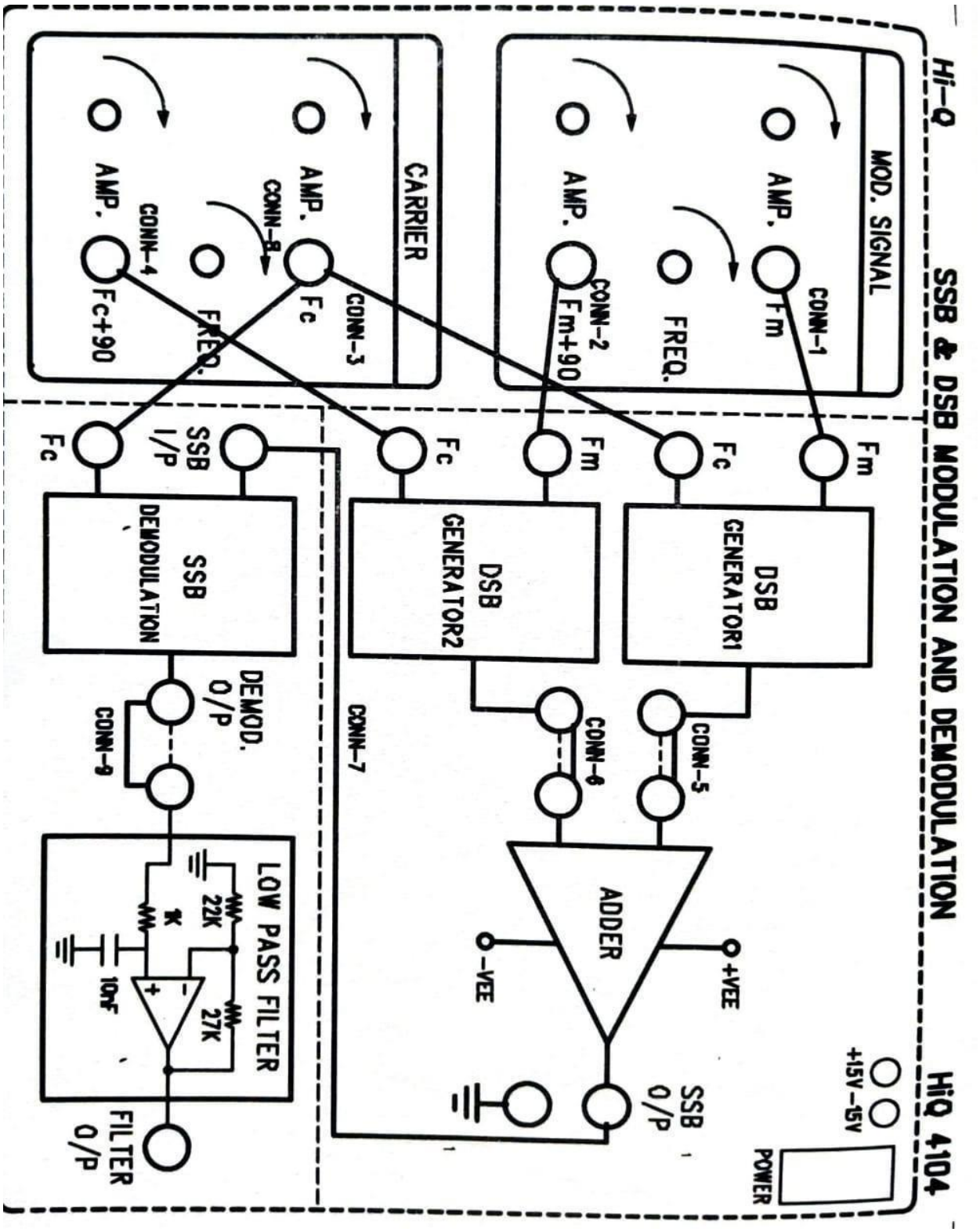
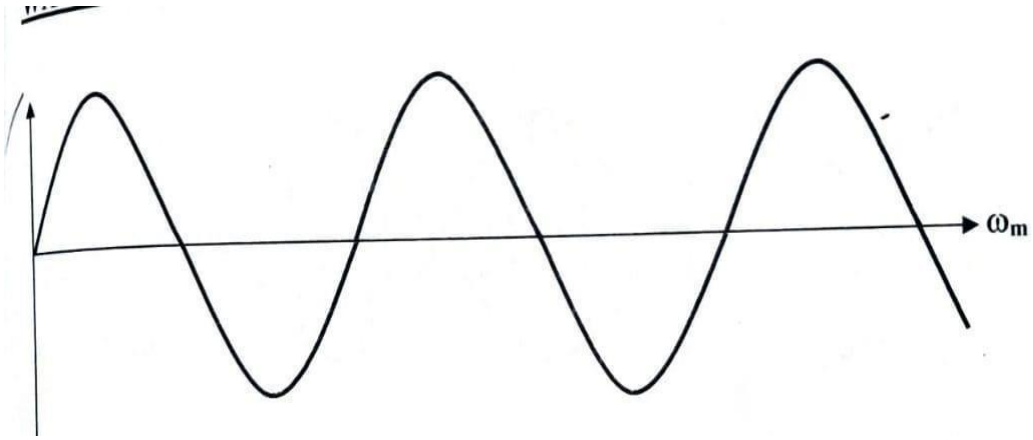
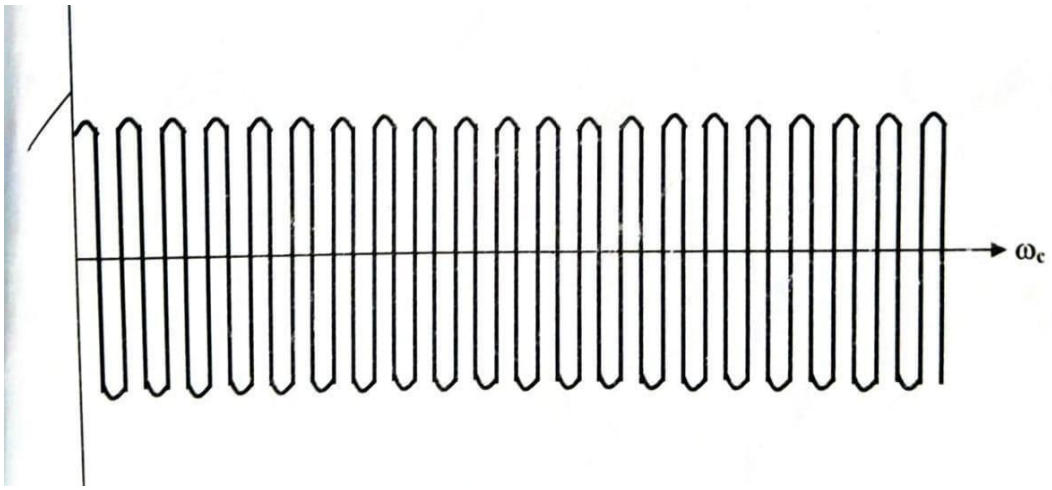
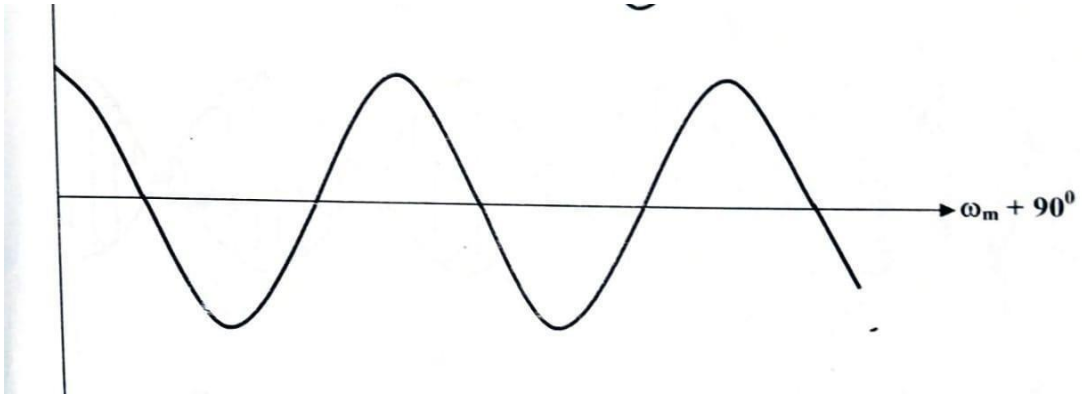

Hi-Q
SSB & DSB MODULATION AND DEMODULATION
HiQ 4104
MOD. SIGNAL
CARRIER
AMP.
FREQ.
CONN-1
CONN-2
CONN-3
CONN-4
CONN-5
CONN-6
CONN-7
CONN-8
CONN-9
Fm
Fm+90
Fc
Fc+90
DSB GENERATOR1
DSB GENERATOR2
ADDER
+VEE
-VEE
SSB O/P
+15V -15V
POWER
SSB DEMODULATION
SSB I/P
DEMOD. O/P
LOW PASS FILTER
22K
27K
10nF
FILTER O/P

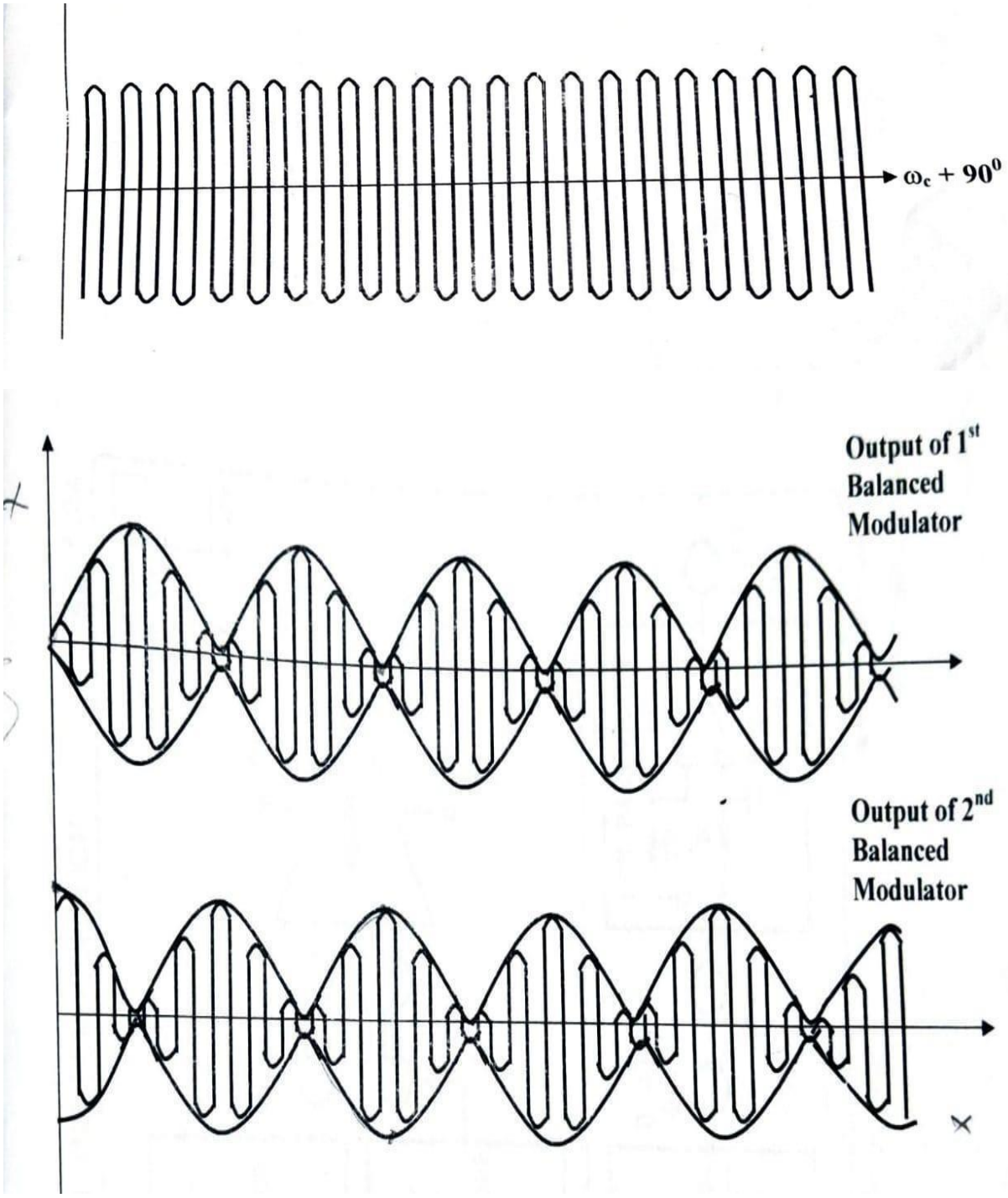
Fig.3.2

Waveforms:








$\omega_c + 90^0$
Output of 1st Balanced Modulator
Output of 2nd Balanced Modulator

Procedure:

Modulation:

1. Switch ON the power supply.
2. Observe the outputs of modulating signal generator .Set
   a. f_m= 1.5KHz & Amp pot in maximum position.
   b. $f_m + 90^o$ = 1.5KHz (Amp pot in maximum position)
   c. f_c = Frequency =35KHz Amp pot in maximum position.
   d. $f_c + 90^o$ = 35KHz Amp pot in maximum position.
   e. Connect the circuit as shown in test diagram.
   f. Connect f_m signal to f_m input of DSB GEN1 & f_c signal to f_c input of DSB GEN1.
   g. Connect $f_m + 90^o$ and $f_c + 90^o$ to inputs of DSB GEN2.
   h. Observe the output of DSB GEN1 by varying the carrier adjust pots.
   i. And also observe the output of DSB GEN 2 by varying the pots make. Connect the outputs of DSB GEN1 &DSB GEN2 to input of adder circuit and observe the SSB output.
   j. In this method of SSB GEN both the LSB signals get added as they are in phase and USB get cancelled. As they are out of phase by 180°. This is the output of LSB SSB
   k. For obtaining USB as the SSB signal connect the circuit as shown in wiring diagrams 3.
   l. Connect f_m and $f_c + 90^o$ to inputs of DSB GEN1.
   m. Connect $f_m + 90^o$ and f_c to inputs of DSB GEN2.
   n. Connect the outputs of DSB GEN1 &DSB GEN2 to input of adder circuit and observe the SSB output. You will get single carrier frequency at SSB output.
   o. In this method of SSB GEN the lower sidebands gets added as they are in phase. This is the output of upper sideband SSB at TP_{15}

Demodulation:

Connect the circuit as shown in test diagram for de-modulation output,

1. For demodulation connect SSB o/p to the SSB demodulator i/p and also connect fc

to SSB demodulation of f_c and observed its o/p.

2. Connect the SSB demodulation output to i/p of low pass filter. And observe filter output as smooth modulating signal.
3. Switch OFF the power supply.

Precautions:

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

VIVA VOCE QUESTIONS:

1. What are the different methods to generate SSB-SC signal?
2. What is the advantage of SSB-SC over DSB-SC?
3. Give the circuit for synchronous detector?
4. What are the uses of synchronous or coherent detector?

4. Frequency Modulation & Demodulation

Aim: To study the process of Frequency modulation & demodulation and to calculate the depth of the modulation.

Apparatus:

1. Hi-Q Test Equipment Pvt Ltd amplitude modulation and demodulation trainer kit
2. CRO-20MHZ dual channel
3. Patch Chords

Theory:

In frequency Modulation the frequency of the carrier is varied in accordance with the instantaneous values of the modulating signal. Thus the amplitude of the carrier does not change due to frequency modulation. This is an advantage, since any incidental disturbances such as atmospheric disturbances or man-made static primarily appears in the form of variation of amplitude of the carrier voltage and may be eliminated in a frequency modulated Receiver which is made insensitive to amplitude variation.

The frequency variation in the carrier called the frequency deviation is proportional to the instantaneous value of the modulating voltage. The frequency deviation is represented by f_d & given as

$f_d = f_{max} - f_c$ or $f_c - f_{min}$

Where f_c = carrier frequency

$f_{max} = f_c + k_f V_m / 2\Pi$

$f_{min} = f_c - k_f V_m / 2\Pi$

where k_f = constant of proportionality

V_m = modulating signal voltage

$V_m = V_m \cos \omega_m t$

$V_c = V_c \cos \omega_c t$

The modulation Index mf of FM is

$\text{ɞ} = m_f = f_d/f_m = \omega_d/\omega_m = k_f v_m / w_m$

the example for the FM voltage is

$V = Vc \sin(\omega_c + m_f \sin \omega_m t)$

Circuit Diagram:

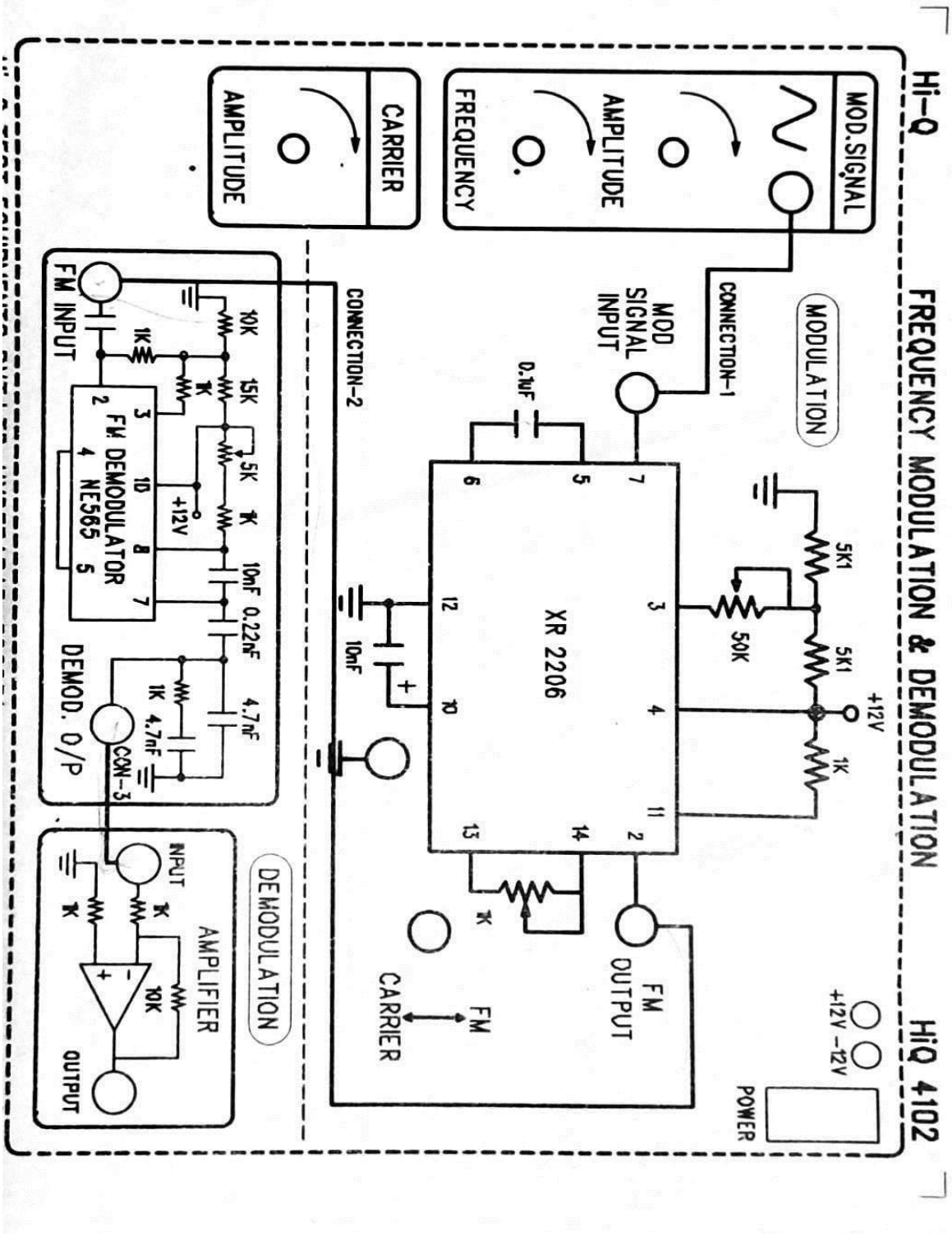
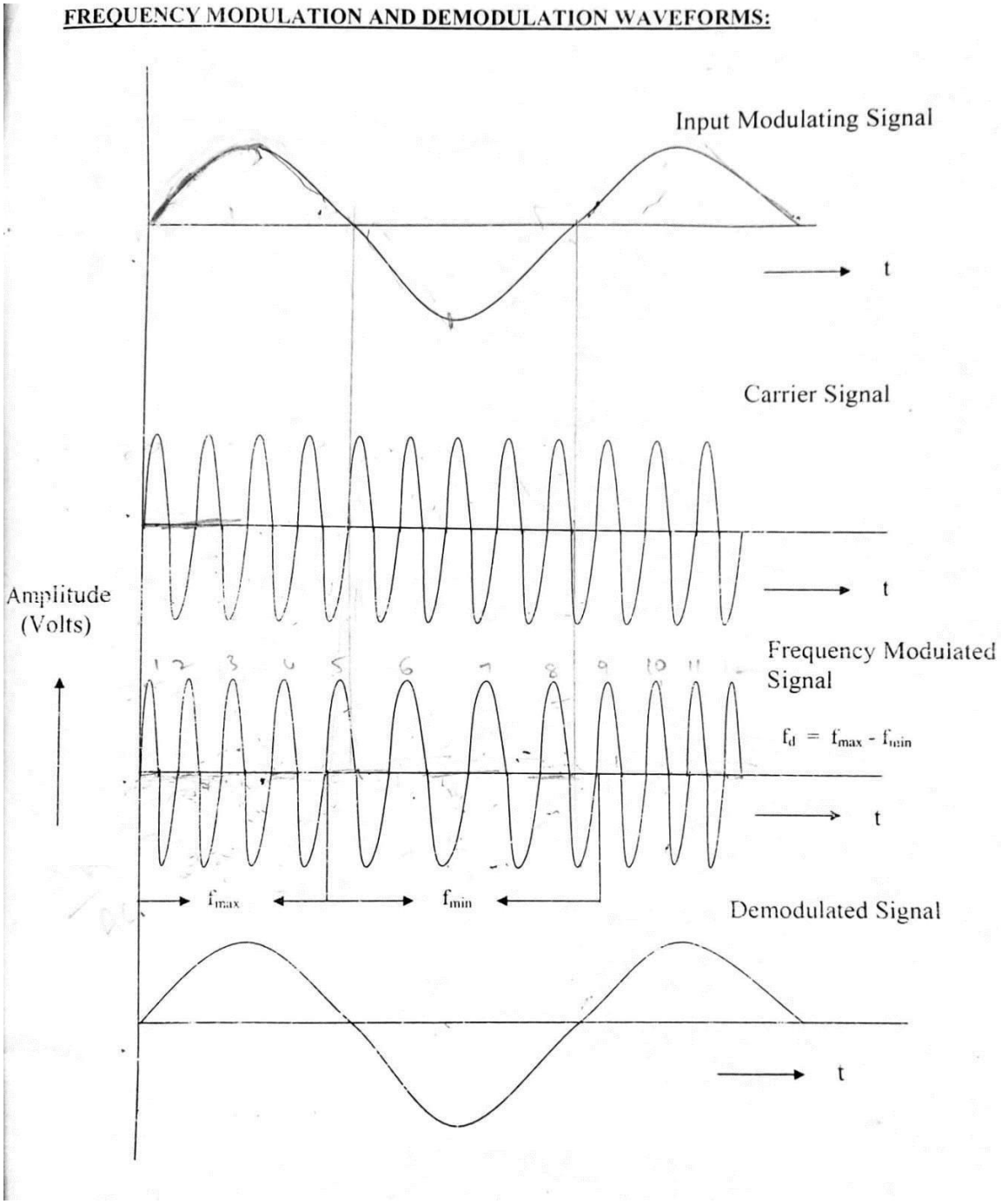


Fig 4.1

Waveforms:


FREQUENCY MODULATION AND DEMODULATION WAVEFORMS:
Input Modulating Signal
t
Carrier Signal
t
Amplitude (Volts)
Frequency Modulated Signal
$f_d = f_{max} - f_{min}$
t
f_{max}
f_{min}
Demodulated Signal
t

Procedure:-

Modulation:

1. Connect the circuit as shown for modulation type-1.
2. Switch On the power supply.
   a. The sine wave from the modulating signal generator, to modulating signal input.
   b. Adjust the amplitude of the modulating signal in modulating signal generator 3V p-p and frequency of the modulating signal 1KHZ by varying the respective pots.
   c. Adjust the carrier frequency to 16KHz
3. Observe the Frequency Modulator output on CRO.
4. Switch OFF the Power supply.

Demodulation:

1. Connect the circuit as shown in test diagram for demodulation type-1.
   a. The sine wave from the modulating signal generator, to modulating signal input.
   b. Adjust the amplitude of the modulating signal in modulating signal generator 3V p-p and frequency of the modulating signal 1KHZ by varying the respective pots.
   c. Frequency Modulator output
   d. Output of FM De-Modulation to AC amplifier input.
2. Switch ON power supply.
3. Observe the demodulated output on CRO and the output is th exact replica of the input.
4. Switch OFF the Power supply.

Precautions:

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

VIVA - VOCE QUESTIONS:

1. Define FM & PM.
2. What are the advantages of Angle modulation over amplitude modulation?
3. What is the relationship between PM and FM?
4. With a neat block diagram explain how PM is generated using FM ?

5. Pre Emphasis – De Emphasis Circuits

Aim:

1. To study the Pre- emphasis and De-emphasis circuits.
2. To calculate the gain of Pre -emphasis and De-emphasis.
3. To plot the corresponding frequency response curves.

Apparatus:

1. Pre-Emphasis and De-Emphasis Trainer kit
2. CRO-20MHZ dual channel
3. Patch Chords
4. Connecting Wires

Theory:

Noise produces greater effect on the higher modulating frequencies, than on the lower ones. It is therefore desirable that the higher modulating frequencies.

-emphasis and de-emphasis is system used for improving the signal to noise ratio of the recovered audio at the receiver. No amount of filtering will remove noise from the RF circuits, but noise control in the low frequency amplifiers is achieved through a high pass filter at the transmitter (Pre-Emphasis) and low pass filter at the receiver (De-Emphasis)

This greatly improves the noise immunity at these higher modulating frequencies. The boosting of the higher modulation frequency at the transmitter in any desired manner is called pre-emphasis. While the relative attenuation of these higher modulating frequencies at the demodulation output in the receiver is called de-emphasis.

The amount of Pre-emphasis in U.S frequency modulation broad casting, and in the sound transmission accompanying television, has been standardized at 75 micro seconds, where as a number of other services, notably CCIR and Australian TV sound transmission, used 50 micro seconds. The usage of micro seconds for defining emphasis is standard. A 75 micro seconds de-emphasis corresponds to a frequency curve that is 3DB down at the frequency whose time constant RC is 75 micro seconds. This frequency is given by

$$f1 = 1/(2\Pi RC) \text{ and is therefore } 2122Hz.$$

The dB increased for any frequency over the range can be found as,

$$\text{dB gain} = 20 \log \sqrt{1 + (f/f_1)^2}$$

Where f1 is the frequency at the 3dB point and f is the frequency under investigation.

The de-emphasis characteristic curve 75 micro seconds is determined as

$$dB\ loss = 20 \log 1/\sqrt{1 + (f/f_1)^2}$$

The dB improvement in the signal to noise ratio at any frequency is found as the power ratio,

$$dB = 10 \log (1/3) (f/f_1)^2$$

Circuit Diagrams:

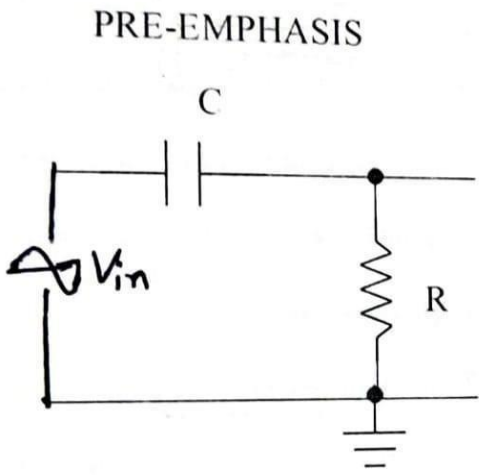


Fig 5.1

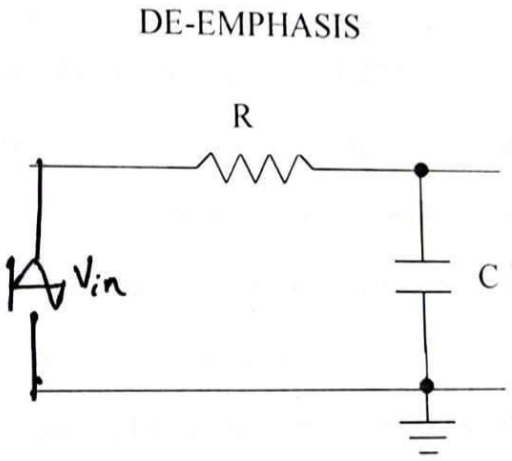
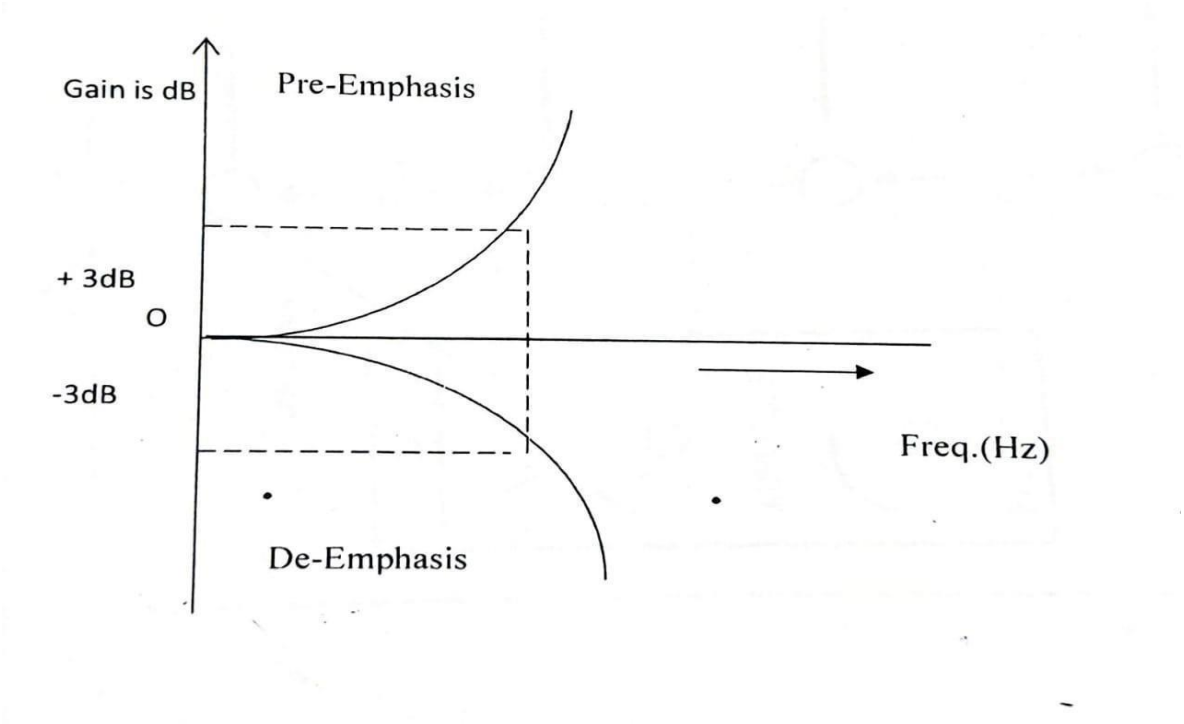


Fig 5.2



Procedure:

Pre-emphasis:

1. Connect the circuit as shown in test diagram for output.
2. Switch on the power supply.
    a. Set input frequency of 200Hz and amplitude of 2v(p-p)
    b. Output of sine wave generator to the input of pre emphasis circuit.
    c. Vary the amplitude pot in the function generator, so that the sine wave amplitude is 2 volts.
    d. Vary the frequency pot in function generator, so the frequency of the sine wave is 1000Hz.
3. Observe the output on the oscilloscope.
4. Now, observe the pre-emphasis output for different frequencies of the sine wave.
5. Switch OFF the power supply.

De-emphasis:

1. Connect the circuit as shown in test diagram for De-emphasis.
2. Switch ON the power supply
3. Set input frequency 200Hz and amplitude of 2v (P-P).
    a. Output of sine wave generator

b. Vary the amplitude pot in the function generator, son that the sine wave Amplitude is 2 volts.

c. Vary the frequency pot in function generator, so the frequency of the sine Wave is 1000Hz.

d. Observe the output on the oscilloscope.

4. Now, observe the De-emphasis output for different frequencies of the sine wave.
5. Switch OFF the power supply.

Observations:

Pre -Emphasis:

Frequency under Investigation (Hz)	Output Voltage (Volts)	Gain = V_o/V_i	Gain (dB) = 20 log 1+ $(f/f_1)^2$

De-Emphasis:

Frequency under Investigation (Hz)	Output Voltage (Volts)	Gain = V_o/V_i	Gain (dB) = 20 log 1+ $(f/f_1)^2$

Precautions:

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

VIVA-VOCE QUESTIONS:

1. What is the need for pre-emphasis?
2. Explain the operation of pre-emphasis circuit?
3. Pre emphasis operation is similar to high pass filter explain how?
4. De-emphasis operKJIUJ98Y80ation is similar to low pass filter justify?
5. What is de-emphasis? 6. Draw the frequency response of a pre-emphasis circui

6. Verification of Sampling Theorem

Aim:

1. To study the sampling theorem & its reconstruction.
2. To study the effect of amplitude & frequency variation of modulating signal on the output.
3. To study the effect of variation of sampling frequency on the demodulated output.

Apparatus:

1. Hi-Q test Equipment Pvt Ltd Sampling & Reconstruction kit.
2. CRO-20MHZ dual channel
3. Patch cords.

Theory:

The statement of sampling theorem can be given in two parts as:

i. A band-limited signal of finite energy, which has no frequency component higher than fm Hz, is completely described by its sample values at uniform intervals less or equal to ½ fm

ii. A band-limited signal of finite energy, which has no frequency components higher than fm Hz, may be completely recovered from the knowledge of its samples taken at the rate of 2fm samples per second.

"A continuous time signal may be completely represented in its samples & recovered back if the sampling frequency is

$$f_s >> 2f_m.$$

Here fs is the sampling frequency and fm is the maximum frequency present in the signal."

Circuit Diagram:

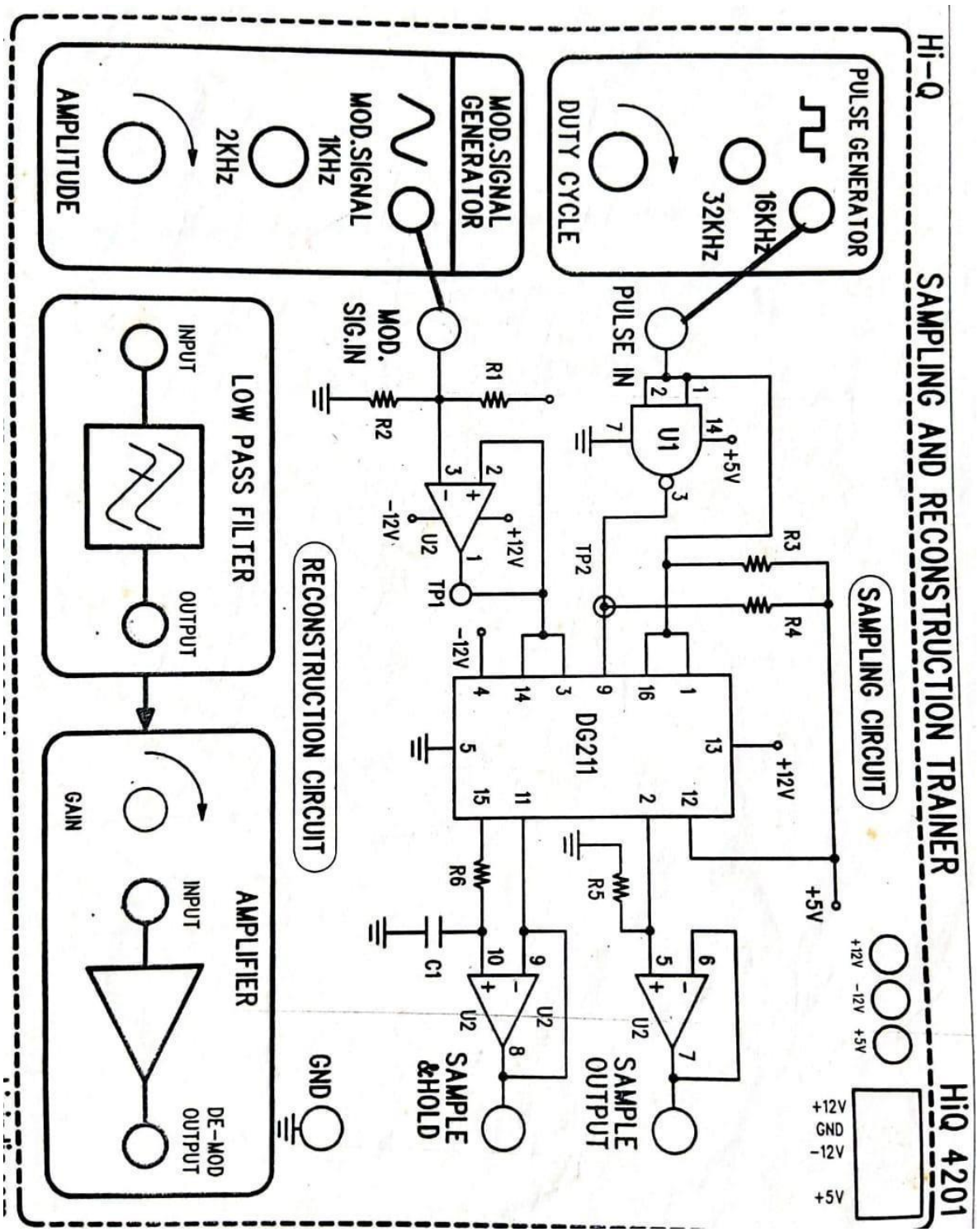
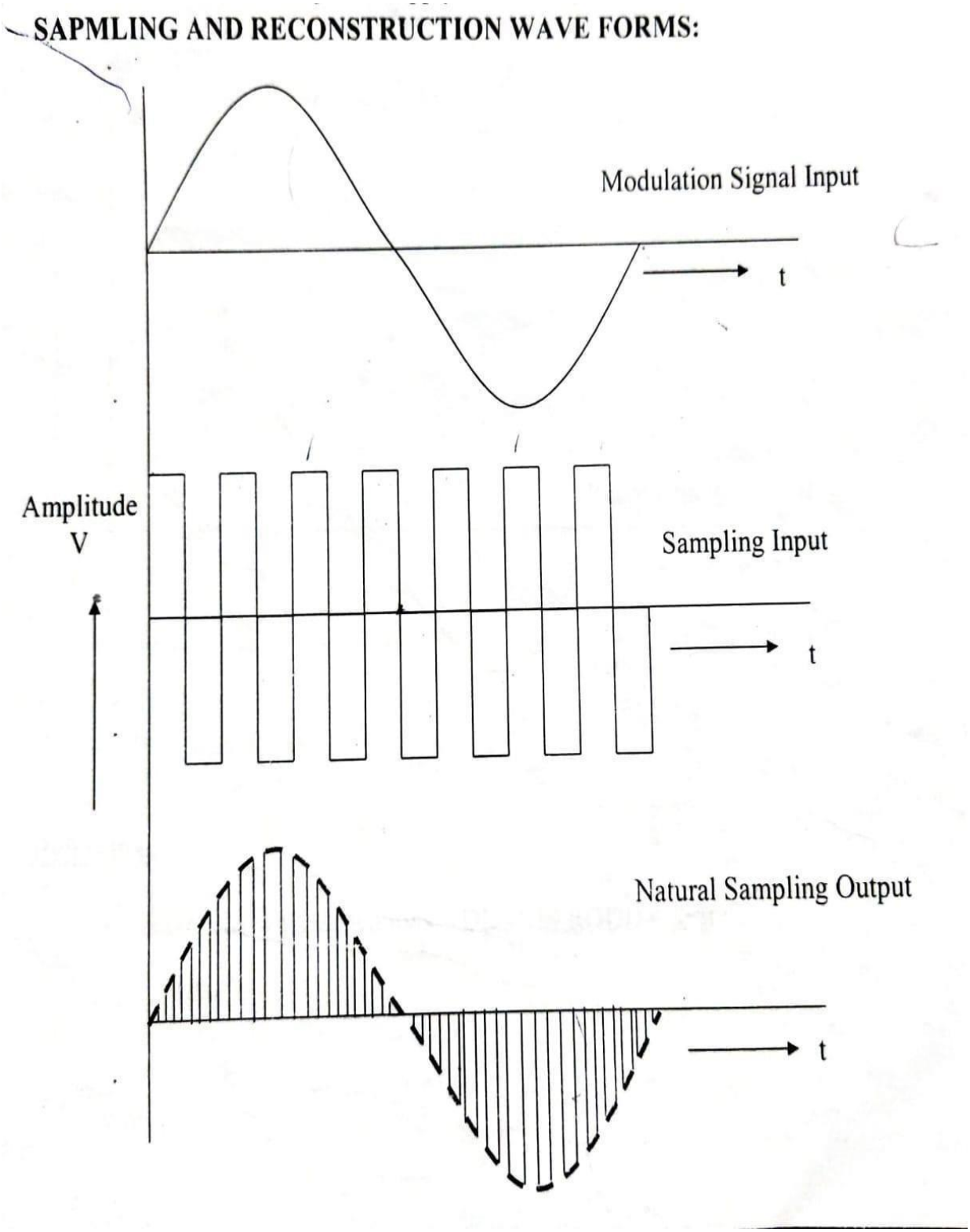
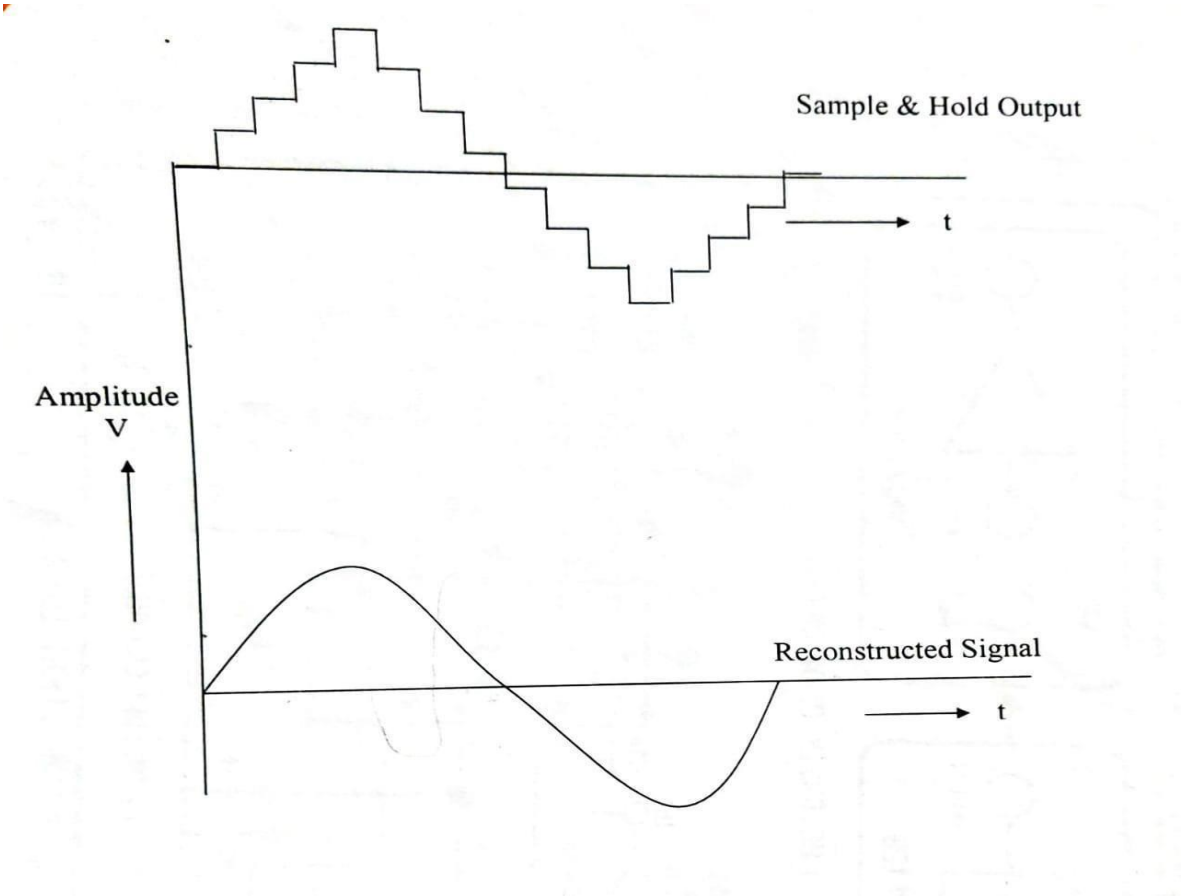


Fig 6.1

Waveforms:


SAPMLING AND RECONSTRUCTION WAVE FORMS:
Modulation Signal Input
t
Amplitude
V
Sampling Input
t
Natural Sampling Output
t



Procedure:

Sampling:

1. Connect the circuit as shown in the diagram 1
   a) Output of modulating signal generator to modulating signal input in sampling circuit keeping the switch in 1 KHz position & amplitude pot to max position.
   b) Output of pulse generator to sampling pulse input in sampling circuit keeping the switch 16 KHz position (Adjust the duty cycle pot to mid position i.e. 50%)
2. Switch ON the power supply.
3. Observe the outputs of sampling, sampling hold & flat top output. By varying the amplitude pot also observe the effect on outputs.
4. By varying duty cycle pot observe the effect on sampling outputs (Duty cycle is varying from 10-50%)
5. Vary the switch position in the pulse generator circuit to 32 KHz and now observe the outputs. By varying the amplitude pot also observe the effect on outputs.
6. Now, vary the switch position in modulating signal generation to 2KHz & repeat all

the above steps 3&4.

7. Switch OFF the power supply.

Recontruction:

1. Connect the circuit as shown in the diagram 2.

   a) Output of modulating signal generator to modulating signal input in sampling circuit keeping the switch in 1 KHz position & amplitude pot to max position.

   b) Output of pulse generator to sampling pulse input in sampling circuit keeping the switch 16KHz position (Adjust the duty cycle pot to mid position i.e. 50%)

   c) Connect the sample output to the input of low pass filter.

   d) Output of low pass filter to input of AC amplifier, keep the gain pot in AC amplifier to max position.

2. Switch the power supply.
3. Observe the output of AC amplifier. The output will be the replica of the input. By varying the gain pot observe the demodulating signal amplification.
4. Similarly connect the sample and hold output and observe reconstructed signal.
5. Vary the switch position in the sampling frequency circuit to 32 KHz and now repeat the steps 3 & 4.
6. Vary the switch position in the Modulating signal generator to 2 KHz and repeat all the above steps 3 to 5.
7. Switch OFF the power supply.

Precautions:

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

VIVA-VOCE QUESTIONS:

1. What are the types of sampling?
2. State sampling theorem?
3. What happens when fs < 2 fm?
4. Explain the operation of sampling circuit?

7. Pulse Amplitude Modulation and Demodulation

Aim:

1. To study the Pulse Amplitude modulation and demodulation Techniques.
2. To study the effect of amplitude & frequency variation of modulating signal on the output.

Apparatus:

1. Hi-Q test Equipment Pvt Ltd Pulse Amplitude modulation and demodulation kit.
2. CRO-20MHZ dual channel
3. Patch cords.

Theory:

Pulse modulation may be used to transmit analog information. It is a system in which continuous waveforms are sampled at regular intervals. Information regarding the signal is transmitted only at the sampling times, together with any synchronizing pulses that may be required.

At the receiving end, the original waveforms may be reconstituted from the information regarding the samples.

The Pulse Amplitude Modulation is the simplest form of the pulse Modulation. PAM is a pulse modulation system is which the signal is sampled at regular intervals, and each sample is made proportional to the amplitude of the signal at the instant of sampling. The pulses are then sent by either wire or cables are used to modulate carrier.

The two types of PAM are (i) Double polarity PAM, and (ii) The single polarity PAM, in which a fixed dc level is added to the signal to ensure that the pulse is always positive. Instantaneous PAM sampling occurs if the pulses used in the modulator are infinitely short.

Natural PAM sampling occurs when finite -width pulses are used in the modulator, but the tops of the pulses are forced to follow the modulating waveform.

Flat-topped sampling is a system quite often used because of the ease of generating the modulated wave.

PAM signals are very rarely used for transmission purposes directly. The reason for this lies in the fact that the modulating information is contained in the amplitude factor of the pulses, which can be easily distorted during transmission by noise, crosstalk, or other forms of distortion. They are used frequently as an intermediate step in other pulse modulating methods, especially where time division multiplexing is used.

Circuit Diagram:

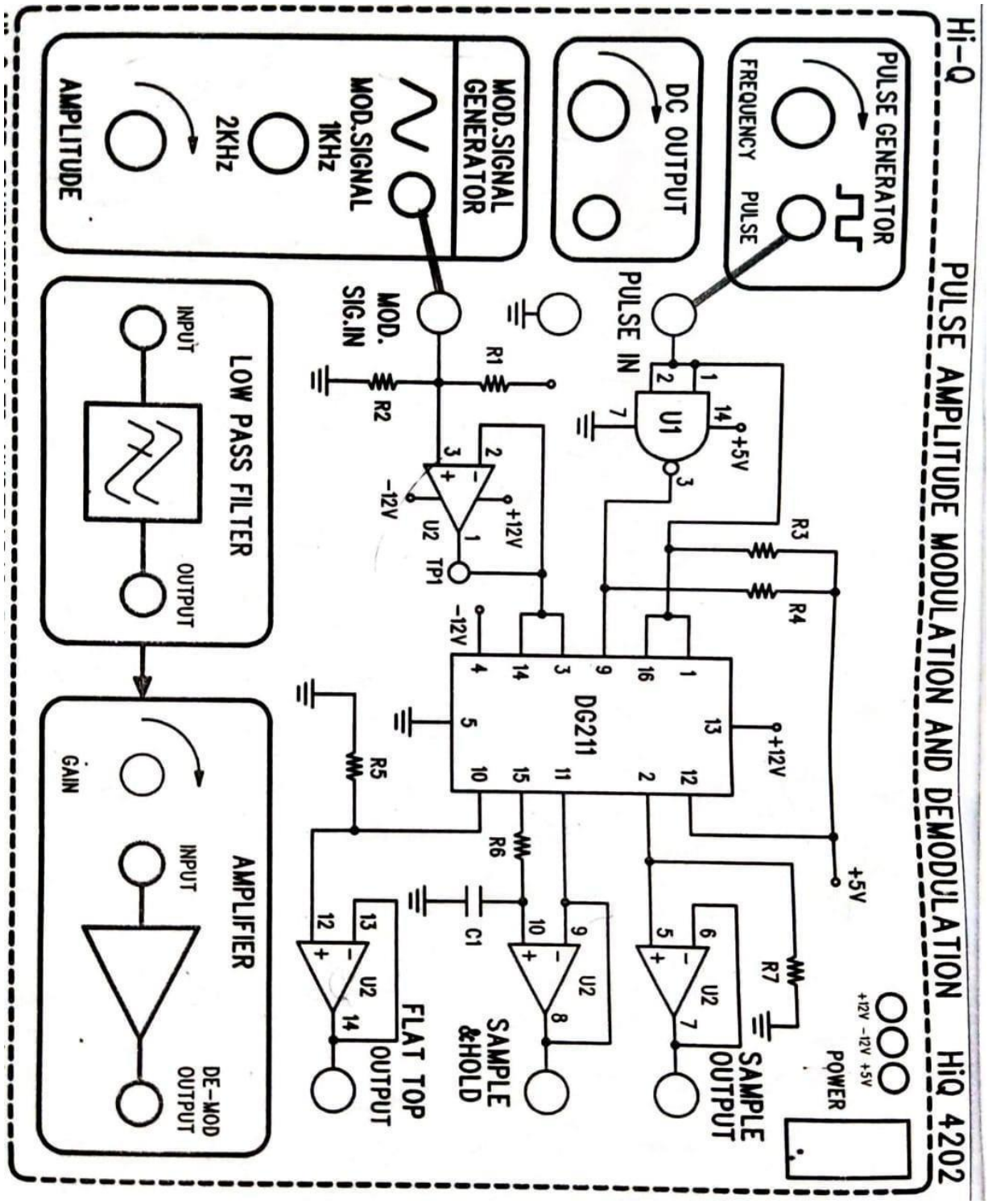


Fig.7.1

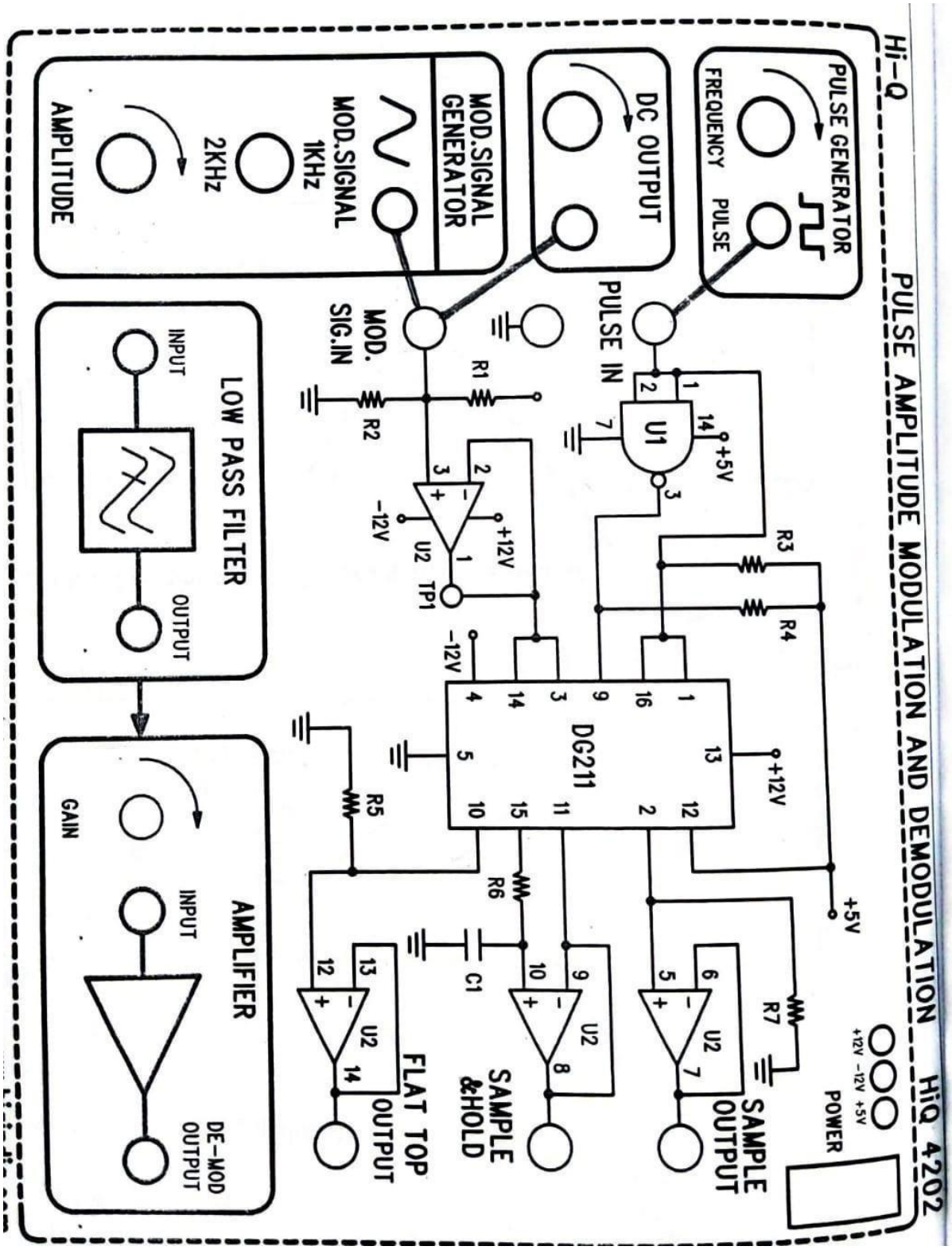
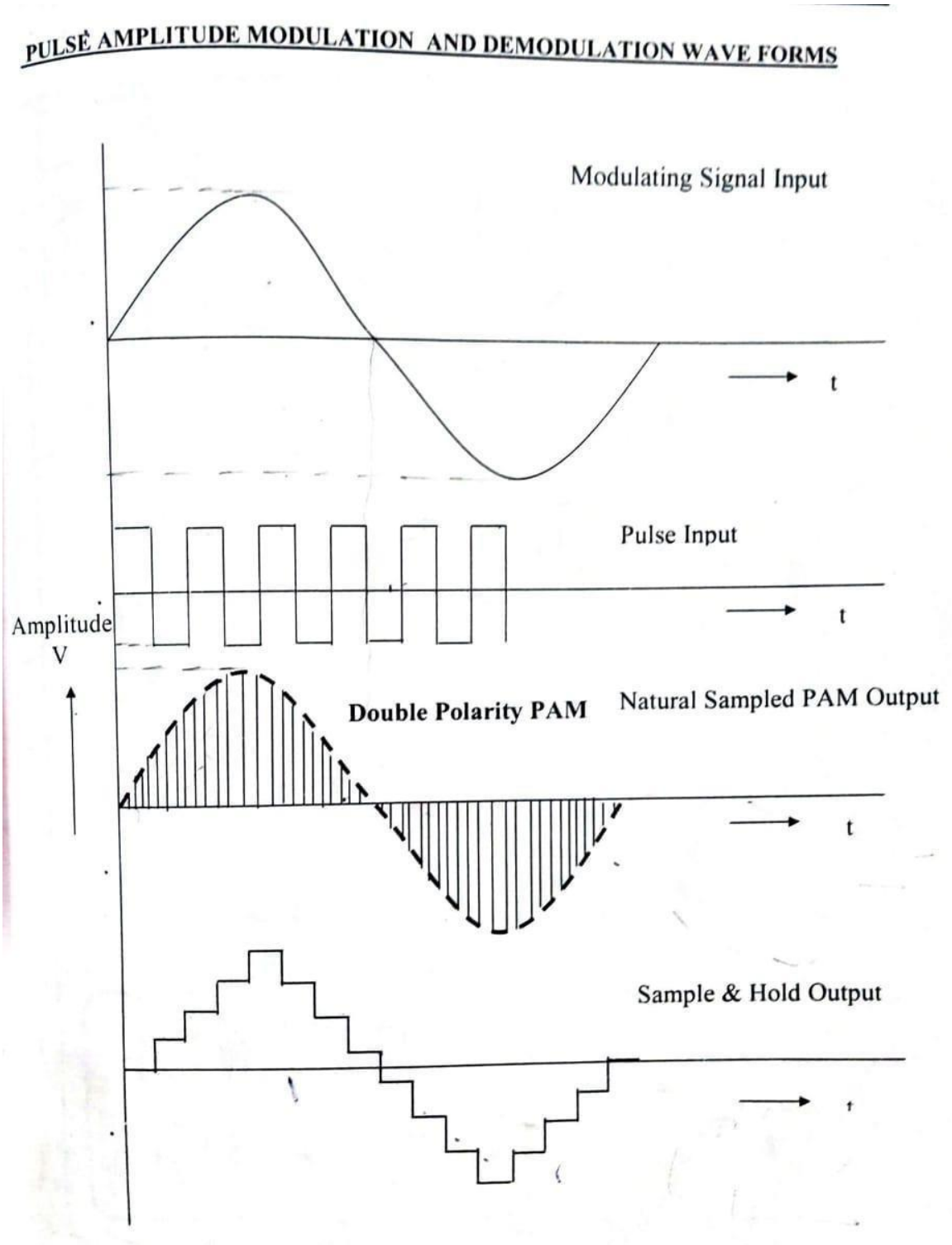

Hi-Q
PULSE AMPLITUDE MODULATION AND DEMODULATION HiQ 4202
PULSE GENERATOR
FREQUENCY
PULSE
DC OUTPUT
MOD.SIGNAL GENERATOR
MOD.SIGNAL
1KHz
2KHz
AMPLITUDE
PULSE IN
MOD. SIG.IN
U1
+5V
R1
R2
R3
R4
R5
R6
R7
C1
-12V
+12V
U2
TP1
DG211
+12V
+5V
SAMPLE OUTPUT
SAMPLE &HOLD
FLAT TOP OUTPUT
POWER
+12V -12V +5V
LOW PASS FILTER
INPUT
OUTPUT
AMPLIFIER
INPUT
GAIN
DE-MOD OUTPUT

Fig.7.2

Waveforms:


PULSE AMPLITUDE MODULATION AND DEMODULATION WAVE FORMS
Modulating Signal Input
t
Pulse Input
t
Amplitude
V
Double Polarity PAM
Natural Sampled PAM Output
t
Sample & Hold Output
t

Procedure:-

Double Polarity:-

Modulation:-

1. Connect the circuit as shown in diagram 1.
    a. Output of the sine wave to modulating signal input TP2 keeping the switch in 1 KHz position, and amplitude pot to max position.
    b. 16 KHz pulse output to pulse input. (Keep the frequency pot in minimum position in pulse generator block).
2. Switch ON the power supply.
3. Observe the outputs also by varying amplitude pot (which is in modulation signal generator block).
4. Now vary the frequency selection switch position in modulating signal generator block to 2 KHz, amplitude pot in max position.
5. Repeat all the above steps for the pulse frequency 32 KHz (By varying the Frequency pot in the pulse generator block).
6. Switch OFF the power supply.
7. Connect the circuit as shown in diagram 2.
    a. Output of the sine wave to modulating signal input keeping the switch in 1 KHz position, amplitude pot in max position.
    b. 16 KHz pulse output to pulse input.
8. Switch ON the power supply.
9. Repeat the above steps 3 to 6, and observe the outputs.
10. Vary the DC output pot until you get single polarity PAM.
11. Switch OFF the power supply.

Demodulation:

1. Connect the circuit as shown in diagram 3.
    a. Output of the sine wave to modulating signal input keeping the switch in 1 KHz position, amplitude pot in max position.
    b. 16 KHz pulse output to pulse input.

c. Sample output, sample and hold output and Flat-Top outputs respectively to the input of low pass filter and LPF output to AC Amplifier input.

2. Observe the output of low pass filter and AC Amplifier, corresponding to inputs, the outputs will be the true replica of the input.
3. Now, set the switch position in modulating signal generator to 2 KHz and observe the outputs, corresponding to inputs.
4. Vary the frequency of the pulse to 32 KHz (put it in max. position) and repeat the above steps 2 & 3.
5. Switch OFF the power supply.

Precautions:

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

VIVA-VOCE QUESTIONS:

1. What is the minimum rate at which a speech signal can be sampled for the purpose of PAM?
2. What is cross talk in the context of time division multiplexing?
3. Which is better, natural sampling or flat topped sampling and why?

8. Pulse Width Modulation and Pulse Position Modulation: Generation and Reconstruction

(a) Pulse Width Modulation: Generation and Reconstruction

Aim:

1. To study the Pulse Width Modulation and Demodulation Techniques.
2. To study the effect of Amplitude and Frequency of Modulating Signal on PWM output.

Equipment:

1. Hi-Q Test Equipment Pvt. Ltd.
   Pulse Width Modulation and Demodulation Trainer kit
2. Oscilloscope-20 MHz Dual channel.
3. Patch Chords.

Theory:

Pulse Modulation is used to transmit analog information. In this system continuous wave forms are sampled at regular intervals. Information regarding the signal is transmitted only at the sampling times together with synchronizing signals.

At the receiving end, the original 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) & less often Pulse length Modulation (PLM).

In Pulse Width Modulation method, we have fixed amplitude 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 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 (at the samplingrate) to control the starting time of pulses from a monostable 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 simple Integrator (LPF)

Circuit Diagrams:

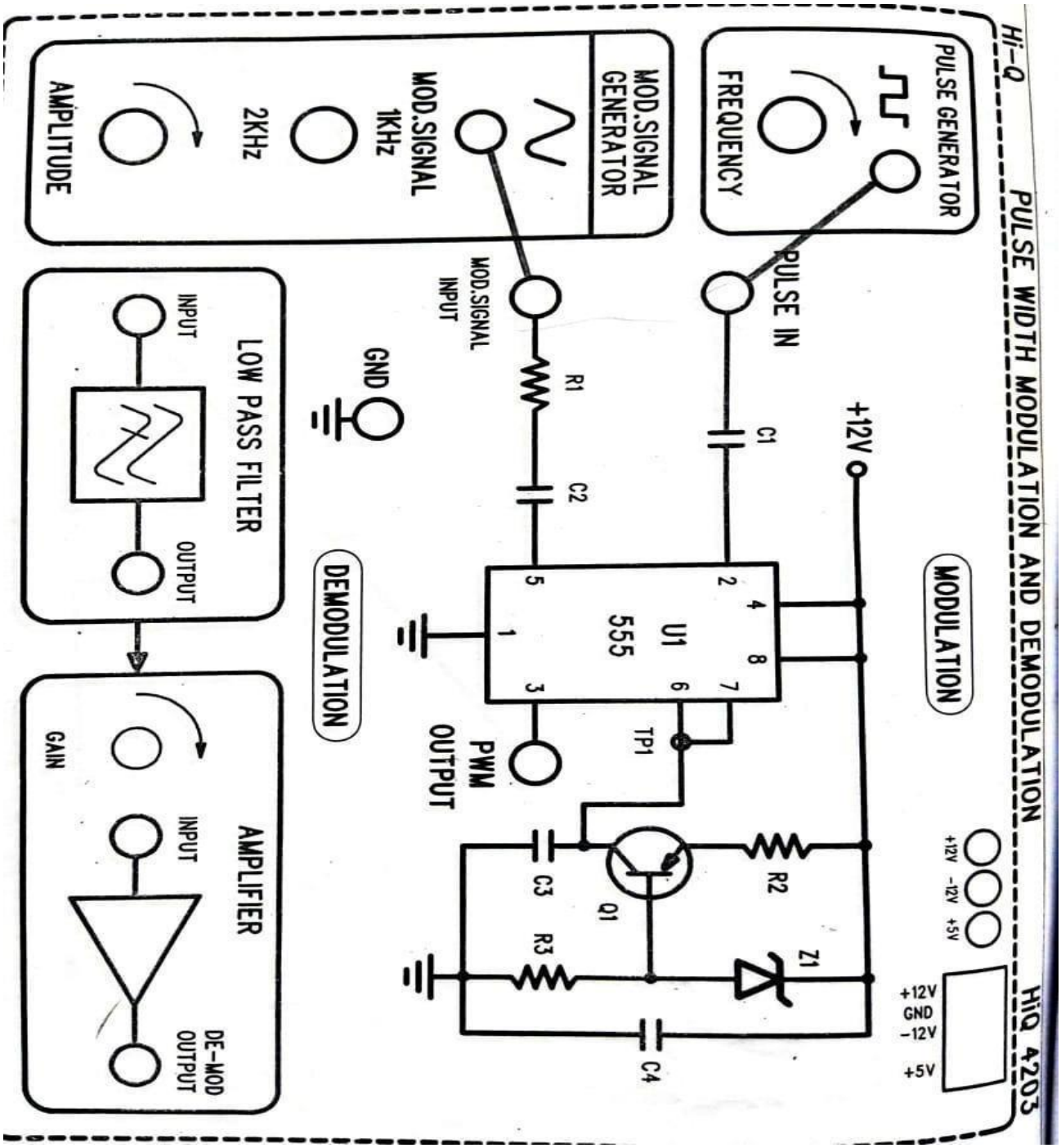


Fig.8.1

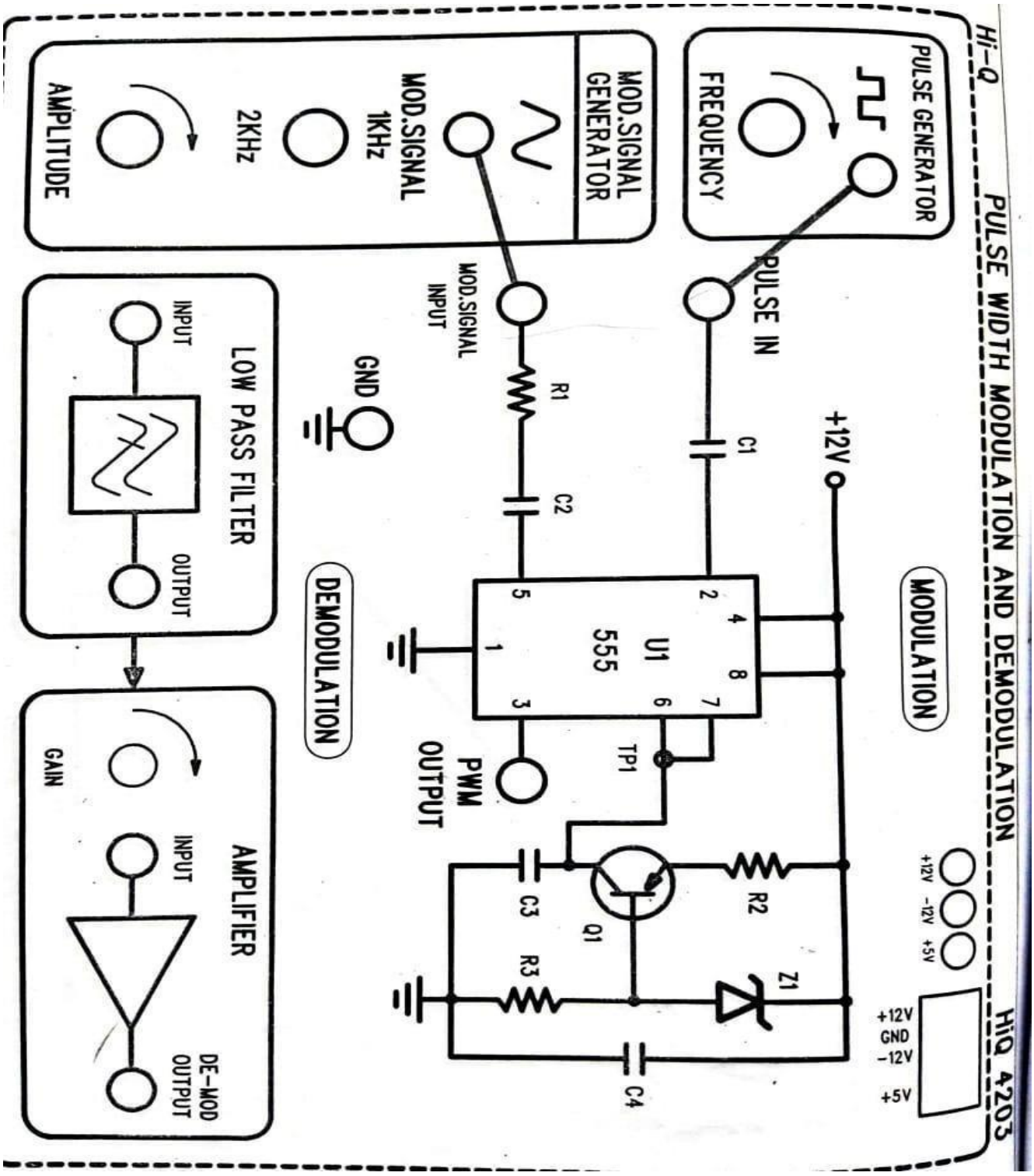
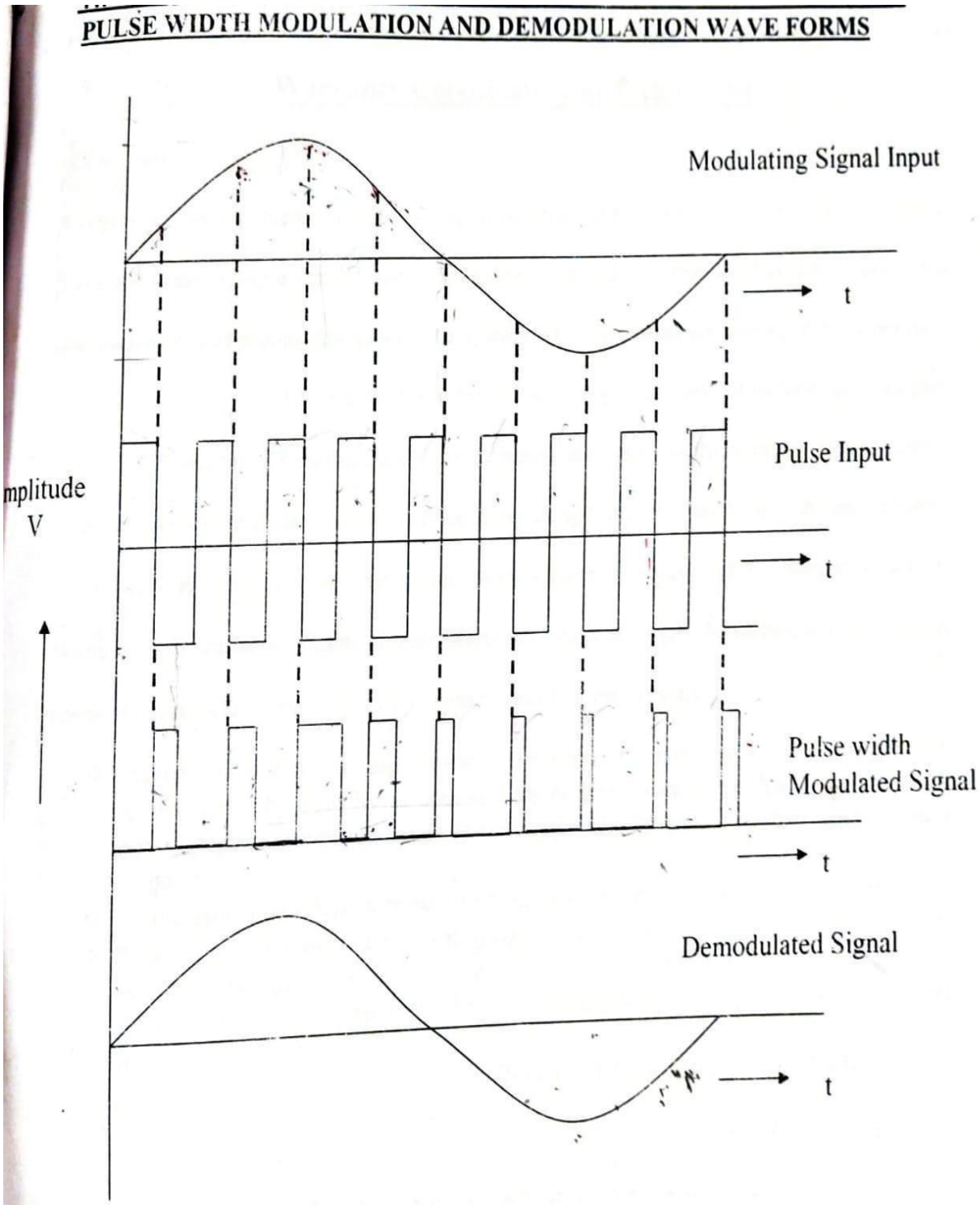

Hi-Q
PULSE WIDTH MODULATION AND DEMODULATION
HiQ 4203
PULSE GENERATOR
FREQUENCY
MOD.SIGNAL GENERATOR
MOD.SIGNAL 1KHz
2KHz
AMPLITUDE
PULSE IN
MOD.SIGNAL INPUT
GND
+12V
C1
C2
R1
U1
555
TP1
PWM OUTPUT
MODULATION
DEMODULATION
R2
C3
R3
Q1
Z1
C4
+12V -12V +5V
+12V
GND
-12V
+5V
LOW PASS FILTER
INPUT
OUTPUT
AMPLIFIER
GAIN
INPUT
DE-MOD OUTPUT

Fig.8.2

Waveforms :


PULSE WIDTH MODULATION AND DEMODULATION WAVE FORMS
Modulating Signal Input
t
Pulse Input
t
mplitude
V
Pulse width
Modulated Signal
t
Demodulated Signal
t

Procedure:

Modulation:

1. Connect the circuit as shown in the diagram 1.
    a. Sine wave output of Modulating signal generator to Modulating signal input (TP2), keeping the switch in 1 KHz position and amplitude pot in max position.
    b. 16 KHz pulse output (by varying the frequency pot (put it minimum position) in pulse generator block) from pulse generator to pulse input.
2. Switch ON the power supply.
3. Observe the output of pulse width modulation block. (By varying the amplitude pot).
4. Vary the modulating signal generator frequency by switching the frequency selector switch to 2 KHz.
5. Now, again observe the PWM output. (By varying the amplitude pot).
6. Repeat the above steps (3 to 5) for the pulse frequency of 32 KHz by varying the frequency pot (put it in maximum position) in pulse generator block.
7. Switch PFF the power supply.

Demodulation:

1. Connect the circuit as shown in diagram 2.
    a. Sine wave output of modulating signal generator block to modulating signal input.
    b. 16 KHz pulse output (put it in minimum position) from pulse generator block to pulse input.
    c. PWM output to LPF input.
    d. LPF output to AC amplifier input.
8. Switch ON the power supply.
9. Observe the output of low pass filter and A.C. amplifier. The output will be the true replica of the input.

10. Now vary the position of the switch in modulating signal generator to 2 KHz and observe the outputs.
11. Repeat the steps 10 & 11 for pulse frequency 32 KHz (By varying the frequency pot (put it in minimum position) in pulse generator block). Observe the output waveforms.
12. Switch OFF the power supply.

Precautions:

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

VIVA-VOCE QUESTIONS:

1. Define PWM?
2. What is the other name for PWM?
3. What is the disadvantage of PWM?
4. Why integrator is required in demodulation of PWM?
5. What kind of conversion is done in PWM generation?

(b) Pulse Position Modulation: Generation and Reconstruction

Aim:

1. To study the generation of Pulse position Modulation and Demodulation Techniques.
2. To study the effect of Amplitude and Frequency of Modulating Signal on its output and observe the wave forms

Equipment:

1. Hi-Q Test Equipment Pvt. Ltd.
   Pulse Position Modulation and Demodulation Trainer kit
2. Oscilloscope-20 MHz Dual channel.
3. Patch Chords.

Theory:

Pulse modulation is used to transmit analog information. In this system continuous wave forms are sampled at regular intervals. Information regarding the signal is transmitted only at the sampling times together with synchronizing signals.

At the receiving end, the original waveforms may be reconstructed 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& 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. However, in PWM the locations of the leading edges are fixed, whereas those of the trailing edges are not.

Their position depends on pulse width, which is determined by the signal amplitude at that instant. Thus, it may be said that the trailing edges of PWM pulses are, in fact, position-modulated. This has positive-going narrow pulses corresponding to leading edges and negative-going pulses corresponding to trailing edges. If the position corresponding to the trailing edge of an un modulated pulse is counted as zero displacement, then the other trailing edges will arrive earlier or later. They will therefore have a time displacement other than zero; this time displacement is proportional to the instantaneous value of the signal voltage. The differentiated pulses corresponding to the leading edges are removed with a diode clipper or rectifier, and the remaining pulses, is position-modulated.

Circuit Diagrams:

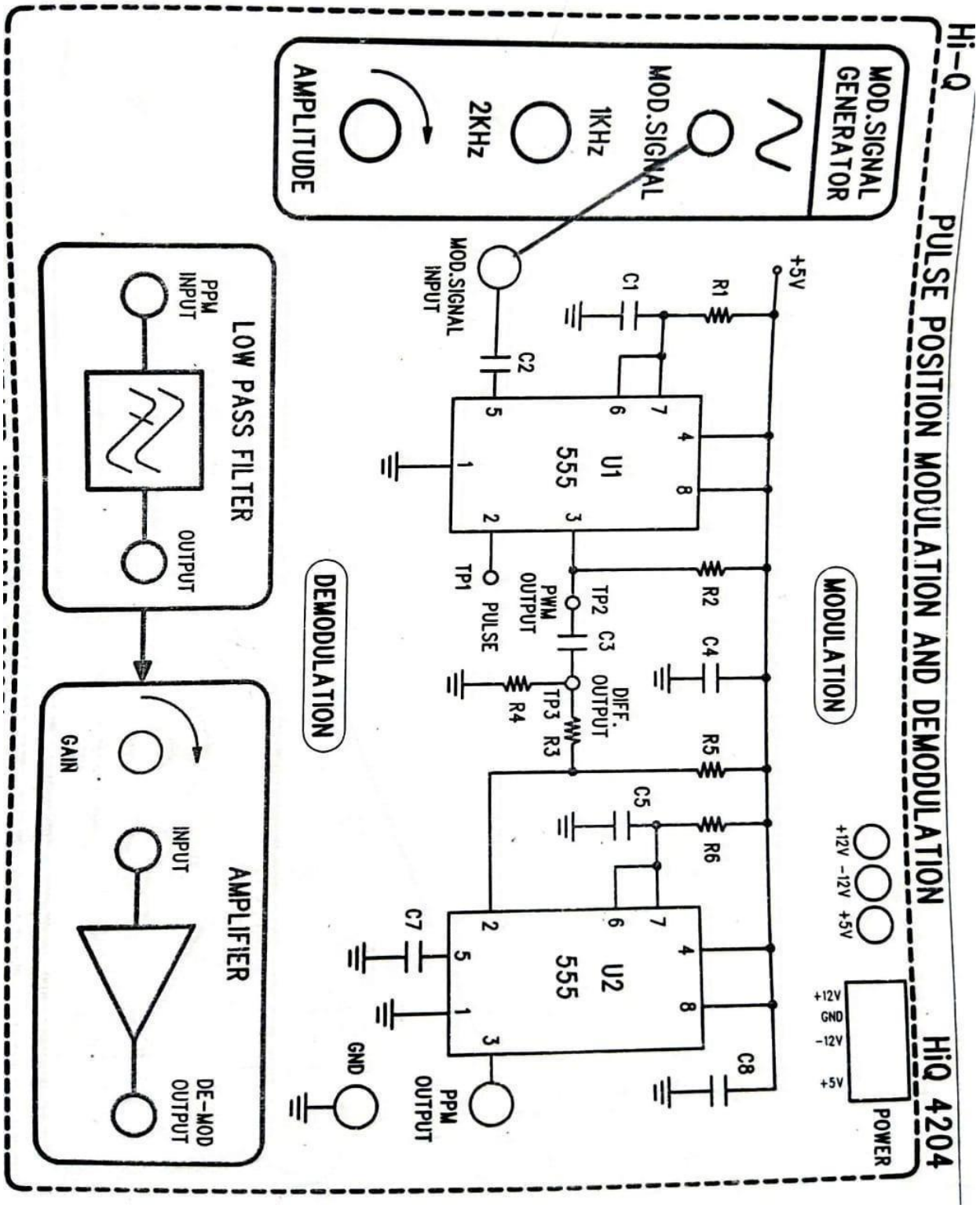


Fig.8.3

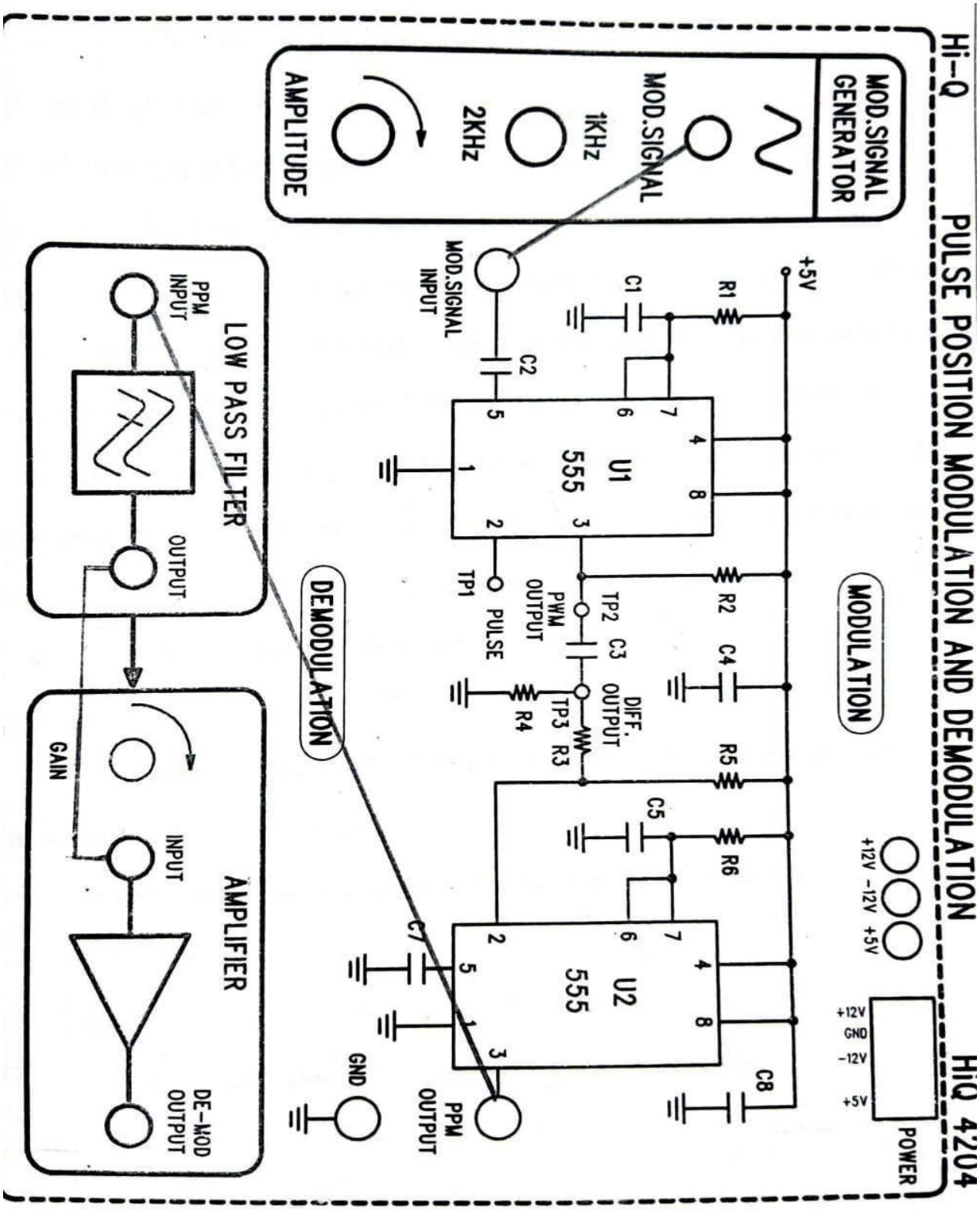
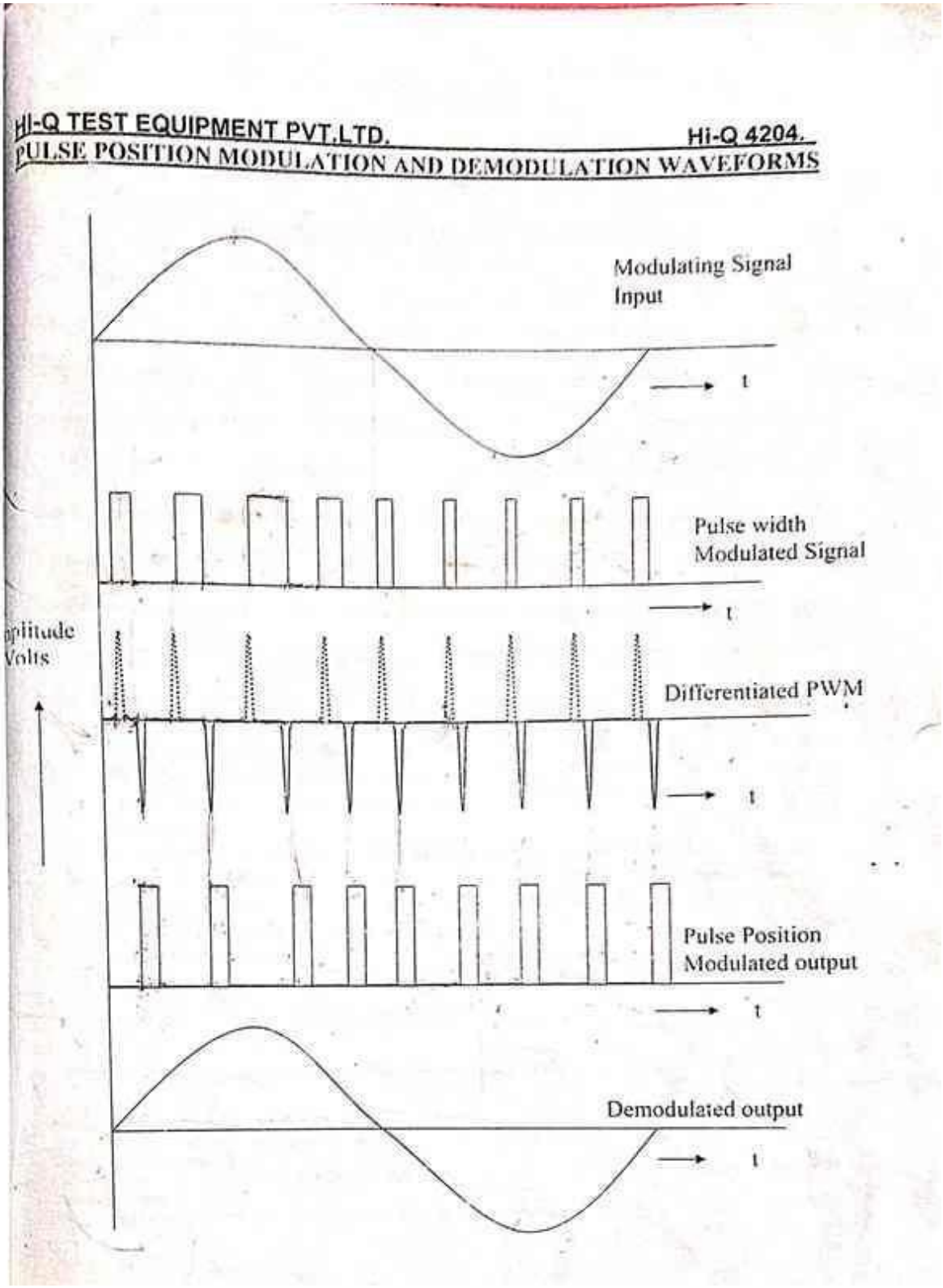

Hi-Q
PULSE POSITION MODULATION AND DEMODULATION
HiQ 4204
MOD.SIGNAL GENERATOR
MOD.SIGNAL
1KHz
2KHz
AMPLITUDE
MOD.SIGNAL INPUT
+5V
R1
C1
C2
U1
555
R2
C4
TP1
PULSE
TP2
PWM OUTPUT
C3
TP3
R3
R4
DIFF. OUTPUT
R5
C5
R6
U2
555
C7
C8
GND
PPM OUTPUT
MODULATION
DEMODULATION
+12V -12V +5V
+12V
GND
-12V
+5V
POWER
LOW PASS FILTER
PPM INPUT
OUTPUT
AMPLIFIER
GAIN
INPUT
DE-MOD OUTPUT

Fig.8.4


HI-Q TEST EQUIPMENT PVT.LTD.
Hi-Q 4204.
PULSE POSITION MODULATION AND DEMODULATION WAVEFORMS
Modulating Signal Input
t
Pulse width Modulated Signal
t
plitude Volts
Differentiated PWM
t
Pulse Position Modulated output
t
Demodulated output
t

Procedure:

Modulation:

1. Connect the circuit as shown in the diagram 1.
   a. Output of the sine wave to modulation signal input in PPM block
   b. Keeping the switch in 1 KHz position and amplitude pot in max position
2. Switch ON the power supply.
3. Observe the PWM output, and the differentiated output signal at TP3.
4. Now, Monitor the PPM output at PPM OUT.
5. Try varying the amplitude & frequency of sine wave by varying amplitude pot and frequency selection switch to 2 KHz and observe the PPM output.
6. Switch OFF the power supply.

Demodulation:

7. Connect the circuit as shown in diagram 2.
   a. Sine wave output of 1 KHz from modulating signal generator to modulating signal input.
   b. Connect the PPM output to input of LPF.
8. Switch ON the power supply.
9. Observe the demodulated signal at the output of LPF out.
10. Thus the recovered signal is the true replica of the input signal.
11. a. As the output of LPF has less amplitude, connect the output of LPF to the input of an A.C. amplifier.
    b. Observe the demodulated output on the oscilloscope and also observe the amplitude of demodulated signal by varying gain pot. This is amplified demodulated output.
12. Repeat the steps (7 to 9) for the modulating signal for at frequency 2KHz. (with switch in position 2 KHz).
13. Switch OFF the power supply.

Precautions:

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

VIVA-VOCE QUESTIONS:

3. Define PWM?
4. What is the other name for PWM?
5. What is the disadvantage of PWM?
6. Why integrator is required in demodulation of PWM?
7. What kind of conversion is done in PWM generation?

9. TIME DIVISION MULTIPLEXING & DEMULTIPLEXING

Aim:

1. Study of 4 channel Analog Multiplexing and Demultiplexing Techniques.
2. Study of the effect of sampling frequency variation on the output
3. Study of input signal amplitude on the output.

Equipment:

1. Hi-Q Test Equipment Pvt. Ltd. TIME DIVISION MULTIPLEXING & DEMULTIPLEXING Trainer.
2. Oscilloscope-20 MHz Dual Channel.
3. Patch Chords.

Theory:-

The TDM is used for transmitting several analog message signals over a communication channel by dividing the time frame into slots, one slot for ecah message signal. The four input signals, all band limited by the input filters are sequentially sampled, the output of which is a PAM waveform containing samples of the input signals nperiodically interlaced in time. The samples from adjacent input message channels are separated by Ts/M, where M is the number of input channels. A set of M pulses consisting of one sample from each of the input M- input channels is called a frame

At the receiver the samples from individual channels are separated by carefully synchronizing and is critical part TDM. The samples from each channel are filtered to reproduce the original message signal. There are two levels of synchronization. Frame sychronization is necessary to establish when each group of samples begine and word syncronization is necessary to property separate the samples within each frame.

Besides the space diversity & frequency diversity there is a method of sending multipe analog signals on a channel using “TIME DIVISION MULTIPLEXING & DEMULTIPLEXING” technique.

Circuit Diagrams:

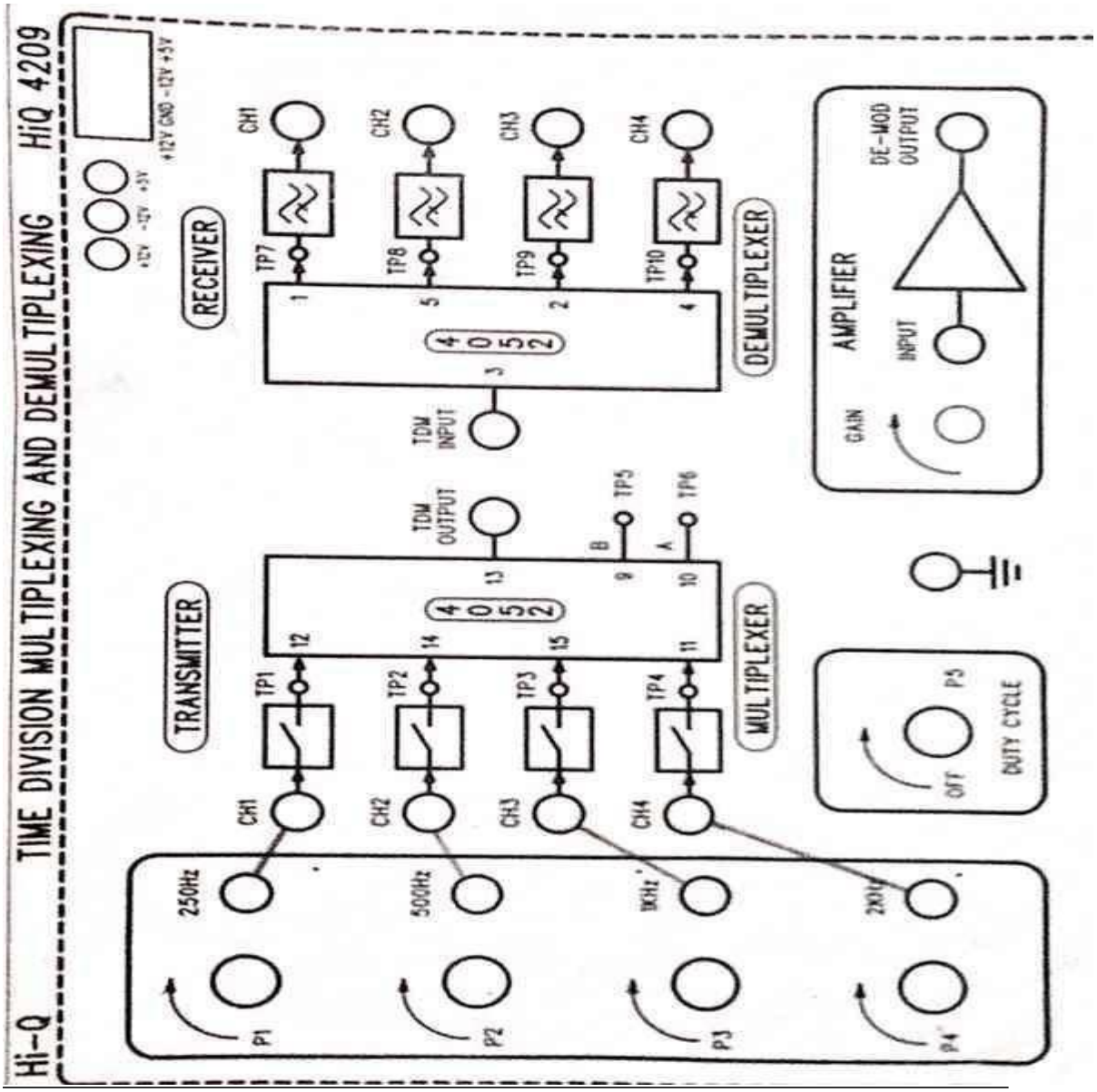


Fig.9.1

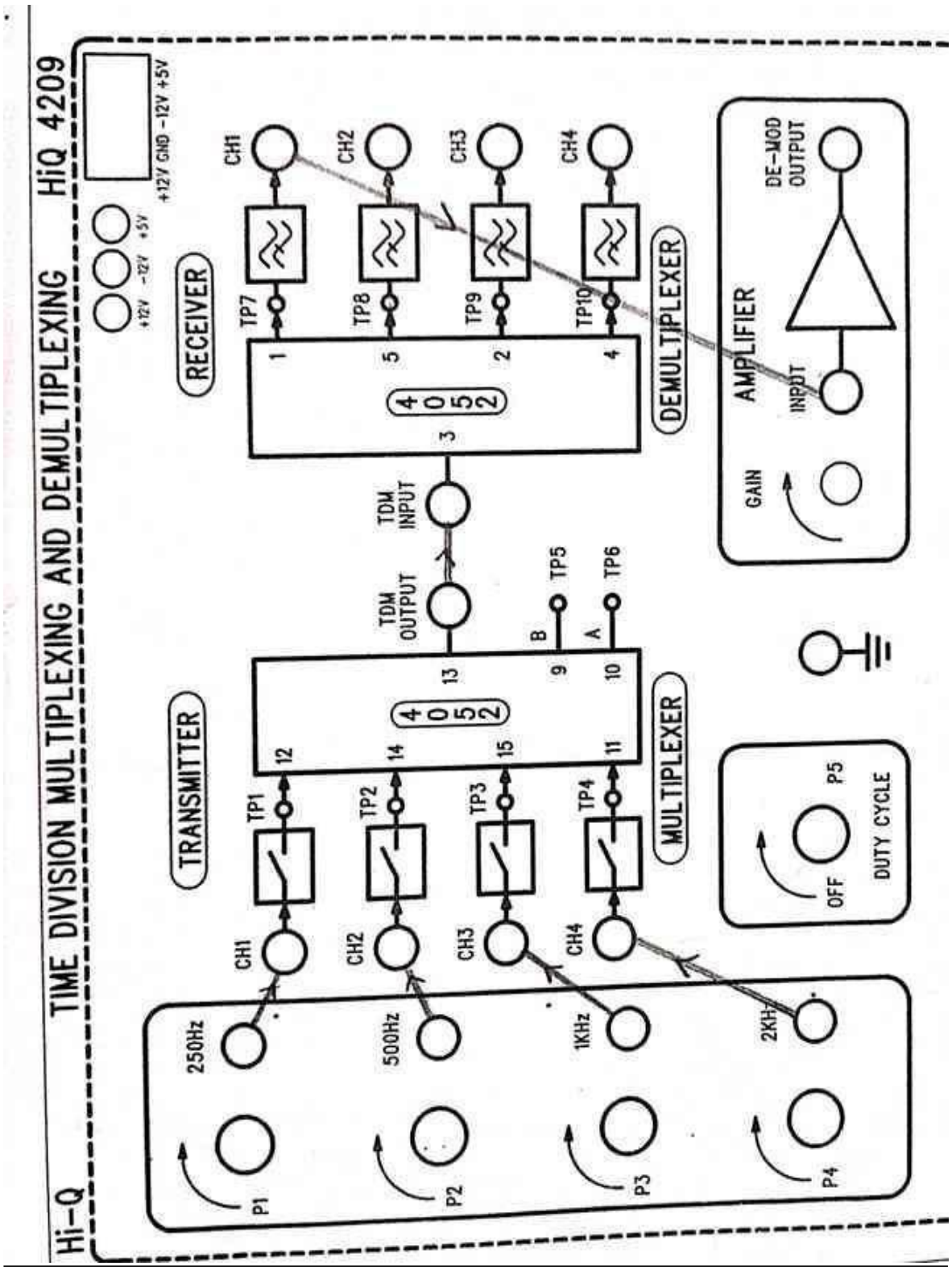
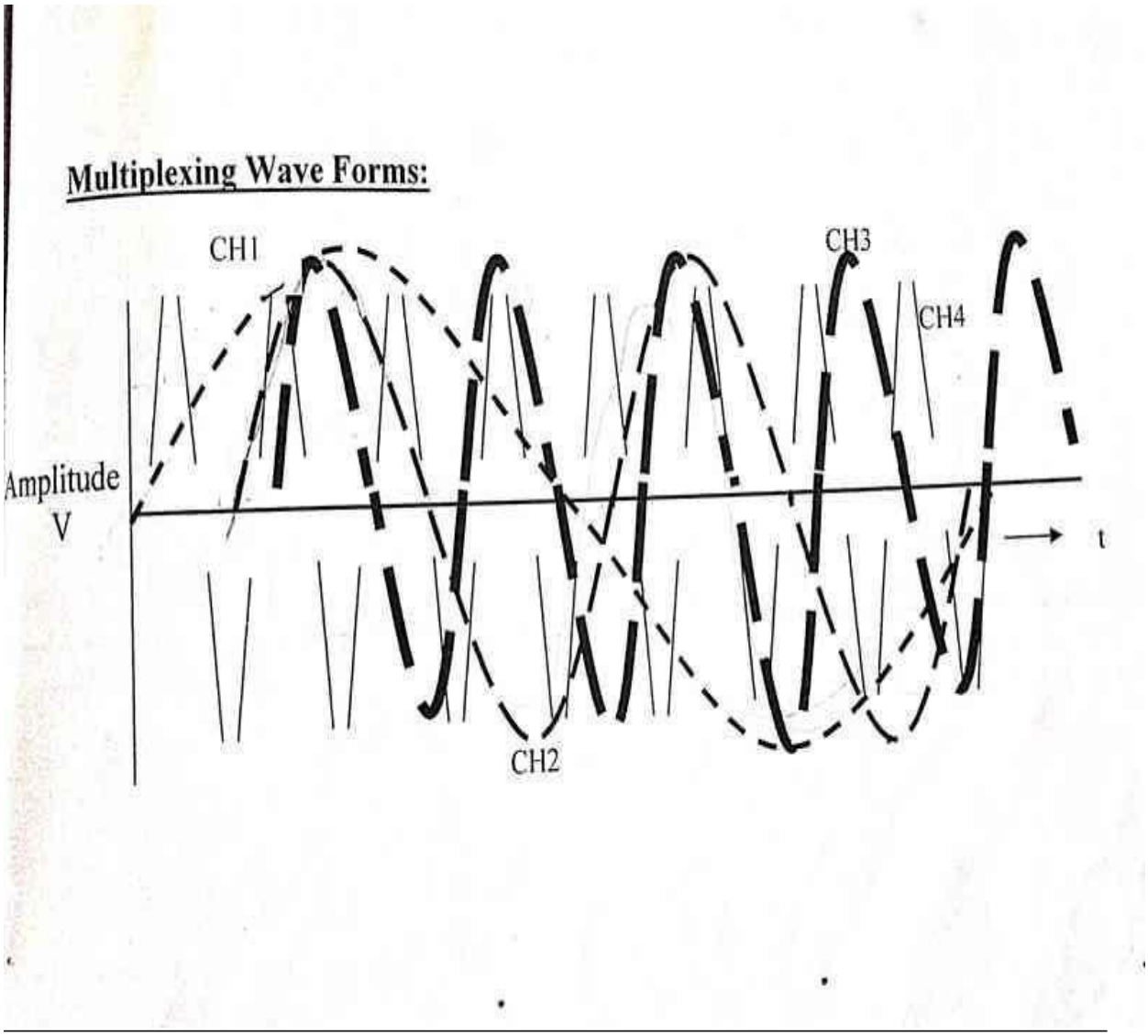
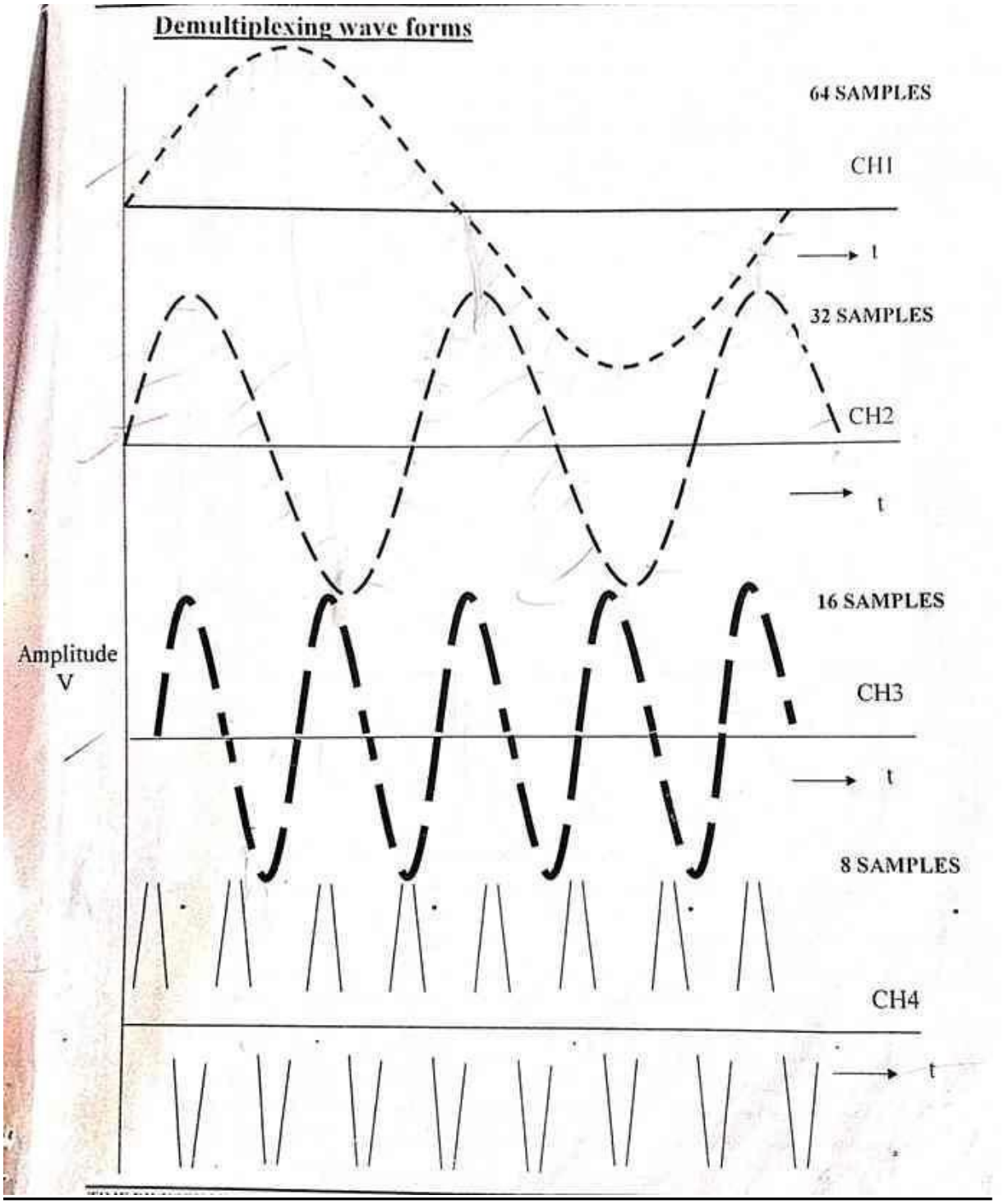

Hi-Q
TIME DIVISION MULTIPLEXING AND DEMULTIPLEXING
HiQ 4209
+12V GND -12V +5V
+12V -12V +5V
RECEIVER
TRANSMITTER
DEMULTIPLEXER
MULTIPLEXER
AMPLIFIER
CH1
CH2
CH3
CH4
TP1
TP2
TP3
TP4
TP5
TP6
TP7
TP8
TP9
TP10
TDM INPUT
TDM OUTPUT
DE-MOD OUTPUT
INPUT
GAIN
OFF
P5
DUTY CYCLE
250Hz
500Hz
1KHz
2KHz
P1
P2
P3
P4

Fig.9.2

Multiplexing waveforms:



Demeltiplexing waveforms:



Procedure:-

Multiplexing:-

1.Connect the circuit as shown in diagram 1.

2.Switch ON the power supply.

3. Set the amplitude of each modulating signal as 5v peak-peak.

4. Monitor the output at test points 1,2,3,4. These are natural sampling Pam outputs.

5. Observe the outputs by varying the duty cycle pot (P5). The PAM outputs will varying with 10% to 50% duty cycle.

6. Try varying the amplitude of modulating signal corresponding each channel by using amplitude pots P1, P2, P3, P4. Observe the effect on all outputs.

7. Observe theTDM output at pin no. 13 of 4052. All the multiplexer channels are observed during the full period of the clock (1/32 KHz).

Demultliplexing & Low Pass Filter:-

1. Connect the circuit as shown in diagram 2.

2. Observe the demultliplexed outputs at test points 7,8,9,10 respectively.

3. Observe by varying theduty cycle pot P5 and see the effect on the outputs.

4. Oberve the low pass filter outputs for CH1, CH2, CH3,CH4. These signals are true replica of the inputs. These signals have lower amplitude.

5. The Low pass filter output is obviously less and it is fed to the A.C. Amplifier which comprises of a single opamp and whose output is amplified

Precautions:

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

VIVA-VOCE QUESTIONS:

1. Define guard time & frame time?
2. Explain block schematic of TDM?
3. How TDM differ from FDM?
4. What type of filter is used at receiver end in TDM system?
5. What are the applications of TDM?
6. Is the bandwidth requirement for TDM & FDM will be same?
7. Is TDM system is relatively immune to interference with in channels (inter channel cross talk) as compared to FDM?
8. Is the FDM susceptible to harmonic distortion compared to TDM?
9. In what aspects, TDM is superior to FDM?

10. Frequency Division Multiplexing and De Multiplexing

Aim:- To study Frequency Division Multiplexing and De Multiplexing.

Equipment Required:

1. Hi-Q model Frequency Multiplexing and De Multiplexing trainer.

2. CRO 20 MHz Dual Trace.

3. Patch Chords.

Theory:

Frequency Division Multiplexing is a process where in modulated signals of allotted carrier slots are simultaneously transmit through channel or cable and during de multiplexing, these signlas are separated by band pass filters or by coherent demodulation at the receiver. Thus many number of channel signals can be transmitted simultaneously and demodulated at the receiver. In practice 12 such modulated convenience. 3 such channels provided here for the study purpose.

6. Now connect FDM signal to each de modulator simultaneously using patch chords. Connect FDM output socket of each demodulator.

7. Connect RF1, RF2, RF3 signals to RF sockets of modulator 1, 2 and 3.

8. On CRO observe the demodulated output of each channel by connecting AF1, AF2, AF3 sockets of demodulator.

Circuit Diagram:-

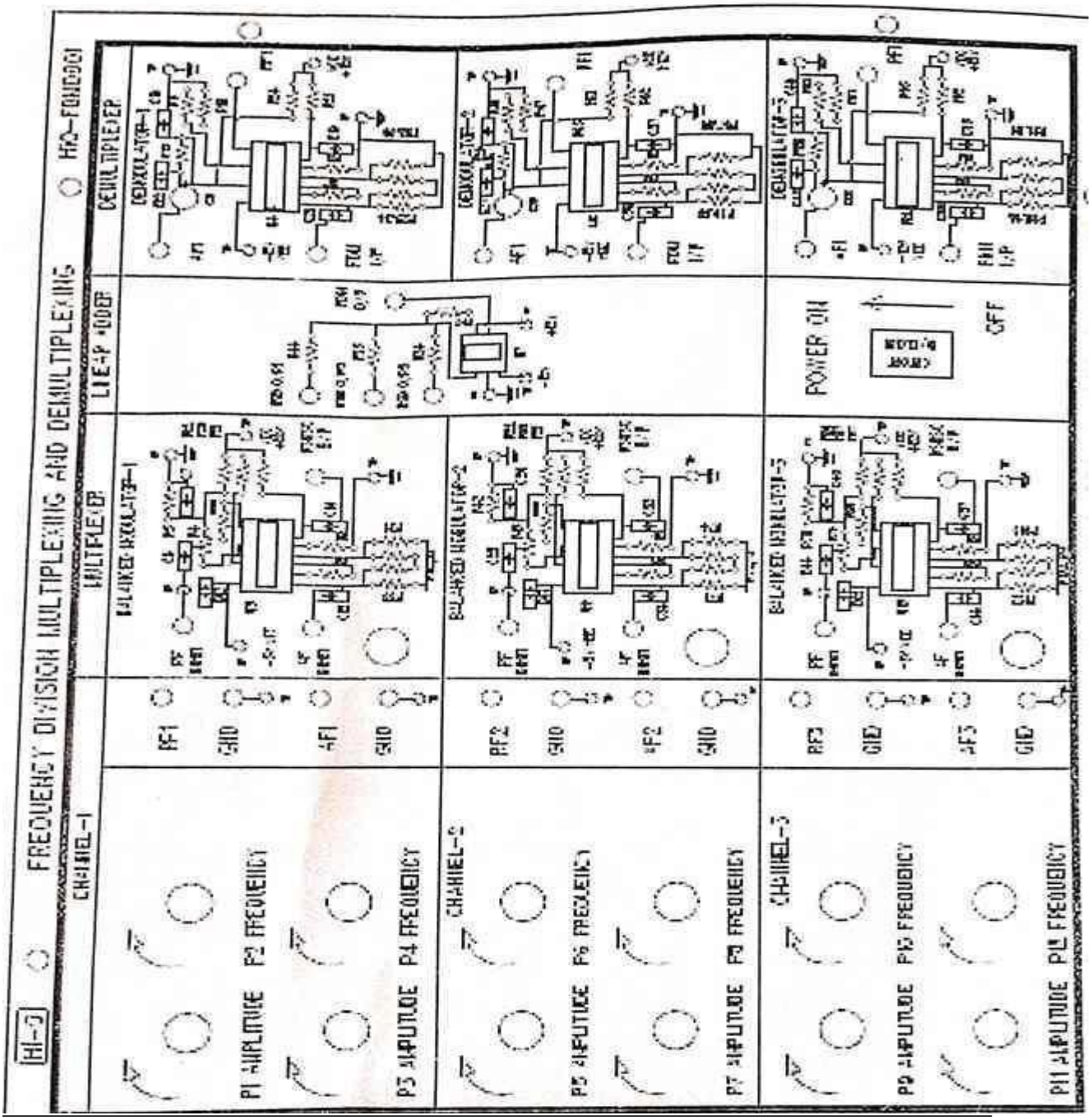
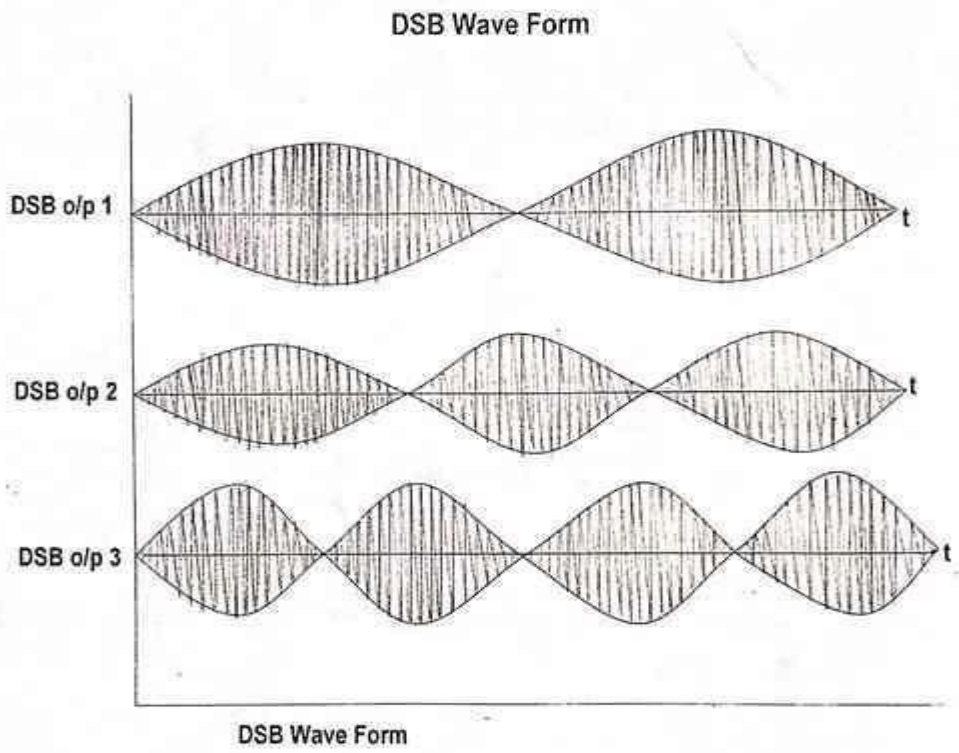


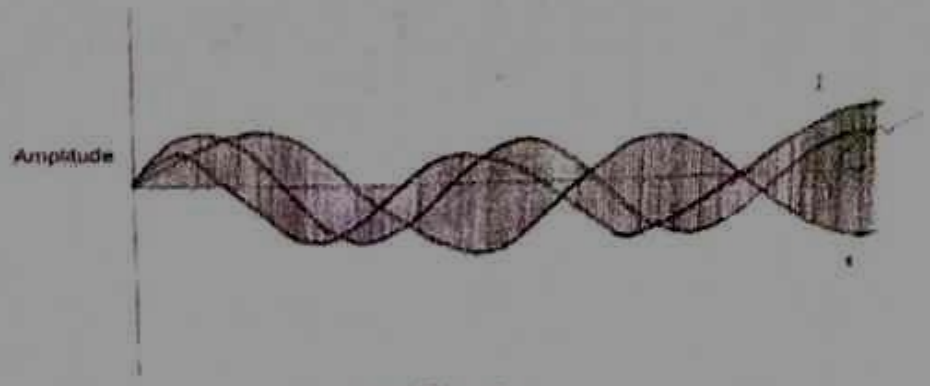
Fig. 10.1

FREQUENCY DIVISION MULTIPLEXING AND DEMULTIPLEXING
Hi-Q
HiQ-FDMD
MULTIPLEXER
DEMULTIPLEXER
LINEAR ADDER
CHANNEL-1
CHANNEL-2
CHANNEL-3
BALANCED MODULATOR-1
BALANCED MODULATOR-2
BALANCED MODULATOR-3
DEMODULATOR-1
DEMODULATOR-2
DEMODULATOR-3
RF1
RF2
RF3
AF1
AF2
AF3
GND
FDM I/P
FDM O/P
POWER ON
OFF
P1 AMPLITUDE
P2 FREQUENCY
P3 AMPLITUDE
P4 FREQUENCY
P5 AMPLITUDE
P6 FREQUENCY
Hi-Q TEST EQUIPMENT PVT.LTD HYD-051 www.hiqindia.com

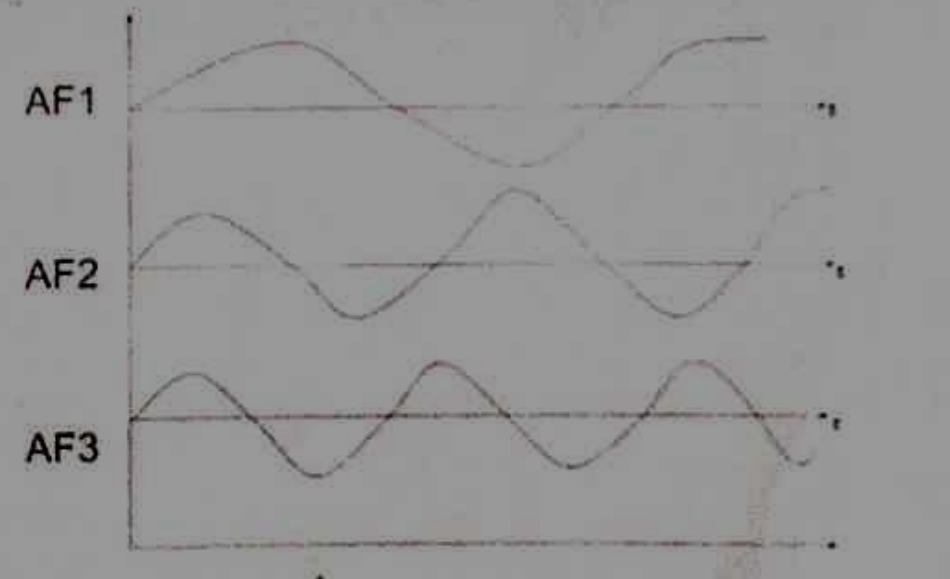
Waveforms:



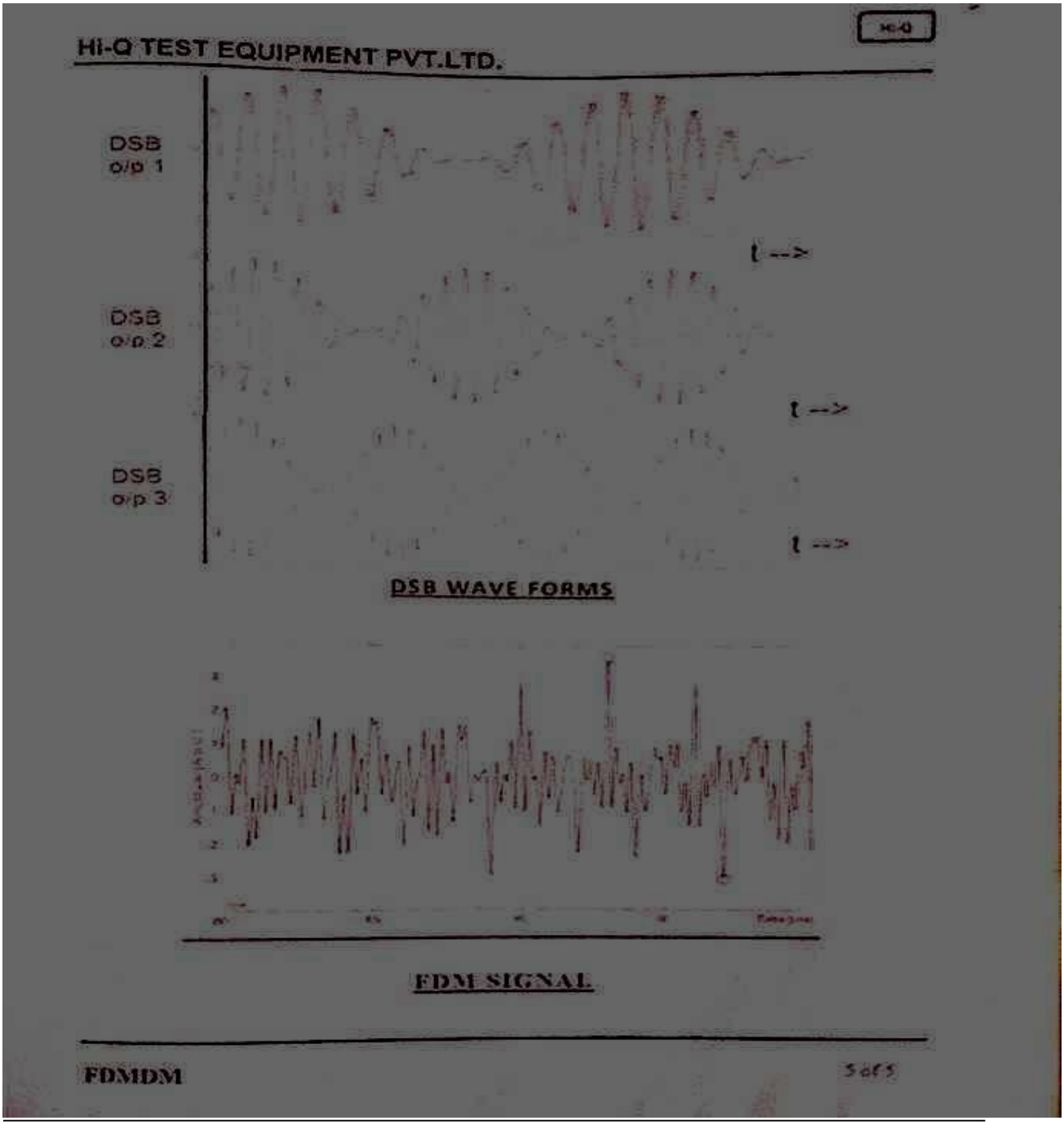
FDM SIGNAL:



FDM Signal



De Multiplexed Outputs


HI-Q TEST EQUIPMENT PVT.LTD.
DSB o/p 1
t -->
DSB o/p 2
t -->
DSB o/p 3
t -->
DSB WAVE FORMS
FDM SIGNAL
FDMDM

Procedure:

1. By giving power to trainer, observe RF1, AF1, RF2, AF2, RF3, AF3 signals on CRO and set channel carrier frequencies at 100 KHz, 150 KHz and 200 KHz. Similarly set the AF frequenices at 1 KHz, 1.5 KHz and 2 KHz.

2. Connect output sockets of RF and AF generators to the corresponding modulators using patch chords.

3. On CRO observe the OSBSC output of each modulator. Adjust the pot for null adjustment of RF if necessary.

4. Now connect the individual DSBSC output signals to the adder using patch chords.

5. On CRO observe the FDM output signal.

Precautions:

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

VIVA-VOCE QUESTIONS:

1. Define FDM
2. What is the advantage of FDM?
3. What is the disadvantage of FDM?
4. Why FDM is used for analog signals
5. What are the applications of FDM?

EXPERIMENT(S) BEYOND THE SYLLABUS

1. Design of Mixer

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

Apparatus Required:

Name of the Component/Equipment	Specifications/Range	Quantity (No's)`
Transistors (BC 107)	f_T = 300 MHz,P_d = 1W $I_{c(max)}$ = 100 mA	1
Resistors Capacitor 0.01µF 1	1 KΩ , 6.8 KΩ, 10KΩ	1 each
Inductor	1mH	1
CRO	20MHz	1
Function Generator	1MHz	1
Regulated Power Supply	0-30v, 1A	1

Theory:

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

Procedure:

1. Connect the circuit as per the circuit diagram as shown in Fig.1. Assume C=0.1μF and calculate value ofL1 using f= 1/2Π sqrt(LC) where f=7KHz
2. Apply the input signals at the appropriate terminals in the circuit.
3. Note down the frequency of the output signal, which is same as difference frequency of given signals.

Sample readings:

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

Circuit Diagram:

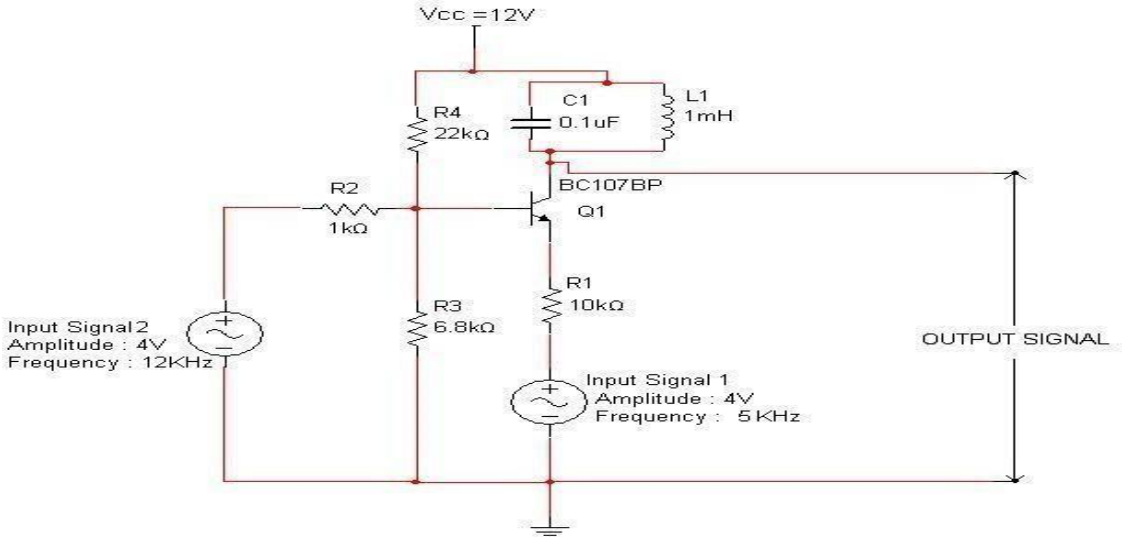
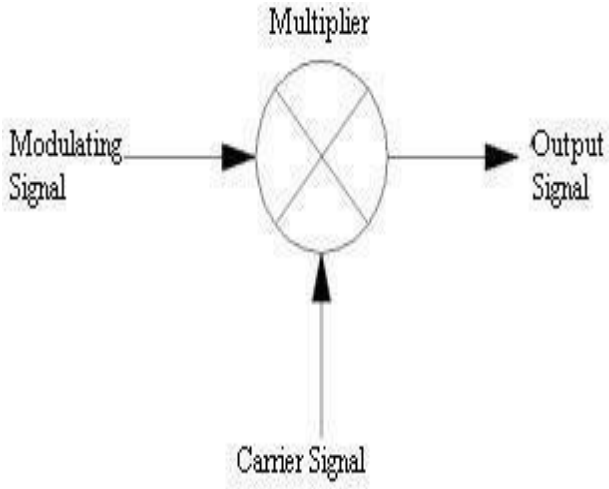
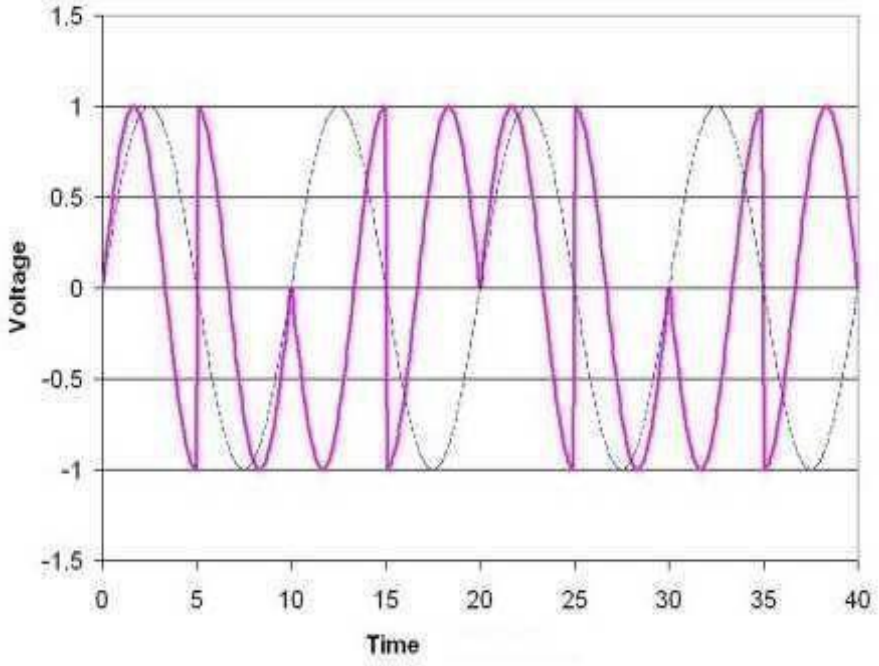


Fig. 1.1

Waveforms:


Multiplier
Modulating Signal
Output Signal
Carrier Signal


1.5
1
0.5
0
-0.5
-1
-1.5
Voltage
0
5
10
15
20
25
30
35
40
Time

Precautions:

1.Check the connections before giving the supply

2.Observations should be done carefully

VIVA-VOCE QUESTIONS

1. What is mixer

2. What is in phase and out phase in waveform