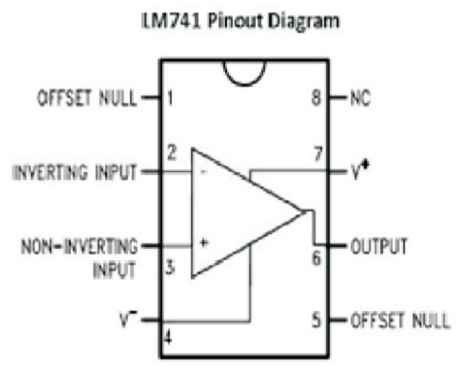
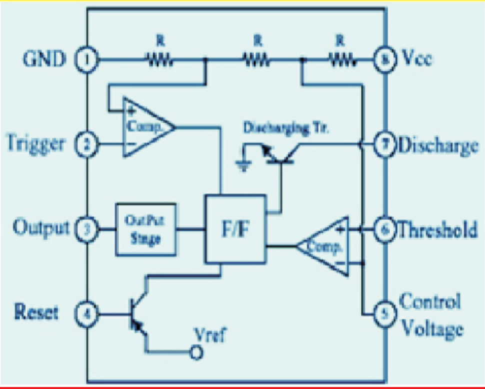
I

Name ____________________
Roll No. ____________ Year 20 ______ 20 ______
Exam Seat No. ____________________

ELECTRONICS GROUP | SEMESTER - IV | DIPLOMA IN ENGINEERING AND TECHNOLOGY

A LABORATORY MANUAL FOR LINEAR INTEGRATED CIRCUITS (22423)





MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI

(Autonomous) (ISO 9001 : 2015) (ISO / IEC 27001 : 2013)

VISION

To ensure that the Diploma level Technical Education constantly matches the latest requirements of technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the changing technological and environmental challenges.

QUALITY POLICY

We, at MSBTE are committed to offer the best in class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programmes.

CORE VALUES

MSBTE believes in the followings:

- Education industry produces live products.
- Market requirements do not wait for curriculum changes.
- Question paper is the reflector of academic standards of educational organization.
- Well designed curriculum needs effective implementation too.
- Competency based curriculum is the backbone of need based program.
- Technical skills do need support of life skills.
- Best teachers are the national assets.
- Effective teaching learning process is impossible without learning resources.

A Laboratory Manual
for

Linear Integrated Circuits

(22423)

Semester-IV

(EJ, DE, ET, EN, EX, EQ, IF, IS, IC)

Maharashtra State
Board of Technical Education, Mumbai
(Autonomous) (ISO 9001:2015) (ISO/IEC 27001:2013)

Maharashtra State Board of Technical Education,
(Autonomous) (ISO 9001 : 2015) (ISO/IEC 27001 : 2013)
4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai - 400051.
(Printed on November 2018)

Maharashtra State
Board of Technical Education

Certificate

This is to certify that Mr. / Ms ……………………………………. Roll No……………………….of IV Semester of Diploma in ………………………………………………………. of Institute ……………………………………………. (Code………………..) has attained pre-defined practical outcomes (PROs) satisfactorily in course **Linear Integrated Circuits (22423)** for the academic year 20…….to 20…..... as prescribed in the curriculum.

Place ……………….   Enrollment No……………………

Date:…....................   Exam Seat No. …………………......

Course Teacher   **Head of the Department**   **Principal**

Seal of the Institute

Preface

The primary focus of any engineering laboratory/ field work in the technical education system is to develop the much needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'I' Scheme curricula for engineering diploma programmes with outcome-base education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher; instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a ***'vehicle'*** to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accordingly, the 'I' scheme laboratory manual development team designed the practical to ***focus*** on the ***outcomes***, rather than the traditional age old practice of conducting practical to 'verify the theory' (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

Operational Amplifier (Op-Amp) is the most versatile Linear Integrated Circuit (IC) used to develop various application in electronic circuits and equipment. Hence this course is intended to develop the skills to build, test, diagnose and rectify the Op-Amp based electronic circuits. This course deals with various aspects of Linear Integrated circuits used in various industrial, consumer and domestic applications.

Although all care has been taken to check for mistakes in this laboratory manual, yet it is impossible to claim perfection especially as this is the first edition. Any such errors and suggestions for improvement can be brought to our notice and are highly welcome

Programme Outcomes (POs) to be achieved through Practical of this Course:

Following programme outcomes are expected to be achieved through the practicals of this course

PO1. Basic knowledge: Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.

PO2. Discipline knowledge: Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.

PO3. Experiments and practice: Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.

PO4. Engineering tools: Apply relevant Electronics and Telecommunications technologies and tools with an understanding of the limitations

PO5. The engineer and society: Assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to practice in field of Electronics and Telecommunication engineering.

PO6. Environment and sustainability: Apply Electronics and Telecommunication engineering solutions also for sustainable development practices in societal and environmental contexts.

PO7. Ethics: Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Electronics and Telecommunication engineering.

PO8. Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PO9. Communication: Communicate effectively in oral and written form.

PO10. Life-long learning: Engage in independent and life-long learning activities in the context of technological changes also in the Electronics and Telecommunication engineering and allied industry.

Program Specific Outcomes (PSO) (What s/he will be able to do in the Electronics and Telecommunication engineering specific industry soon after the diploma programme).

PSO1. Electronics and Telecommunication Systems: Maintain various types of Electronics and Telecommunication systems.

PSO2. EDA Tools Usage: Use EDA tools to develop simple Electronics and Telecommunication engineering related circuits.

List of Industry Relevant Skills

- The following industry relevant skills of the competency '**Maintain electronic circuits consisting of Linear Integrated Circuits'** are expected to be developed in students by undertaking the practical of this laboratory manual.

1. Select the appropriate IC with the help of data sheet.
2. Testing of the different IC'
3. Select the electronic component of proper value as per the requirement.
4. Mount the electronic component on breadboard as per circuit diagram.
5. Test the circuit for the given application.
6. Compare the observed output with the expected output.
7. Find faults and trouble shoot the given circuit
8. Use of relevant EDA tool for Simulation of analog electronics circuits

Practical- Course Outcome matrix

Course Outcomes (COs)

a. Use Op-Amp in linear electronic circuits.
b. Use various configurations of Op-Amp for different applications.
c. Troubleshoot various linear applications of Op-Amp for the given specifications.
d. Maintain filters and oscillators used in various electronic circuits.
e. Troubleshoot specified applications using various linear ICs.

Sr. No.	Practical Outcomes(PrO)	CO a.	CO b.	CO c.	CO d.	CO e.
1.	Use relevant instruments to measure input offset voltage, output offset voltage and common mode rejection ratio (CMRR) of IC741.	√	-	-	-	-
2.	Use relevant instruments to measure the Output voltage swing parameter of op-amp IC741	√	-	-	-	-
3.	Use relevant instruments to determine gain of the Inverting amplifier and Non Inverting amplifier consist of IC741.	-	√	-	-	-
4.	Build/Test adder and subtractor circuit consist of IC 741.	-	√	-	-	-
5.	Build/Test Integrator circuit consist of IC741.	-	√		-	-
6.	Build/Test differentiator circuit consist of IC741.	-	√	-	-	-
7.	Build/Test Voltage to Current converter and Current to Voltage converter circuit consist of IC 741.	-	√	-	-	-
8.	Build/Test comparator circuit consist of IC741 as Zero crossing detector and active positive peak detector.	-	√	-	-	-
9.	Build/Test Instrumentation amplifier circuit using IC LM324.	-	-	√	-	-
10.	Use relevant instruments to measure the bandwidth and cutoff frequency of the given first order low pass Butterworth filter .	-	-	-	√	-
11.	Use relevant instruments to measure the bandwidth and cutoff frequency of the given first order high pass Butterworth filter .	-	-	-	√	-
12.	Use relevant instruments to measure the cutoff frequency of the given notch filter.	-	-	-	√	-
13.	Use relevant instruments to measure the frequency of oscillation of the given RC Phase shift oscillator circuit using IC741.	-	-	-	√	-
14.	Measure the frequency of oscillation of the given wien bridge oscillator circuit using IC741.	-	-	-	√	-

15.	Build/Test astable multivibrator using IC555 for the given specifications.	-	-		-	√
16.	Build/Test monostable multivibrator using IC555 for the given specifications.	-	-		-	√

Guidelines to Teachers

1. Teacher is expected to refer complete curriculum document and follow guidelines for implementation
2. Teacher should provide the guideline with demonstration of practical to the students with all features.
3. Teacher shall explain prior concepts to the students before starting of each practical
4. Involve students in performance of each practical.
5. Teacher should ensure that the respective skills and competencies are developed in the students after the completion of the practical exercise.
6. Teachers should give opportunity to students for hands on experience after the demonstration.
7. Teacher is expected to share the skills and competencies to be developed in the students.
8. Teacher may provide additional knowledge and skills to the students even though not covered in the manual but are expected the students by the industry.
9. Give practical assignment and assess the performance of students based on task assigned to check whether it is as per the instructions.
10. Assess the skill achievement of the students and COs of each unit.
11. To achieve the PSO2 certain practical's can be conducted using EDA Tools.
12. At the beginning Teacher should make the students acquainted with any of the simulation software environment as few practical may be performed using EDA tools.

Instructions for Students

1. Listen carefully the lecture given by teacher about course, curriculum, learning structure, skills to be developed.
2. Before performing the practical student shall read lab manual of related practical to be conducted.
3. For incidental writing on the day of each practical session every student should maintain a ***dated log book*** for the whole semester, apart from this laboratory manual which s/he has to ***submit for assessment to the teacher***.
4. Organize the work in the group and make record of all observations.
5. Students shall develop maintenance skill as expected by industries.
6. Student shall attempt to develop related hand-on skills and gain confidence.
7. Student shall develop the habits of evolving more ideas, innovations, skills etc. those included in scope of manual
8. Student shall refer technical magazines, IS codes and data books.
9. Student should develop habit to submit the practical on date and time.
10. Student should well prepare while submitting write-up of exercise.

Content Page

List of Practical and Progressive Assessment Sheet

S. No.	Title of the practical	Page No.	Date of performa nce	Date of submission	Assessment marks(25)	Dated sign. of teacher	Remarks (if any)
1*	Use relevant instruments to measure the input offset voltage, output offset voltage and common mode rejection ratio (CMRR) of IC741.	1					
2	Use relevant instruments to measure the Output voltage swing parameter of op-amp IC741	13					
3*	Use relevant instruments to determine gain of the Inverting amplifier and Non Inverting amplifier consist of IC741.	21					
4*	Build/Test adder and subtractor circuit consist of IC 741.	33					
5	Build/Test Integrator circuit consists of IC741.	41					
6	Build/Test differentiator circuit consist of IC741.	51					
7	Build/Test Voltage to Current converter and Current to Voltage converter circuit consist of IC 741.	59					
8*	Build/Test comparator circuit consist of IC741 as Zero crossing detector and active positive peak detector.	67					
9	Build/Test Instrumentation amplifier circuit using IC LM324.	76					

S. No.	Title of the practical	Page No.	Date of performa nce	Date of submission	Assessment marks(25)	Dated sign. of teacher	Remarks (if any)
10*	Use relevant instruments to measure the bandwidth and cutoff frequency of the given first order low pass Butterworth filter .	86					
11*	Use relevant instruments to measure the bandwidth and cutoff frequency of the given first order high pass Butterworth filter .	96					
12	Use relevant instruments to measure the cutoff frequency of the given notch filter .	105					
13	Use relevant instruments to measure the frequency of oscillation of the given RC Phase shift oscillator circuit using IC741.	114					
14	Measure the frequency of oscillation of the given Wien bridge oscillator circuit using IC741.	123					
15*	Build/Test astable multi vibrator using IC555 for the given specifications.	130					
16	Build/Test monostable multivibrator using IC555 for the given specifications.	139					
Total							

- ***The practical marked as '*' are compulsory,***
- **Column 6th marks to be transferred to Proforma of CIAAN-2017**.

Practical No.1: Use relevant instruments to measure the input offset voltage, output offset voltage and common mode rejection ratio (CMRR) of IC 741

I Practical Significance

Op-Amps are very popular building blocks in electronic circuits. Op-Amps are used for a variety of applications such as AC and DC signal amplification, filters, oscillators, voltage regulators, comparators and in most of the consumer and industrial devices. Op-Amps exhibit little dependence on temperature-changes or manufacturing variations, which makes them ideal building blocks in electronic circuits. The performance of above mentioned circuits depends on various parameters of Op-Amp.

II Relevant Program Outcomes (POs)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Discipline knowledge:** Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Maintain electronic circuits consisting of linear Integrated Circuits.'**

- Test Analog IC-741C.
- Mount the electronic component on breadboard as per circuit diagram.
- Use DC power supply to provide power to the given circuit

IV Relevant Course Outcome(s)

- Use Op-Amp in linear electronic circuits.

V Practical Outcome

- Use relevant instruments to measure the input offset voltage, output offset voltage and common mode rejection ratio (CMRR) of IC741.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Follow ethical practices
- Demonstrate working as a leader/a team member

VII Minimum Theoretical Background

Operational amplifiers are a direct coupled high gain amplifier usually consisting of one or more differential amplifier followed by level shifter and output stage. An Op Amp is available as a single integrated circuit package .There are various parameters of Op-Amp is to be measured are necessary for faithful amplification. Op-Amp has different electrical parameters like differential input resistance, input offset voltage, output offset voltage and common mode rejection ratio .

Differential input resistance (Ri): It is equivalent resistance measured at either input terminal with other terminal grounded.

Input offset voltage (Vio):It is the voltage applied between two terminals to Op-Amp to null Voo.   Vio = |Vdc1-Vdc2|

Output Offset voltage(V_{00}):It is the output of the Op-Amp when the input terminals are grounded.

Common mode rejection ratio (CMRR): The ability of differential amplifier to reject a common mode signal is expressed by its common mode rejection ratio. It is the ratio of differential mode gain A_d to the common mode A_{cm}.   CMRR= A_d/ A_{cm}

It is usually expressed in decibel.(db).

The IC is identified by marking the device Type Number on the face of the IC. This number is usually

accompanied by the date code, indicating the year and week the device was manufactured.

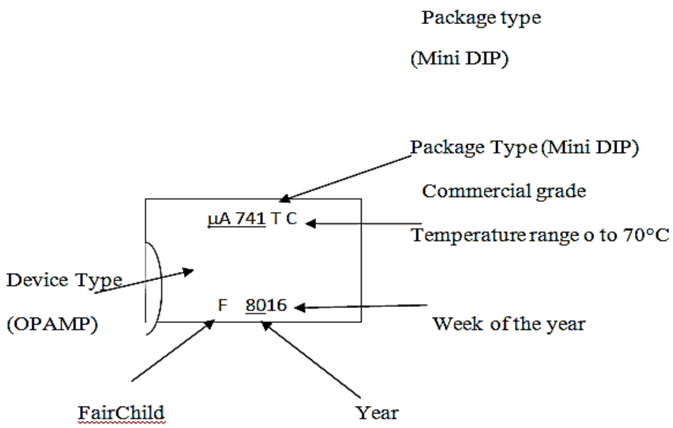


Figure 1.1 Nomenclature of IC741

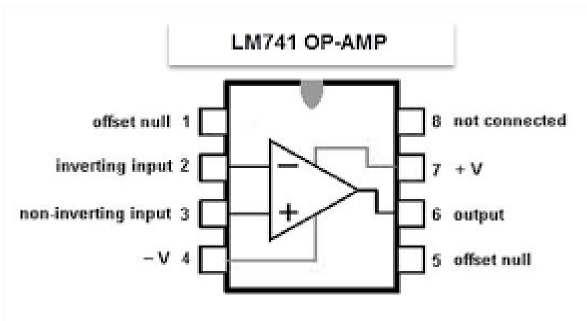


Figure 1.2 Pin diagram of IC741

VIII Practical Circuit diagram :

a) Sample circuit diagram

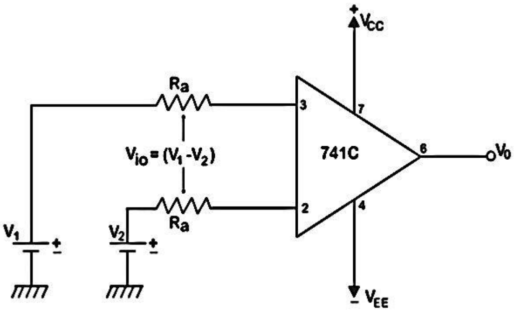


Figure 1.3Input offset voltage (Vio)

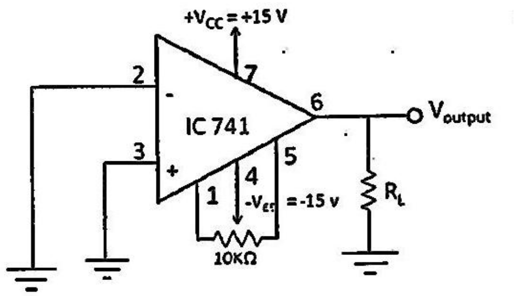


Figure 1.4 Output offset voltage (Voo)

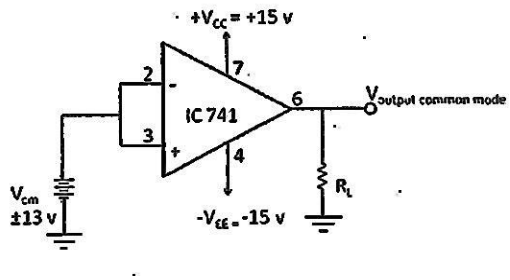


Figure 1.5 Common mode rejection ratio (CMRR)

b) Actual Circuit diagram

c) Sample Experimental set up

d) Actual Experimental set up

IX Resources Required

S. No.	Instrument /Components	Specification	Quantity
1.	Variable DC power supply	0- 30V, 2A Dual tracking power supply	2 No.
2.	Analog IC tester	Suitable to test l analog ICs	1 No
3.	IC-741C	Dual-In-Line or S.O. Package	1 No.
4.	Resistors Ra	10KΩ,	2 No
5.	Potentiometer	10KΩ	1 No.
6.	Breadboard	5.5 cm X 17cm	1 No.
7.	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

X Precautions to be Followed

1. Ensure proper connections are made to the equipment.
2. Ensure the power switch is in 'off' condition initially.
3. Ensure the use of proper settings of input DC voltage

XI Procedure

Procedure for measurement of Input offset voltage (Vio)

1. Test and mount the IC741 on the bread board.
2. Make connections per given circuit diagram.
3. Connect dual power supply to pin No.7 (+ Vcc) and pin No.4 (- $V_{EE)}$ and DMM to pin No. 6 shown in figure no.1.1
4. Apply DC voltage Vdc1 and Vdc2, in 1V to 15V range to the two input terminals of an Op-Amp to get zero output voltage. (Vo = 0V).
5. Calculate Vio = |Vdc1-Vdc2|
6. Using DMM measure Vio in between two input terminals (that is between pin No.2 and pinNo.3)

Note: Practically Vio varies in between 20mV to 80mV

Procedure for measurement of output offset voltage (Voo)

1. Make the connections as per given circuit diagram.
2. Connect dual power supply to pin No.7 (+ Vcc) and pin No.4 (- $V_{EE)}$ and DMM to pin No. 6 shown in figure no.1.2
3. Ground both input terminals of Op-Amp.
4. Measure the output voltage using DMM at pin No.6
5. Adjust 10KΩ potentiometer connected in between pin-1 and pin-5 of IC 741 to get output voltage equal to 0V.
6. Measure Voo range by varying the potentiometer.

Procedure for measurement of common mode rejection ratio (CMRR)

1. Make the connections as per given circuit diagram.
2. Connect dual power supply to pin No.7 (+ Vcc) and pin No.4 (- $V_{EE)}$ and DMM to pin No. 6 shown in figure no.1.3
3. Apply common voltage Vcm to both the input terminals of IC741.
4. Measure the output voltage Vocm by using DMM at pin No.6

5. Calculate $A_{CM} = V_{ocm} / V_{cm}$
6. Calculate CMRR =Ad/Acm
   Where Ad= A =Large signal voltage gain specified in data sheet.

XII Resources Used

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			
5.			

XIII Actual Procedure Followed (use blank sheet provided if space not sufficient)

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XIV Precautions Followed (use blank sheet provided if space not sufficient)

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XV Observations and Calculations(use blank sheet provided if space not sufficient)

Table No: 1.1 Observation Table for Input offset voltage (Vio)

S.No.	Vdc1 Volts	Vdc2 Volts	Vio = |Vdc1-Vdc2| Volts
1.			
2.			
3.			
4.			

Table No: 1.2 Observation Table for Output offset voltage (Voo)

Sr.No.	Vcm	Voo
1.		
2.		
3.		
4.		

Table No: 1.3 Observation Table for Common mode rejection ratio (CMRR)

Sr.No.	Vcm	Vocm	Acm	Ad=A	CMRR=Ad/Ac
1.					
2.					
3.					
4.					

Ad=A= Large signal voltage gain specified in datasheet

Calculations:

Vcm=
Vocm=
Acm=Vocm/Vcm=
Ad=A= Large signal voltage gain specified in datasheet
CMRR=Ad/Acm=
CMRR in dB-20log$_{10}$ Ad/Acm=

XVI Results

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....
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....

XVII Interpretation of Results (Give meaning of the above obtained results)

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....
....
....

XVIII Conclusions and Recommendation

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....
....
....

XIX Practical Related Questions (Note: Teacher shall assign batch wise additional one or two questions related to practical)

1. Using data sheet find the equivalent IC for IC 741
2. Write various parameter values using data sheet of IC 741
3. State different packages available for IC 741
4. State significance of level shifter circuit of IC 741

[Space for Answers]

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....

XX References / Suggestions for further reading

1. Laboratory Manual for Introductory Electronics Experiments, Maheshwari, L.K.; Anand, M.M.S., New Age International Pvt. Ltd. New Delhi; ISBN: 9780852265543
2. Electronics Component Handbook; Jones, Thomas H., Reston Publishing, Resto,
3. Virginia, USA, ISBN: 978087909222
4. https://www.youtube.com/watch?v=NEiVSbPYWNE
5. Ramakant A.Gayakwad, *Op-Amps and linear Integrated Circuits*, Prentice -Hall India,3rdedition, 2001,ISBN NO : 81-203-0807-7
6. K.R.Botkar, *Integrated Circuits*, Khanna publication,10th edition,2005,ISBN NO :81-7409-208-0
7. http://www.ti.com/lit/ds/symlink/lm741.pdf

XXI Assessment Scheme

Performance Indicators		Weightage
Process related: 15 Marks		**60%**
1	Handling of the components	10 %
2	Mounting of component	20 %
3	Measuring value using CRO	20 %
4	Working in team	10 %
Product related:10 Marks		**40%**
5	Calculate various parameters	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Name of Team Members

1. …………………………......
2. …………………………......
3. …………………………..
4. …………………………..

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

TEXAS INSTRUMENTS

LM741

SNOSC25D –MAY 1998–REVISED OCTOBER 2015

LM741 Operational Amplifier

1 Features

- Overload Protection on the Input and Output
- No Latch-Up When the Common-Mode Range is Exceeded

2 Applications

- Comparators
- Multivibrators
- DC Amplifiers
- Summing Amplifiers
- Integrator or Differentiators
- Active Filters

3 Description

The LM741 series are general-purpose operational amplifiers which feature improved performance over industry standards like the LM709. They are direct, plug-in replacements for the 709C, LM201, MC1439, and 748 in most applications.

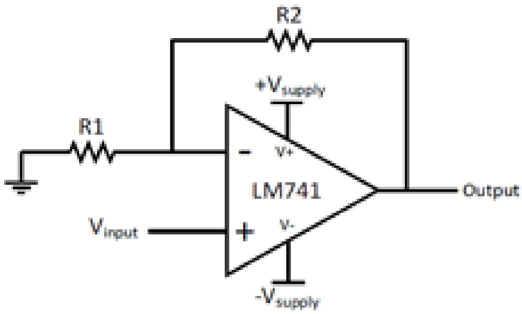
The amplifiers offer many features which make their application nearly foolproof: overload protection on the input and output, no latch-up when the common-mode range is exceeded, as well as freedom from oscillations.

The LM741C is identical to the LM741 and LM741A except that the LM741C has their performance ensured over a 0°C to +70°C temperature range, instead of -55°C to +125°C.

Device Information[1]

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM741	TO-99 (8)	9.08 mm x 9.08 mm
	CDIP (8)	10.16 mm x 6.502 mm
	PDIP (8)	9.81 mm x 6.35 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.



PIN		I/O	DESCRIPTION
NAME	NO.		
INVERTING INPUT	2	I	Inverting signal input
NC	8	N/A	No Connect, should be left floating
NONINVERTING INPUT	3	I	Noninverting signal input
OFFSET NULL	1, 5	I	Offset null pin used to eliminate the offset voltage and balance the input voltages.
OFFSET NULL			
OUTPUT	6	O	Amplified signal output
V+	7	I	Positive supply voltage
V—	4	I	Negative supply voltage

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)[1][2]

		MIN	MAX	UNIT
Supply voltage	LM741, LM741A		±22	V
	LM741C		±18	
Power dissipation [4]			500	mW
Differential input voltage			±30	V
Input voltage [5]			±15	V
Output short circuit duration		Continuous		
Operating temperature	LM741, LM741A	−50	125	°C
	LM741C	0	70	
Junction temperature	LM741, LM741A		150	°C
	LM741C		100	
Soldering information	PDIP package (10 seconds)		260	°C
	CDIP or TO-99 package (10 seconds)		300	°C
Storage temperature, T_{stg}		−65	150	°C

6.7 Electrical Characteristics, LM741C[1]

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Input offset voltage		Rs 10 kΩ	TA = 25°C	2		6	mV
			TAMIN < TA < TAMAX			7.5	mV
Input offset voltage adjustment range		TA = 25°C, VS = ±20 V			±15		mV
Input offset current		TA = 25°C		20		200	nA
		TAMIN<TA TAMAX				300	
Input bias current		TA = 25°C		80		500	nA
		TAMIN<TA TAMAX				0.8	μA
Input resistance		TA = 25°C, VS = ±20 V		0.3	2		MΩ
Input voltage range		TA = 25°C		±12	±13		V
Large signal voltage gain		VS = ±15 V, VO = ±10 V, RL	TA = 25°C	20	200		V/mV
			TAMIN < TA < TAMAX	15			
Output voltage swing		VS = ±15 V	RL 10 kΩ	±12	±14		V
			RL 2 kΩ	±10	±13		
Output short circuit current		TA = 25°C			25		mA
Common-mode rejection ratio		RS 10 kΩ, VCM = ±12 V, TAMIN TA TAMAX		70	90		dB
Supply voltage rejection ratio		VS = ±20 V to VS = ±5 V, RS 10 Ω, TAMIN TA TAMAX		77	96		dB
Transient response	Rise time	TA = 25°C, Unity Gain			0.3		μs
	Overshoot				5%		
Slew rate		TA = 25°C, Unity Gain			0.5		V/μs
Supply current		TA = 25°C		1.7		2.8	mA
Power consumption		VS = ±15 V, TA = 25°C		50		85	mW

Practical No.2: Use relevant instruments to measure the Output voltage Swing parameter of Op-Amp IC741.

I Practical Significance

The output voltage swing is the range of voltage that an Op Amp physically provide at its output. Output Voltage Swing defines how close the op-amp output can be driven to saturation voltage under defined operating conditions where the op-amp still can function correctly. To design the preferable amplifier circuit used in industry measurement of voltage swing is necessary to enhance the performance of amplifier circuit using IC 741.This practical will enables student to measure the output voltage swing of Op Amp using IC741

II Relevant Program Outcomes (POs)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Discipline knowledge:** Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Maintain electronic circuits consisting of linear Integrated Circuits.'**

- Select relevant electronic components IC 741 and resistor value for specified gain
- Mounting of the electronic component on breadboard as per circuit diagram.

IV Relevant Course Outcome(s)

- Use Op-Amp in linear electronic circuits.

V Practical Outcome

- Use relevant instruments to measure the Output voltage Swing parameter of op-amp IC741.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Demonstrate working as a leader/a team member
- Follow ethical practices

VII Minimum Theoretical Background

The ac output is the maximum unclipped peak to peak output voltage that an OpAmp can produce. Since the quiescent output is ideally zero, the ac output voltage can swing positive or negative. This also indicates the values of positive and negative saturation voltages of the OPAMP. The output voltage never exceeds these limits for a given supply voltages $+V_{CC}$ and $-V_{EE}$. For a 741C it is ± 13 V.

VIII Practical Circuit diagram:

a) Sample circuit diagram

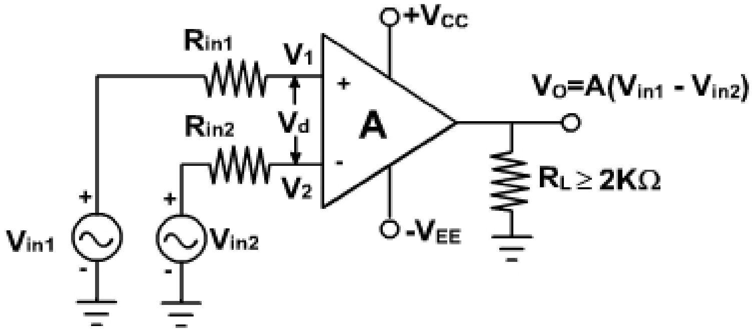


Figure 2.1 Output voltage swing.

b) Actual Circuit diagram

c) Actual Experimental set up

IX Resources Required

S. No.	Instrument /Components	Specification	Quantity
1.	Dual Power supply	0- 30V, 2A Dual tracking power supply	1 No.
2.	IC-741C	Dual-In-Line or S.O. Package	2 No.
3.	Resistors Rin_1	1KΩ	1 No.
4.	Resistors Rin_2	1KΩ	1 No.
5.	Function Generator	20MHz	2 No.
6.	Analog IC tester	Suitable to test analog IC	1 No.
7.	CRO	20MHz Dual Trace Oscilloscope	1 No.
8.	Breadboard	5.5 cm X 17cm	1 No.
9.	Connecting wires	Single strand Teflon coating (0.6mm diameter)	Asper requirement

X Precautions to be followed

1. Ensure proper mounting of IC 741 and Resistor on Breadboard.
2. Ensure proper connection of Circuit
3. Ensure proper Input Voltage and Supply voltage to the Circuit.

XI Procedure

1. Assemble the circuit on breadboard as per circuit diagram given in figure number 2.1.
2. Connect dual power supply to pin No. 7 (+Vcc) and pin No. 4 ($-V_{EE}$) of IC 741.
3. Set two function generator to produce a sine waveform of 1V pp amplitude at 1 KHz.
4. Check the output of the function generator on CRO before applying it as input.
5. Apply input signal Vin1 to pin No. 3 and Vin2 to pin No.2 from function generator.
6. Vary input voltage Vin1 and Vin2 till the output waveform is clipped.
7. Observe input and output (pin No. 6) waveforms on CRO.
8. Note down the reading of peak to peak voltage of output waveform.
9. Plot the graph for input and output waveforms observed on CRO.

XII Resources Used

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			
5.			

XIII Actual Procedure Followed (use blank sheet provided if space not sufficient)

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XIV Precaution Followed (use blank sheet provided if space not sufficient)

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XV Observations and Calculations (use blank sheet provided if space not sufficient)

Table No: 2.1 Observation Table for output voltage swing

Sr. No.	Vin1(p-p)	Vin2 (p-p)	Vo (p-p)

Calculations:

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XVI Results

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XVII Interpretation of Results (Give meaning of the above obtained results)

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XVIII Conclusions and Recommendation

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XIX Practical Related Questions (Note: Teacher shall assign batch wise additional one or two questions related to practical)

1. Change the IC 741 and note the output voltage swing**.**
2. State the value of Vin1 and Vin2 for output voltage swing.

[Space for Answers]

XX References / Suggestions for further reading

1. K.R.Botkar, *Integrated Circuits*, Khanna publication,10th edition,2005,ISBN NO :81-7409-208-0
2. Ramakant A.Gayakwad, *Op-Amps and linear Integrated Circuits*, Prentice -Hall India,3rd edition, 2001,ISBN NO : 81-203-0807-7
3. Tower's International data book for OpAmp

XXI Assessment Scheme

Performance Indicators		Weightage
Process related: 15 Marks		**60%**
1.	Mounting of IC 741 and resister on breadboard	10 %
2.	Connection of circuit diagram	20 %
3.	Measuring the values of output voltage for different frequency	20 %
4.	Working in team	10 %
Product related:10 Marks		**40%**
5.	Calculate parameter value	10 %
6.	Interpretation of result	05 %
7.	Conclusions	05 %
8.	Practical related questions	15 %
9.	Submitting the journal in time	05%
Total (25 Marks)		100 %

Name of Team Members

1. …………………………......
2. …………………………......
3. …………………………..
4. …………………………..

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Scale

X-axis -

Y-axis -

Practical No.3: Use relevant instruments to determine gain of the Inverting amplifier and Non Inverting amplifier consist of IC741.

I Practical Significance

Op-amps are among the most widely used electronic devices today, being used in a vast array of consumer, industrial, and scientific devices. Op-amps may be packaged as components or used as elements of more complex integrated circuits.

The inverting operational amplifier configuration is one of the simplest and most commonly used op amp topologies.

The non-inverting amplifier configuration is one of the most popular and widely used forms of operational amplifier circuit.

The op amp non-inverting amplifier circuit provides a high input impedance along with all the advantages gained from using an operational amplifier.

This practical will enables student to use Op Amp in inverting and non inverting configuration and find its output.

II Relevant Program Outcomes (POs)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Discipline knowledge:** Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Maintain electronic circuits consisting of linear Integrated Circuits.'**

- Select relevant electronic components IC 741 and resistor value for specified gain
- Mounting of the electronic component on breadboard as per circuit diagram.

IV Relevant Course Outcome(s)

- Use various configurations of Op-Amp for different applications.

V Practical Outcome

- Use relevant instruments to determine gain of the Inverting amplifier and Non Inverting amplifier consist of IC741.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Demonstrate working as a leader/a team member
- Follow ethical practices

VII Minimum Theoretical Background

Inverting amplifier is one in which the output is exactly 180^0 out of phase with respect to input(i.e. if you apply a positive voltage, output will be negative). Output is an inverted(in terms of phase) amplified version of input: Vo= -(Rf/R1) *Vi

Non Inverting amplifier is one in which the output is in phase with respect to input(i.e. if you apply a positive voltage, output will be positive). Output is an Non inverted(in terms of phase) amplified version of input. Vo=(1+Rf/R1)*Vi

VIII Practical Circuit diagram:

a) Sample circuit diagram

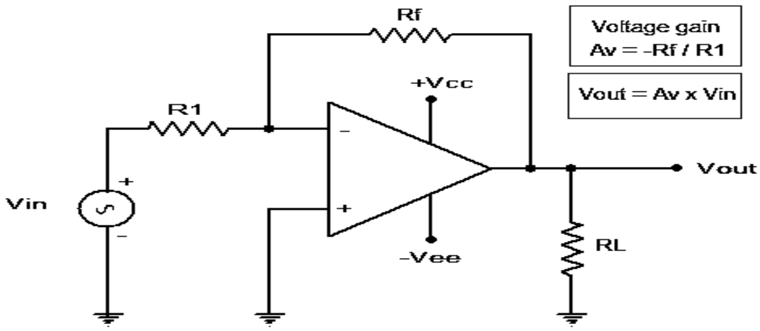

Figure 3.1 Inverting Amplifier

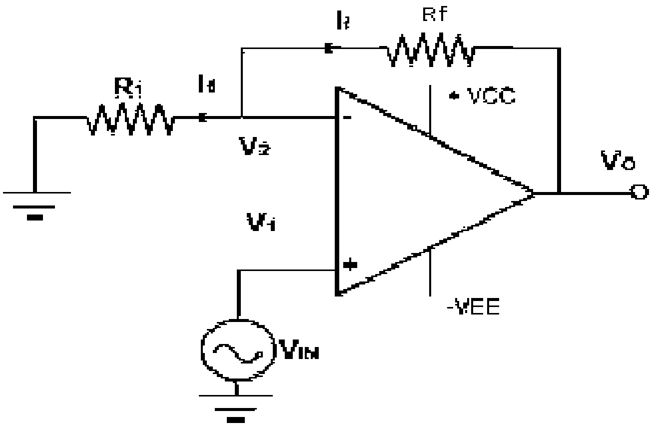

Figure 3.2 Non Inverting Amplifier

b) Actual Circuit diagram

c) Sample Experimental set up

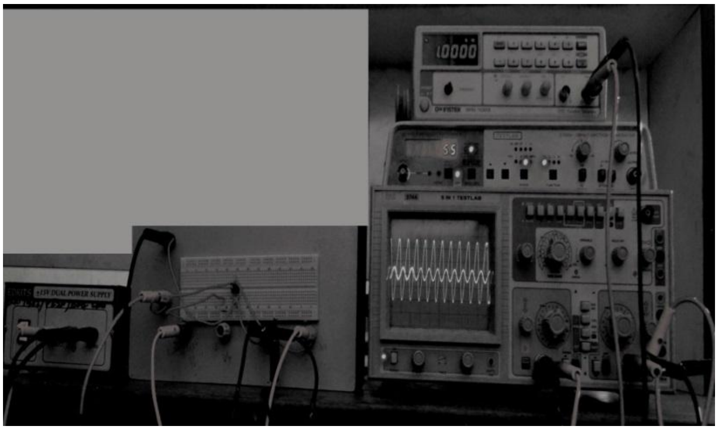

Figure 3.3 Inverting amplifier

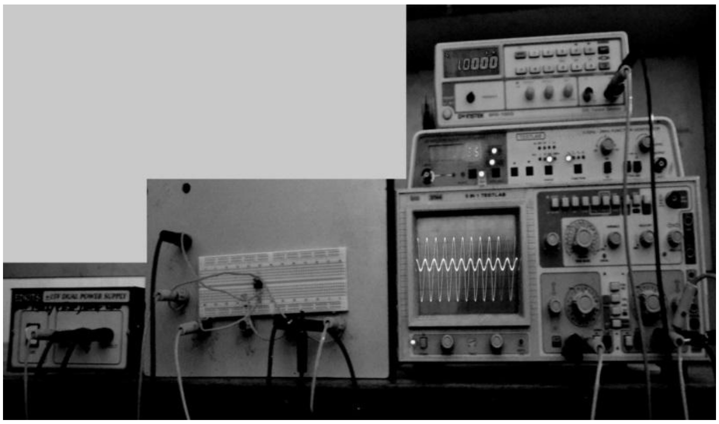

Figure 3.4 Non Inverting amplifier

d) Actual Experimental set up

IX Resources Required

Sr. No.	Instrument / Components	Specification	Quantity
1	Dual Power supply	0- 30V, 2A Dual tracking power supply	1 No.
2	IC-741C	Dual-In-Line or S.O. Package	2 No.
3	Resistors R_1	1KΩ	2 No.
4	Resistors R_f	10KΩ,	2 No.
5	Function Generator	20MHz	2 No.
6	Analog IC tester	Suitable to test analog ICs	1 No.
7	CRO	20MHz Dual Trace Oscilloscope	2 No.
8	Breadboard	5.5 cm X 17cm	2 No.
9	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

X Precautions to be followed

1. Ensure proper mounting of IC 741 and Resistor on Breadboard.
2. Ensure proper connection of Circuit
3. Ensure proper Input Voltage and Supply voltage to the Circuit.

XI Procedure

Inverting amplifier

1. Test IC741 with analog IC tester.
2. Make the point of supply voltage +15V, -15V and Ground on the Breadboard.
3. Connect pin No. 7 to +15V and pin No. 4 to -15V and pin No. 3 to Ground.
4. Connect R_1 and R_f as shown in Figure 3.1
5. Select Sine wave Vin of (1V, 500 Hz) from Function generator, Check the wave on CRO.
6. Apply the selected Sine wave input to pin No. 2.
7. Keep the amplitude constant and change input frequency from 100Hz to 1MHz.
8. Measure V_{Out} on CRO from pin No.6 and note down the reading.
9. Plot graph of frequency versus gain on semi log.
10. Find out band width and cut off frequency from semi log

Non Inverting amplifier

1. Test IC741 with analog IC tester.
2. Make the point of supply voltage +15V, -15V and Ground on the Breadboard.
3. Connect pin No. 7 to +15V and pin No. 4 to -15V and pin No. 2 to Ground.
4. Connect R_1 and R_F as shown in Figure 3.2
5. Select Sine wave Vin of (1V, 500 Hz) from Function generator, Check the wave on CRO.
6. Apply the selected Sine wave input to Pin No. 3.
7. Keep the amplitude constant and change input frequency from 100Hz to 1MHz.
8. Measure V_{out} on CRO from pin No. 6 and note down the reading.
9. Plot graph of frequency versus gain on semi log.
10. Find out band width and cut off frequency from semi log

XII Resources Used

S. No.	Instrument / Components	Specification	Quantity
1.			
2.			
3.			
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XIII Actual Procedure Followed (use blank sheet provided if space not sufficient)

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XIV Precaution Followed (use blank sheet provided if space not sufficient)

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XV Observations and Calculations (use blank sheet provided if space not sufficient)

Table No: 3.1 Observation Table For inverting amplifier Vi = 1V pp.

Sr. No.	Input Frequency(Hz)	Output Voltage, Vout(Volts)	Voltage Gain (A= Vout/Vi)	Gain in dB 20 log(Vout/Vi)
1.	100Hz			
2.	500Hz			
3.	1K			
4.	3K			
5.	6K			
6.	10K			
7.	20K			
8.	30K			
9.	40K			
10.	50K			
11.	60K			
12.	70K			
13.	80K			
14.	90K			
15.	100K			
16.	200K			
17.	300K			
18.	400K			
19.	500K			
20.	1M			

Table No: 3.2 Observation Table For Non Inverting amplifier Vi = 1V pp.

Sr. No.	Input Frequency(Hz)	Output Voltage,Vo (Volts)	Voltage Gain (A= Vo/Vi)	Gain in dB 20 log(Vo/Vi)
1.	100 Hz			
2.	500 Hz			
3.	1K			
4.	3K			
5.	6K			
6.	10K			
7.	20K			
8.	30K			
9.	40K			
10.	50K			
11.	60K			
12.	70K			
13.	80K			
14.	90K			
15.	100K			
16.	200K			
17.	300K			
18.	400K			
19.	500K			
20.	1M			

Calculations:

i. Voltage Gain: Vo/Vi =

ii. Voltage Gain in dB : 20log (Vo/Vi) =

XVI Results

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XVII Interpretation of Results (Give meaning of the above obtained results)

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XVIII Conclusions and Recommendation

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XIX Practical Related Questions (Note: Teacher shall assign batch wise additional one or two questions related to practical)

1. Draw the nature of output waveform for inverting and non-inverting amplifier which is shown in figure 3.1 and 3.2 for given sine wave.
2. State the effect of negative feedback in inverting amplifier?
3. Design a non-inverting amplifier for gain =5
4. State the maximum input signal voltage that can be applied in experimental circuit for linear operation?

[Space for Answers]

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XX References / Suggestions for further reading

1. Electronics Component Handbook; Jones, Thomas H., Reston Publishing, Resto, Virginia, USA, ISBN: 978087909222
2. Tower's International data book for OpAmp
3. Ramakant A.Gayakwad, *Op-Amps and linear Integrated Circuits*, Prentice -Hall India,3rd edition, 2001,ISBN NO : 81-203-0807-7
4. K.R.Botkar, *Integrated Circuits*, Khanna publication,10th edition,2005,ISBN NO :81-7409-208-0

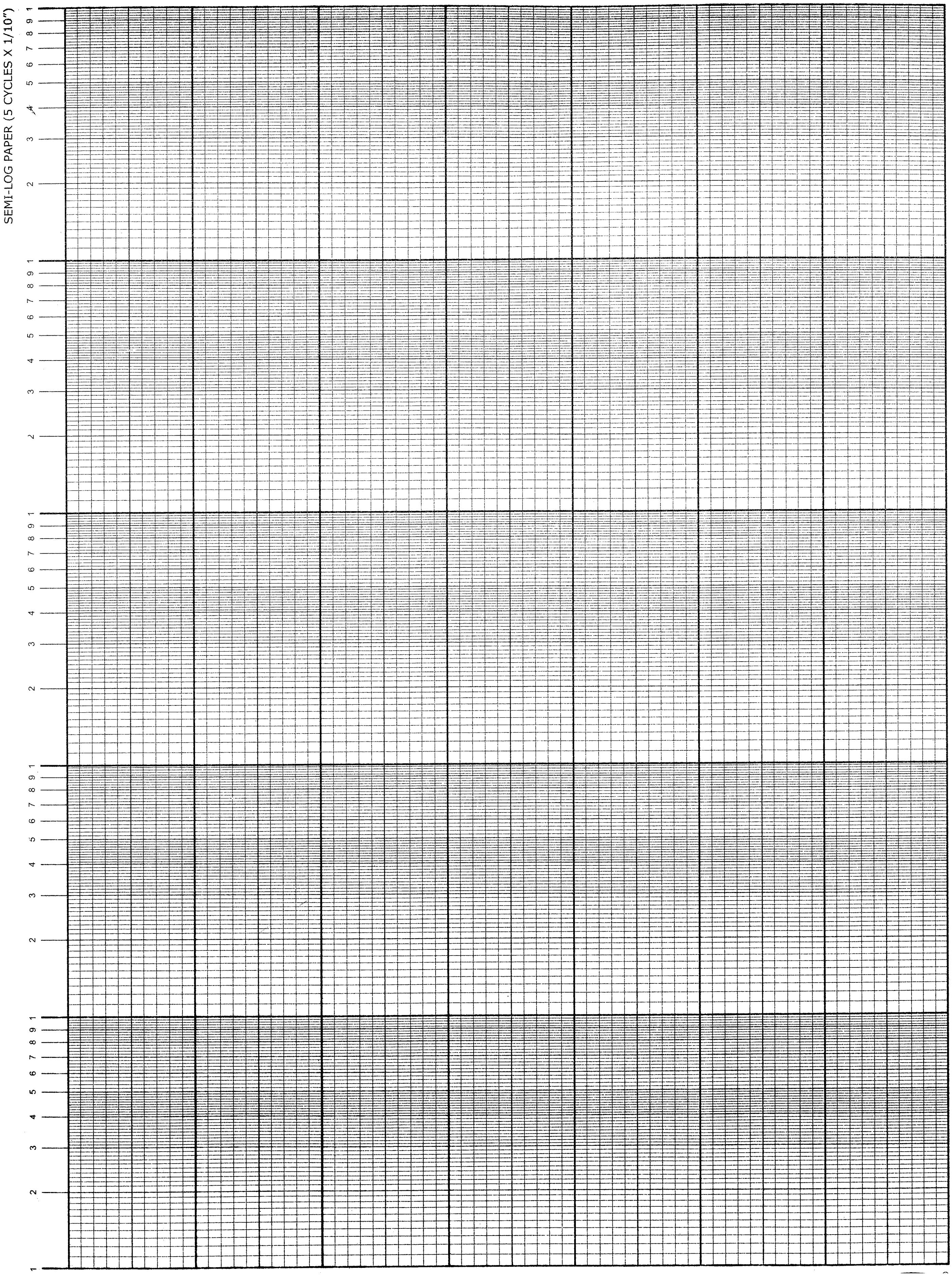
XXI Assessment Scheme

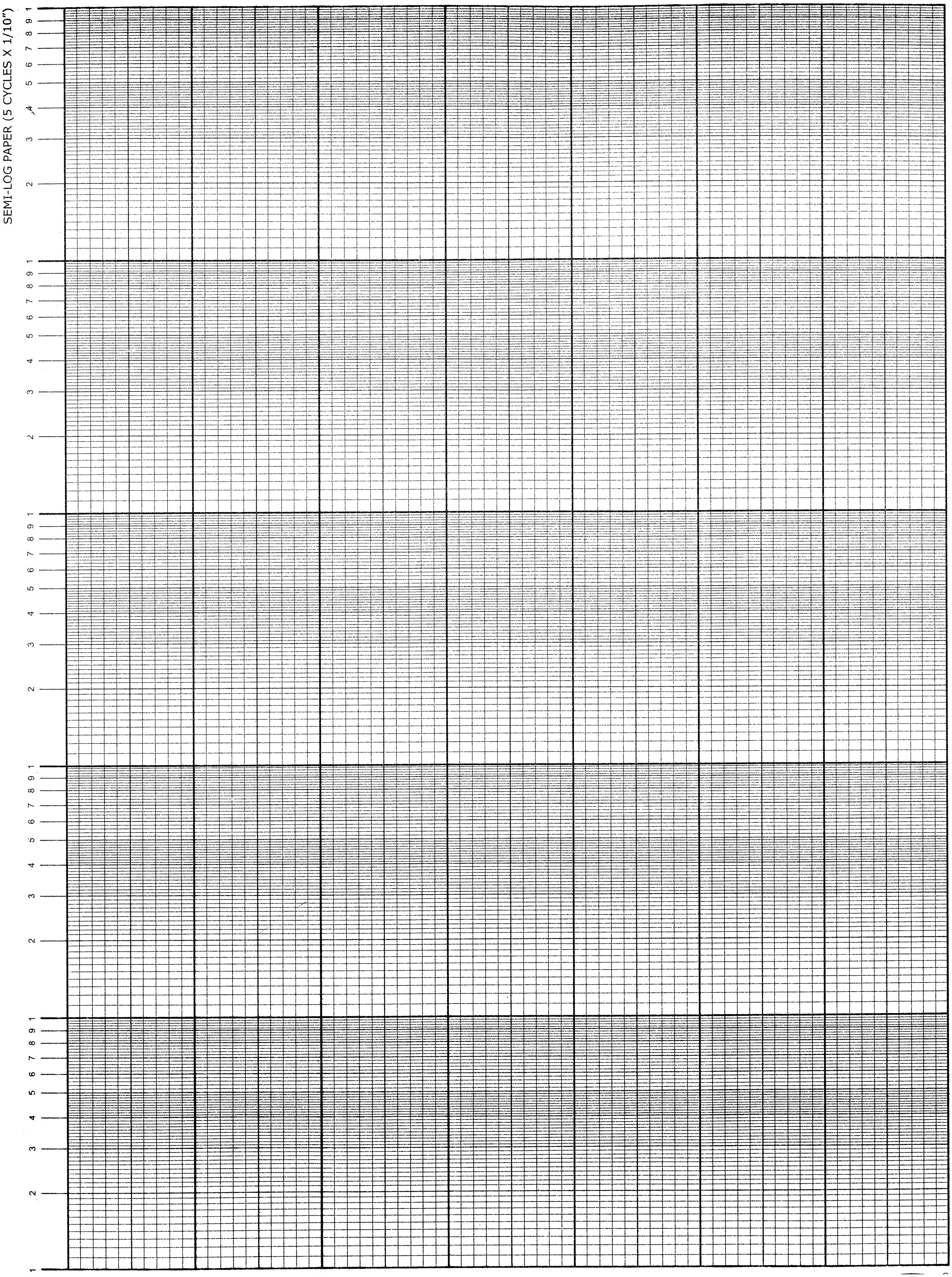
Performance Indicators		**Weightage**
Process related: 15 Marks		**60%**
1.	Mounting of IC 741 and resistor on breadboard	10 %
2.	Connection of circuit diagram	20 %
3.	Measuring the values of output voltage for different frequency	20 %
4.	Working in team	10 %
Product related:10 Marks		**40%**
	Calculate Gain and Bandwidth	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Name of Team Members

1. ………………………......
2. ………………………......
3. ………………………..
4. ………………………..

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	


SEMI-LOG PAPER (5 CYCLES X 1/10")


SEMI-LOG PAPER (5 CYCLES X 1/10")

Practical No. 4: Build/Test adder and subtractor circuit consist of IC 741.

I Practical Significance

In adder and subtractor circuit the input signal can be added and subtracted to the desire value by selecting appropriate values for the external resisters. These arithmetic functions employed in analog circuits. This circuit can be used to add ac or dc signals. This circuit provides an output voltage proportional to or equal to the algebraic sum of two or more input voltage each multiplied by a constant gain factor. This practical will enable student to add and subtract signals using IC 741

II Relevant Program Outcomes (POs)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Discipline knowledge:** Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Maintain electronic circuits consisting of linear Integrated Circuits.'**

- Select relevant electronic components IC 741 and resister value for specified gain.
- Mounting of the electronic component on breadboard as per circuit diagram.

IV Relevant Course Outcome(s)

- Use various configurations of Op-Amp for different applications.

V Practical Outcome

- Build/Test adder and subtractor circuit consist of IC 741.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Demonstrate working as a leader/a team member.
- Follow ethical practices

VII Minimum Theoretical Background

Adder and subtractor circuit using Op Amp is used to perform arithmetic operations like addition, subtraction etc. it is always used in close loop mode with negative feedback and the voltage gain is controlled by external component R1 and Rf when the power supply is connected there is output even when the two inputs are grounded this is called offset. It can be made zero by connecting 10KΩ POT between pin 1 and 5 and connecting wiper to pin 4. In inverting configuration of an op-amp if more than one input is given to inverting terminal then resultant circuits work as summing amplifier or adder.

$Vout = -(R_f / R) * (V_1 + V_2)$

Using a basic differential OpAmp configuration a subtractor can be designed. A difference amplifier has an output proportional to difference between the inputs. In difference amplifier resistors are of same value. Hence gain of difference amplifier is one.

Vout = (Rf / R)* (V1 -V2)

VIII Practical Circuit diagram:

a) Sample circuit diagram

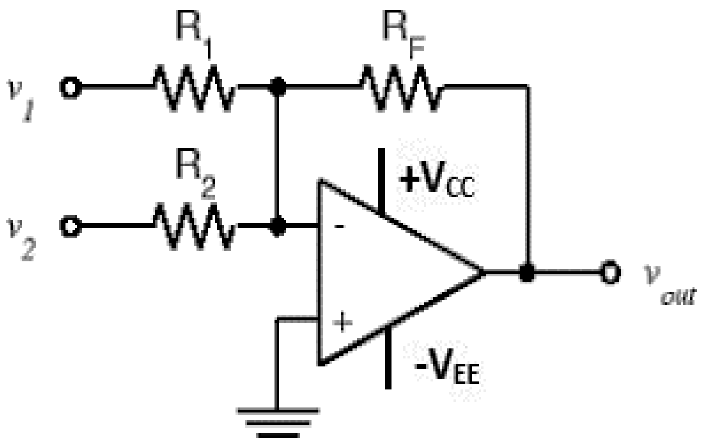


Figure 4.1 Inverting Adder

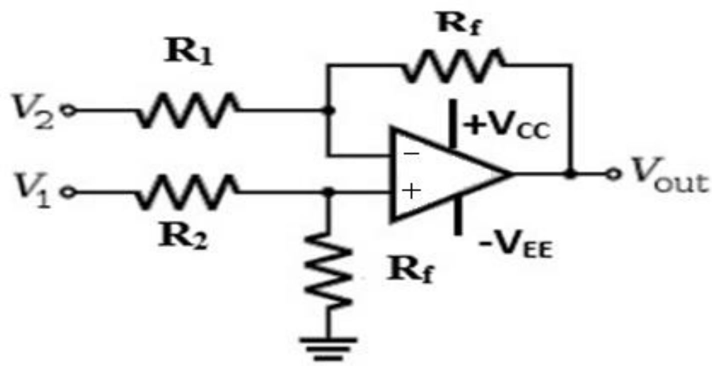


Figure 4.2 Subtractor

b) Actual Circuit diagram

c) Sample Experimental set up

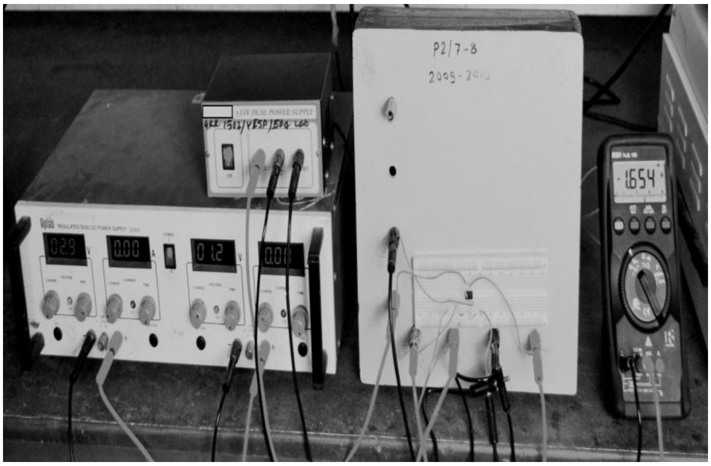


Figure 4.3 Subtractor

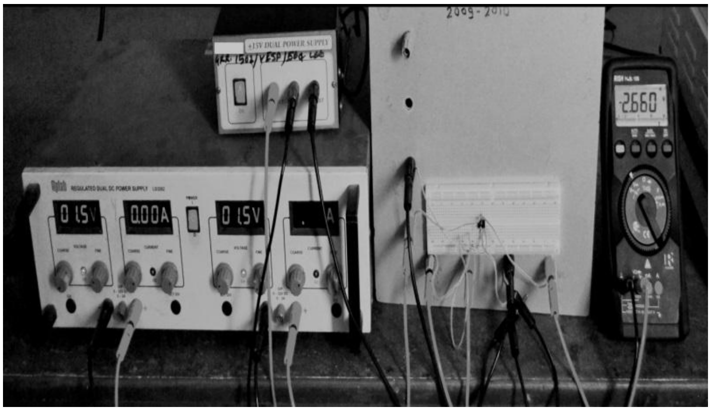


Figure 4.4 Adder

d) Actual Experimental set up

IX Resources Required Inverting Adder and subtractor

Sr. No.	Instrument /Components	Specification	Quantity
1.	Dual Power supply	0- 30V, 2A Dual tracking power supply	1 No.
2.	IC-741C	Dual-In-Line or S.O. Package	2 No.
3.	Resistors R_1 , R_2	1KΩ	4 No.
4.	Resistors R_f	1KΩ,	2 No.
5.	Analog IC tester	Suitable to test analog ICs	1 No.
6.	DMM	0-30V,2A	2 No.
7	Breadboard	5.5 cm X 17cm	2 No.
8	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

X Precautions to be followed

1. Ensure the proper value of resistor for specified gain.
2. Ensure proper connections are made to the equipment.
3. Ensure the power switch is in 'off' condition initially.
4. Ensure the input voltage is in proper value.

XI Procedure

Inverting Adder

1. Test and mount the IC on the breadboard.
2. Make connection as per circuit diagram.
3. Connect dual power supply.
4. Apply input voltages V1 and V2 using regulated power supply.
5. Connect DMM to the output of circuit pin No.6
6. Perform offset nulling (Ground both the inputs and measure output on DMM. Adjust 10KΩ Potentiometer Connected between 1 and 5 to get 0 volt at the output)
7. Adjust input voltages V1 and V2 using regulated power supply.
8. Calculate (V1 + V2) and the theoretical output voltage using the formula
9. Vout = -(Rf/ R) * (V1 + V2) Note: R=R1=R2
10. Using DMM, measure V0and record it in the observation table
11. Compare theoretical and observed output.
12. Repeat steps 5 and 8 for different values of $V_{1,}$ $V_{2.}$

Subtractor

1. Test and mount the IC on the breadboard.
2. Make connection as per circuit diagram.
3. Connect dual power supply.
4. Apply input voltages V1 and V2 using regulated power supply.
5. Connect DMM to the output of circuit pin No.6
6. Perform offset nulling (Ground both the inputs and measure output on DMM. Adjust 10KΩ Potentiometer Connected between 1 and 5 to get 0 volt at the output)
7. Adjust input voltages V1 and V2 using regulated power supply.
8. Calculate (V1 - V2) and the theoretical output voltage using the formula
9. Vout = Rf/ R* (V1 - V2) Note: R=R1=R2=Rf
10. Using DMM, measure V0 and record it in the observation table
11. Compare theoretical and observed output.
12. Repeat steps 5 and 8 for different values of $V_{1,}$ $V_{2.}$

XII Resources Used

Sr. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			
5.			

XIII Actual Procedure Followed (use blank sheet provided if space not sufficient)

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XIV Precautions Followed (use blank sheet provided if space not sufficient)

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XV Observations and Calculations (use blank sheet provided if space not sufficient)

Table No: 4.1 Observation Table for Inverting Adder

SR No.	Input Voltage (volts)		$(V_1 + V_2)$	Vout = $-(R_f/R) * (V_1 + V_2)$ (theoretical)	Output voltage Vout (practical)	Practical Gain = Vout $/(V_1 + V_2)$
	V_1	V_2				
1.						
2.						
3.						
4.						
5.						

Note: $R_1 = R_2 = R_f = R$

Table No: 4.2 Observation Table for Subtractor

SR No.	Input Voltage (volts)		$(V_1 - V_2)$	Vout = $(R_f/ R) * (V_1 - V_2)$ (theoretical)	Output voltage Vout (practical)	Practical Gain = Vout $/(V_1 - V_2)$
	V_1	V_2				
1.						
2.						
3.						
4.						
5.						

Note: $R_1 = R_2 = R_3 = R_f = R$

Calculations:

Inverting Adder

1. $(V_1 + V_2) =$
2. Vout = $-R_f/ R * (V_1 + V_2)$
3. Practical Gain =Vout $/(V_1 + V_2)$

Subtractor

1. $(V_1 - V_2) =$
2. Vout = $R_f/ R * (V_1 - V_2)$
3. Practical Gain =Vout $/(V_1 - V_2)$

XVI Results

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XVII Interpretation of Results (Give meaning of the above obtained results)

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XVIII Conclusions and Recommendation

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XIX Practical Related Questions

1. Can the given adder circuit be used for averaging? If yes, how? Justify
2. Why it is necessary to null the offset voltage before using the OPAMP?
3. Draw the circuit diagram of non-inverting Adder.
4. State the expression for output voltage of non-inverting summing amplifier?
5. Draw the circuit for the define output equation $Vo = 2(V_1 + V_2 + V_3)$
6. Suggest the circuit and value of input and feedback resistor for given output equation $Vo = -3(V_a - V_b)$
7. State two basic differences between inverting and non inverting averaging amplifier.

[Space for Answers]

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XX References / Suggestions for further reading

1. Electronics Component Handbook; Jones, Thomas H., Reston Publishing, Resto, Virginia, USA, ISBN: 978087909222
2. Tower's International data book for OpAmp
3. Ramakant A.Gayakwad, *Op-Amps and linear Integrated Circuits*, Prentice -Hall India,3rd edition, 2001,ISBN NO : 81-203-0807-7
4. K.R.Botkar, *Integrated Circuits*, Khanna publication,10th edition,2005,ISBN NO :81-7409-208-0

XXI Assessment Scheme

Performance Indicators		**Weightage**
Process related: 15 Marks		**60%**
1	Mounting of IC 741 and proper value of resistor on breadboard	10 %
2	Connection of circuit diagram	20 %
3	Measuring the values of output voltage for different value of input voltage	20 %
4	Working in team	10 %
Product related:10 Marks		**40%**
5	Calculate theoretical value of output	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Answer to practical related questions	15 %
9	Submitting the journal in time	05%
Total (25 Marks)		100 %

Name of Team Members

1. …………………………......
2. …………………………......
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Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 5: Build / Test Integrator circuit consist of IC741

I Practical Significance

Operational amplifier can be configured as integration. In an integrating circuit, the output is the integration of the input voltage with respect to time. An integrator circuit which consists of active devices is called an Active integrator. An active integrator provides a much lower output resistance and higher output voltage than is possible with a simple RC circuit. Integrator circuits are usually designed to produce a triangular wave output from a square wave input. Integrating circuits have frequency limitations while operating on sine wave input signals. This practical will enable student to convert the square wave to triangular wave using IC 741

II Relevant Program Outcomes (POs)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Discipline knowledge:** Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Maintain electronic circuits consisting of linear Integrated Circuits.'**

- Select relevant electronic components IC 741 and resistor and capacitor value for specified gain
- Mounting of the electronic component on breadboard as per circuit diagram of integrator

IV Relevant Course Outcome(s)

- Use various configurations of Op-Amp for different applications.

V Practical Outcome

- Build/Test Integrator circuit consists of IC741.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Demonstrate working as a leader/a team member.
- Follow ethical practices

VII Minimum Theoretical Background

An integrator is a circuit that performs a mathematical operation called integration. Integration is a process of continues additions. The most popular application of an integrator is to produce a ramp of output voltage which is linearly increasing or decreasing voltage. It is similar to inverting amplifier circuit except that the feedback is through capacitor C instead of register $R_{F.}$ If the input voltage is step voltage then output voltage will be ramp or linearly changing voltage. Integrators are widely used in ramp or sweep generator, in filter, analog computer etc.

$V_O = -1/RC \int V_i \, dt$

VIII Practical Circuit diagram :

a) Sample Circuit diagram

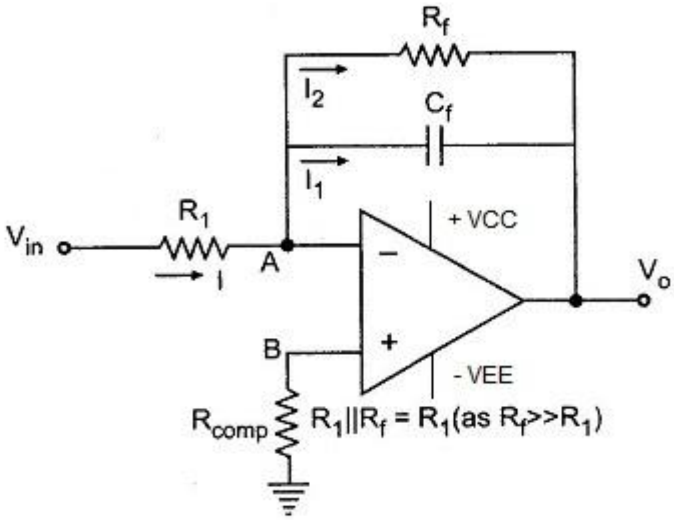

Figure 5.1 Active Integrator

b) Actual Circuit diagram

c) Sample Experimental set up

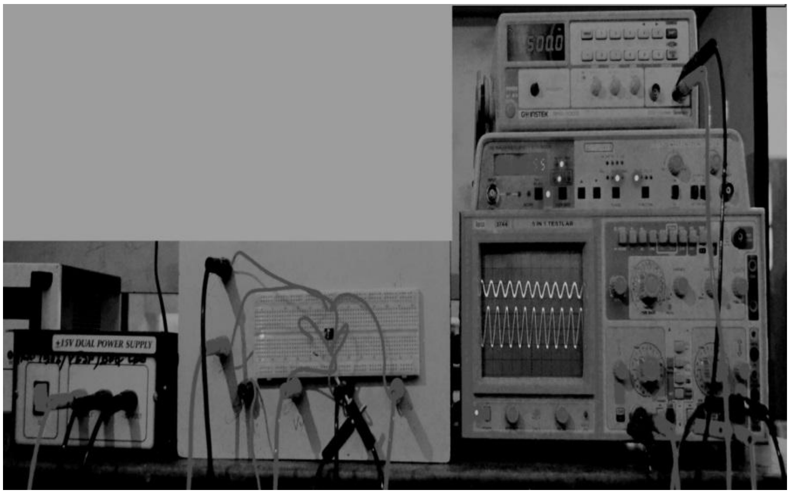

Figure 5.2 Active Integrator

d) Actual Experimental set up

IX Resources Required

Sr. No.	Instrument /Components	Specification	Quantity
1.	Dual Power supply	± 15 V 2A Dual tracking power supply	1 No.
2.	IC-741C	Dual-In-Line or S.O. Package	1 No.
3.	Resistors R_1	10KΩ	1 No.
4.	Resistors R_f	100KΩ,	1 No.
5.	Capacitor C_F	0.01µF	1 No.
6.	Function generator	02 Hz to 2 MHz	1 No.
7.	CRO	0 to 20 MHz	1 No.
8.	Analog IC tester	Suitable to test analog IC	1 No.
9.	Breadboard	5.5 cm X 17cm	1 No.
10.	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

X Precautions to be Followed

1. Ensure proper connections are made to the equipment.
2. Ensure the power switch is in ‘off’ condition initially.
3. Ensure the use of proper settings of function generator and CRO.
4. Insure the proper value of resistor and capacitor.

XI Procedure

1. Assemble the circuit on breadboard as per circuit diagram.
2. Connect dual power supply to pins No.7 (+Vcc) and pin No.4 ($-V_{EE}$) of IC 741.
3. Set the function generator to produce a sine waveform of 1V pp amplitude at 1 KHz to pin No. 2
4. Check the waveform on CRO before applying it as input.
5. Observe input and output (pin No.6) waveforms on CRO for 1 KHz frequency and check the phase shift for the given input from function generator and CRO.
6. Vary the input frequency from 100 Hz to 10 KHz keeping input voltage 1V.
7. Measure the output voltage for each frequency and note the output voltage in observation table.
8. Plot the graph gain vs. frequency on semi log paper. Calculate gain for different input frequency in decibels.

XII Resources Used

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			

XIII Actual Procedure Followed (use blank sheet provided if space not sufficient)

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XIV Precaution Followed (use blank sheet provided if space not sufficient)

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XV Observations and Calculations(use blank sheet provided if space not sufficient)

Table No: 5.1 Observation Table for Integrator Input Voltage Vi = 1 V pp

Sr. No.	Input Frequency (Hz)	Output Voltage, Vo (Volts)	Gain in dB $20 \log_{10}(Vo/Vi)$
1.	100 Hz		
2.	200 Hz		
3.	300 Hz		
4.	400 Hz		
5.	500 Hz		
6.	600 Hz		
7.	700 Hz		
8.	800 Hz		
9.	900 Hz		
10.	1 K		
11.	2 K		
12.	3 K		
13.	4 K		
14.	5 K		
15.	6 K		
16.	7 K		
17.	8 K		
18.	9 K		
19.	10 K		

Calculations:

i. Voltage Gain : Vo/Vi

ii. Voltage Gain in dB : $20 \log_{10}(Vo/Vi)$

iii. 3 dB Bandwidth, $B/W = F_H - F_L$

XVI Results

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XVII Interpretation of Results (Give meaning of the above obtained results)

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XVIII Conclusions and Recommendation

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XIX Practical Related Questions

1. Apply different inputs: sine wave, square wave and triangular wave to the integrator and observe the output. Draw input and output waveforms on graph paper.
2. Repeat the integrator practical for R1= 10K, Cf = 0.02μf and the input voltage is V in = 4 Vpp
3. Can integrator act as low pass filter? Justify your answer with the help of frequency response.
4. State the effect on output of an integrator circuit for a condition $T<R_fC_f$? Give reason.

[Space for Answers]

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XX References / Suggestions for further reading

1. Electronics Component Handbook; Jones, Thomas H., Reston Publishing, Resto, Virginia, USA, ISBN: 978087909222
2. Tower's International data book for OpAmp
3. Ramakant A.Gayakwad, *Op-Amps and linear Integrated Circuits*, Prentice -Hall India,3rd edition, 2001,ISBN NO : 81-203-0807-7
4. K.R.Botkar, *Integrated Circuits*, Khanna publication,10th edition,2005,ISBN NO :81-7409-208-0

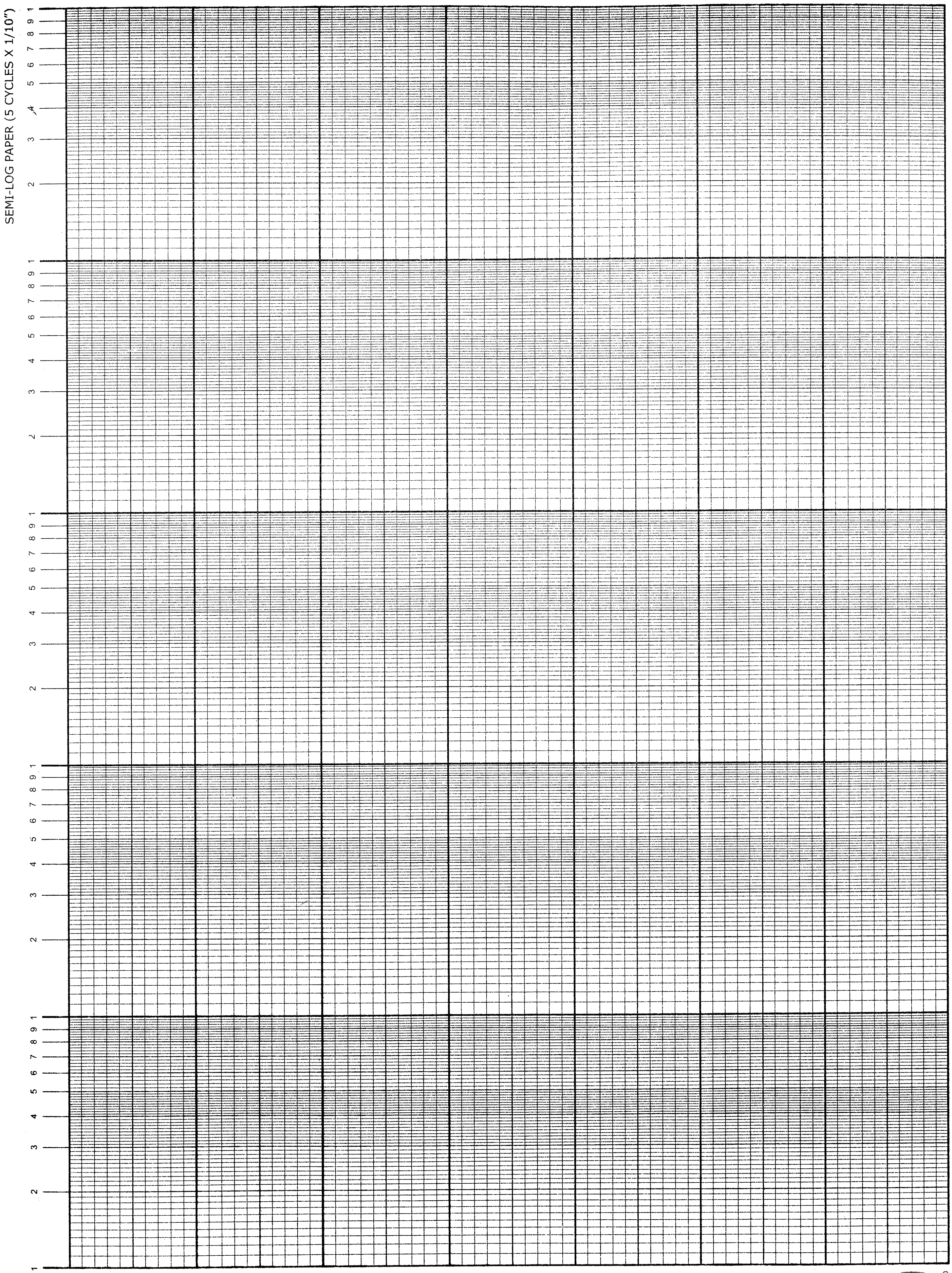
XXI Assessment Scheme

Performance Indicators		Weightage
Process related: 15 Marks		**60%**
1.	Mounting of IC 741 and proper value of resistor and capacitor on breadboard	10 %
2.	Connection of circuit diagram	20 %
3.	Measuring value using CRO	20 %
4.	Working in team	10 %
Product related:10 Marks		**40%**
5.	Calculate theoretical value of output	10 %
6.	Interpretation of result	05 %
7.	Conclusions	05 %
8.	Answer to practical related questions	15 %
9.	Submitting the journal in time	05%
T**otal (25 Marks)**		100 %

Name of Team Members

1. …………………………......
2. …………………………......
3. …………………………..
4. …………………………..

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	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Practical No. 6: Build/Test differentiator circuit consists of IC741.

I Practical Significance

In differentiator circuit the position of the capacitor and resistor have been reversed and now the reactance, X_C is connected to the input terminal of the inverting amplifier while the resistor, R_f forms the negative feedback element across the operational amplifier. The differentiator circuit performs the mathematical operation of and "produces a voltage output voltage which is directly proportional to the input voltages rate-of-change with respect to time". The faster or larger the change to the input voltage signal, the greater the input current, the greater will be the output voltage change becoming more of a "spike" in shape. The input signal to the differentiator is applied to the capacitor. The capacitor blocks DC content so there is no current flow to the amplifier summing point. Resulting in zero output voltage. The capacitor only allows AC type input voltage changes to pass through and whose frequency is dependent on the rate of change of the input signal. This practical will enable student to convert the square wave to spike wave using IC 741.

II Relevant Program Outcomes (POs)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Discipline knowledge:** Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Maintain electronic circuits consisting of linear Integrated Circuits.'**

- Select relevant electronic components IC741, resistor and capacitor value for specified gain
- Mounting of the electronic component on breadboard as per circuit diagram.

IV Relevant Course Outcome(s)

- Use various configurations of Op-Amp for different applications.

V Practical Outcome

- Build/Test differentiator circuit consist of IC741

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Demonstrate working as a leader/a team member.
- Follow ethical practices

VII Minimum Theoretical Background

The differentiator circuit performs the mathematical operation of differentiation i.e. the output waveform is the derivative of the input waveform. The differentiator may be constructed from a basic inverting amplifier if an input resistor R1 is replaced by a capacitor C1 .

The expression for the output voltage can be obtained as the output V0 is equal to RF C1 times the negative rate of change of the input voltage Vin with time. The (–) sign indicates a 180 phase shift of the output waveform V_0 with respect to the input signal. Since the differentiator performs the reverse of the integrator function.
V_O= -RC dv_i/dt

VIII Practical Circuit diagram :

a) Sample circuit diagram

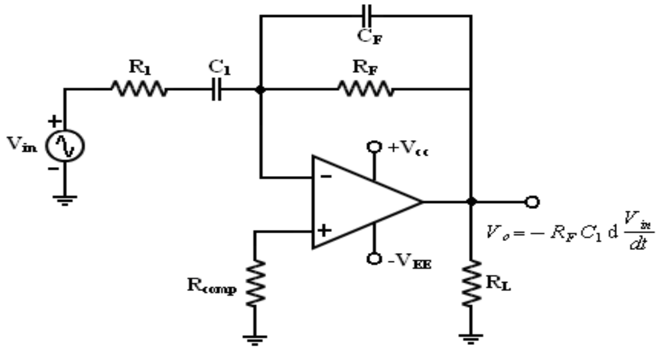

Figure 6.1 Active differentiator

b) Actual Circuit diagram

c) Sample Experimental set up

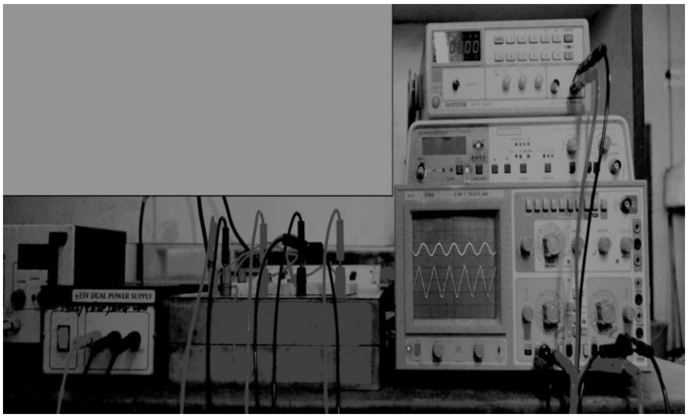

Figure 6.2 Active differentiator

d) Actual Experimental set up

IX Resources Required

Sr. No.	Instrument /Components	Specification	Quantity
1.	Dual Power supply	0- 30V, 2A Dual tracking power supply	1 No.
2.	IC-741C	Dual-In-Line or S.O. Package	1 No.
3.	Resistors R_1	82Ω	1 No.
4.	Resistors R_f	1.5KΩ,	1 No.
5.	Capacitor C_F	0.01µF	1 No.
6.	Capacitor C_1	0.1µF	1 No.
7.	Resistors R_l	10 KΩ,	1 No.
8.	Resistors R_{ROM}	1.5KΩ,	1 No.
9.	Function generator	02 Hz to 2 MHz	1 No
10.	CRO	0 to 20 MHz	1 No
11.	Analog IC tester	All analog IC tester	1 No.
12	Breadboard	5.5 cm X 17cm	1 No.
13	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

X Precautions to be Followed

1. Ensure proper connections are made to the equipment.
2. Ensure the power switch is in ‘off’ condition initially.
3. Ensure the use of proper settings of function generator and CRO.
4. Ensure the proper value of resistor and capacitor.

XI Procedure

1. Assemble the circuit on breadboard as per circuit diagram.
2. Connect dual power supply to pin No.7 (+Vcc) and pin No.4 (-V_{EE}) of IC 741.
3. Set the function generator to produce a sine waveform of 1V pp amplitude at 1 KHz.
4. Check the waveform on CRO before applying it as input.
5. Observe input and output waveforms (at pin No.6) on CRO for 1 KHz frequency and check the phase shift for the given input from function generator and CRO
6. Vary the input frequency from 100 Hz to 10 KHz keeping input voltage 1V.
7. Measure the output voltage for each frequency and note the output voltage in observation table 5.1
8. Plot the graph gain vs. frequency on semi log paper. Calculate gain for different input frequency in decibels.

XII Resources Used

Sr. No.	Instrument /Components	Specification	Quantity
1.			
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XIII Actual Procedure Followed (use blank sheet provided if space not sufficient)

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XIV Precaution Followed (use blank sheet provided if space not sufficient)

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XV Observations and Calculations(use blank sheet provided if space not sufficient)

Table No: 6.1 Observation Table for differentiator Input Voltage Vi = 1 V pp

Sr. No.	Input Frequency (Hz)	Output Voltage, Vo (Volts)	Gain in dB $20 \log_{10}(Vo/Vi)$
1.	100 Hz		
2.	200 Hz		
3.	300 Hz		
4.	400 Hz		
5.	500 Hz		
6.	600 Hz		
7.	700 Hz		
8.	800 Hz		
9.	900 Hz		
10.	1 K		
11.	2 K		
12.	3 K		
13.	4 K		
14.	5 K		
15.	6 K		
16.	7 K		
17.	8 K		
18.	9 K		
19.	10 K		

Calculations:

i. Voltage Gain : Vo/Vi

ii. Voltage Gain in dB : $20 \log_{10}(Vo/Vi)$

iii. 3 dB Bandwidth, $B/W = F_H - F_L$

XVI Results

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XVII Interpretation of Results (Give meaning of the above obtained results)

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XVIII Conclusions and Recommendation

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XIX Practical Related Questions

1. Apply different inputs: sine wave, square wave and triangular wave to the differentiator and observe the output. Draw input and output waveforms on graph paper.
2. Can the active high pass filter acts as differentiator? Justify
3. State the effect of time constant on the differentiator waveform?
4. Draw the output of differentiator if the input is symmetrical triangular waveform?

[Space for Answers]

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XX References / Suggestions for further reading

1. Ramakant A.Gayakwad, Op-Amps and linear Integrated Circuits, Prentice -Hall India,3rd edition, 2001,ISBN NO : 81-203-0807-7
2. Electronics Component Handbook; Jones, Thomas H., Reston Publishing, Resto, Virginia, USA, ISBN: 978087909222
3. Tower's International data book for Op Amp

XXI Assessment Scheme

Performance Indicators		Weightage
Process related: 15 Marks		**60%**
1.	Mounting of IC 741 and proper value of resister and capacitor on breadboard	10 %
2.	Connection of circuit diagram	20 %
3.	Measuring value using CRO	20 %
4.	Working in team	10 %
Product related:10 Marks		**40%**
5.	Calculate theoretical value of gain	10 %
6.	Interpretation of result	05 %
7.	Conclusions	05 %
8.	Practical related questions	15 %
9.	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Name of Team Members

1. …………………………......
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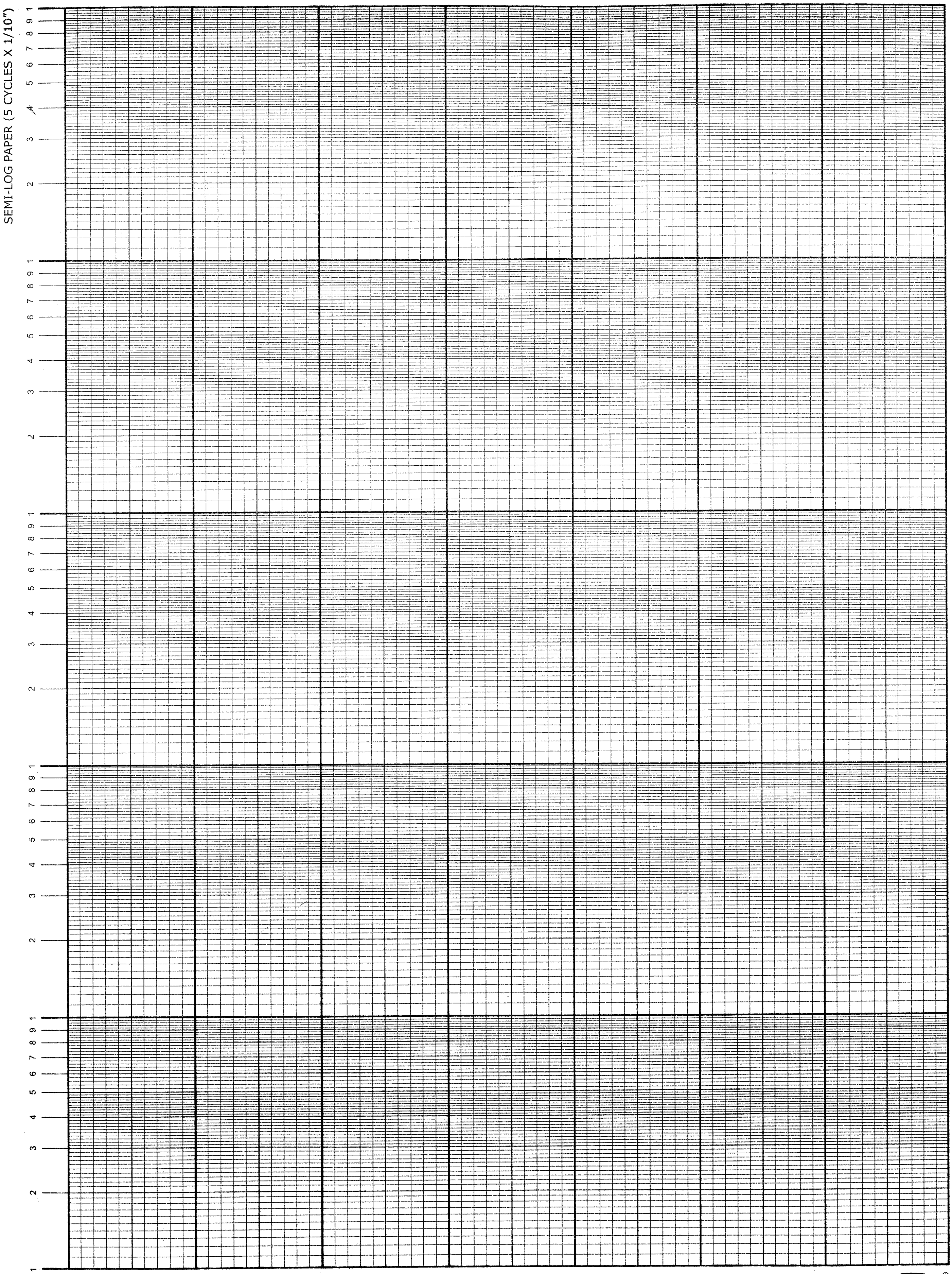
Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	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Practical No.7: Build/Test Voltage to Current converter and Current to Voltage converter circuit consist of IC 741.

I Practical Significance

In voltage to current convertor the current is proportional to certain voltage, even though the load resistance may vary, the feedback resistor Rf is replaced by a load resistor $R_{L.}$Voltage to current converter is useful to convert transducer output signal (which is generally in voltage form) into current.

In current to voltage convertor the current is converted into a proportional output voltage. The current to voltage used in digital to analog convertor circuit .This practical will enable student to convert the voltage to current and current to voltage using IC 741

II Relevant Program Outcomes (POs)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Discipline knowledge:** Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Maintain electronic circuits consisting of linear Integrated Circuits.'**

- Select relevant electronic components IC 741 and resistor and capacitor value for specified gain
- Mounting of the electronic component on breadboard as per circuit diagram.

IV Relevant Course Outcome(s)

- Troubleshoot various linear applications of Op-Amp for the given specifications

V Practical Outcome

- Build/Test Voltage to Current converter and Current to Voltage converter circuit consist of IC 741.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Demonstrate working as a leader/a team member.
- Follow ethical practices

VII Minimum Theoretical Background

Voltage to current convertor in which load resistor RL is floating .The input voltage is applied to the non-inverting terminal and the feedback voltage across R1 drive the inverting input terminal .this circuit also called as current-series negative feedback amplifier because feedback voltage across R1 depends on the output current Io and is in series with the input difference voltage Vid.

Current–to-voltage convertor was presented as a special case of the inverting amplifier in which an input current is converted into a proportional output voltage.

VIII Practical Circuit diagram :

a) Sample circuit diagram

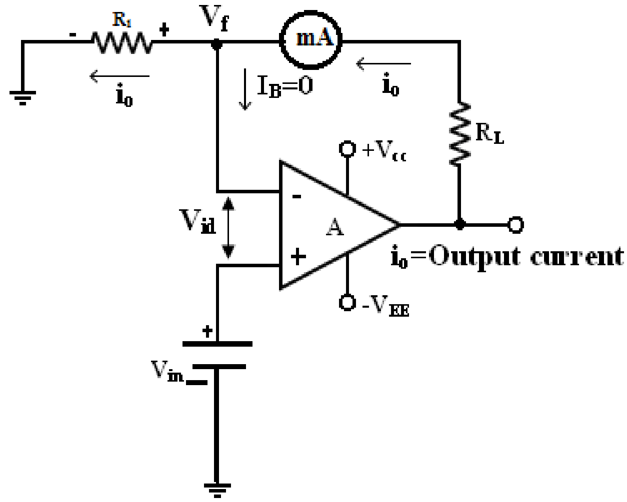

Figure 7.1 Voltage to Current converter

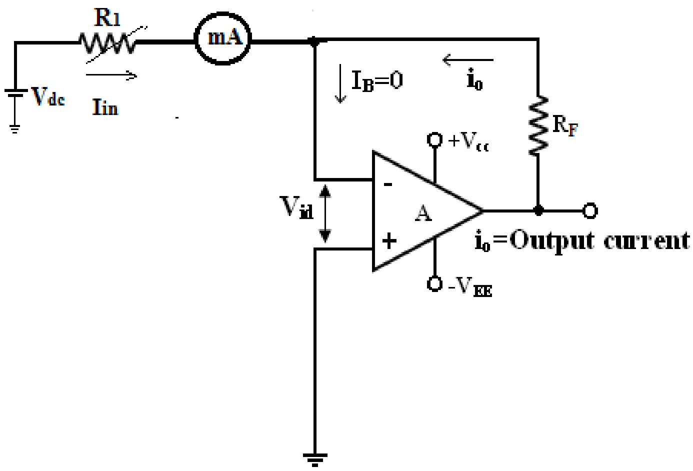

Figure 7.2 Current to voltage converter

b) Actual Circuit diagram

c) Sample Experimental set up

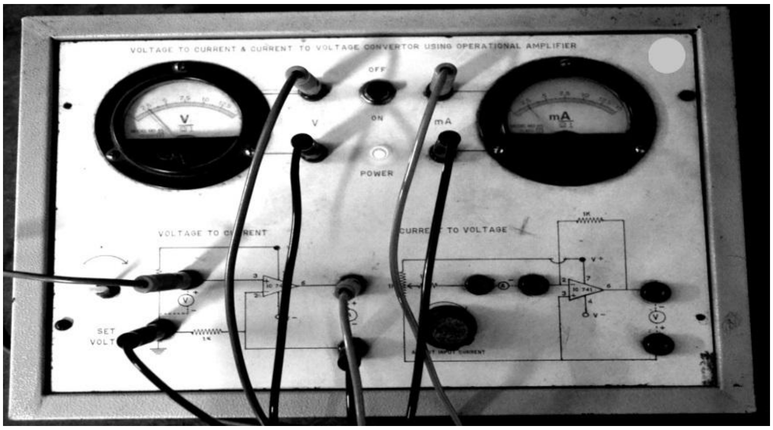

Figure 7. 3 Voltage to Current converter

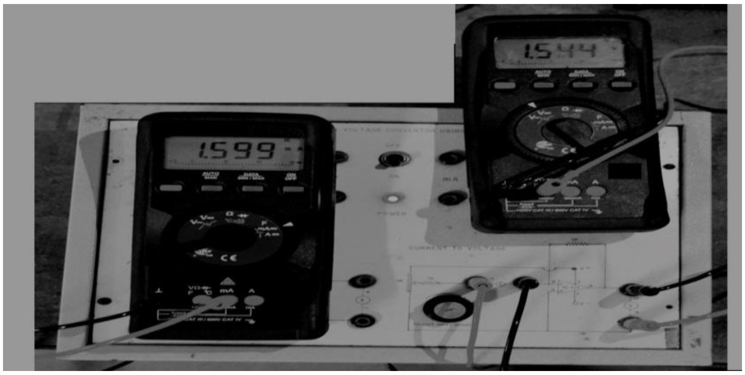

Figure 7.4 Current to Voltage converter

d) Actual Experimental set up

IX Resources Required

S. No.	Instrument /Components	Specification	Quantity
1.	Dual Power supply	± 15 V 1 A Dual tracking power supply	1 No.
2	D C Power supply	0 to 30 V 1 A with SC protection Digital meter	1 No.
3.	IC-741C	Dual-In-Line or S.O. Package	2 No.
4.	Resistors R_1	1KΩ	2 No.
5.	Resistors R_L	1KΩ,	1 No.
6.	Resistors R_f	3KΩ,	1 No.
7.	DMM	0 to 20 mA,10V	2 No.
8.	Analog IC tester	Suitable to test l analog IC	1 No.
9.	Breadboard	5.5 cm X 17cm	2 No.
10.	Connecting wires	Single strand Teflon coating (0.6mm diameter)	Asper requirement

X Precautions to be Followed

1. Ensure proper connections are made to the equipment.
2. Ensure the power switch is in ‘off’ condition initially.
3. Ensure the use of proper settings of input voltage.
4. Ensure the proper value of resistor.

XI Procedure for voltage to current convertor

1. Test and mount IC 741, resistor on breadboard.
2. Connect dual power supply to pin No. 7 (+Vcc) and pin No.4 (-V_{EE}) of IC 741 as shown in circuit diagram
3. Connect power supply to input of circuit diagram Vary input voltage in the range of 1 to 5 volt in step of 1 volt.
4. Vary input voltage in the range of 1 to 5 volt in step of 1 volt.
5. Measure the corresponding current using Ammeter record reading in the observation table No.7.1.
6. Calculate theoretical value of current using Io= (Vo-Vin) /R1.
7. Compare theoretical current and practical current values.

Procedure for current to voltage convertor

1. Test and mount IC 741,resistor on breadboard.
2. Connect dual power supply to pin No. 7 (+Vcc) and pin No. 4 (-V_{EE}) of IC 741 as shown in circuit diagram
3. Connect power supply to input of circuit diagram Vary input current in the range of 1 to 5 mA in step of 1 volt.
4. Vary input current in the range of 1 to 5 mA in step of 1 mA.
5. Measure the corresponding current using Ammeter.
6. Measure the corresponding output voltage using voltmeter and record reading in the observation table no.7.2.
7. Calculate theoretical value of current using Vo= -IR
8. Compare theoretical values of voltage and practical values of voltage

XII Resources Used

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			
5.			

XIII Actual Procedure Followed (use blank sheet provided if space not sufficient)

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XIV Precaution Followed (use blank sheet provided if space not sufficient)

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XV Observations and Calculations(use blank sheet provided if space not sufficient)

Table No: 7.1 Observation Table for voltage to current convertor

Sr.No.	DC Input voltage (Vin)V	Output current (Io)mA	
		Theoretical	Practical
1.	1V		
2.	2V		
3.	3V		
4.	4V		
5.	5V		

Calculations:

i. Io = (Vo-Vin) /R1

Table No: 7.2 Observation Table for current to voltage convertor

Sr. No.	DC Input current (Iin)mA	Output Voltage (Vo)V	
		Theoretical	Practical
1.	1mA		
2.	2mA		
3.	3mA		
4.	4mA		
5.	5mA		

Calculations:

i. $V_o = -I_{in} * R_1$

XVI Results

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XVII Interpretation of Results (Give meaning of the above obtained results)

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XVIII Conclusions and Recommendation

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XIX Practical Related Questions

1. Design a low voltage DC voltmeter with full scale voltage range of 1 to 10 volt using IC 741
2. Give output expression for I to V convertor.
3. Give output expression for V to I convertor with floating load

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XX References / Suggestions for further reading

1. Ramakant A.Gayakwad, Op-Amps and linear Integrated Circuits, Prentice -Hall India,3rd edition, 2001,ISBN NO : 81-203-0807-7
2. Electronics Component Handbook; Jones, Thomas H., Reston Publishing, Resto, Virginia, USA, ISBN: 978087909222.
3. Tower's International data book for OpAmp.

XXI Assessment Scheme

	Performance Indicators	Weightage
	Process related: 15 Marks	**60%**
1.	Mounting of IC 741 and proper value of resistor on breadboard	10 %
2.	Connection of circuit diagram	20 %
3.	Measuring value using CRO	20 %
4.	Working in team	10 %
	Product related:10 Marks	**40%**
5.	Calculate theoretical value of gain	10 %
6.	Interpretation of result	05 %
7.	Conclusions	05 %
8.	Practical related questions	15 %
9.	Submitting the journal in time	05%
	Total (25 Marks)	100 %

Name of Team Members

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Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 8: Build/Test comparator circuit consist of IC741 as Zero crossing detector and active positive peak detector.

I Practical Significance

A zero crossing detector can be used to measure the phase angle between two voltages. when an input signal Vin crosses zero volts in positive direction the output V0 is driven into negative saturation. when an input signal Vin crosses zero volts in negative direction the output V0 is driven into positive saturation. This practical will enable student to measure phase and peak value of input signal using IC 741

II Relevant Program Outcomes (POs)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Discipline knowledge:** Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Maintain electronic circuits consisting of linear Integrated Circuits.'**

- Select relevant electronic components IC741 and resistor and capacitor value for specified gain
- Mounting of the electronic component on breadboard as per circuit diagram.

IV Relevant Course Outcome(s)

- Troubleshoot various linear applications of Op-Amp for the given specifications

V Practical Outcome

- Build/Test comparator circuit consist of IC741 as Zero crossing detector and active positive peak detector.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Demonstrate working as a leader/a team member.
- Follow ethical practices

VII Minimum Theoretical Background

Comparator is a circuit which compare the input signal (Vin) with a reference signal (Vref.), which are applied at the input terminal and depending on its comparison it gives the result at the output terminal of Op-Amp. In comparator circuit, when reference signal (Vref.) is given as zero volt i.e. grounded Comparator then acts as a zero crossing detector. The output changes very rapidly from one saturation level to another level through zero. This circuit is also called as square wave convertor.

Square, Triangular, Saw tooth and pulse waves are examples of non-sinusoidal waveforms. A conventional ac voltmeter cannot be used to measure these sinusoidal waveforms because it is designed to measure the rms value of the pure sine wave. Therefore active Peak detector is used to measures the positive peak value of the square wave input.

VIII Practical Circuit diagram :

a) Sample circuit diagram

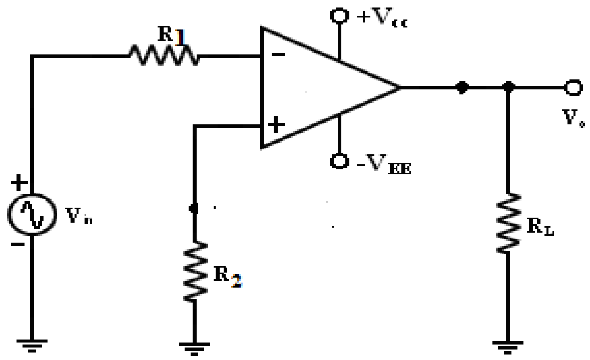

Figure 8.1 Zero crossing detector

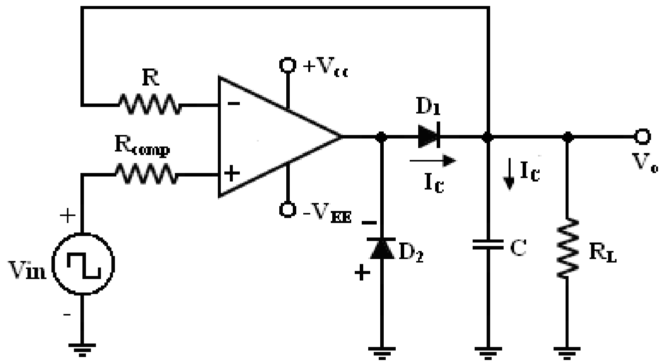

Figure 8.2 Active Peak detector

b) Actual Circuit diagram

c) Sample Experimental set up

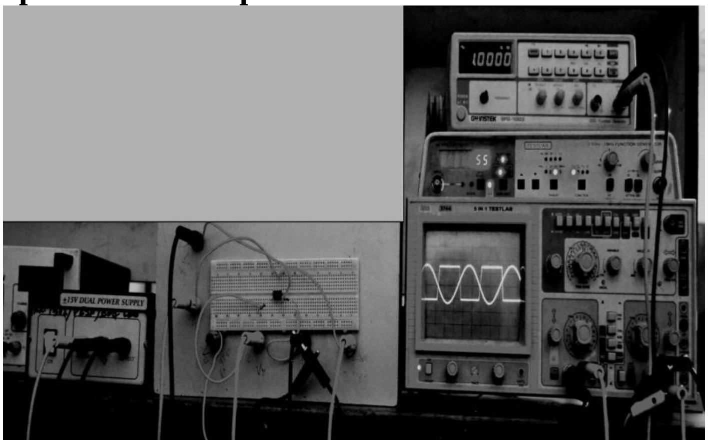

Figure 8.3 Zero crossing detector

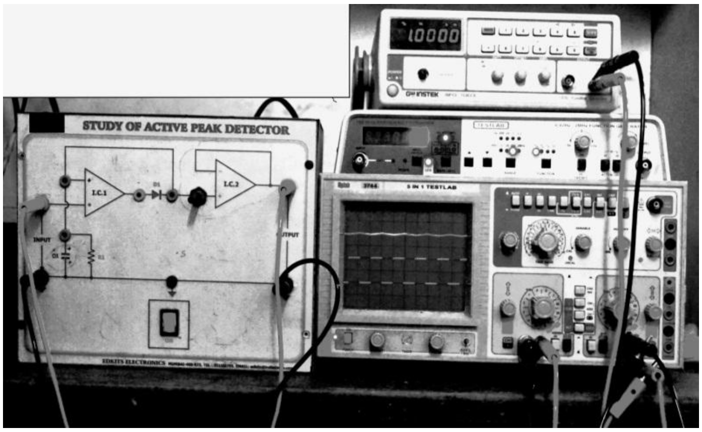

Figure 8.4 Active Peak detect

d) Actual Experimental set up

IX Resources Required

Sr. No.	Instrument /Components	Specification	Quantity
1.	Dual Power supply	0- 30V, 2A Dual tracking power supply	1 No.
2.	IC-741C	Dual-In-Line or S.O. Package	2 No.
3.	Resistors R1	1KΩ	1No.
4.	Resistors R2	1KΩ	1 No.
5.	Resistors R_L	10 KΩ,	2 No.
6.	Resistors R	10 KΩ,	1 No.
7	Resistors R_{COMP}	10 KΩ,	1 No.
8.	Diode	IN4007	2 No.
9.	Capacitor	1µf	1 No
10.	Function generator	02 Hz to 2 MHz	1 No
11.	CRO	0 to 20 MHz	2 No
12.	Analog IC tester	Suitable to test analog IC	1 No.
13	Breadboard	5.5 cm X 17cm	2 No.
14	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

X Precautions to be Followed

1. Ensure proper connections are made to the equipment.
2. Ensure the power switch is in 'off' condition initially.
3. Ensure the use of proper settings of function generator and CRO.
4. Ensure the proper value of resistor, capacitor and diode.

XI Procedure for Zero crossing detector

1. Assemble the circuit on breadboard as per circuit diagram.
2. Connect dual power supply to pin No. 7 (+Vcc) and pin No. 4 (-V_{EE}) of IC 741.
3. Set the function generator to produce a sine waveform of 1V pp amplitude at 1 KHz.
4. Check the waveform on CRO before applying it as input.
5. Apply input signal Vin from function generator to input pin No.2 and vary upto value as per variation given in observation table no.8.1.
6. Observe input and output (pin No. 6) waveforms on CRO.
7. Plot the graph for input and output waveforms observed on CRO.

Procedure for active peak detector

1. Assemble the circuit on breadboard as per circuit diagram.
2. Connect dual power supply to pin No. 7 (+Vcc) and pin No. 4 (-V_{EE}) of IC 741.
3. Set the function generator to produce a square waveform of 10V pp amplitude at 1 KHz.
4. Check the waveform on CRO before applying it as input.
5. Apply input signal Vin (square wave) from function generator shown in figure no.8.2 to pin No. 3
6. Observe input and output (pin No. 6) waveforms on CRO.
7. Plot the graph for input and output waveforms observed on CRO.

XII Resources Used

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			
5.			

XIII Actual Procedure Followed (use blank sheet provided if space not sufficient)

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XIV Precaution Followed (use blank sheet provided if space not sufficient)

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XV Observations and Calculations(use blank sheet provided if space not sufficient)

Table No: 8.1 Observation Table for Zero crossing detector

Sr. No.	Apply Input Voltage (Volts)	Applied Voltage (Vin)	Difference Voltage, Vid=V1-V2 (Volts)	Output Voltage, Vo (Volts)
1.	Vin=0			
2.	Vin>0			
3.	Vin<0			

Table No: 8.2Observation Table for active peak detector

Sr. No.	Input Voltage (Volts)	Output Voltage, Vo (Volts)
1.		
2.		
3.		

XVI Results

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XVII Interpretation of Results (Give meaning of the above obtained results)

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XVIII Conclusions and Recommendation

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XIX Practical Related Questions

1. Apply the given input signal to non inverting terminal of Op Amp and compare it with inverting zero crossing detectors.
2. Why comparator is sometimes also called as voltage level detector?
3. In given figure no.8.2, connect the diodes D1 and D2 in reverse direction and observe the waveform.

[Space for Answers]

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XX References / Suggestions for further reading

1. K.R.Botkar, *Integrated Circuits*, Khanna publication,10th edition,2005,ISBN NO :81-7409-208-0
2. Ramakant A.Gayakwad, *Op-Amps and linear Integrated Circuits*, Prentice -Hall India,3rd edition, 2001,ISBN NO : 81-203-0807-7
3. Tower's International data book for OpAmp.

XXI Assessment Scheme

	Performance Indicators	Weightage
	Process related: 15 Marks	**60%**
1.	Mounting of IC 741 and proper value of resistor and capacitor on breadboard	10 %
2.	Connection of circuit diagram	20 %
3.	Measuring value using CRO	20 %
4.	Working in team	10 %
	Product related:10 Marks	**40%**
5.	Calculate theoretical value of gain	10 %
6.	Interpretation of result	05 %
7.	Conclusions	05 %
8.	Practical related questions	15 %
9.	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

Name of Team Members

1. ………………………......
2. ………………………......
3. …………………………..
4. …………………………..

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Scale

X-axis -

Y-axis -

Scale

X-axis -

Y-axis -

Practical No.9: Build / Test instrumentation amplifier circuit using IC LM324.

I Practical Significance

In measuring instruments the output of the transducer is generally a low level signal which is insufficient to drive the display indicators for displaying Physical quantities like temperature, pressure, so the Instrumentation amplifier is connected to the output of transducer through the bridge circuitry to amplify the low level signals in any of the measuring instruments. In this practical student will assemble IC LM324 as instrumentation amplifier and observe the amplification of low level signals.

II Relevant Program Outcomes (POs)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Discipline knowledge:** Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Maintain electronic circuits consisting of Linear Integrated Circuits**':

- Testing of relevant active and passive electronic components required to assemble instrumentation amplifier.
- Mounting of the electronic components on breadboard as per circuit diagram of instrumentation amplifier.
- Trouble shoot instrumentation amplifier.

IV Relevant Course Outcome(s)

- Use various configurations of Op-Amp for different applications.

V Practical Outcome

- Build/Test Instrumentation amplifier circuit using IC LM324.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Follow ethical practices
- Demonstrate working as a leader/a team member

VII Minimum Theoretical Background

Instrumentation amplifier is configured for high input impedance, high CMRR and have single ended output.

Instrumentation amplifier is used for precise, low level signal amplification where low noise, low thermal and temperature drifts, high input impedance and accurate closed loop gain is required.

Instrumentation amplifier is having adjustable gain.

Output voltage is given by

$$V_{out} = \left[\left(1 + \frac{2R_1}{R_{gain}}\right)\frac{R_3}{R_2}\right](V_2 - V_1)$$

Gain can be changed varying R_{gain} as shown in the Figure 9.4.

IC LM324 is quad Op-Amp.

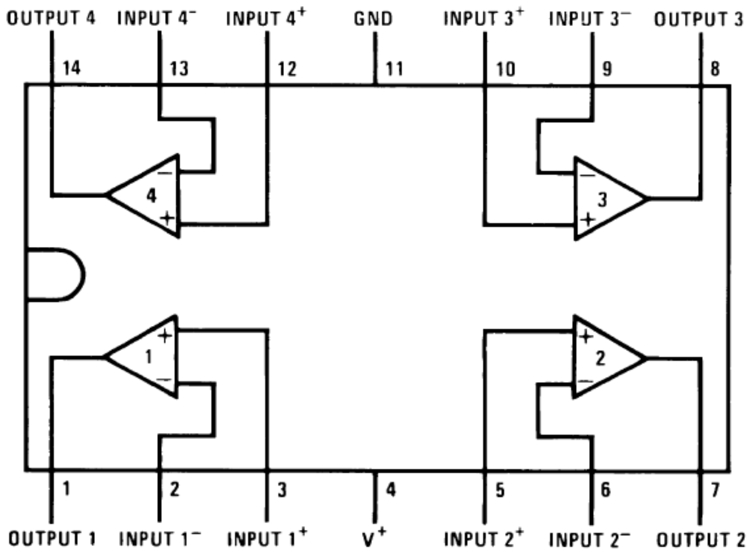


Figure 9.1 Pin connection diagram of IC LM324

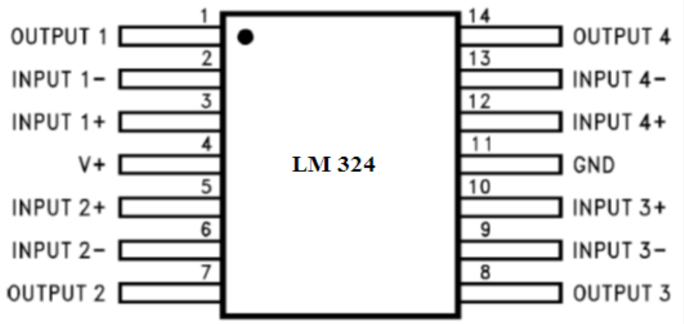


Figure 9.2 Pin diagram of IC LM324

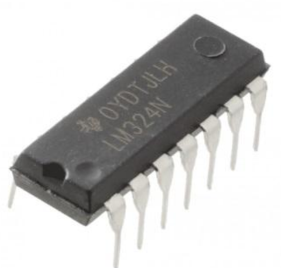
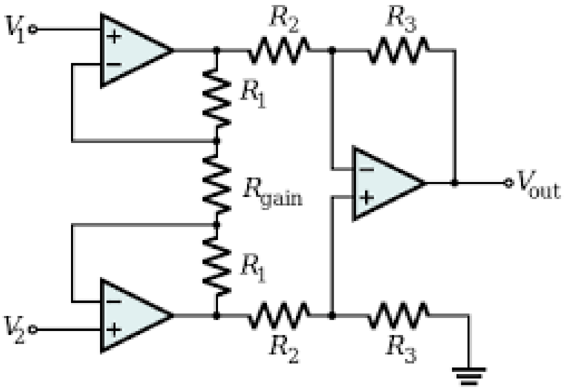


Figure 9.3 IC LM324
(*https://www.xcluma.com/lm324-quad-operational-amplifier-14-pin-dip*)

VIII Practical Circuit diagram:

a) Sample Circuit diagram



Note: Use "Rgain" as Variable resistor

Figure 9.4 Circuit diagram of Instrumentation amplifier

b) Actual Circuit used in laboratory

c) Sample Experimental set up

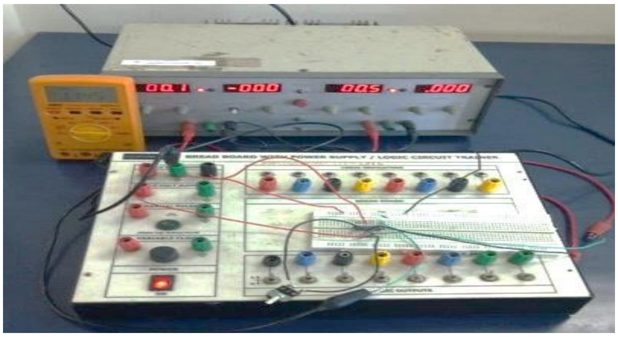


Figure 9.5Instrumentation amplifier

d) Actual Experimental set up

IX Resources Required

Sr. No.	Instrument /Components	Specification	Quantity
1.	Variable DC power supply	0- 30V, 2A Dual tracking power supply	1 No.
2.	IC-LM324	14 pin, DIP	1 No.
3.	Resistors	10KΩ,	4 No
4.	Potentiometer	1 KΩ,10KΩ	1 No.
5.	Analog IC tester	Suitable to test analog ICs,	1 No.
6.	DMM	DC VOLTAGE Ranges : 200mV, 2V, 20V, 200V	1 No.
7.	Breadboard	5.5 cm X 17 cm	1 No.
8.	Connecting wires	Single strand Teflon coating (0.6 mm diameter)	As per requirement

X Precautions to be Followed

1. Ensure proper connections are made as per the given setup.
2. Ensure the power switch is in ‘off’ condition initially.
3. Ensure the use of proper settings of input DC voltage.

XI Procedure

1. Test IC LM324 using IC tester and mount it on breadboard.
2. Make the connections as shown in the Figure 9.4.
3. Apply voltage $V_{cc} = +15V$ and $V_{EE} = -15V$ using DC power supply to pin no 4 and pin no 11 respectively, V_1 and V_2 in the range from 100mvolts to 500mvolts.
4. Measure the output voltage V_{out} for the given corresponding input voltage, using DMM.
5. Calculate theoretical and practical gain.
6. Repeat steps from 4 to 7 for different values of V_1 and V_2 DC input voltage.
7. After the completion of practical switch off the supply, remove the connections and submit wires and equipment’s.

XII Resources Used

Sr. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			

XIII Actual Procedure Followed (use blank sheet provided if space not sufficient)

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XIV Precautions Followed (use blank sheet provided if space not sufficient)

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XV Observations and Calculations (use blank sheet provided if space not sufficient)

Table No: 9.1 Observation Table for gain of instrumentation amplifier.

Sr. No.	DC Input Voltage		Input Difference	Output Voltage		Gain	
	V_1 in mV	V_2 in mV	$V_d = V_2 - V_1$	Practical	Theoretical	Practical	Theoretical
1.							
2.							
3.							
4.							

Calculations:

i. Theoretical output voltage $V_{out} = \left[\left(1 + \frac{2R_1}{R_{gain}}\right)\frac{R_3}{R_2}\right](V_2 - V_1)$

ii. Theoretical Gain = $\left(1 + \frac{2R_1}{R_{gain}}\right)\frac{R_3}{R_2}$

iii. Practical Gain $= \frac{V_{out}\,(\text{Practical})}{V_d(\text{Input difference})} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots$

XVI Results

1. Measured output voltage =…………………..
2. Theoretical Gain =…………………………..
3. Practical Gain = ……………………………

XVII Interpretation of Results (Give meaning of the above obtained results)

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XVIII Conclusions and Recommendation

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XIX Practical Related Questions

1. Repeat the above experiment procedure for $V_1 = 100mV$ and $V_2 = 0$ Volts
2. Find practical output for output given at V_1 and V_2.
3. Explore internet and draw internal diagram of LM 324 IC.

[Space for Answers]

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XX References / Suggestions for further reading

1. https://www.youtube.com/watch?v=1dJ5VP6MidY&feature=youtu.be
2. http://www.ti.com/sitesearch/docs/universalsearch.tsp?searchTerm=LM324#linkId=1&src=top
3. K.R.Botkar, *Integrated Circuits*, Khanna publication,10th edition,2005,ISBN NO :81-7409-208-0

XXI Assessment Scheme

Performance Indicators		Weightage
Process related: 15 Marks		**60%**
1	Handling of the components	10 %
2	Mounting of component	20 %
3	Measuring value using DMM	20 %
4	Working in team	10 %
Product related: 10 Marks		**40%**
5	Calculate Gain and Theoretical output voltage	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Name of Team Members

1. ………………………......
2. ………………………......
3. …………………………..
4. …………………………..

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

TEXAS INSTRUMENTS

LM124-N, LM224-N
LM2902-N, LM324-N

SNOSC16D – MARCH 2000 – REVISED JANUARY 2015

LMx24-N, LM2902-N Low-Power, Quad-Operational Amplifiers

1 Features

- Internally Frequency Compensated for Unity Gain
- Large DC Voltage Gain 100 dB
- Wide Bandwidth (Unity Gain) 1 MHz (Temperature Compensated)
- Wide Power Supply Range:
  - Single Supply 3 V to 32 V
  - or Dual Supplies ±1.5 V to ±16 V
- Very Low Supply Current Drain (700 μA) —Essentially Independent of Supply Voltage
- Low Input Biasing Current 45 nA (Temperature Compensated)
- Low Input Offset Voltage 2 mV and Offset Current: 5 nA
- Input Common-Mode Voltage Range Includes Ground
- Differential Input Voltage Range Equal to the Power Supply Voltage
- Large Output Voltage Swing 0 V to V^+ − 1.5 V
- **Advantages:**
  - Eliminates Need for Dual Supplies
  - Four Internally Compensated Op Amps in a Single Package
  - Allows Direct Sensing Near GND and V_{OUT} also Goes to GND
  - Compatible With All Forms of Logic
  - Power Drain Suitable for Battery Operation
  - In the Linear Mode the Input Common-Mode, Voltage Range Includes Ground and the Output Voltage
  - Can Swing to Ground, Even Though Operated from Only a Single Power Supply Voltage
  - Unity Gain Cross Frequency is Temperature Compensated
  - Input Bias Current is Also Temperature Compensated

2 Applications

- Transducer Amplifiers
- DC Gain Blocks
- Conventional Op Amp Circuits

3 Description

The LM124-N series consists of four independent, high-gain, internally frequency compensated operational amplifiers designed to operate from a single power supply over a wide range of voltages. Operation from split-power supplies is also possible and the low-power supply current drain is independent of the magnitude of the power supply voltage.

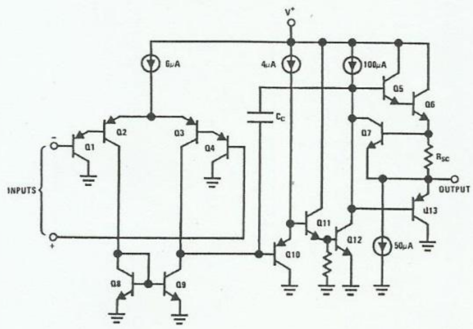
Application areas include transducer amplifiers, DC gain blocks and all the conventional op amp circuits which now can be more easily implemented in single power supply systems. For example, the LM124-N series can directly operate off of the standard 5-V power supply voltage which is used in digital systems and easily provides the required interface electronics without requiring the additional ±15 V power supplies.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM124-N	CDIP (14)	19.56 mm × 6.67 mm
LM224-N		
LM324-N	CDIP (14)	19.56 mm × 6.67 mm
	PDIP (14)	19.177 mm × 6.35 mm
	SOIC (14)	8.65 mm × 3.91 mm
	TSSOP (14)	5.00 mm × 4.40 mm
LM2902-N	PDIP (14)	19.177 mm × 6.35 mm
	SOIC (14)	8.65 mm × 3.91 mm
	TSSOP (14)	5.00 mm × 4.40 mm

(1) For all available packages, see the orderable addendum at the end of the datasheet.

Schematic Diagram



6.4 Thermal Information

THERMAL METRIC(1)		LM124-N / LM224-N	LM324-N / LM2902-N	UNIT
		J/CDIP	D/SOIC	
		14 PINS	14 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	88	88	°C/W

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, SPRA953.

6.5 Electrical Characteristics: LM124A/224A/324A

$V^+ = 5.0$ V, (1), unless otherwise stated

PARAMETER		TEST CONDITIONS	LM124A			LM224A			LM324A			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage		$T_A = 25°C$ (2)		1	2		1	3		2	3	mV
Input Bias Current(3)		$I_{IN(+)}$ or $I_{IN(-)}$, $V_{CM} = 0$ V, $T_A = 25°C$		20	50		40	80		45	100	nA
Input Offset Current		$I_{IN(+)}$ or $I_{IN(-)}$, $V_{CM} = 0$ V, $T_A = 25°C$		2	10		2	15		5	30	nA
Input Common-Mode Voltage Range(4)		$V^+ = 30$ V, (LM2902-N, $V^+ = 26$ V), $T_A = 25°C$	0		$V^+-1.5$	0		$V^+-1.5$	0		$V^+-1.5$	V
Supply Current		Over Full Temperature Range, $R_L = \infty$ On All Op Amps $V^+ = 30$ V (LM2902-N $V^+ = 26$ V)		1.5	3		1.5	3		1.5	3	mA
		$V^+ = 5$ V		0.7	1.2		0.7	1.2		0.7	1.2	
Large Signal Voltage Gain		$V^+ = 15$ V, $R_L \geq 2$ kΩ, ($V_O = 1$ V to 11 V), $T_A = 25°C$	50	100		50	100		25	100		V/mV
Common-Mode Rejection Ratio		DC, $V_{CM} = 0$ V to $V^+ - 1.5$ V, $T_A = 25°C$	70	85		70	85		65	85		dB
Power Supply Rejection Ratio		$V^+ = 5$ V to 30 V, (LM2902-N, $V^+ = 5$V to 26 V), $T_A = 25°C$	65	100		65	100		65	100		dB
Amplifier-to-Amplifier Coupling(5)		f = 1 kHz to 20 kHz, $T_A = 25°C$, (Input Referred)		−120			−120			−120		dB
Output Current	Source	$V_{IN}^+ = 1$ V, $V_{IN}^- = 0$ V, $V^+ = 15$ V, $V_O = 2$ V, $T_A = 25°C$	20	40		20	40		20	40		mA
	Sink	$V_{IN}^- = 1$ V, $V_{IN}^+ = 0$ V, $V^+ = 15$ V, $V_O = 2$ V, $T_A = 25°C$	10	20		10	20		10	20		
		$V_{IN}^- = 1$ V, $V_{IN}^+ = 0$ V, $V^+ = 15$ V, $V_O = 200$ mV, $T_A = 25°C$	12	50		12	50		12	50		μA
Short Circuit to Ground		$V^+ = 15$ V, $T_A = 25°C$ (6)		40	60		40	60		40	60	mA
Input Offset Voltage		See(2)			4			4			5	mV
V_{OS} Drift		$R_S = 0$ Ω		7	20		7	20		7	30	μV/°C
Input Offset Current		$I_{IN(+)} - I_{IN(-)}$, $V_{CM} = 0$ V			30			30			75	nA

(1) These specifications are limited to $-55°C \leq T_A \leq +125°C$ for the LM124-N/LM124A. With the LM224-N/LM224A, all temperature specifications are limited to $-25°C \leq T_A \leq +85°C$, the LM324-N/LM324A temperature specifications are limited to $0°C \leq T_A \leq +70°C$, and the LM2902-N specifications are limited to $-40°C \leq T_A \leq +85°C$.

(2) $V_O \approx 1.4$V, $R_S = 0$ Ω with V^+ from 5 V to 30 V; and over the full input common-mode range (0 V to $V^+ - 1.5$ V) for LM2902-N, V^+ from 5 V to 26 V.

(3) The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.

(4) The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3 V (at 25°C). The upper end of the common-mode voltage range is $V^+ - 1.5$ V (at 25°C), but either or both inputs can go to 32 V without damage (26 V for LM2902-N), independent of the magnitude of V^+.

(5) Due to proximity of external components, insure that coupling is not originating via stray capacitance between these external parts. This typically can be detected as this type of capacitance increases at higher frequencies.

(6) Short circuits from the output to V^+ can cause excessive heating and eventual destruction. When considering short circuits to ground, the maximum output current is approximately 40 mA independent of the magnitude of V^+. At values of supply voltage in excess of 15 V, continuous short-circuits can exceed the power dissipation ratings and cause eventual destruction. Destructive dissipation can result from simultaneous shorts on all amplifiers.

Practical No. 10: Measure the bandwidth and cutoff frequency of the given first order low pass (LPF) Butterworth filter.

I Practical Significance

A low-pass filter (LPF) is a filter that passes signals with a frequency lower than a certain cutoff frequency and attenuates signals with frequencies higher than the cutoff frequency. LPF is used in Audio Applications for Equalization purposes. In medical instrumentation LPF is used in ECG/EEG to eliminate ambient noise. This practical will enable student to view LPF exhibit low gain after certain cut off frequency.

II Relevant Program Outcomes (POs)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Discipline knowledge:** Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Maintain electronic circuits consisting of Linear Integrated Circuits**':

- Testing of relevant active and passive electronic components required to assemble the first order low pass (LPF)Butterworth filter.
- Mounting of the electronic components on breadboard as per circuit diagram of first order low pass (LPF)Butterworth filter.
- Trouble shoot first order low pass (LPF) Butterworth filter.

IV Relevant Course Outcome(s)

- Maintain filters and oscillators used in various electronic circuits.

V Practical Outcome

- Use relevant instruments to measure the bandwidth and cutoff frequency of the given first order low pass Butterworth filter.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Demonstrate working as a leader/a team member
- Maintain tools and equipment's

VII Minimum Theoretical Background

A low-pass filter is a filter that allows signals with a frequency lower than the cut-off frequency (the frequency at which the output voltage is 70.7% of the source voltage) to pass through it. It also attenuates those signals whose frequency is higher than the cut-off frequency. Low-pass filters help in removing short-term fluctuations, and provide a smoother form of signal. Low pass Butterworth filter is designed to have a flat frequency response in pass band and stop band. Hence called as flat-flat filter.

Depending on the Roll of Rate of the LPF it is classified as first order ,second order filters and so on.

Roll of rate is defined as the rate at which the gain of the filter changes with frequency in stop band. In First order Low pass Butterworth filter gain roll of at $-20\mathrm{dB/decade}$. In

second order Low pass Butterworth filter gain roll of at $-40\mathrm{dB/decade}$.

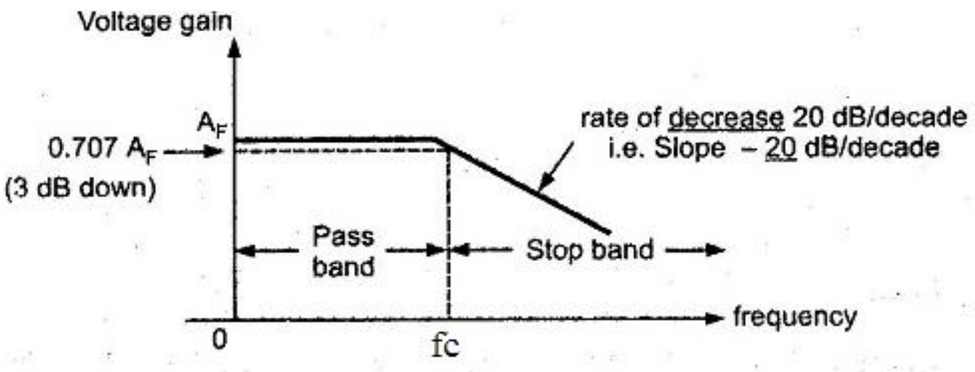


Figure10.1 Frequency response of First order Low pass Butterworth filter

*[**Courtesy**:http://www.eeeguide.com/first-order-low-pass-butterworth-filter/]*

Output voltage for First order low pass butterworth filter is given by

$$\frac{V_0}{V_{in}} = \frac{A_F}{1 + j(\frac{f}{f_c})}$$

Where $A_F = 1 + \frac{R_F}{R_1}$

f = frequency of the input signal (Hz)

$f_C = \frac{1}{2\pi RC}$ = Cutoff frequency (Hz)

Magnitude of the voltage gain is given by

$$\left|\frac{V_0}{V_{in}}\right| = \frac{A_F}{\sqrt{1 + (\frac{f}{f_c})^2}}$$

VIII Practical Circuit diagram :

a) Sample Circuit diagram

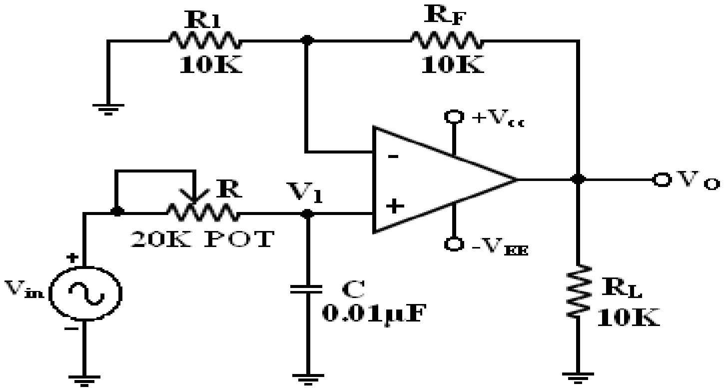


Figure 10.2 Circuit diagram of First order Low pass Butterworth filter

b) Actual Circuit diagram

c) Sample Experimental set up

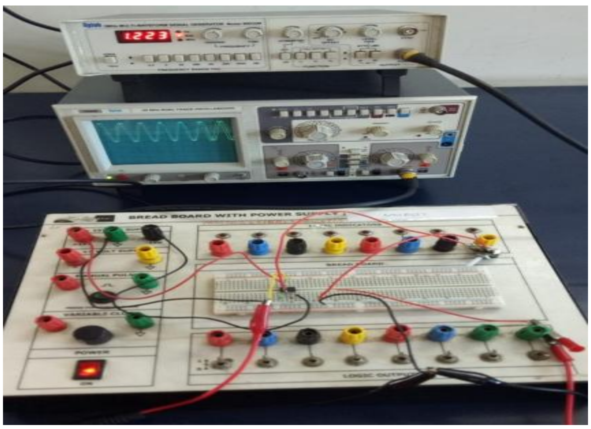


Figure 10.3 First order Low pass Butterworth filter

d) Actual Experimental set up

IX Resources Required

Sr. No.	Instrument/ Component	Specification	Quantity
1.	Cathode Ray Oscilloscope (Analog type)	20/30/100 MHz Frequency	1 No.
2.	Function Generator	0-2 MHz with Sine, square and triangular output with variable frequency and amplitude	1 No.
3.	Regulated DC Power Supply	0-30V, 2Amp SC protection Dual tracking power supply	1 No.
4.	Op-Amp IC	IC 741C	1 No.
5.	Resistors	R_1=10KΩ, R=20KΩ pot, R_f=10KΩ	2 No.
6.	Capacitor	C_1=0.01µf	2 No.
7.	Analog IC tester	Suitable to test analog ICs,	1 No.
8.	Breadboard	5.5 cm X 17 cm	1 No.
9.	Connecting wires	Single strand Teflon coating (0.6 mm diameter)	As per requirement

X Precautions to be Followed

1. Ensure proper connections are made to the equipment.
2. Ensure the power switch is in ‘off’ condition initially.
3. Ensure the use of proper settings of function generator and CRO.

XI Procedure

1. Test and mount the IC741 on breadboard.
2. Connect the circuit as per the circuit diagram show in fig 10.2.
3. Apply voltage $V_{cc} = +15V$ and $V_{EE} = -15V$ using DC power supply to pin no 7 and pin no. 4 respectively.

4. Connect the (1volt peak to peak, 100Hz) sine wave input from function generator and observe the corresponding output of pin number 6 on CRO.
5. Measure the output voltage of LPF on CRO for the applied signal as in step 4.
6. Vary input signal frequency step by step as shown in observation table and note down the corresponding output voltage.
7. Repeat step 4 to 6 up to frequency 1MHz.
8. Calculate gain in decibels using formula: $\text{Gain in dB} = 20\log_{10}\left(\frac{V_o}{V_{in}}\right)$.
9. Calculate the cutoff frequency theoretically using formula: $F_c = \frac{1}{2\pi RC}$
10. Plot the frequency response on semi log paper for frequency on x axis and gain in dB on y axis.
11. Find practical cutoff frequency from graph and compare theoretical and practical cutoff frequency.
12. Calculate roll-off rate from graph plotted in step 10 by considering any two consecutive gain values and corresponding frequency values.
13. After the completion of practical switch off the supply, remove the connections and submit wires and equipment.

XII Resources Used

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			
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XIII Actual Procedure Followed (use blank sheet provided if space not sufficient)

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XIV Precaution Followed (use blank sheet provided if space not sufficient)

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XIV Observations and Calculations (use blank sheet provided if space not sufficient)

Table No: 10.1 Observation table for Gain of LPF

Input Voltage in Volts (To be kept Constant),Vi = 1Volt Peak to Peak(Sine Wave)

Sr. No.	Input Frequency(Hz)	Output Voltage, Vo (Volts)	Voltage Gain (A= Vo/Vi)	Gain in dB =20 log(Vo/Vi)
1.	100 Hz			
2.	200Hz			
3.	400 Hz			
4.	500 Hz			
5.	600 Hz			
6.	800 Hz			
7.	1KHz			
8.	2KHz			
9.	4KHz			
10.	6KHz			
11.	8KHz			
12.	10KHz			
13.	20KHz			
14.	40KHz			
15.	60KHz			
16.	80KHz			
17.	100KHz			
18.	500KHz			
19.	800KHz			
20.	1MHz			

Calculations :

i. Cutoff frequency $F_c = \frac{1}{2\pi RC} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ KHz

ii. At F_c , Gain in db $= 20\log_{10}\left(\frac{V_o}{V_{in}}\right) = \ldots\ldots\ldots\ldots\ldots\ldots$ dB.

iii. Roll of rate $= \frac{(G_1 - G_2)}{(\log_{10} f_1 - \log_{10} f_2)} =$ ……………………………. db/decade

iv. Bandwidth =…………………………

XVI Results

1. Cutoff Frequency =…………………..
2. Roll of rate =…..……………………

XVII Interpretation of Results (Give meaning of the above obtained results)

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XVIII Conclusions and Recommendation

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XIX Practical Related Questions

1. Design LPF at a cutoff frequency of 1 KHz and pass band gain of 2. Assume $C = 0.01\mu F$.
2. Plot frequency response on semi log graph of the filter designed in question-1 and calculate practical cutoff frequency.
3. …………………… ……………………………………………………………

[Space for Answers]

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XX References / Suggestions for further reading

1. Ramakant A. Gayakwad, *Op-Amps and Linear Integrated Circuits*, Prentice -Hall India,3rd edition, 2001,ISBN NO : 81-203-0807-7
2. https://youtu.be/HEMM26YEN-s

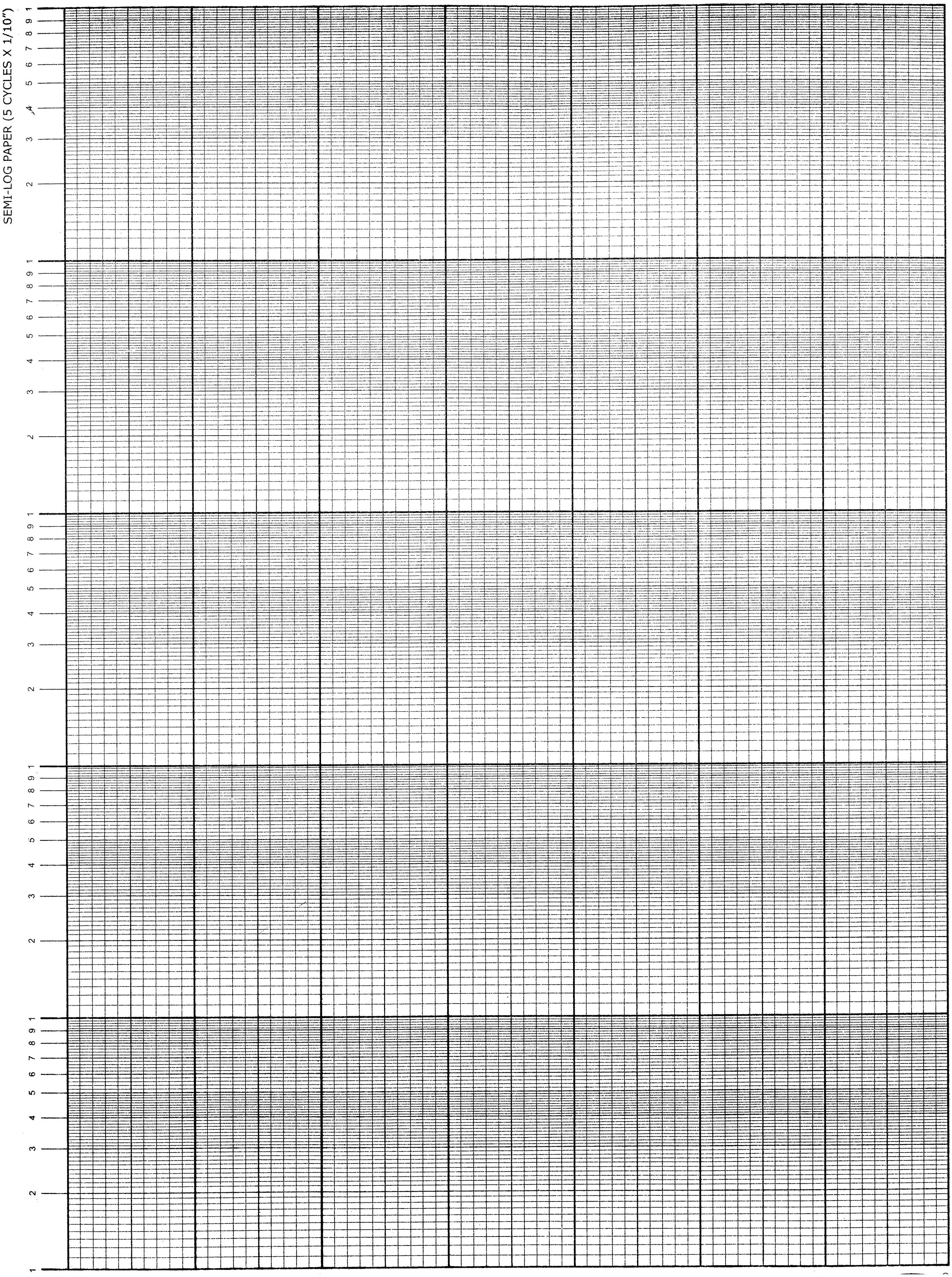
XXI Assessment Scheme

Performance Indicators		Weightage
Process related: 15 Marks		**60%**
1.	Handling of the components	10 %
2.	Mounting of component	20 %
3.	Measuring value using CRO	20 %
4.	Working in team	10 %
Product related: 10 Marks		**40%**
5.	Calculate theoretical value of output	10 %
6.	Interpretation of result	05 %
7.	Conclusions	05 %
8.	Practical related questions	15 %
9.	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Name of Team Members

1. …………………………......
2. …………………………......
3. …………………………..
4. …………………………..

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	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1 9 8 7 6 5 4 3 2 1

Practical No. 11: Use relevant instruments to measure the bandwidth and cutoff frequency of the given first order high pass Butterworth filter.

I Practical Significance

A High-pass filter (HPF) is a filter that passes signals with a frequency higher than a certain cutoff frequency and attenuates signals with frequencies lower than the cutoff frequency. HPF is used in blocking DC from circuitry sensitive to non-zero average voltages or radio frequency devices. Active High Pass Filters are used in audio amplifiers, equalizers or speaker systems to direct the high frequency signals to the smaller tweeter speakers or to reduce any low frequency noise or "rumble" type distortion. This practical will enable student to view HPF exhibit high gain after certain cut off frequency.

II Relevant Program Outcomes (POs)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Discipline knowledge:** Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Maintain electronic circuits consisting of Linear Integrated Circuits**':

- Testing of relevant active and passive electronic components required to assemble first order high pass (HPF) butterworth filter.
- Mounting of the electronic components on breadboard as per circuit diagram of first order high pass (HPF) butterworth filter.
- Trouble shoot first order high pass (HPF) butterworth filter.

IV Relevant Course Outcome(s)

- Maintain filters and oscillators used in various electronic circuits.

V Practical Outcome

- Use relevant instruments to measure the bandwidth and cutoff frequency of the given first order high pass Butterworth filter.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Demonstrate working as a leader/a team member
- Maintain tools and equipment's

VII Minimum Theoretical Background

A high-pass filter is a filter that allows signals with a frequency higher than the cut-off frequency (the frequency at which the output voltage is 70.7% of the source voltage) to pass through it. It also attenuates those signals whose frequency is lower than the cut-off frequency. High-pass filters are used for AC coupling at the inputs of many audio power amplifiers, for preventing the amplification of DC currents which may harm the amplifier, rob the amplifier of headroom, and generate waste heat at the loudspeakers voice coil.

Output voltage for First order high pass butterworth filter is given by

$$\frac{V_0}{V_{in}} = A_F\left[\frac{j(\frac{f}{f_c})}{1 + j(\frac{f}{f_c})}\right]$$

Where $A_F = 1 + \frac{R_F}{R_1}$

f = frequency of the input signal (Hz)

$f_c = \frac{1}{2\pi RC}$ = Cutoff frequency (Hz)

Magnitude of the voltage gain is given by

$$\left|\frac{V_0}{V_{in}}\right| = \frac{A_F(\frac{f}{f_c})}{\sqrt{1 + (\frac{f}{f_c})^2}}$$

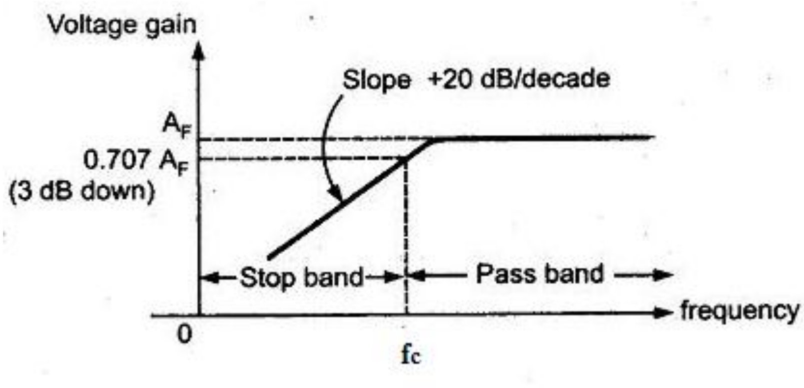


Figure 11.1 Frequency response of First order High pass Butterworth filter

*[**Courtesy**:http://www.eeeguide.com/wp-content/uploads/2016/09/First-Order-High-Pass-Butterworth-Filter-9.jpg]*

VIII Practical Circuit diagram :

a) Sample Circuit diagram

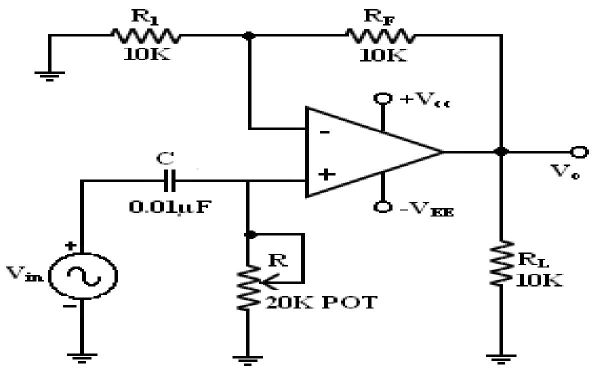
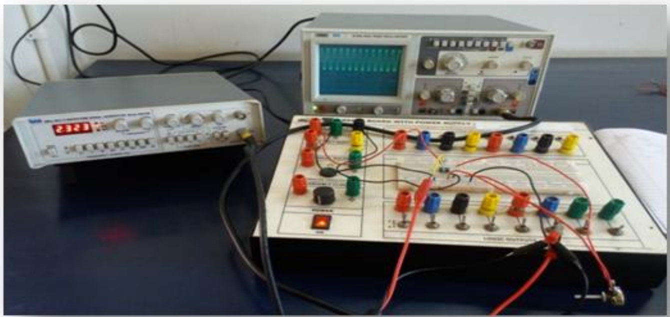


Figure11.2 Circuit diagram of first order high pass butterworth filter

b) Actual Circuit diagram

c) Sample Experimental set up



Fgure 1132 First order high pass butterworth filter

d) Actual Experimental set up

IX Resources Required

Sr. No.	Instrument/ Component	Specification	Quantity
1.	Cathode Ray Oscilloscope (Analog type)	20/30/100 MHz Frequency	1 No.
2.	Function Generator	0-2 MHz with Sine, square and triangular output with variable frequency and amplitude	1 No.
3.	Regulated DC Power Supply	0-30V, 2Amp SC protection Dual tracking power supply	1 No.
4.	Op-Amp IC	IC 741C	1 No.
5.	Resistors	R_1=10KΩ, R=20KΩ pot, R_f=10KΩ	2 No.
6.	Capacitor	C_1=0.01µf	2 No.
7.	Analog IC tester	Suitable to test analog ICs,	1 No
8.	Breadboard	5.5 cm X 17 cm	1 No.
9.	Connecting wires	Single strand Teflon coating (0.6 mm diameter)	As per requirement

X Precautions to be Followed

1. Ensure proper connections are made to the equipment.
2. Ensure the power switch is in ‘off’ condition initially.
3. Ensure the use of proper settings of function generator and CRO.

XI Procedure

1. Test and mount the IC741 on breadboard.
2. Connect the circuit as per the circuit diagram shown in fig 11.2.
3. Apply voltage $V_{cc} = +15V$ and $V_{EE} = -15V$ using DC power supply to pin no 7 and pin no. 4 respectively.
4. Connect the (1volt peak to peak, 100Hz) sine wave input from function generator and observe the corresponding output of pin number 6 on CRO.
5. Measure the output voltage of HPF on CRO for the applied signal as in step 4.

6. Vary input signal frequency step by step as shown in observation table and note down the corresponding output voltage.
7. Repeat step 4 to 6 up to frequency 1MHz.
8. Calculate gain in decibels using formula: $\text{Gain in dB} = 20\log_{10}\left(\frac{V_o}{V_{in}}\right)$.
9. Calculate the cutoff frequency theoretically using formula: $F_c = \frac{1}{2\pi RC}$
10. Plot the frequency response on semi log paper for frequency on x axis and gain in dB on y axis.
11. Find practical cutoff frequency from graph and compare theoretical and practical cutoff frequency.
12. Calculate roll-off rate from graph plotted in step 10 by considering any two consecutive gain values and corresponding frequency values.
13. After the completion of practical switch off the supply, remove the connections and submit wires and equipment.

XII Resources Used

Sr. No.	Instrument /Components	Specification	Quantity
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XIII Actual Procedure Followed (use blank sheet provided if space not sufficient)

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XIV Precaution Followed (use blank sheet provided if space not sufficient)

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XV Observations and Calculations (use blank sheet provided if space not sufficient)

Table No: 11.1 Observation table for Gain of HPF

Input Voltage in Volts (To be kept Constant),Vi = 1Volt Peak to Peak (Sine Wave)

Sr. No.	Input Frequency(Hz)	Output Voltage, Vo (Volts)	Voltage Gain (A= Vo/Vi)	Gain in dB =20 log(Vo/Vi)
1.	100 Hz			
2.	200Hz			
3.	400 Hz			
4.	500 Hz			
5.	600 Hz			
6.	800 Hz			
7.	1KHz			
8.	2KHz			
9.	4KHz			
10.	6KHz			
11.	8KHz			
12.	10KHz			
13.	20KHz			
14.	40KHz			
15.	60KHz			
16.	80KHz			
17.	100KHz			
18.	500KHz			
19.	800KHz			
20.	1MHz			

Calculations :

i. Cutoff frequency $F_c = \frac{1}{2\pi RC} =$ ……………………KHz

ii. At F_c ,Gain in db $= 20\log_{10}\left(\frac{V_o}{V_{in}}\right) =$ ……………….dB.

iv. $\text{Roll } of \text{ } rate = \frac{(G_2 - G_1)}{(log_{10}f_2 - log_{10}f_1)} =$ ……………………………. $db/decade$

XVI Results

1. Cutoff Frequency =…………………..
2. Roll of rate =…..……………………..

XVII Interpretation of Results (Give meaning of the above obtained results)

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XVIII Conclusions and Recommendation

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XIX Practical Related Questions

1. Design first order HPF at a cutoff frequency of 1 KHz and pass band gain of 1. Assume $C = 0.1\mu F$.
2. Plot frequency response on semilog graph for above designed HPF and calculate practical cutoff frequency.
3. ……………………………………………………………………………………..

[Space for Answers]

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XX References / Suggestions for further reading

1. Ramakant A.Gayakwad, *Op-Amps and linear Integrated Circuits*, Prentice -Hall India,3rd edition, 2001,ISBN NO : 81-203-0807-7
2. https://www.youtube.com/watch?v=qzaG8aFKL8k&feature=youtu.be

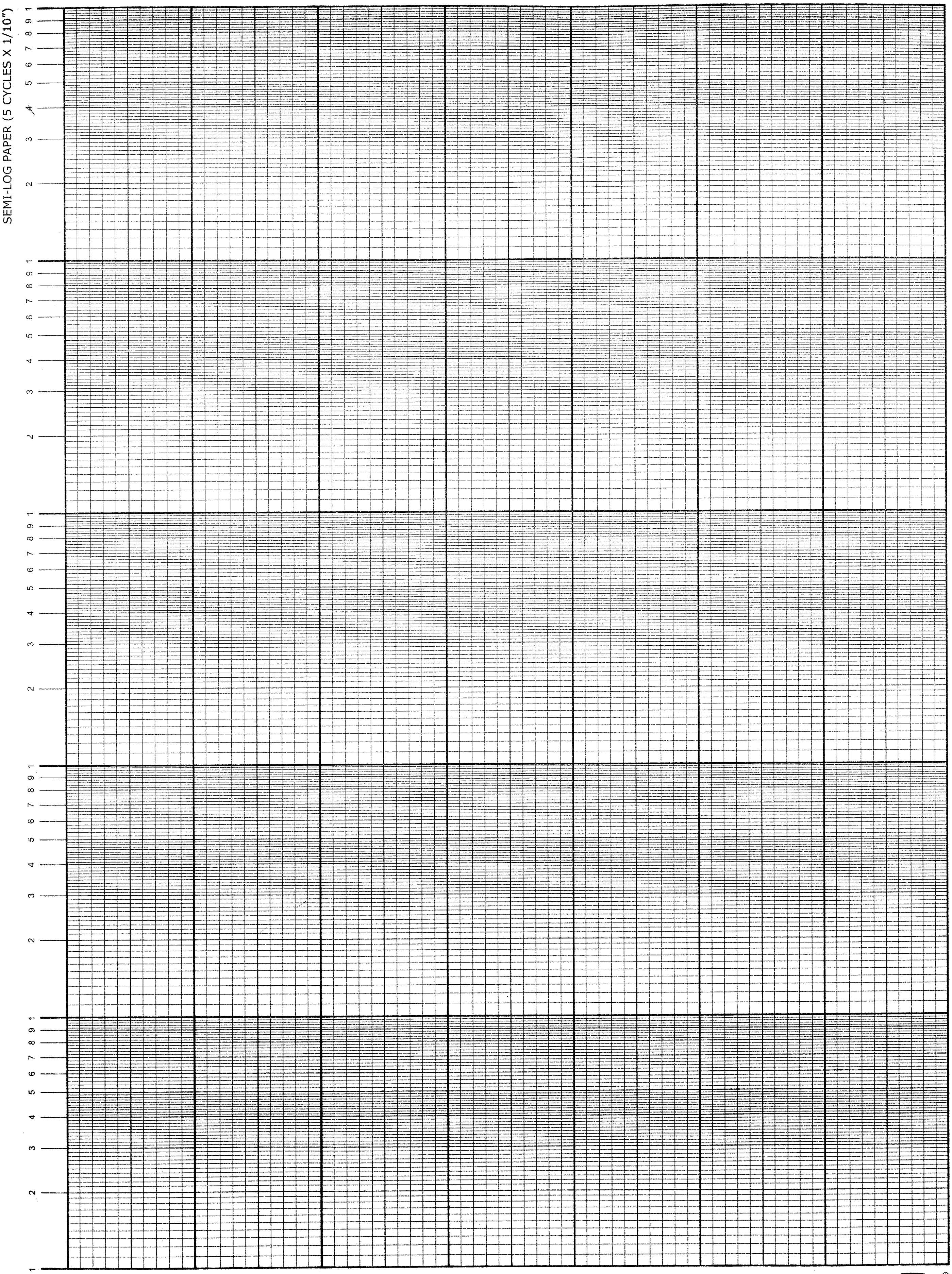
XXI Assessment Scheme

Performance Indicators		Weightage
Process related: 15 Marks		**60%**
1.	Handling of the components	10 %
2.	Mounting of component	20 %
3.	Measuring value using CRO	20 %
4.	Working in team	10 %
Product related: 10 Marks		**40%**
5.	Calculate theoretical value	10 %
6.	Interpretation of result	05 %
7.	Conclusions	05 %
8.	Answer to practical related questions	15 %
9.	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Name of Team Members

1. …………………………......
2. …………………………......
3. …………………………..
4. …………………………..

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	


SEMI-LOG PAPER (5 CYCLES X 1/10")

Practical No. 12: Use relevant instruments to measure the cutoff frequency of the given notch filter.

I Practical Significance

A band reject filter produces a sharp notch in the frequency response curve of a system. It is used for the rejection of a single frequency such as 60Hz power line frequency hum. It is also used in television transmitters to provide attenuation at the low frequency end of the channel, to prevent possible interferences with the sound carrier of the next lower channel. This practical will enable student to view notch filter exhibit low gain for certain cut off frequency.

II Relevant Program Outcomes (POs)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Discipline knowledge:** Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Maintain electronic circuits consisting of Linear Integrated Circuits**':

- Testing of relevant active and passive electronic components required to assemble narrow band reject filter.
- Mounting of the electronic components on breadboard as per circuit diagram of narrow band reject filter.
- Trouble shoot narrow band reject filter.

IV Relevant Course Outcome(s)

- Maintain filters and oscillators used in various electronic circuits.

V Practical Outcome

- Use relevant instruments to measure the cutoff frequency of the given notch filter.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Demonstrate working as a leader/a team member
- Maintain tools and equipment's

VII Minimum Theoretical Background

A band reject filter is also called as band stop filter. In this filter, frequencies are attenuated in the stop band while they are allowed to pass outside this band.

Band reject filters are classified as wide band reject filter and narrow band reject filter. The narrow band reject filter is also called as notch filter. Bandwidth of narrow band reject is very much smaller than wide band reject filter.

Passive band reject filter composed of two T-shaped networks. One T-network made up of two resistors and one capacitor, while other uses one resistor and two capacitors.

The notch frequency is the frequency at which maximum attenuation occurs, it is given by

$$F_N = \frac{1}{2\pi RC}$$

The passive twin T network has low figure of merit Q. The Q of the network can be increased by if it is used with voltage follower.

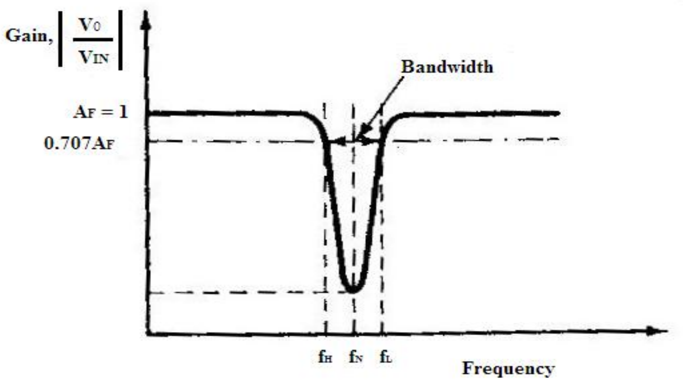


Figure 12.1 Frequency response of Narrow band reject filter

VIII Practical Circuit diagram :

a) Sample circuit diagram

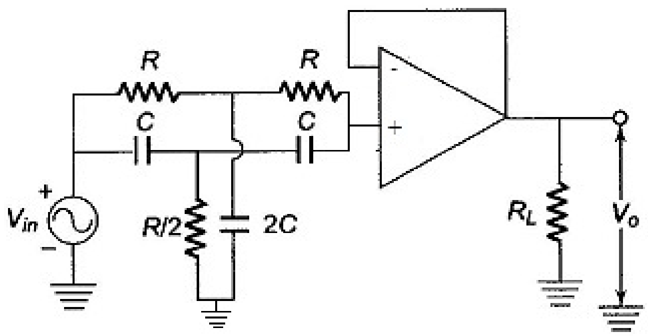


Figure 12.2 Circuit diagram of Narrow band reject filter

b) Actual Circuit diagram

c) Sample Experimental set up

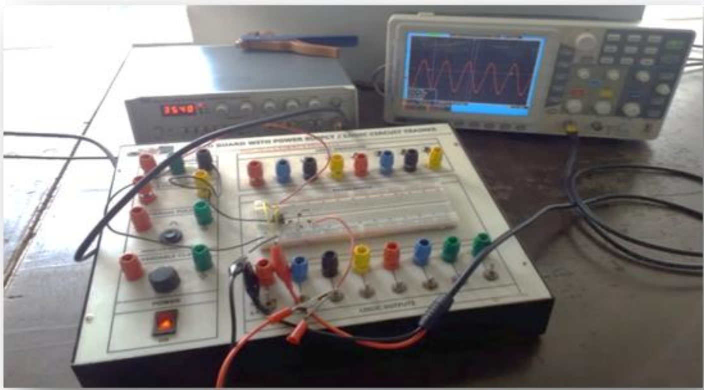


Figure 12.3Narrow band reject filter

d) Actual Experimental set up

IX Resources Required

Sr. No.	Instrument/ Component	Specification	Quantity
1.	Cathode Ray Oscilloscope (Analog type)/DSO	20/30/100 MHz Frequency	1 No.
2.	Function Generator	0-2 MHz with Sine, square and triangular output with variable frequency and amplitude	1 No.
3.	Regulated DC Power Supply	0-30V, 2Amp SC protection Dual tracking power supply	1 No.
4.	Op-Amp IC	IC 741C	1 No.
5.	Resistors	R= 39KΩ,	3 No.
6.	Capacitor	C=0.01μf	3 No.
7.	Analog IC tester	Suitable to test analog ICs,	1 No
8.	Breadboard	5.5 cm X 17 cm	1 No.
9.	Connecting wires	Single strand Teflon coating (0.6 mm diameter)	As per requirement

X Precautions to be Followed

1. Ensure proper connections are made to the equipment.
2. Ensure the power switch is in ‘off’ condition initially.
3. Ensure the use of proper settings of function generator and CRO.

XI Procedure

1. Test and mount the IC741 on breadboard.
2. Connect the circuit as per the circuit diagram show in fig 12.2.
3. Apply voltage $V_{cc} = +15V$ and $V_{EE} = -15V$ using DC power supply to pin no 7 and pin no. 4 respectively.
4. Connect the (10volt peak to peak, 100Hz) sine wave input from function generator and observe the corresponding output of pin number 6 on CRO.
5. Measure the output voltage of LPF on CRO for the applied signal as in step 4.
6. Vary input signal frequency step by step as shown in observation table and note down the corresponding output voltage.
7. Repeat step 4 to 6 up to frequency up to 100K Hz.
8. Calculate gain in decibels using formula: $\text{Gain in dB} = 20\log_{10}\left(\frac{V_o}{V_{in}}\right)$.
9. Calculate the cutoff frequency theoretically using formula: $F_N = \frac{1}{2\pi RC}$
10. Plot the frequency response on semi log paper for frequency on x axis and gain in dB on y axis.
11. Find practical notch frequency from graph and compare theoretical and practical cutoff frequency.
12. After the completion of practical switch off the supply, remove the connections and submit wires and equipment.

XII Resources Used

Sr. No.	Instrument /Components	Specification	Quantity
1.			
2.			
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XIII Actual Procedure Followed (use blank sheet provided if space not sufficient)

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XIV Precaution Followed (use blank sheet provided if space not sufficient)

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XV Observations and Calculations (use blank sheet provided if space not sufficient)

Table No: 12.1 Observation table for Gain of notch filter

Input Voltage in Volts (To be kept Constant),Vi = 10Volt Peak to peak (Sine Wave)

Sr. No.	Input Frequency (Hz)	Output Voltage, Vo (Volts)	Voltage Gain (A= Vo/Vi)	Gain in dB =20 log(Vo/Vi)
1.	100 Hz			
2.	200Hz			
3.	300 Hz			
4.	400 Hz			
5.	500 Hz			
6.	600 Hz			
7.	700Hz			
8.	800Hz			
9.	900Hz			
10.	1KHz			
11.	1.5KHz			
12.	2KHz			
13.	3KHz			
14.	5KHz			
15.	10KHz			
16.	20KHz			
17.	40KHz			
18.	80KHz			
19.	100KHz			

Calculations :

i. Notch frequency $F_N = \frac{1}{2\pi RC} =$ ……………………Hz

ii. At F_N ,Gain in db $= 20\log_{10}\left(\frac{V_o}{V_{in}}\right) =$ ………………..dB.

XVI Results

1. Notch Frequency =…………………..

XVII Interpretation of Results (Give meaning of the above obtained results)

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XVII Conclusions and Recommendation

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XVIII Practical Related Question

1. Design a 400Hz active Notch filter.

[Space for Answers]

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XX References / Suggestions for further reading

1. Ramakant A.Gayakwad, Op-Amps and linear Integrated Circuits, Prentice -Hall India,3rd edition, 2001,ISBN NO : 81-203-0807-7
2. https://www.coursera.org/.../3-4-bandpass-and-notch-filters-PeahQ
3. https://www.youtube.com/watch?v=377vpWIjQ4U

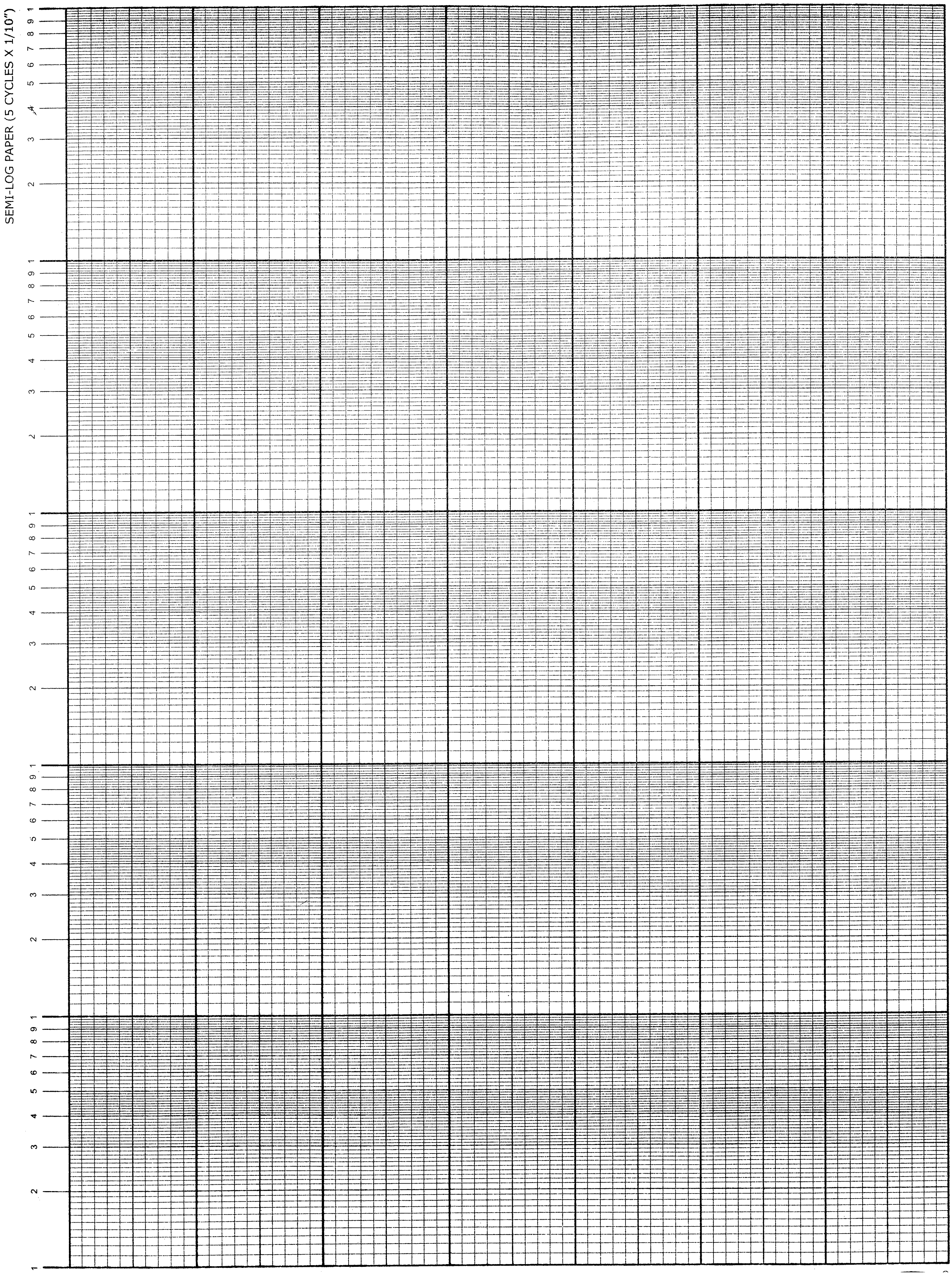
XXI Assessment Scheme

Performance Indicators		Weightage
Process related: 15 Marks		**60%**
1.	Handling of the components	10 %
2.	Mounting of component	20 %
3.	Measuring F_N value using CRO	20 %
4.	Working in team	10 %
Product related: 10 Marks		**40%**
5.	Calculate theoretical Notch frequency.	10 %
6.	Interpretation of result	05 %
7.	Conclusions	05 %
8.	Practical related questions	15 %
9.	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Name of Team Members

1. …………………………......
2. …………………………......
3. …………………………..
4. …………………………..

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	


SEMI-LOG PAPER (5 CYCLES X 1/10")

Practical No.13: Use relevant instruments to measure the frequency of oscillation of the given RC phase shift oscillator circuit using IC741.

I Practical Significance

Oscillators are circuits that produce periodic waveforms without any input signal. They generally use some form of active devices like transistors or Op-Amps as amplifiers with feedback network consisting of passive devices such as resistors, capacitors, or Inductors. A RC Phase shift oscillator is an oscillator that generates sine waves. RC Phase shift oscillator is used for audio frequency generator in the radio receiver. RC Phase Shift Oscillators are used in musical instruments, voice synthesis and in Global Positioning System. This practical will enable student to view RC phase shift oscillator generates oscillations of certain frequency.

II Relevant Program Outcomes (POs)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.
- **Engineering tools:** Apply relevant Electronics and Telecommunications technologies and tools with an understanding of the limitations

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency '**Maintain electronic circuits consisting of Linear Integrated Circuits**':

- Testing of relevant active and passive electronic components required to assemble RC Phase shift oscillator.
- Mounting of the electronic components on breadboard as per circuit diagram of RC Phase shift oscillator.
- Trouble shoot RC Phase shift oscillator.

IV Relevant Course Outcome(s)

- Maintain filters and oscillators used in various electronic circuits.

V Practical Outcome

- Use relevant instruments to measure the frequency of oscillation of the given RC Phase shift oscillator circuit using IC741.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Follow ethical practices
- Demonstrate working as a leader/a team member

VII Minimum Theoretical Background

A RC phase shift oscillator consists of Op-Amps as the amplifying stage and 3-RC cascaded network as the feedback circuit. The feedback circuit provides feedback voltage from the output back to the input. This voltage is the input to the Op-Amps. The Op-

Amps is used in inverting mode, therefore any signal appears at the inverting terminal is shifted by the 180° at the output. An additional 180° phase shift required for oscillation is provided by cascaded RC network.
For RC phase shift oscillator the frequency of oscillation is given by

$$F = \frac{1}{2\pi\sqrt{6}RC}$$

At this frequency, the gain A_v must be at least 29.

$$A_V = \frac{R_F}{R_1} = 29$$

Or

$$R_F = 29R_1$$

VIII Practical Circuit diagram :

a) Sample Circuit diagram

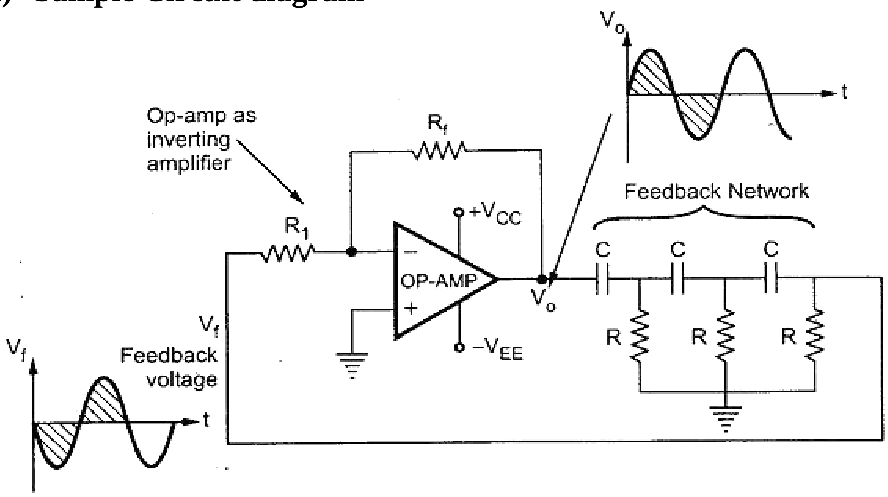


Figure 13.1 Circuit diagram of RC phase shift oscillator

***[Courtesy**:http://www.eeeguide.com/wp-content/uploads/2016/09/Sine-Wave-Generators-Using-Op-amp-7.jpg]*

b) Actual Circuit diagram

c) Sample Experimental set up

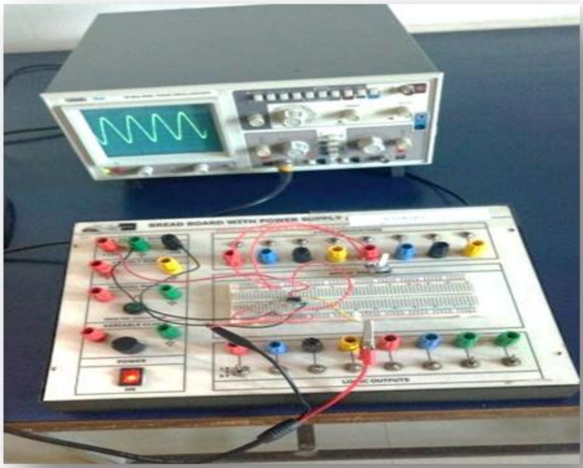


Figure 13.2 RC phase shift oscillator

d) Actual Experimental set up

IX Resources Required

Sr. No.	Instrument /Components	Specification	Quantity
1.	Variable DC power supply	0- 30V, 2A Dual tracking power supply	1 No.
2.	Cathode Ray Oscilloscope (Analog type)	20/30/100 MHz Frequency	1 No.
3.	Capacitors	C=0.1µF	3 No.
4.	Potentiometer	R_F=1MΩ	1 No.
5.	IC-LM318/LM741	Op Amp Ic	1 No.
6.	Resistors	R_1 =33KΩ ,R= 3.3KΩ	4No.
7.	DMM	DC VOLTAGE Ranges : 200mV, 2V, 20V, 200V	1 No.
8.	Analog IC tester	Suitable to test analog ICs,	1 No
9.	Breadboard	5.5 cm X 17 cm	1 No.
10.	Connecting wires	Single strand Teflon coating (0.6 mm diameter)	As per requirement

X Precautions to be Followed

1. Ensure proper connections are made as per the given setup.
2. Ensure the power switch is in 'off' condition initially.
3. Ensure the use of proper settings of CRO and DC Power supply.

XI Procedure

1. Test and mount the IC 741 on breadboard.
2. Connect the circuit as per the circuit diagram as shown in figure 13.1 .
3. Apply voltage $V_{cc} = +15V$ and $V_{EE} = -15V$ using DC power supply to pin no 7 and pin no. 4 of IC 741 respectively.
4. Connect CRO at the output terminals of the circuit (Pin no. 6 of IC 741).
5. Vary potentiometer to get stable sine wave output.
6. Observe the sine wave output on CRO.
7. Measure the frequency of sine wave output on CRO.
8. Calculate the frequency of sine wave theoretically using formula: $F = \frac{1}{2\pi\sqrt{6}RC}$
9. Compare theoretical and practical frequency of sine wave output.
10. After the completion of practical switch off the supply, remove the connections and submit wires and equipment.

XII Resources Used

Sr. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			
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10.			

XIII Actual Procedure Followed (use blank sheet provided if space not sufficient)

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XIV Precautions Followed (use blank sheet provided if space not sufficient)

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XV Observations and Calculations (use blank sheet provided if space not sufficient)

Table No: 13.1 Observation table for Frequency of RC phase shift oscillator

Sr.No.	R	C	Practical Frequency Hz	Theoretical Frequency(Hz) $F = \frac{1}{2\pi\sqrt{6}RC}$
1				

Calculations:

Output frequency

$$F = \frac{1}{2\pi\sqrt{6}RC}$$

XVI Results

1. Output frequency =……………………

XVII Interpretation of Results (Give meaning of the above obtained results)

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XVIII Conclusions and Recommendation

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XIX Practical Related Questions

1. Give the values of slew rate of IC: LM 318,LM: 351 and LM:741 (Refer Data sheet)
2. Design a RC phase shift oscillator using Op-Amp for F=1KHz.
3. ……………………………………………………………………………….......

[Space for Answers]

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XX References / Suggestions for further reading

1. Ramakant A.Gayakwad, *Op-Amps and linear Integrated Circuits*, Prentice -Hall India,3rd edition, 2001,ISBN NO : 81-203-0807-7
2. http://vlabs.iitb.ac.in/vlabs-dev/bootcamp/labs/ic/exp6/exp/simulation.php
3. https://www.youtube.com/watch?v=u4cQllyEgPA
4. http://www.ti.com/product/LM318-N?keyMatch=LM318&tisearch=Search-EN-Everything

XXI Assessment Scheme

Performance indicators		Weightage
Process related: 15 Marks		**60%**
1	Handling of the components	10 %
2	Mounting of component	20 %
3	Measuring value Frequency using CRO	20 %
4	Working in team	10 %
Product related: 10 Marks		**40%**
5	Calculate Theoretical frequency.	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Name of Team Members

1. …………………………......
2. …………………………......
3. …………………………..
4. …………………………..

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

LM118-N/lm218-N/LM318-N Operational Amplifiers

Check for Samples: LM118-N, LM218-N, LM318-N

FEATURES

- 15 MHz Small Signal Bandwidth
- Ensured 50V/μs Slew Rate
- Maximum Bias Current of 250 nA
- Operates from Supplies of ±5V to ±20V
- Internal Frequency Compensation
- Input and Output Overload Protected
- Pin Compatible with General Purpose Op Amps

DESCRIPTION

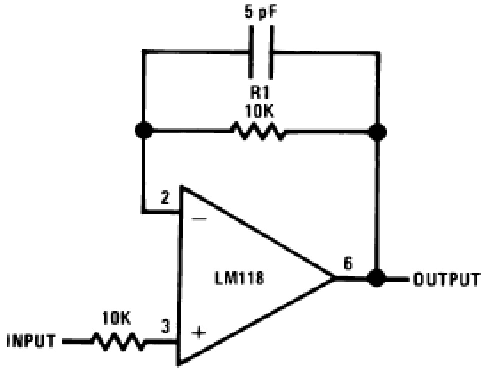
The LM118 series are precision high speed operational amplifiers designed for applications requiring wide bandwidth and high slew rate. They feature a factor of ten increase in speed over general purpose devices without sacrificing DC performance.

The LM118 series has internal unity gain frequency compensation. This considerably simplifies its application since no external components are necessary for operation. However, unlike most internally compensated amplifiers, external frequency compensation may be added for optimum performance. For inverting applications, feedforward compensation will boost the slew rate to over 150V/μs and almost double the bandwidth. Overcompensation can be used with the amplifier for greater stability when maximum bandwidth is not needed. Further, a single capacitor can be added to reduce the 0.1% settling time to under 1 μs.

The high speed and fast settling time of these op amps make them useful in A/D converters, oscillators, active filters, sample and hold circuits, or general purpose amplifiers. These devices are easy to apply and offer an order of magnitude better AC performance than industry standards such as the LM709.

The LM218-N is identical to the LM118 except that the LM218-N has its performance specified over a −25°C to +85°C temperature range. The LM318-N is specified from 0°C to +70°C.

Fast Voltage Follower



Do not hard-wire as voltage follower (R1 ≥ 5 kΩ)

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings (1)(2)

Supply Voltage	±20V
Power Dissipation (3)	500 mW
Differential Input Current (4)	±10 mA
Input Voltage (5)	±15V
Output Short-Circuit Duration	Continuous
Operating Temperature Range	
lm118-n	−55°C to +125°C
LM218-N	−25°C to +85°C
LM318-N	0°C to +70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	
TO-99 Package	300°C
PDIP Package	260°C
Soldering Information	
Dual-In-Line Package	
Soldering (10 sec.)	260°C
SOIC Package	
Vapor Phase (60 sec.)	215°C
Infrared (15 sec.)	220°C
ESD Tolerance (6)	2000V

(1) Refer to RETS118X for LM118H and LM118J military specifications.
(2) If Military/Aerospace specified devices are required, please contact the TI Sales Office/Distributors for availability and specifications.
(3) The maximum junction temperature of the lm118-n is 150°C, the LM218-N is 110°C, and the LM318-N is 110°C. For operating at elevated temperatures, devices in the LMC package must be derated based on a thermal resistance of 160°C/W, junction to ambient, or 20°C/W, junction to case. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.
(4) The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.
(5) For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
(6) Human body model, 1.5 kΩ in series with 100 pF.

Electrical Characteristics (1)

Parameter	Conditions	LM118-N/LM218-N			LM318-N			Units
		Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	T_A = 25°C		2	4		4	10	mV
Input Offset Current	T_A = 25°C		6	50		30	200	nA
Input Bias Current	T_A = 25°C		120	250		150	500	nA
Input Resistance	T_A = 25°C	1	3		0.5	3		MΩ
Supply Current	T_A = 25°C		5	8		5	10	mA
Large Signal Voltage Gain	T_A = 25°C, V_S = ±15V V_{OUT} = ±10V, R_L ≥ 2 kΩ	50	200		25	200		V/mV
Slew Rate	T_A = 25°C, V_S = ±15V, A_V = 1 (2)	50	70		50	70		V/µs
Small Signal Bandwidth	T_A = 25°C, V_S = ±15V		15			15		MHz
Input Offset Voltage				6			15	mV
Input Offset Current				100			300	nA

(1) These specifications apply for ±5V ≤ V_S ≤ ±20V and −55°C ≤ T_A ≤ +125°C (lm118-n), −25°C ≤ T_A ≤ +85°C (LM218-N), and 0°C ≤ T_A ≤ +70°C (LM318-N). Also, power supplies must be bypassed with 0.1 µF disc capacitors.
(2) Slew rate is tested with V_S = ±15V. The lm118-n is in a unity-gain non-inverting configuration. V_{IN} is stepped from −7.5V to +7.5V and vice versa. The slew rates between −5.0V and +5.0V and vice versa are tested and specified to exceed 50V/µs.

Practical No.14: Measure the frequency of oscillation of the given Wien bridge oscillator circuit using IC741.

I Practical Significance

Oscillators are circuits that produce periodic waveforms without any input signal. They generally use some form of active devices like transistors or OPAMPs as amplifiers with feedback network consisting of passive devices such as resistors, capacitors, or Inductors. A Wien bridge oscillator is an oscillator that generates sine waves. Wien bridge oscillator is used in audio and acoustics applications. This practical will enable student to view Wien bridge oscillator generates oscillations of certain frequency

II Relevant Program Outcomes (POs)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.
- **Engineering tools:** Apply relevant Electronics and Telecommunications technologies and tools with an understanding of the limitations

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Maintain electronic circuits consisting of Linear Integrated Circuits**':

- Testing of relevant active and passive electronic components required to assemble Wien bridge oscillator.
- Testing of relevant active and passive electronic components required to assemble Wien bridge oscillator.
- Trouble shoot Wien bridge oscillator.

IV Relevant Course Outcome(s)

- Maintain filters and oscillators used in various electronic circuits.

V Practical Outcome

- Measure the frequency of oscillation of the given wien bridge oscillator circuit using IC741.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Follow ethical practices
- Demonstrate working as a leader/a team member

VII Minimum Theoretical Background

A Wien bridge oscillator is based on a bridge circuit originally developed for the measurement of impedances. The bridge comprises four resistors and two capacitors. Op-Amp is used as the amplifying device and the Wien bridge is used as the feedback element. The Op-Amp is used in noninverting mode that provides a phase shift of 00 and the phase shift introduced by the feedback network is also 00.

The feedback network provides gain of 1/3. Hence, the amplifier gain in inverting mode should be slightly greater than 3.
Under the condition that R1=R2=R and C1=C2=C, the frequency of oscillation is given by:

$$F = \frac{1}{2\pi RC} = \frac{0.159}{RC}$$

and at this frequency the gain required for sustained oscillation is given by

$$A_V = \frac{1}{B} = 3$$

That is,

$$1 + \frac{R_F}{R_1} = 3$$

Or

$$R_F = 2R_1$$

VIII Practical Circuit diagram :

a) Sample Circuit diagram

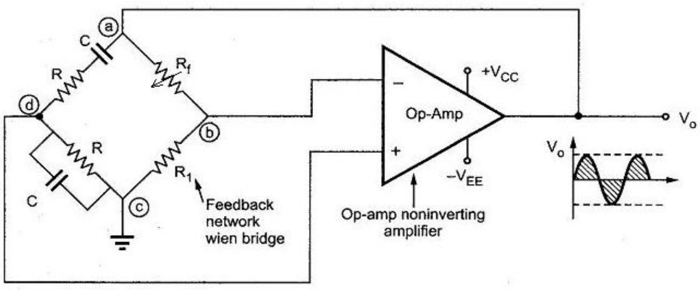


Figure 14.1: Circuit diagram of wien bridge oscillator
[Courtesy:http://www.eeeguide.com/wp-content/uploads/2016/09/Wien-Bridge-Oscillator-1.jpg]

b) Actual Circuit diagram

c) Sample Experimental set up

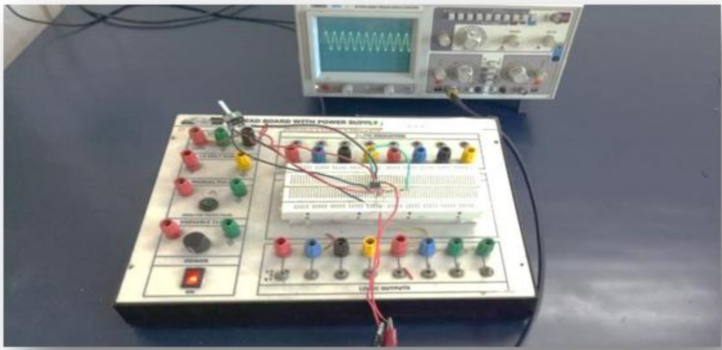


Figure 14.2: Circuit diagram of wien bridge oscillator

d) Actual Experimental set up

IX Resources Required

Sr. No.	Instrument /Components	Specification	Quantity
1.	Variable DC power supply	0- 30V, 2A Dual tracking power supply	1 No.
2.	Cathode Ray Oscilloscope (Analog type)	20/30/100 MHz Frequency	1 No.
3.	Capacitors	C=0.1µF or 1 µF	1 No.
4.	Potentiometer	50KΩ	1 No.
5.	IC-741	Dual-In-Line or S.O. Package	1 No.
6.	Resistors	R_1 =12KΩ ,R= 3.3KΩ	3No.
7.	DMM	DC VOLTAGE Ranges : 200mV, 2V, 20V, 200V	1 No.
8.	Analog IC tester	Suitable to test analog ICs,	1 No
9.	Breadboard	5.5 cm X 17 cm	1 No.
10.	Connecting wires	Single strand Teflon coating (0.6 mm diameter)	As per requirement

X Precautions to be Followed

1. Ensure proper connections are made as per the given setup.
2. Ensure the power switch is in 'off' condition initially.
3. Ensure the use of proper settings of CRO and DC Power supply.

XI Procedure

1. Test and mount the IC741 on breadboard.
2. Connect the circuit as per the circuit diagram show in fig 14.1.
3. Apply voltage $V_{cc} = +15V$ and $V_{EE} = -15V$ using DC power supply to pin no 7 and pin no. 4 respectively.
4. Connect CRO at the output terminals of the circuit (Pin no. 6 of IC741).
5. Vary potentiometer to get stable sine wave output.
6. Observe the sine wave output on CRO.
7. Measure the frequency of sine wave output on CRO.
8. Calculate the frequency of sine wave theoretically using formula: $F = \frac{1}{2\pi RC}$
9. Compare theoretical and practical frequency of sine wave output.
10. After the completion of practical switch off the supply, remove the connections and submit wires and equipment.

XII Resources Used

Sr. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			
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9.			

XIII Actual Procedure Followed (use blank sheet provided if space not sufficient)

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XIV Precautions Followed (use blank sheet provided if space not sufficient)

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XV Observations and Calculations (use blank sheet provided if space not sufficient)

Table No: 14.1 Observation table for Frequency of Wien bridge oscillator

Sr. No.	R	C	Practical Frequency Hz	Theoretical Frequency(Hz) $F = \frac{1}{2\pi RC}$
1				

Calculations:

i. Output frequency

$$F = \frac{1}{2\pi RC}$$

XVI Results

1. Output frequency =……………………

XVII Interpretation of Results (Give meaning of the above obtained results)

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XVIII Conclusions and Recommendation

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XIX Practical Related Questions

1. Why variable resistance is connected in the feedback of OP-Amp used in Wien bridge oscillator?
2. Design a Wien bridge oscillator using Op-Amp for F=965Hz.

[Space for Answers]

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XX References / Suggestions for further reading

1. Ramakant A.Gayakwad, *Op-Amps and linear Integrated Circuits*, Prentice -Hall India,3rd edition, 2001,ISBN NO : 81-203-0807-7
2. http://www.eeeguide.com/wien-bridge-oscillator/
3. https://www.youtube.com/watch?v=td3xrkewzHw

XXI Assessment Scheme

Performance Indicators		Weightage
Process related: 15 Marks		**60%**
10	Handling of the components	10 %
11	Mounting of component	20 %
12	Measuring value Frequency using CRO	20 %
13	Working in team	10 %
Product related: 10 Marks		**40%**
14	Calculate Theoretical frequency.	10 %
15	Interpretation of result	05 %
16	Conclusions	05 %
17	Practical related questions	15 %
18	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Name of Team Members

1. …………………………......
2. …………………………......
3. …………………………..
4. …………………………..

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical no.15: Build/Test astable multivibrator using IC555 for the given specifications.

I Practical Significance

Astable multivibrator is a rectangular wave generating circuit. It has two quasistable state. This circuit is used in square wave oscillators, Electrical control panel used for industrial drives often used Pulse width Modulation (PWM) techniques and astable multivibrator is one of the active block for PWM. They are also used in decorative lighting systems(running LEDs) and timing applications. In this practical students will be able to construct astable multivibrator on bread board and measure % duty cycle of the output waveform.

II Relevant Program Outcomes (POs)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.
- **Engineering tools:** Apply relevant Electronics and Telecommunications technologies and tools with an understanding of the limitations

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Maintain electronic circuits consisting of Linear Integrated Circuits**':

- Testing of relevant active and passive electronic components required to assemble Astable Multivibrator.
- Mounting of the electronic components on breadboard as per circuit diagram of Astable Multivibrator.
- Trouble shoot Astable Multivibrator.

IV Relevant Course Outcome(s)

- Trooubleshoot specified applications using various linear ICs.

V Practical Outcome

- Build/Test astable multivibrator using IC555 for the given specifications.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Follow ethical practices
- Demonstrate working as a leader/a team member

VII Minimum Theoretical Background

Astable multivibrator is also called as Free Running Multivibrator. It has no stable states and continuously switches between the two states without application of any external trigger. The IC 555 can be made to work as an astable multivibrator with the addition of three external components: two resistors (R_A and R_B) and a capacitor (C).

The pins 2 and 6 are connected and hence there is no need for an external trigger pulse. It will self trigger and act as a free running multivibrator. Output is available at pin-3. Pin 4

is the external reset pin. A momentary low on this pin will reset the timer. Hence when not in use, pin 4 is usually tied to V_{CC}.
The control voltage applied at pin 5 will change the threshold voltage level. But for normal use, pin 5 is connected to ground via a capacitor (usually 0.01µF), so the external noise from the terminal is filtered out. Pin 1 is ground terminal.

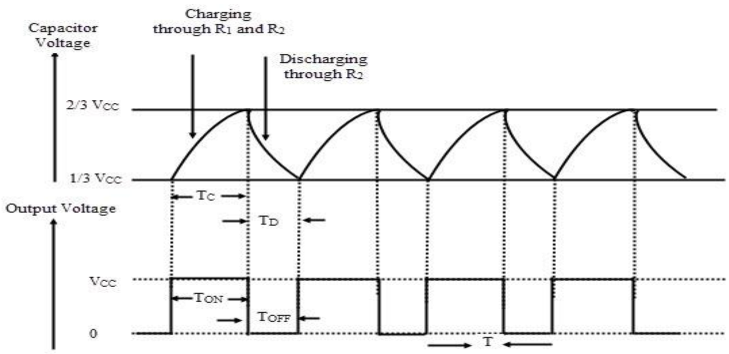

Figure 15.1 :Waveforms of Astable multivibrator using IC 555
***[Courtesy**:https://www.electronicshub.org/wp-content/uploads/2015/06/Waveforms-in-Astable-mode-of-operation.jpg]*

Duty cycle of the astable multivibrator is determined from the values of R_A, R_B and C.
The value of T_{ON} or the charge time (for high output) T_C is given by

$$T_{ON} = 0.693\,(R_A + R_B)\,C$$

The value of TOFF or the discharge time (for low output) TD is given by

$$T_{OFF} = 0.693\,R_B C$$

Therefore, the time period for one cycle T is given by

$$T = T_{ON} + T_{OFF} = T_C + T_D$$

$$T = 0.693(R_A + 2R_B)\,C$$

Duty cycle is the ratio of the time T_{ON} during which the output is high to the total time period T.
The duty cycle % D is given by

$$\%D = \frac{T_{ON}}{T}\,(100)$$

$$= \frac{R_A + R_B}{R_A + 2R_B}\,(100)$$

If $T = 0.693\,(R_A + 2R_B)\,C$, then the frequency f is given by

$$f = \frac{1.45}{(R_A + 2R_B)\,C} \quad Hz$$

VIII Practical Circuit diagram :

a) Sample Circuit diagram

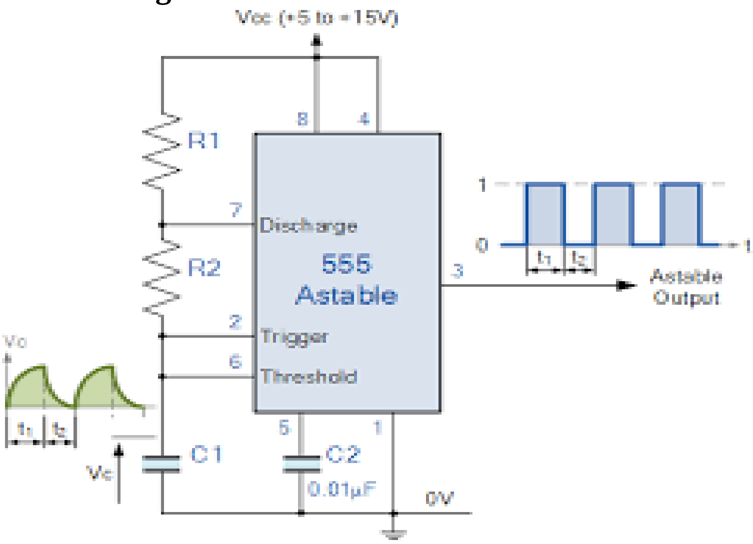

Figure 15.2 Circuit diagram of Astable multivibrator using IC 555

b) Actual Circuit diagram

c) Sample Experimental set up

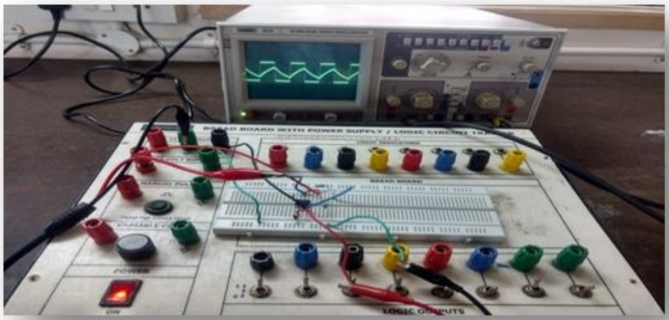

Figure 15.3 Astable multivibrator using IC555

d) Actual Experimental set up

IX Resources Required

Sr. No.	Instrument /Components	Specification	Quantity
1.	Variable DC power supply	0- 30V, 2A Dual tracking power supply	1 No.
2.	Cathode Ray Oscilloscope (Analog type)	20/30/100 MHz Frequency	1 No.
3.	Capacitors	C_1=0.1µF,C_2=0.01 µF	1 No.
4.	IC-555	8 Pin, DIP	1 No.
5.	Resistors	R_A =15KΩ and12KΩ ,R_B=10KΩ	3No.
6.	DMM	DC VOLTAGE Ranges : 200mV, 2V, 20V, 200V	1 No.
7.	Analog IC tester	Suitable to test analog ICs,	1 No
8.	Breadboard	5.5 cm X 17 cm	1 No.
9.	Connecting wires	Single strand Teflon coating (0.6 mm diameter)	As per requirement

X Precautions to be Followed

1. Ensure proper connections are made as per the given setup.
2. Ensure the power switch is in ‘off’ condition initially.
3. Ensure the use of proper settings of CRO and DC Power supply.

XI Procedure

1. Test and mount the IC 555 in breadboard and make the connections as shown in fig. 15.2.
2. Apply DC supply voltage $V_{cc} = 5V$ to pin number 8 of IC555 using DC power supply.

3. Observe the output waveform (pin no.3) and waveform across capacitor (pin no. 6) on CRO.
4. Measure the T_{ON}, T_{OFF} and frequency of output waveform.
5. Calculate theoretical T_{ON}, T_{OFF} and frequency.
6. Compare theoretical and practical values of T_{ON}, T_{OFF} and frequency.
7. Repeat steps from 4 to 7 for R_A=12KΩ
8. Plot output waveform and waveform across capacitor on graph paper (only for RA = 15KΩ).
9. After the completion of practical switch off the supply, remove the connections and submit wires and equipment.

XII Resources Used

Sr. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			

XIII Actual Procedure Followed (use blank sheet provided if space not sufficient)

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XIV Precautions Followed (use blank sheet provided if space not sufficient)

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XV Observations and Calculations (use blank sheet provided if space not sufficient)

Table No: 15.1 Observation Table for Duty cycle

Sr. No.	R_A	T_{ON}	T_{OFF}	$T=T_{ON}+T_{OFF}$	Frequency $F = 1/T$		$\% \text{ Duty Cycle} = \frac{T_{ON}}{T}$
					Practical	Theoretical	
1							
2							

Calculations :

i. $T_{ON} = 0.693\,(R_A + R_B)\,C$

ii. $T_{OFF} = 0.693\,R_B C$

iii. $T = T_{ON} + T_{OFF}$

iv. Percentage Duty Cycle $\%D = \frac{T_{ON}}{T}\ 100$

v. Output frequency $f = \frac{1.45}{(R_A + 2R_B)\,C}\ Hz$

XVI Results

1. Percentage Duty Cycle =……………………
2. Output frequency =……………………

XVII Interpretation of Results (Give meaning of the above obtained results)

XVIII Conclusions and Recommendation

……

……

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XIX Practical Related Questions

1. Design Astable multivibrator using IC555 for 50% duty cycle.
2. Mount the circuit designed in Q-1 on breadboard and draw observed output waveforms.

[Space for Answers]

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XX References / Suggestions for further reading

1. Ramakant A.Gayakwad, *Op-Amps and linear Integrated Circuits*, Prentice -Hall India,3rd edition, 2001,ISBN NO : 81-203-0807-7
2. K.R.Botkar, *Integrated Circuits*, Khanna publication,10th edition,2005,ISBN NO :81-7409-208-0
3. http://vlabs.iitb.ac.in/vlabs-dev/bootcamp/labs/ic/exp9/exp/theory.php
4. https://www.youtube.com/watch?v=75hYqRtLJTQ

XXI Assessment Scheme

	Performance Indicators	Weightage
	Process related: 15 Marks	**60%**
1	Handling of the components	10 %
2	Mounting of component	20 %
3	Measuring values of T_{ON}, T_{OFF} and Frequency using CRO	20 %
4	Working in team	10 %
	Product related: 10 Marks	**40%**
5	Calculate Theoretical values of T_{ON}, T_{OFF} and % Duty cycle.	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

Name of Team Members

1. …………………………......
2. …………………………......
3. …………………………..
4. …………………………..

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Scale

X-axis -

Y-axis -

Practical No.16: Build/Test monostable multivibrator using IC555 for the given specifications.

I Practical Significance

A Monostable multivibrator is a pulse generating circuit. It has only one stable state. Monostable Multivibrator is used in timer, delay line, synchronization circuits in video communications equipment. . In this practical students will be able to construct monostable multivibrator on bread board and measure pulse width of the output waveform.

II Relevant Program Outcomes (POs)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.
- **Engineering tools:** Apply relevant Electronics and Telecommunications technologies and tools with an understanding of the limitations

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Maintain electronic circuits consisting of Linear Integrated Circuits**':

- Testing of relevant active and passive electronic components required to assemble Monostable Multivibrator.
- Mounting of the electronic components on breadboard as per circuit diagram of Monostable Multivibrator.
- Troubleshoot Monostable Multivibrator.

IV Relevant Course Outcome(s)

- Troubleshoot specified applications using various linear ICs.

V Practical Outcome

- Build/Test monostable multivibrator using IC555 for the given specifications.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Follow ethical practices
- Demonstrate working as a leader/a team member.

VII Minimum Theoretical Background

In a Monostable multivibrator a pulse is produced at the output and returns back to the stable state after a time interval. The duration of time for which the pulse is high will depend on the timing circuit that comprises of a resistor (R_T) and a capacitor (C_T).

The pulse width of the output rectangular pulse is $T_{ON} = 1.1\ R_T C_T$

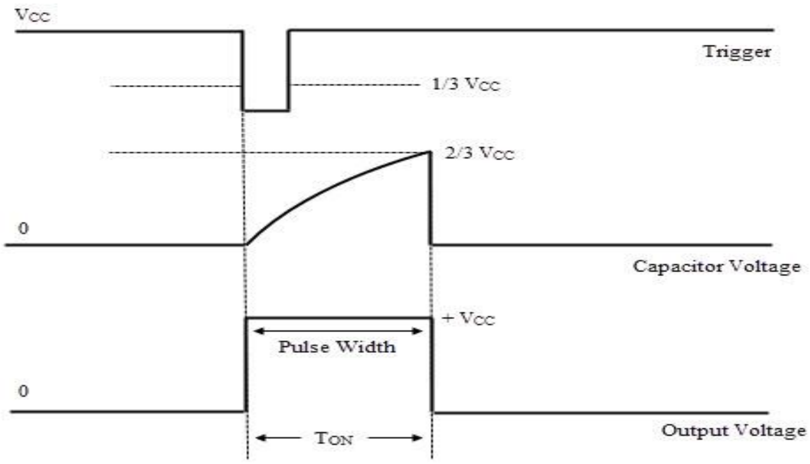

Figure 16.1 waveforms of Astable multivibrator using IC 555
[Courtesy:https://www.electronicshub.org/wp-content/uploads/2015/06/Waveforms-in-Monostable-Mode.jpg]

The 555 Timer is available in 8-pin Metal Can Package, 8-pin Mini Dual in-line Package (DIP) and 14-pin DIP. The 14-pin DIP is IC 556 which consists of two 555 timers.The 8-pin DIP is most commonly used. The pin out diagrams of 555 Timer 8-pin package is shown below.

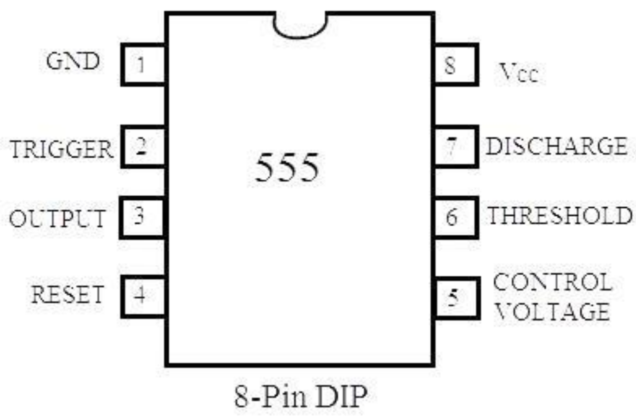

Figure 16.2 Pin diagram of IC 555
[Courtesy:https://www.electronicshub.org/wp-content/uploads/2015/06/8-Pin-Dip.jpg]

Table No: 16.1 Pin Functions of IC555

Pin		I/O	DESCRIPTION
NO.	NAME		
1	GND	O	Ground Reference Voltage
2	Trigger	I	Responsible for transition of SR flip-flop
3	Output	O	Output driven waveform
4	Reset	I	A negative pulse on reset will disable or reset the timer
5	Control Voltage	I	Controls the width of the output pulse by controlling the threshold and trigger levels
6	Threshold	I	Compares the voltage applied at the terminal with a reference voltage of 2/3
7	Discharge	I	Connected to open collector of a transistor which discharges a capacitor between intervals.
8	V_{CC} Supply	I	Supply voltage

*[**Courtesy**:https://www.electronicshub.org/wp-content/uploads/2015/06/table-11.jpg]*

VIII Practical Circuit diagram :

a) Sample Circuit diagram

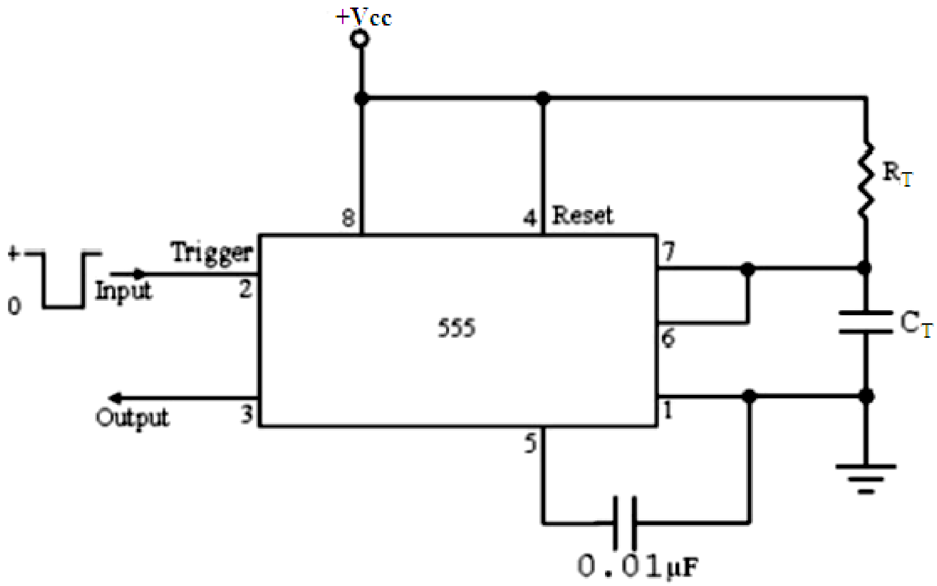

Figure 16.3: Circuit diagram of Monostable multivibrator using IC555

b) Actual Circuit diagram

c) Sample Experimental set up

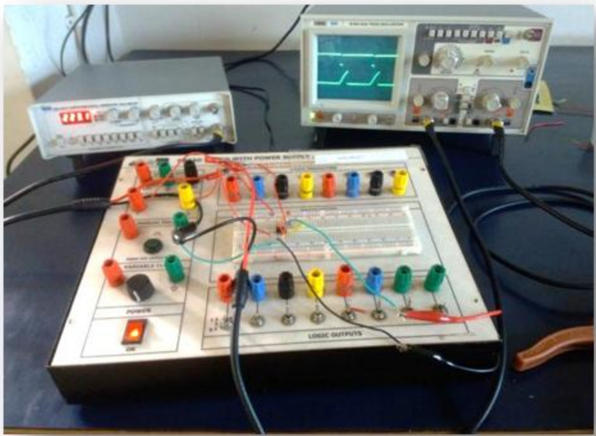

Figure 16.4 Monostable multivibrator using IC555.

d) Actual Experimental set up

IX Resources Required

Sr. No.	Instrument /Components	Specification	Quantity
1.	Variable DC power supply	0- 30V, 2A with SC protection	1 No.
2.	Cathode Ray Oscilloscope (Analog type)	20/30/100 MHz Frequency	1 No.
3.	Capacitors	C_T=0.1µF,C_2=0.01 µF	2 No.
4.	IC-555	8 Pin, DIP	1 No.
5.	Resistors	R_T =10KΩ and 20KΩ	2No.
6.	DMM	DC VOLTAGE Ranges : 200mV, 2V, 20V, 200V	1 No.
7.	Analog IC tester	Suitable to test analog ICs,	1 No
8.	Breadboard	5.5 cm X 17 cm	1 No.
9.	Connecting wires	Single strand Teflon coating (0.6 mm diameter)	As per requirement

X Precautions to be Followed

1. Ensure proper connections are made as per the given setup.
2. Ensure the power switch is in ‘off’ condition initially.
3. Ensure the use of proper settings of CRO and DC Power supply.

XI Procedure

1. Test and mount the IC 555 in breadboard
2. Connect the circuit as per the circuit diagram show in fig 16.3.
3. Set trigger pulse from function generator (Use DC Offset and Symmetry controls on function generator) and observe it CRO.
4. Connect $+V_{cc}$ of 5 volt to pin no.8 and trigger signal to pin no.2 of IC 555.
5. Connect trigger signal to channel 1 and output of IC 555 to channel 2 of CRO.
6. Observe two waveforms on CRO.
7. Measure pulse width T_{ON}, for R_T = 10 KΩ.
8. Now connect the voltage drop across C_T to channel 1 and output of IC 555 to channel 2 of CRO and compare the two waveforms.
9. Draw labeled waveforms of input trigger, output at pin no.3 and voltage across capacitor C_T on graph paper.
10. Calculate the theoretical value of T_{ON} using the formulae and compare with practical value.
11. Change the value of R_T = 20 KΩ and repeat the above procedure.
12. After the completion of practical switch off the supply, remove the connections and submit wires and equipment.

XII Resources Used

Sr. No.	Instrument /Components	Specification	Quantity
1.			
2.			
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7.			
8.			
9.			

XIII Actual Procedure Followed (use blank sheet provided if space not sufficient)

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XIV Precautions Followed (use blank sheet provided if space not sufficient)

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XV Observations and Calculations (use blank sheet provided if space not sufficient)

Table No: 16.2 Observation table for Pulse Width

Sr. No.	R_T in (KΩ)	T_{ON}	
		Practical	Theoretical $T_{ON} = 1.1\ R_T C_T$

Sample calculation:

1. Pulse width $T_{ON} = 1.1\ R_T C_T$

XVI Results

1. Pulse Width =…………………..

XVII Interpretation of Results (Give meaning of the above obtained results)

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XVIII Conclusions and Recommendation

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XIX Practical Related Questions

1. Find the range of supply voltage for IC SE555(refer datasheet).
2. Design a Monostable mulivibrator using IC55 for a pulse width of 1ms
3. State the function of Pin no.4 of IC SE555(refer Datasheets)
4. Explore internet and find other timer IC name them and give their IC number also.

[Space for Answers]

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XX References / Suggestions for further reading

1. K.R.Botkar, *Integrated Circuits*, Khanna publication,10th edition,2005,ISBN NO :81-7409-208-0
2. Ramakant A.Gayakwad, *Op-Amps and linear Integrated Circuits*, Prentice -Hall India,3rd edition, 2001,ISBN NO : 81-203-0807-7
3. https://www.youtube.com/watch?v=-SbTyRpWdcI
4. http://www.ti.com/product/na555/description?keyMatch=NA555&tisearch=Search-EN-Everything

XXI Assessment Scheme

Performance Indicators		Weightage
Process related: 15 Marks		**60%**
1	Handling of the components	10 %
2	Mounting of component	20 %
3	Measuring pulse width using CRO	20 %
4	Working in team	10 %
Product related: 10 Marks		**40%**
5	Calculate Theoretical pulse width.	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Name of Team Members

1. …………………………......
2. …………………………......
3. …………………………..
4. …………………………..

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Scale

X-axis -

Y-axis -

Product Folder | Sample & Buy | Technical Documents | Tools & Software | Support & Community

TEXAS INSTRUMENTS

NA555, NE555, SA555, SE555

SLFS022I – SEPTEMBER 1973 – REVISED SEPTEMBER 2014

xx555 Precision Timers

1 Features

- Timing From Microseconds to Hours
- Astable or Monostable Operation
- Adjustable Duty Cycle
- TTL-Compatible Output Can Sink or Source Up to 200 mA
- On Products Compliant to MIL-PRF-38535, All Parameters Are Tested Unless Otherwise Noted. On All Other Products, Production Processing Does Not Necessarily Include Testing of All Parameters.

2 Applications

- Fingerprint Biometrics
- Iris Biometrics
- RFID Reader

3 Description

These devices are precision timing circuits capable of producing accurate time delays or oscillation. In the time-delay or mono-stable mode of operation, the timed interval is controlled by a single external resistor and capacitor network. In the a-stable mode of operation, the frequency and duty cycle can be controlled independently with two external resistors and a single external capacitor.

The threshold and trigger levels normally are two-thirds and one-third, respectively, of V_{CC}. These levels can be altered by use of the control-voltage terminal. When the trigger input falls below the trigger level, the flip-flop is set, and the output goes high. If the trigger input is above the trigger level and the threshold input is above the threshold level, the flip-flop is reset and the output is low. The reset (RESET) input can override all other inputs and can be used to initiate a new timing cycle. When RESET goes low, the flip-flop is reset, and the output goes low. When the output is low, a low-impedance path is provided between discharge (DISCH) and ground.

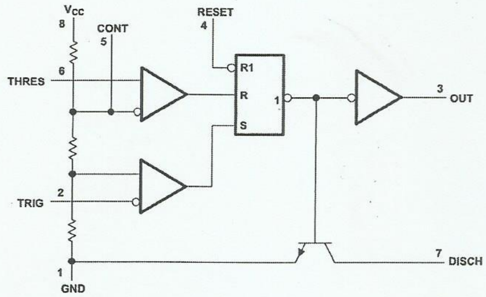
The output circuit is capable of sinking or sourcing current up to 200 mA. Operation is specified for supplies of 5 V to 15 V. With a 5-V supply, output levels are compatible with TTL inputs.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
xx555	PDIP (8)	9.81 mm × 6.35 mm
	SOP (8)	6.20 mm × 5.30 mm
	TSSOP (8)	3.00 mm × 4.40 mm
	SOIC (8)	4.90 mm × 3.91 mm

(1) For all available packages, see the orderable addendum at the end of the datasheet.

4 Simplified Schematic



7 Specifications

7.1 Absolute Maximum Ratings(1)

over operating free-air temperature range (unless otherwise noted)

			MIN	MAX	UNIT
V_{CC}	Supply voltage(2)			18	V
V_I	Input voltage	CONT, RESET, THRES, TRIG		V_{CC}	V
I_O	Output current			±225	mA
θ_{JA}	Package thermal impedance(3)(4)	D package		97	°C/W
		P package		85	
		PS package		95	
		PW package		149	
θ_{JC}	Package thermal impedance(5)(6)	FK package		5.61	°C/W
		JG package		14.5	
T_J	Operating virtual junction temperature			150	°C
	Case temperature for 60 s	FK package		260	°C
	Lead temperature 1,6 mm (1/16 in) from case for 60 s	JG package		300	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) All voltage values are with respect to GND.
(3) Maximum power dissipation is a function of T_J(max), θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) - T_A) / \theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
(4) The package thermal impedance is calculated in accordance with JESD 51-7.
(5) Maximum power dissipation is a function of T_J(max), θ_{JC}, and T_C. The maximum allowable power dissipation at any allowable case temperature is $P_D = (T_J(max) - T_C) / \theta_{JC}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
(6) The package thermal impedance is calculated in accordance with MIL-STD-883.

7.2 Handling Ratings

PARAMETER	DEFINITION	MIN	MAX	UNIT
T_{stg}	Storage temperature range	–65	150	°C

7.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

			MIN	MAX	UNIT
V_{CC}	Supply voltage	NA555, NE555, SA555	4.5	16	V
		SE555	4.5	18	
V_I	Input voltage	CONT, RESET, THRES, and TRIG		V_{CC}	V
I_O	Output current			±200	mA
T_A	Operating free-air temperature	NA555	–40	105	°C
		NE555	0	70	
		SA555	–40	85	
		SE555	–55	125	

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3	English Work Book	22101W
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