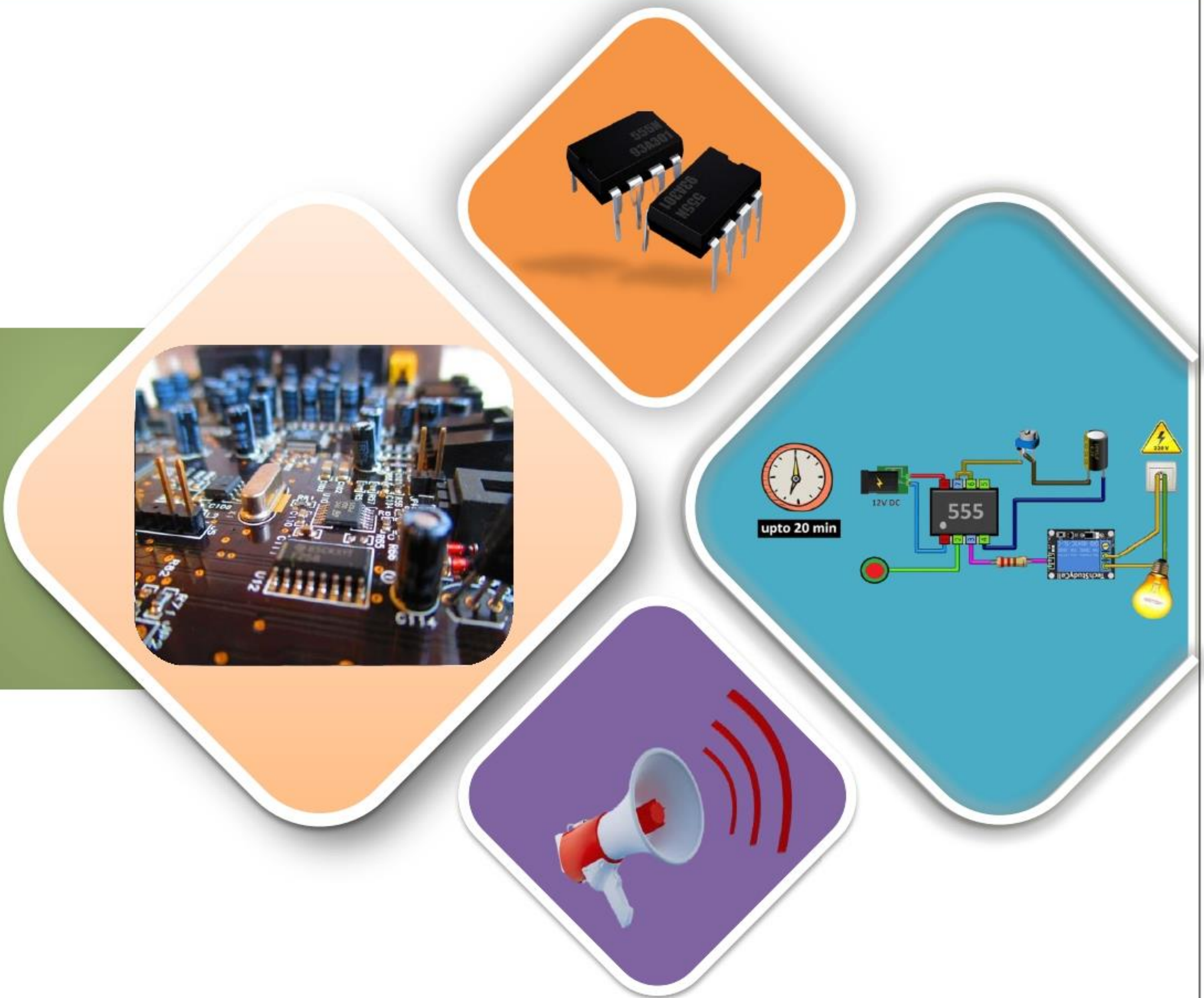
SCHEME : K

Name : ______________________________
Roll No. : ________________ Year : 20___ 20___
Exam Seat No. : ______________________

LABORATORY MANUAL FOR
ANALOG ELECTRONICS
(313324)



ELECTRONICS ENGINEERING GROUP

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 challenging technological & 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 following

- Skill development in line with industry requirements
- Industry readiness and improved employability of Diploma holders
- Synergistic relationship with industry
- Collective and Cooperative development of all stake holders
- Technological interventions in societal development
- Access to uniform quality technical education

A Laboratory manual

for

Analog Electronics

(313324)

Semester – III

(DE/EJ/ET/EX/IC/IE/IS/MU/TE)

Maharashtra State

Board of Technical Education, Mumbai

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

Maharashtra State Board of Technical Education, Mumbai

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

4th Floor, Government Polytechnic Building, 49,

Kherwadi, Bandra (East), Mumbai- 400051.

(Printed on July 2024)

MAHARASHTRA STATE BOARD
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Certificate

This is to certify that Mr./Ms. ……………………………………….....
Roll No. ……… of Third Semester of Diploma in ..…………….. ……………………….......................... of Institute…..………… ……………………………………………………(Code:.………) has completed the term work satisfactorily in course **Analog Electronics (313324)** for the academic year 20……. to 20……... as prescribed in the curriculum.

Place: ………………. **Enrollment No.: ……………..….**

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

Subject Teacher **Head of department** **Principal**

Seal of 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 'K' Scheme curricula for engineering diploma programmes with outcome-based education as the focus and accordingly, a 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 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 "K 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.

The basic aim of this course is that the student must learn the basic concepts, working and applications of electronic circuits which are used for different purposes like power amplifiers, filters and timers. The basic concepts of Operational Amplifier (Op-Amp) is the most versatile Linear Integrated Circuit (IC) used to develop various applications 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 best possible care has been taken to check for errors (if any) in this laboratory manual, perfection may elude us as this is the first edition of this manual. Any errors and suggestions for improvement are solicited and highly welcome.

Program Outcomes (POs) to be achieved through Practicals of this Course

- **PO 1. Basic and Discipline specific knowledge:** Apply knowledge of basic mathematics, sciences and engineering fundamentals and engineering specialization to solve the engineering problems.
- **PO 2. Problem analysis:** Identify and analyze well-defined engineering problems using codified standard methods.
- **PO 3. Design/ development of solutions:** Design solutions for well-defined technical problems and assist with the design of system components or processes to meet specified needs.
- **PO 4. Engineering tools, Experimentation and Testing:** Apply modern engineering tools and appropriate technique to conduct standard tests and measurements.
- **PO 5. Engineering practices for society, sustainability and environment:** Apply appropriate technology in context of society, sustainability, environment and ethical practices.
- **PO 6. Project Management:** Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.
- **PO 7. Life-long learning:** Ability to analyze individual needs and engage in updating in the context of technological changes.

List of relevant expected Psychomotor Domain skills

The following industry relevant skills of the identified competency "Use basic principles of analog electronics engineering in different applications." are expected to be developed in student by undertaking the laboratory work as given in laboratory manual.

1. Select, Identify and test various electronics components with the help of datasheet.
2. Use the heat sink for relevant active components.
3. Test the circuit for the given application.
4. Compare the observed output with the expected output.
5. Find faults and trouble shoot the given circuit.
6. Use appropriate EDA tool for simulation of electronic circuit.
7. Adopt proper procedure while performing the experiment.
8. Interpret the frequency response and calculate various parameters.

Practical-Course outcome matrix

COURSE LEVEL LEARNING OUTCOMES (COS)

CO1 – Use transistor as a Power Amplifier.
CO2 – Construct various configurations of Op-Amp for different applications.
CO3 – Maintain different waveform generator circuits.
CO4 – Analyze active filters used in various electronic circuits.
CO5 – Use specific analog IC to develop various applications.

Sr. No.	Title of the Practical	CO1	CO2	CO3	CO4	CO5
1	Test the performance of single stage Class Apower amplifier.	✓	-	-	-	-
2	Test the performance of Class B push pullpower amplifier.	✓	-	-	-	-
3	Test the performance of Class AB poweramplifier	✓	-	-	-	-
4	Determine the range of output voltageswing of Op-Amp (IC 741).	-	✓	-	-	-
5	Build the circuit to measure input offset voltage and output offset voltage of IC 741.	-	✓	-	-	-
6	Determine the gain of inverting and non- inverting amplifier using IC 741.	-	✓	-	-	-
7	Build /Test adder circuit consist of IC 741.	-	✓	-	-	-
8	Build /Test subtractor circuit consist of IC741.	-	✓	-	-	-
9	Build /Test Integrator circuit consist of IC741.	-	✓	-	-	-
10	Build /Test Differentiator circuit consist of IC 741.	-	✓	-	-	-
11	Build/ Test V to I converter circuit using IC741.	-	✓	-	-	-
12	Build the circuit of zero crossing detectorand test the output.	-	✓	-	-	-
13	Use transistor to build/test voltage seriesfeedback amplifier with feedback.	-	-	✓	-	-
14	Use transistor to build/test voltage shunt feedback amplifier with feedback.	-	-	✓	-	-

Sr. No.	Title of the Practical	CO1	CO2	CO3	CO4	CO5
15	Test the effect of positive and negativefeedback on the output voltage of given amplifier.	-	-	✓	-	-
16	Test the circuit to measure the frequency ofoscillation of the given RC phase shift oscillator consist of IC 741.	-	-	✓	-	-
17	Test the circuit of Crystal Oscillator consist ofcrystal and IC 741.	-	-	✓	-	-
18	Test the Hartley Oscillator based on IC 741.	-	-	✓	-	-
19	Simulate the working of Hartley Oscillator using Multisim or relevant software.	-	-	✓	-	-
20	Build and test the circuit of first order lowpass filter.	-	-	-	✓	-
21	Build and test the circuit of first order highpass filter.	-	-	-	✓	-
22	Simulate the working of high pass filterconsist of IC 741 using Multisim or relevant software.	-	-	-	✓	-
23	Build / test astable multivibrator using IC555 for the specific duty cycle.	-	-	-	-	✓
24	Build / test monostable multivibrator using IC555 for the specific duty cycle.	-	-	-	-	✓
25	Simulate the working of monostable multivibrator using IC 555 using Multisim or relevant software.	-	-	-	-	✓
26	Build/ Test Voltage Controlled Oscillatorusing IC 555.	-	-	-	-	✓
27	Build/ test the circuit of frequency multiplierusing PLL IC 565.	-	-	-	-	✓
28	Check the performance of PLL as FM demodulator (IC 565).	-	-	-	-	✓

Guidelines to Teachers

1. Teacher should provide the guideline with demonstration of practical to the students with allfeatures.
2. Teacher shall explain prior concepts to the students before starting of each experiment.
3. Involve students in performance of each experiment.
4. Teacher should ensure that the respective skills and competencies are developed in. the studentsafter the completion of the practical exercise.
5. Teachers should give opportunity to students for hands on experience after the demonstration.
6. Teacher is expected to share the skills and competencies to be developed in the students.
7. Teacher may provide additional knowledge and skills to the students even though not covered inthe manual but are expected the students by the industry.
8. Finally give practical assignment and assess the performance of students based on task assigned tocheck whether it is as per the instructions.
9. Teacher is expected to refer complete curriculum document and follow guidelines for implementation
10. At the beginning of the practical which is based on the simulation, teacher should make the students acquainted with any simulation software environment.

Instructions for Students

1. Listen carefully the lecture given by teacher about subject, curriculum, learning structure, skills tobe developed.
2. Organize the work in the group and make record all programs.
3. Students shall develop maintenance skill as expected by industries.
4. Student shall attempt to develop related hand-on skills and gain confidence.
5. Student shall develop the habits of evolving more ideas, innovations, skills etc. those included inscope of manual.
6. Student shall refer technical magazines.
7. Student should develop habit to submit the practical on date and time.
8. Student should well prepare while submitting write-up of exercise.
9. Attach/paste separate papers wherever necessary.

Content Page

List of Practical's and Progressive Assessment Sheet

Sr. No.	Title of the Practical	Page no.	Date of Performance	Date of Submission	Assessment Marks (25)	Dated sign. of Teacher	Remark (If any)
1	*Test the performance of single stage Class Apower amplifier.						
2	*Test the performance of Class B push pullpower amplifier.						
3	Test the performance of Class AB poweramplifier						
4	*Determine the range of output voltage swing of Op-Amp (IC 741).						
5	*Build the circuit to measure input offset voltage and output offset voltage of IC 741.						
6	*Determine the gain of inverting and non- inverting amplifier using IC 741.						
7	*Build /Test adder circuit consist of IC 741.						
8	Build /Test subtractor circuit consist of IC741.						
9	*Build /Test Integrator circuit consist of IC741.						
10	*Build /Test Differentiator circuit consist of IC 741.						
11	*Build/ Test V to I converter circuit using IC741.						
12	*Build the circuit of zero crossing detectorand test the output.						
13	Use transistor to build / test voltage series feedback amplifier with feedback.						
14	Use transistor to build / test voltage shunt feedback amplifier with feedback.						
15	*Test the effect of positive and negative feedback on the output voltage of given amplifier.						

Sr. No.	Title of the Practical	Page no.	Date of Performance	Date of Submission	Assessment Marks (25)	Dated sign. of Teacher	Remarks (If any)
16	*Test the circuit to measure the frequency of oscillation of the given RC phase shift oscillator consist of IC 741.						
17	Test the circuit of Crystal Oscillator consisting of Crystal and IC 741.						
18	Test the Hartley Oscillator based on IC 741.						
19	Simulate the working of Hartley Oscillator using Multisim or relevant software.						
20	*Build and test the circuit of first order low pass filter.						
21	*Build and test the circuit of first order highpass filter.						
22	Simulate the working of high pass filter consist of IC 741 using Multisim or relevant software.						
23	*Build / test astable multivibrator using IC555 for the specific duty cycle.						
24	Build / test monostable multivibrator using IC555 for the specific duty cycle.						
25	Simulate the working of monostable multivibrator using IC 555 using Multisim or relevant software.						
26	*Build/ Test Voltage Controlled Oscillatorusing IC 555.						
27	Build/ test the circuit of frequency multiplierusing PLL IC 565.						
28	Check the performance of PLL as FM demodulator (IC 565).						
	Total						

Note:

- '*' Marked Practicals (LLOs) are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes

Practical No.1: Test the performance of single stage Class A power amplifier

I Practical Significance

Class A amplifier is used in the PA system. Class A power amplifier is the simplest of all power amplifier configurations. They have high fidelity and are totally immune to crossover distortion. This practical will help the students to develop skills to build and test performance of class A amplifiers generally used in various consumer electronic products.

II Industry/Employer Expected Outcome(s)

- Maintain analog electronic circuits.
- Select and test relevant electronics components.
- Mount the electronic component on breadboard as per circuit diagram.

III Course Level Learning Outcome(s)

Use transistor as a Power Amplifier

IV Laboratory Learning Outcome(s)

Test the performance of single stage Class A power amplifier

V Relevant Affective Domain related outcome(s)

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

VI Relevant Theoretical Background

Transistor power amplifiers handle large signals. Many of them are driven so hard by the input large signal that collector current is either cut-off or is in the saturation region during a large portion of the input cycle. Therefore, such amplifiers are generally classified according to their mode of operation i.e. the portion of the input cycle during which the collector current is expected to flow. On this basis, they are classified as:

- Class A power amplifier. If the collector current flows at all times during the full cycle of the signal, the power amplifier is known as class A power amplifier.
- Class B power amplifier. If the collector current flows only during the positive half-cycle of the input signal, it is called a class B power amplifier.
- Class C power amplifier. If the collector current flows for less than half-cycle of the input signal, it is called class C power amplifier

The power amplifier is said to be a Class A amplifier if the Q point and the input signal are selected such that the output signal is obtained for a full input signal cycle. For all values of input signal, the transistor remains in the active region and never enters into the cut-off or saturation region. When an AC. signal is applied, the collector voltage varies sinusoidally hence the collector current also varies sinusoidally. The collector current flows for 360° (full cycle) of the input signal i.e. the angle of the collector current flow is 360°.

Circuit diagram/ Laboratory layout

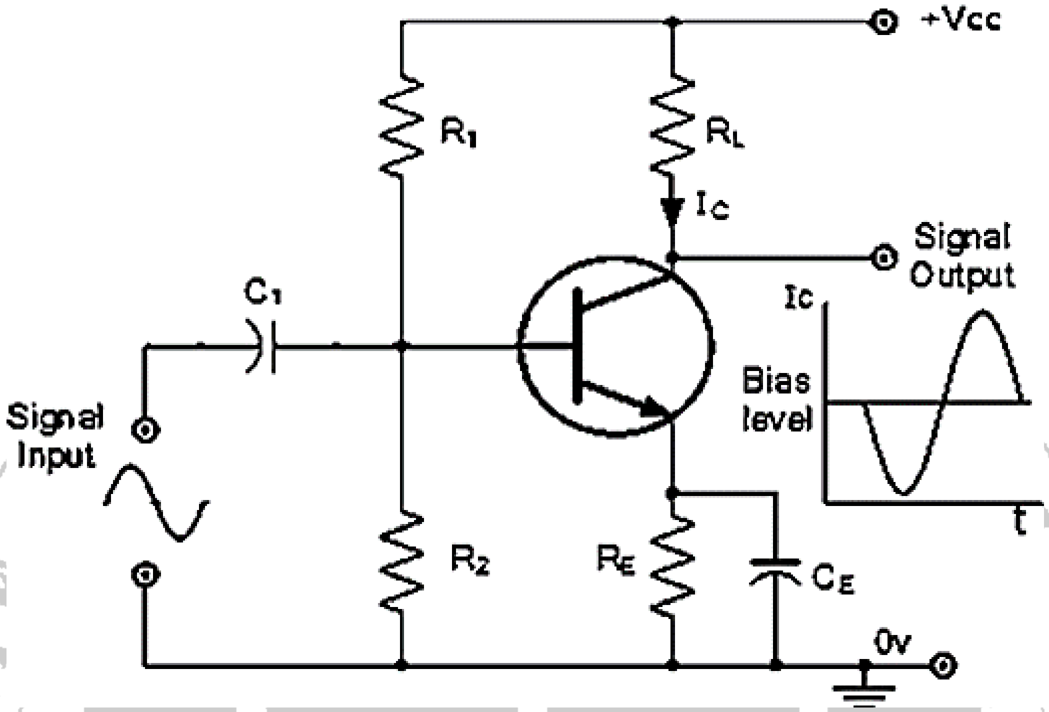


Fig. 1.1: Circuit Diagram of Class A amplifier
(Courtesy:https://www.tutorialspoint.com/amplifiers/classA_power_amplifier.htm)

Actual Experimental set up

VII Resources Required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Cathode Ray Oscilloscope (Analog type)	20/30/100 MHz Frequency	1 No.
2.	Regulated DC Power Supply	0-30V, 2Amp SC protection Vcc=12 volt	1 No.
3.	Function Generator	0-2 MHz with Sine, square and triangular output with variable frequency and amplitude.	1No.
4.	Transistor	SL/CLlOO or BC558 or BD115	1 No.
5.	Resistors	R_1=47KΩ, R_2=33Ω, R_E=560Ω, R_L=220Ω,	1No.
6.	Capacitors	47µF, 10µF	1No.
7.	Breadboard	5.5 CM X 17CM	1 No.
8.	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

VIII Precautions to be followed

1. Ensure proper connections are to be made as per setup.
2. Ensure the power switch is in 'off condition initially while connecting the circuit.
3. Ensure proper settings of function generator and CRO before use.

IX Procedure

1. Build circuit on breadboard as per diagram.
2. Set frequency and amplitude of sine wave input signal on function generator with the help of CRO.
3. Connect Function generator at input terminal of circuit.
4. Connect DC supply to the amplifier circuit.
5. Switch ON the DC Power Supply, function generator and CRO.
6. Vary the amplitude of sine waveform from the function generator at different values and measure the output voltage on CRO.
7. Calculate the Pac, Pdc and % efficiency using the given formula.

X Resources Used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity

XI Actual Procedure

……
……
……
……

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

Table No.1.1

Sr. No.	Input Voltage [Vi] (Volts)	Output Voltage [Vo] (Volts)	$Pac=Vo^2/2RL$ (watts)	$Pdc = Vcc * I_{CQ}$	% Efficiency = Pac / Pdc * 100
1					
2					
3					

Where I_{CQ} is the current measured at the collector terminal when the AC input signal is zero.

XIII Result(s)

% Efficiency =

XIV Interpretation of results

……
……
……
……

XV Conclusion and recommendation

……
……
……

XVI Practical related questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identifying CO.

1. List the low power transistor and high-power transistor using a datasheet.
2. List the ratings of low power transistors and high power transistors using a datasheet.
3. Differentiate Class A, B, AB, C power amplifier.

[Space for Answers]

………
………
………
………
………

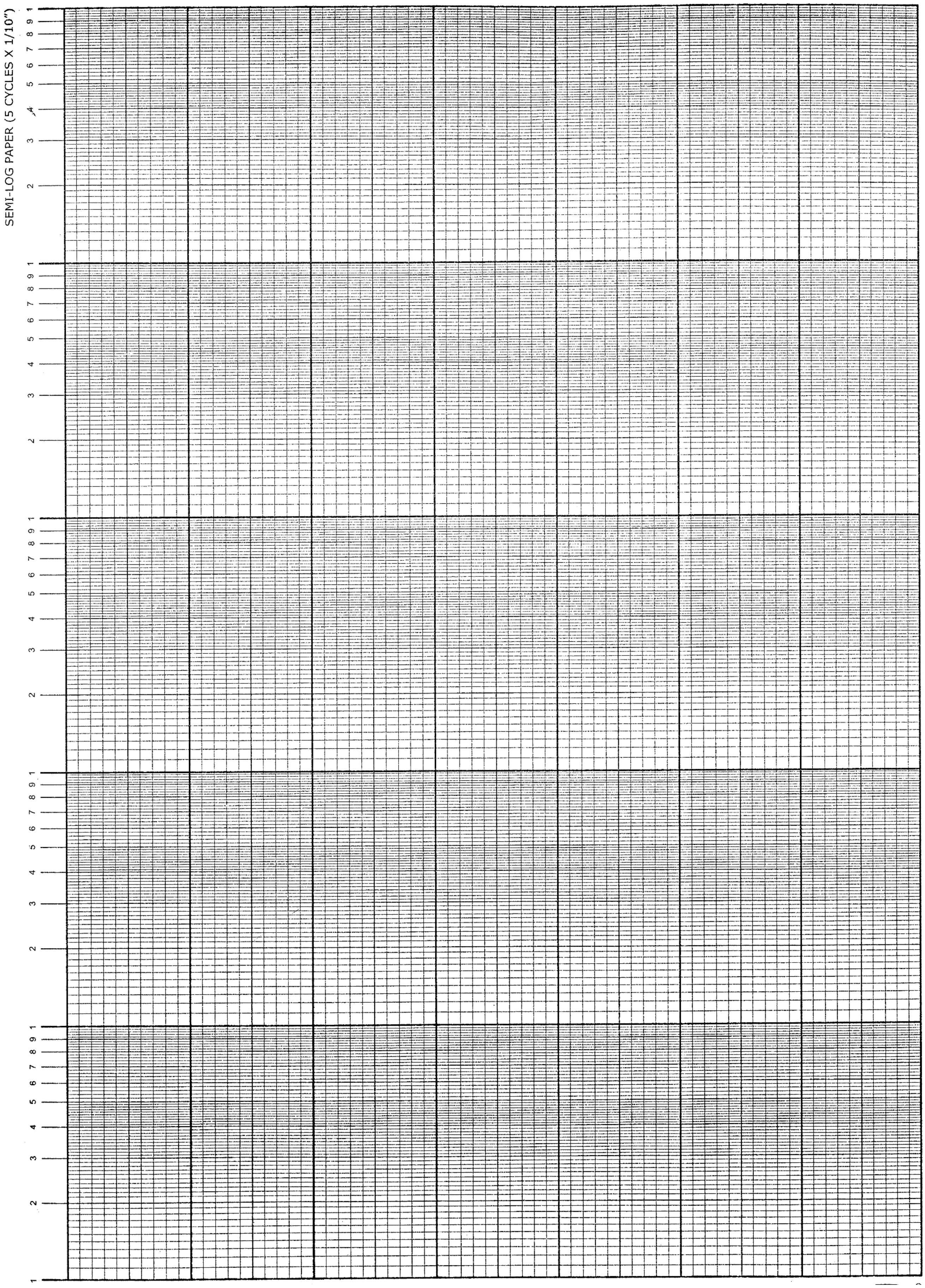
XVII References/Suggestions for further reading

1. https://youtu.be/dKTbrZMscpM?si=6lQ3xdhGvLDZL-VL
2. https://www.youtube.com/watch?v=937FMlUhgN4

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related: 15 Marks		**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of Teacher
Process related (15)	**Product related (10)**	**Total (25)**	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Practical No. 2: Test the performance of Class B Push Pull Amplifier

I Practical Significance

A push pull amplifier is an amplifier which has an output stage that can drive a current in either direction through the load. Push pull amplifiers are superior over single ended amplifiers in terms of distortion and performance. This practical will help the students to understand the working of Push Pull amplifier.

II Industry/Employer Expected Outcome(s)

- Select and test relevant electronics components.
- Mount the electronic component on breadboard as per circuit diagram.
- Maintain analog electronic circuits.

III Course Level Learning Outcome(s)

Use transistor as a Power Amplifier

IV Laboratory Learning Outcome(s)

Interpret the operation of Class B push pull power amplifier.

V Relevant Affective Domain related outcome(s)

1. Follow safe practices.
2. Handle tools and equipment carefully.

VI Relevant Theoretical Background

Push pull amplifiers are commonly used in situations where low distortion, high efficiency and high output power are required. The basic operation of a push pull amplifier is as follows: The signal to be amplified is first split into identical signal 180° out of phase. The Class B push pull amplifier is almost similar to the Class A push pull amplifier and the only difference is that there are no biasing resistors for a Class B push pull amplifier. This means that the two transistors are biased at the cutoff point.

The Class B configuration can provide better power output and has higher efficiency (upto 78.5%). Since the transistor is biased at the cutoff point, they consume no power during idle condition and this adds to the efficiency. The advantages of Class B push pull amplifiers are work in limited power supply conditions with absence of even harmonics in the output and simple circuitry when compared to the Class A configuration.

VII Practical Circuit Diagram

Sample Circuit Diagram

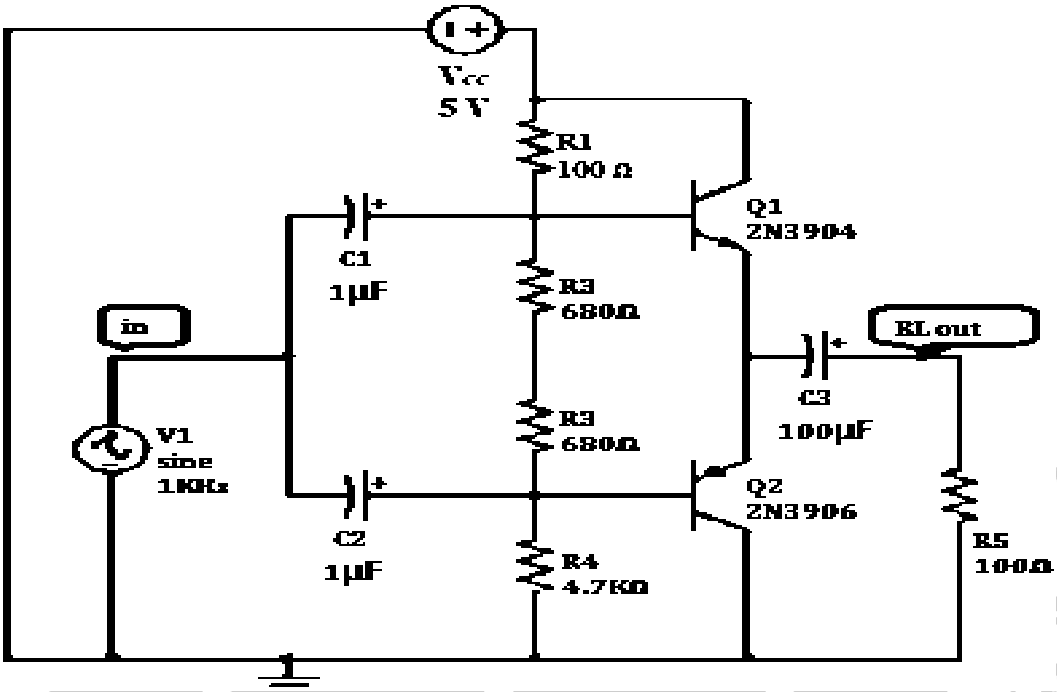

Fig. 2.1: Class - B Push Pull Amplifier

Actual Circuit used in laboratory

VIII Resources Required

Sr. No.	Instrument /Components	Specification	Quantity
1.	Cathode Ray Oscilloscope (Analog type)	20/30/100 MHz Frequency	1 No.
2.	Regulated Power Supply DC Power	0-30V, 2Amp SC protection V_{CC} = 12 volt.	1 No.
3.	Function Generated	(0-3) MHz	1 No.
4.	Transistor	BC147 and BC148	1 No.
5.	Resistors	R1=33kΩ, R2= 3.3kΩ, R=1.5KΩ, RE= 330Ω, R1=1kΩ	1 No.
6.	Capacitors	10 µF	3 No.
7.	Breadboard	5.5 cm X 17cm	1 No.
8.	Connecting wires	Single strand Teflon coating (0.6 mm Diameter)	As per Requirement

IX 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 proper settings of function generator and CRO before use.
4. Ensure the terminals of transistor.

X Procedure

1. Make the connection as per circuit diagram.
2. Connect the input supply with appropriate polarity.
3. Connect DC power supply as per circuit diagram. Set V_{CC} = 5V.
4. Connect CRO at the output. Switch ON CRO.
5. Observe input and output waveforms on CRO.
6. Note down reading of input voltage and output voltage from CRO.
7. Calculate efficiency of amplifier.

XI Resources Used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity

XII Actual Procedure followed (use blank sheet provided if space not sufficient).

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………

………
………

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

Ri = ………………………. (Input resistance measured at the input of Class-B amplifier using DMM)
Ro= …………………… (Output resistance measured at the output of Class-B amplifier using DMM**)**

Table No. 2.1 Observation Table

Sr. No.	Input Voltage (Vi)	Output Voltage (Vo)	Pi=Vi² / Ri	Po=Vo² / Ro	% Efficiency = Po / Pi * 100
1.	2V				
2.					
3.					

Calculations:

i. **% Efficiency = Po / Pi * 100 = ……………………………..**

XIV Results:

i. **% Efficiency = ……………………………... (When Vi = 2 Volt)**
………
………
………
………

XV Interpretation of results
………
………
………
………

XVI Conclusions and Recommendation (Actions /decisions to be taken based on the interpretation of results)
………
………
………

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

1. What is meant by Cross Over Distortion?
2. State the applications of Class B Push Pull Amplifier.
3. State the difference between a voltage and a Power Amplifier.
4. State the difference between an amplifier and oscillator.
5. . . . .

[Space for Answers]

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……
……
……
……

XVIII References / Suggestions for further reading

1. Dr. R.S. Sedha, Applied Electronics, Edition-2013, ISBN NO 81-219-2783-8.
2. K. R. Botkar, Integrated Circuits, Khanna publication, 10th edition,2005, ISBN NO :81- 7409-208-0.

XIX Assessment scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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

Practical No. 3: Test the performance of Class AB power amplifier.

I Practical Significance

Class AB amplifiers combine Class A and Class B to achieve an amplifier with more efficiency than Class A but with lower distortion than class B. This is achieved by biasing both transistors so they conduct when the signal is close to zero (the point where class B amplifiers introduce non-linearities).

II Industry / Employer Expected Outcome(s)

Maintain analog electronic circuits.
Select and test relevant electronics components.
Mount the electronic component on breadboard as per circuit diagram.

III Course Level Learning Outcome(s)

Use transistor as a Power Amplifier.

IV Laboratory Learning Outcome(s):

Test the performance of Class AB power amplifier.

V Relevant Affective Domain related outcome(s)

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

VI Relevant Theoretical Background

In a class AB power amplifier, the operating point is so adjusted that the collector current flows for more than half cycle but less than the full cycle of the input signal. For class AB operation of the amplifier, the biasing circuit is so adjusted that the operating point lies near the cut-off voltage. The input circuit is forward biased during a small portion of negative half-cycle & for the positive half cycle of the signal. Hence during a small portion of the negative half cycle, the input circuit is reverse biased and hence no collector current flows during this period.
The circuit waveform of this amplifier is shown in the figure below.

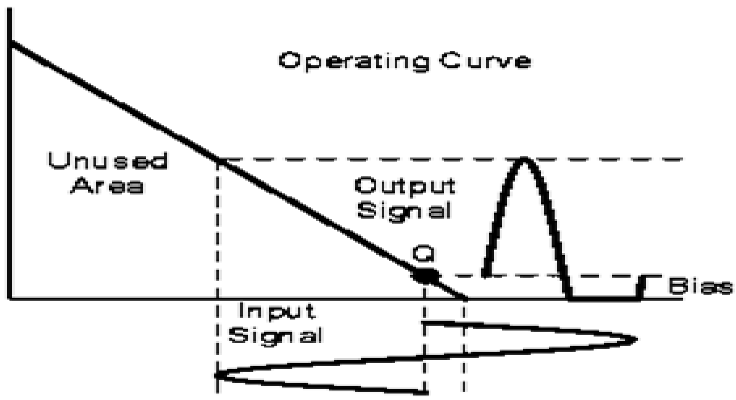

Fig. 3.1: Waveform of Class AB power amplifier

VII Circuit diagram/Laboratory layout

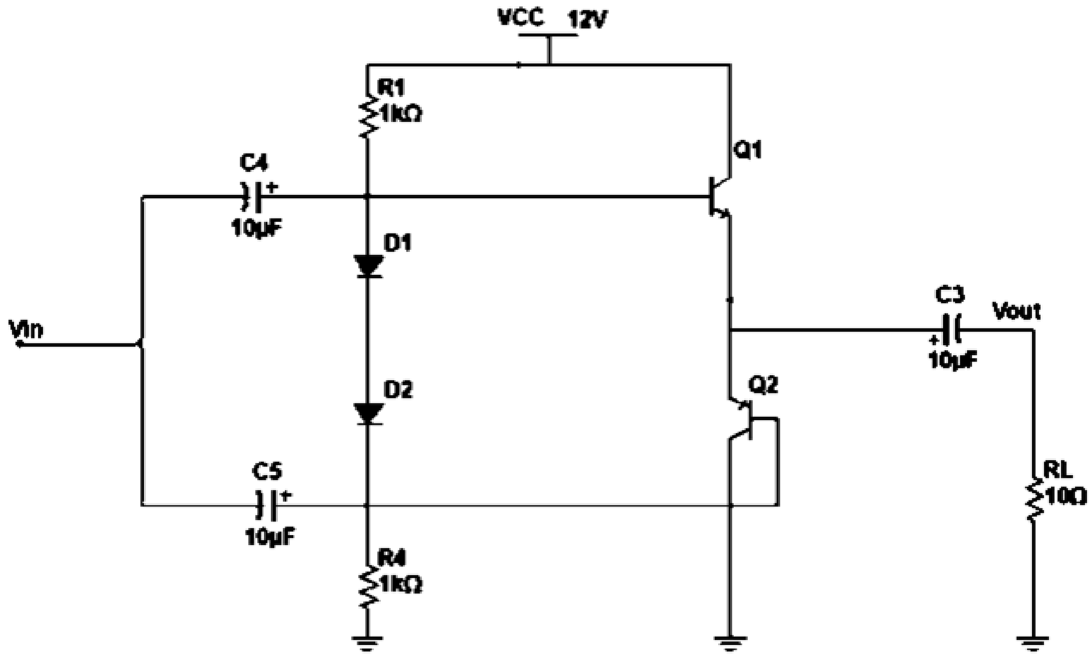

Fig 3.2: Circuit Diagram of class AB amplifier

[Courtesy: https://www.elprocus.com/wp-content/uploads/Class-AB-Amplifier-Circuit-Diagram.jpg]

Actual Experimental set up

VIII Resources Required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Cathode Ray Oscilloscope (Analog type)	20/30/100 MHz Frequency	1 No.
2.	Regulated DC Power Supply	0-30V, 2Amp SC protection Vcc=12 volt	1 No.
3.	Function Generator	0-2 MHz with Sine, square and triangular output with variable frequency and amplitude	1No.
4.	Transistor	N3904, N3906,	1 No.
5.	Resistors	R1=1kΩ,R4=1KΩ,RL=10KΩ	1No.
6.	Capacitors	C4=C5=10uF,C3=10uF	1No.
7.	Diode	D1=IN4148,D2=IN4148	1No.
8.	Breadboard	5.5 CM X 17CM	1 No.
9.	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

IX Precautions to be followed

1. Ensure proper connections are to be made to as per setup.
2. Ensure the power switch is in off condition initially while connecting the circuit.
3. Ensure proper settings of function generator and CRO before use.

X Procedure

1. Build circuit on breadboard as per diagram.
2. Set frequency and amplitude of sine wave input signal on function generator with the help of CRO.
3. Connect Function generator at input terminal of circuit.
4. Connect DC supply to the amplifier circuit.
5. Switch ON the DC Power Supply, function generator and CRO.
6. Vary the amplitude of sine waveform from function generator at different value and measure the output voltage on CRO.
7. Calculate the Pac, Pdc and % Efficiency using the given formula.

XI Resources Used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity

XII Actual Procedure

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

Ri= ………… (Input resistance measured at the input of Class - AB amplifier using DMM).
Ro=………. (Output resistance measured at the output of Class - AB amplifier using DMM).

Table No.3.1: Observation Table

Sr. No.	Input Voltage (Vi)	Output Voltage (Vo)	$Pi= Vi^{2} / Ri$	$Po= Vo^{2} / Ro$	% Efficiency = Po/ Pi * 100
1					
2					
3					

XIV Result(s)

% Efficiency =. (When Vi= 10 Volt)

XV Interpretation of results

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XVI Conclusion and recommendation

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XVII Practical related questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. What is meant by Cross Over Distortion?
2. State the applications of class AB Push Pull Amplifier.
3. State the difference between a voltage and a Power amplifier.

[Space for Answers]

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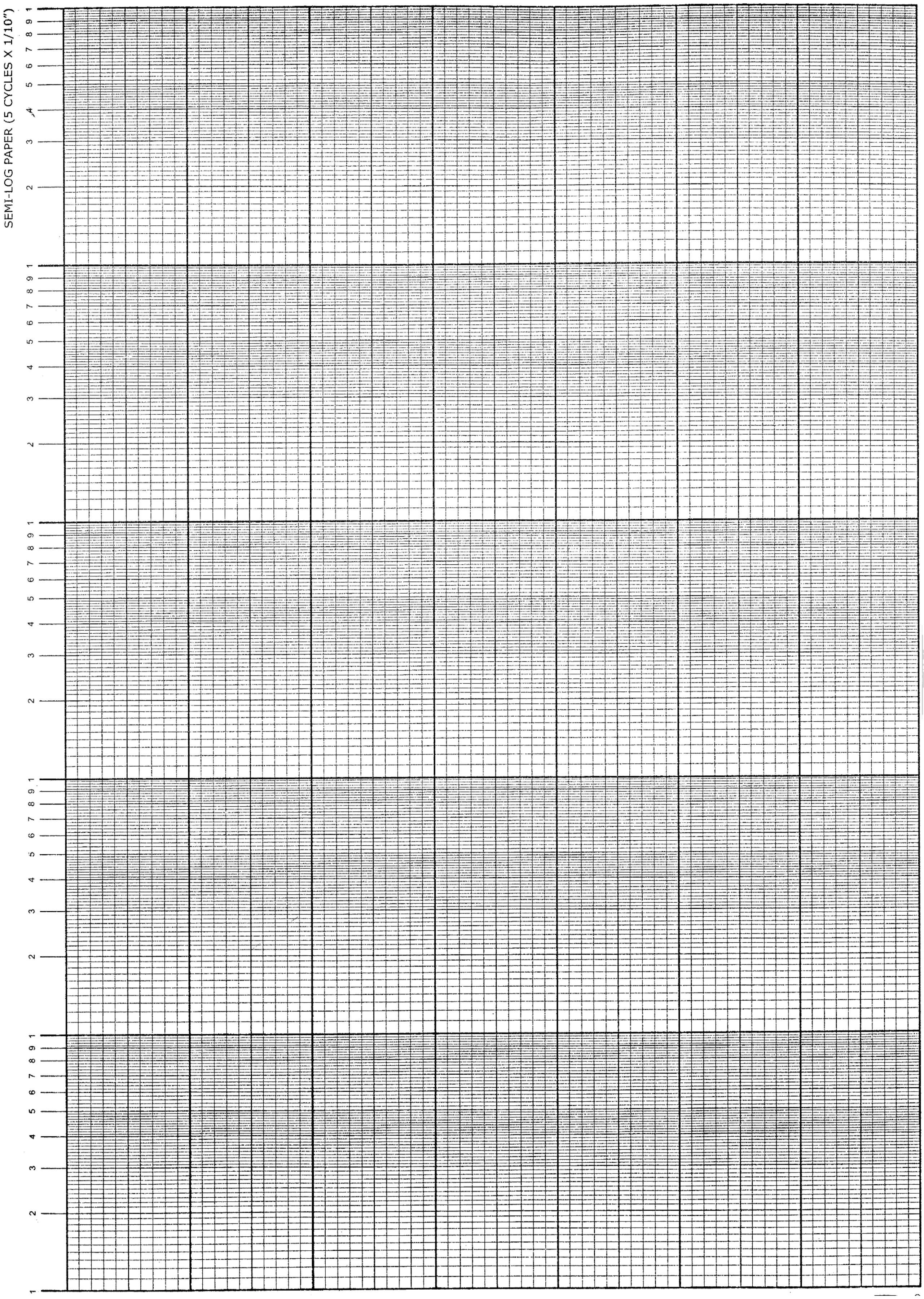
XVIII References/Suggestions for further reading

1. https://testbook.com/electrical-engineering/power-amplifier- definition-types-and-uses
2. https://www.youtube.com/watch?v=ZVK31WCmB4M

XIX Assessment Scheme

Performance Indicators		Weightage
Process Related: 15 Marks		**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

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


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

Practical No. 4: Determine the range of output voltage swing of Op-Amp (IC 741).

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 Industry/Employer Expected Outcome(s)

Maintain analog electronic circuits.
Select relevant electronic components like resistor for determine the voltage swing range.

III Relevant Course Learning Outcome(s)

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

IV Laboratory Learning Outcome(s):

- Measure output voltage swing of Op-Amp (IC 741).

V Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Follow ethical practices
- Handle tools and equipment carefully
- Demonstrate working as a leader/a team member

VI Theoretical Background Relevant

The output voltage swing of an op-amp refers to the maximum peak-to-peak voltage that the op-amp can output without significant distortion. For the 741 op-amp, the output swing is typically within a couple of volts less than the supply voltage (usually ±15V). This range shows the values of positive and negative saturation voltages of op-amp.

VII Circuit diagram / Laboratory layout:

a) Sample Circuit diagram

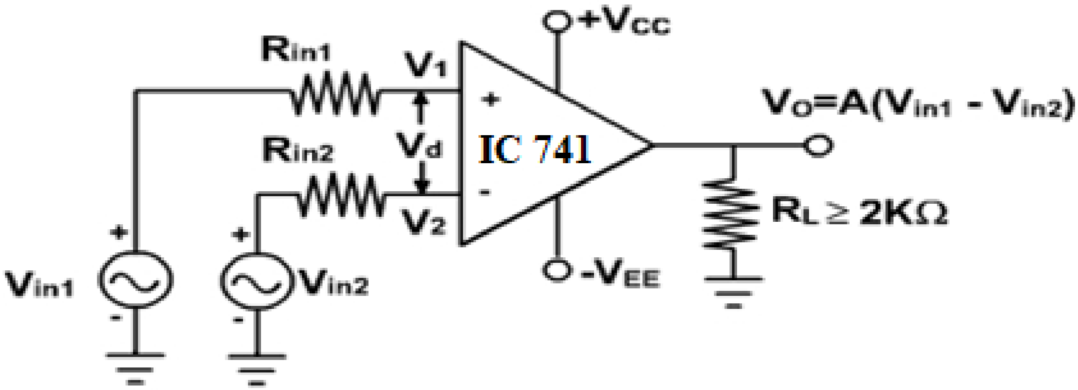


Fig. 4.1 Output voltage swing.

b) Actual Experimental set up

VIII Resources Required

Sr. 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 R_F and R_1	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

IX 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

X 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.

XI Resources Used

Sr. No.	Name of Resource	Specification	Quantity
1.			
2.			
3.			
4.			
5.			

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

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

Table No.: 4.1 Observation Table for output voltage swing

Sr. No.	Vin1 (p-p)	Vin2 (p-p)	Vo (p-p)
1			
2			
3			
4			

Calculations:

Output Voltage Swing Peak-to-Peak Vo(pp): The difference between the positive and negative peaks of the output voltage, calculated as

Vo(pp): $|Vin1 - Vin2|$ = ………………

= ………………

XIV Results

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

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XVI Conclusions and Recommendation

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XVII Practical Related Questions

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

1. What is an operational amplifier, and what are its typical applications?
2. Explain the significance of the output voltage swing in an operational amplifier.
3. Why does the output voltage of an operational amplifier clipped?
4. If the power supply voltages are reduced (e.g., ±12V instead of ±15V), how would you expect the output voltage swing to change?
5. …………………………………………………………………………………………

[Space for Answers]

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XVIII 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

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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

Practical No. 5: Use relevant instruments to measure the input offset voltage and Output offset voltage.

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 Industry/Employer Expected Outcome(s)

Maintain analog electronic circuits.

Student will be able check and observe the different parameters of Op-Amp IC 741 before developing any analog circuit.

- Test Analog IC-741.
- Use DC power supply to provide proper voltage to the IC 741.

III Relevant Course Learning Outcome(s)

Construct various configurations of Op-Amp for different applications.

IV Laboratory Learning Outcome(s):

Measure input offset voltage and output offset voltage of IC 741.

V Relevant Affective domain related Outcome(s)

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

VI Theoretical Background Relevant

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

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

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

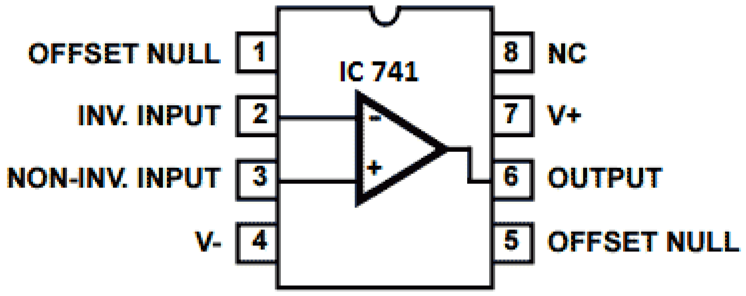

Fig 5.1 Pin diagram of IC741

VII **Circuit diagram/Laboratory Layout:**

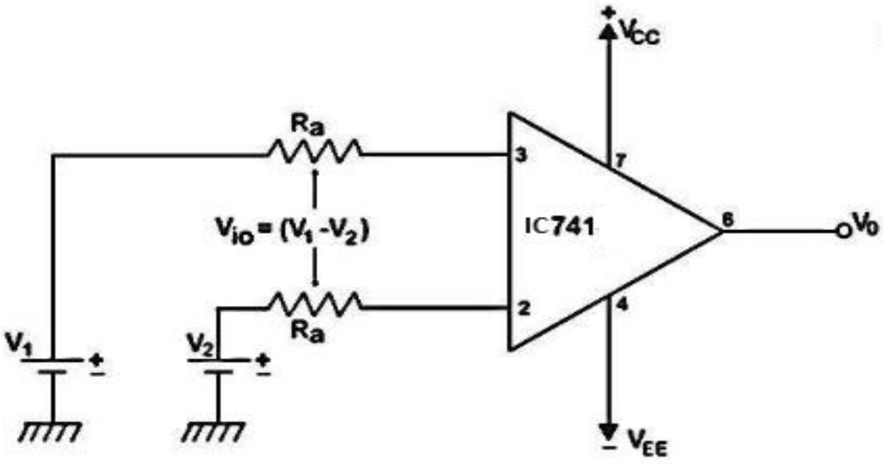

Fig 5.2 Input offset voltage (Vio)
(https://www.circuitstoday.com/wp-content/uploads/2008/08/Input-Offset-Voltage-Of-OP-AMP-741IC.jpg)

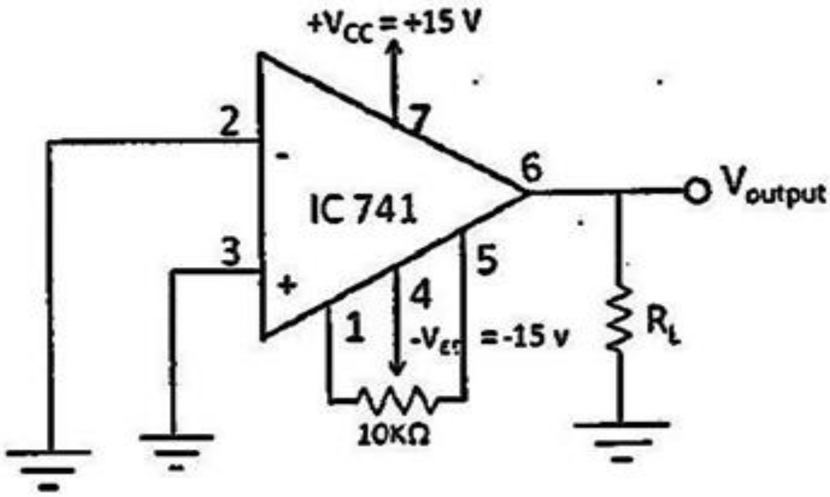

Fig 5.3 Output offset voltage (Voo)

Actual Experimental set up

VIII Resources Required

Sr. 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

IX 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

X Procedure

Procedure for measurement of Input offset voltage (Vio)

1. Test and mount the IC741 on the breadboard.
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.5.2.
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).
7. 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 (- VEE) and DMM to pin No. 6 shown in figure no.5.3
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.

XI Resources Used

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

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

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

Table No.: 5.1 Observation Table for Input offset voltage (Vio)

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

Table No.: 5.2 Observation Table for Output offset voltage (Voo)

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

XIV Results

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

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XVI Conclusions and Recommendation

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XVII Practical Related Questions

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

1. Draw symbol and equivalent circuit of IC 741.
2. Define various parameters of IC 741.
3. Draw ideal and practical characteristics of IC 741.
4. State significance of level shifter circuit of IC 741

[Space for Answers]

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XVIII References / Suggestions for further reading

1. https://www.youtube.com/watch?v=NEiVSbPYWNE
2. Ramakant A. Gayakwad, Op-Amps and linear Integrated Circuits, Prentice -Hall India,3rd edition, 2001, ISBN NO: 81-203-0807-7
3. K.R. Botkar, Integrated Circuits, Khanna publication,10th edition,2005, ISBN NO :81- 7409-208-0
4. http://www.ti.com/lit/ds/symlink/lm741.pdf

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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

Practical No. 6: Determine the gain of inverting and non-inverting amplifier using IC 741.

I Practical Significance

Inverting and non-inverting both amplifier configurations are widely used for signal amplification purposes. By adjusting the values of the feedback and input resistors, precise amplification of analog signals can be achieved. This is crucial in applications where weak signals need to be boosted for further processing or transmission.

II Industry/Employer Expected Outcome(s)

Student will be able to mount circuits on breadboard and test output using multimeter.
Select relevant electronic components IC 741 and resistor value for specified gain.

III Relevant Course Learning Outcome(s)

Construct various configurations of Op-Amp for different applications.

IV Laboratory Learning Outcome(s):

Connect IC 741 in inverting and non-inverting mode.
Measure the voltage gain of inverting and non-inverting amplifier circuit using IC 741.

V Relevant Affective domain related Outcome(s)

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

VI Theoretical Background Relevant

Operational amplifiers are versatile integrated circuits designed to amplify, filter, and process analog signals. They typically have two input terminals (inverting and non-inverting), an output terminal, and a power supply connection.

Inverting Amplifier Configuration
In the inverting amplifier configuration, the input signal is connected to the inverting (-) input terminal of the op-amp, while feedback from the output is applied to the same inverting input terminal through a resistor (). A resistor (Rin) is connected between the input source and the inverting input. The non-inverting (+) input terminal is grounded.

Gain of Inverting Amplifier
The gain (Av) of an inverting amplifier is determined by the ratio of the feedback resistor (R_F) to the input resistor (Rin). Mathematically, the gain (Av) can be expressed as:

$$Av = -R_F / Rin$$

The negative sign indicates phase inversion, meaning the output signal is 180 degrees out of phase with the input signal.

Non-Inverting Amplifier Configuration

In the non-inverting amplifier configuration, the input signal is connected to the non-inverting (+) input terminal of the op-amp, while feedback from the output is applied to the inverting (-) input terminal through a voltage divider network consisting of resistors (R_f and Rin). The non-inverting input terminal is directly connected to the input source.

Gain of Non-Inverting Amplifier

The gain (Av) of a non-inverting amplifier is determined by the ratio of the sum of the feedback resistor (Rf) and the input resistor (Rin) to the input resistor (Rin). Mathematically, the gain ($AvAv$) can be expressed as:

$$Av = 1 + (R_F / Rin)$$

The positive term indicates that the output signal is in phase with the input signal.

VII Circuit diagram/Laboratory layout:

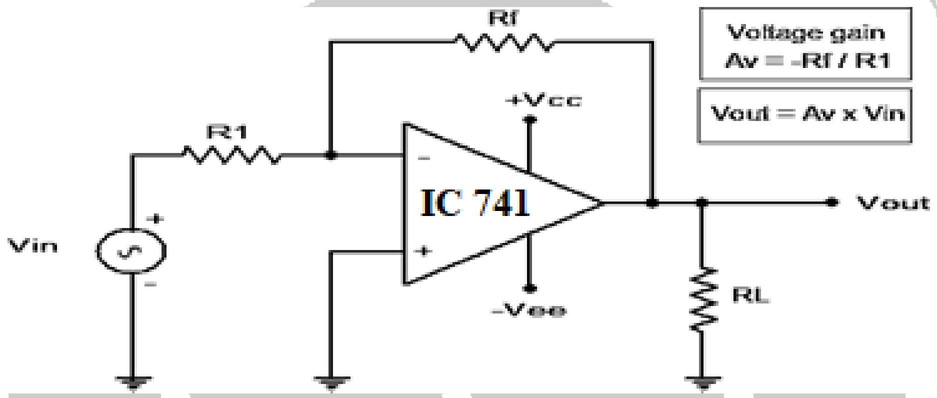

Fig. 6.1: Inverting Amplifier

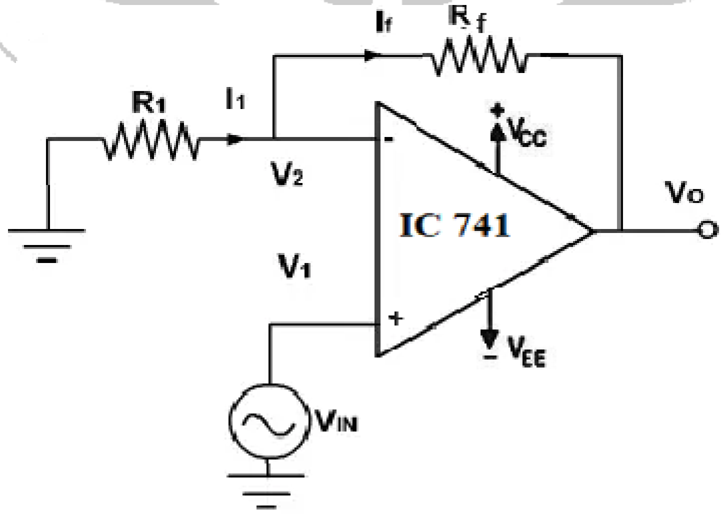

Fig. 6.2: Non Inverting Amplifier

Actual Experimental set up

VIII 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

IX 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.

X Procedure

Procedure for 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 6.1
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

Procedure for 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.

XI Resources Used

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

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

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

Table No. 6.1: Observation Table For inverting amplifier Vi = 0.5 Vpp.

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

Table No. 6.2: Observation Table for Non Inverting amplifier Vi = 0.5 Vpp.

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			

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

Calculations:

For Inverting:

i. Voltage Gain: Vo/Vi =

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

For Non-Inverting:

i Voltage Gain: Vo/Vi =

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

XIV Results

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

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XVI Conclusions and Recommendation

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XVII 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 6.1 and 6.2 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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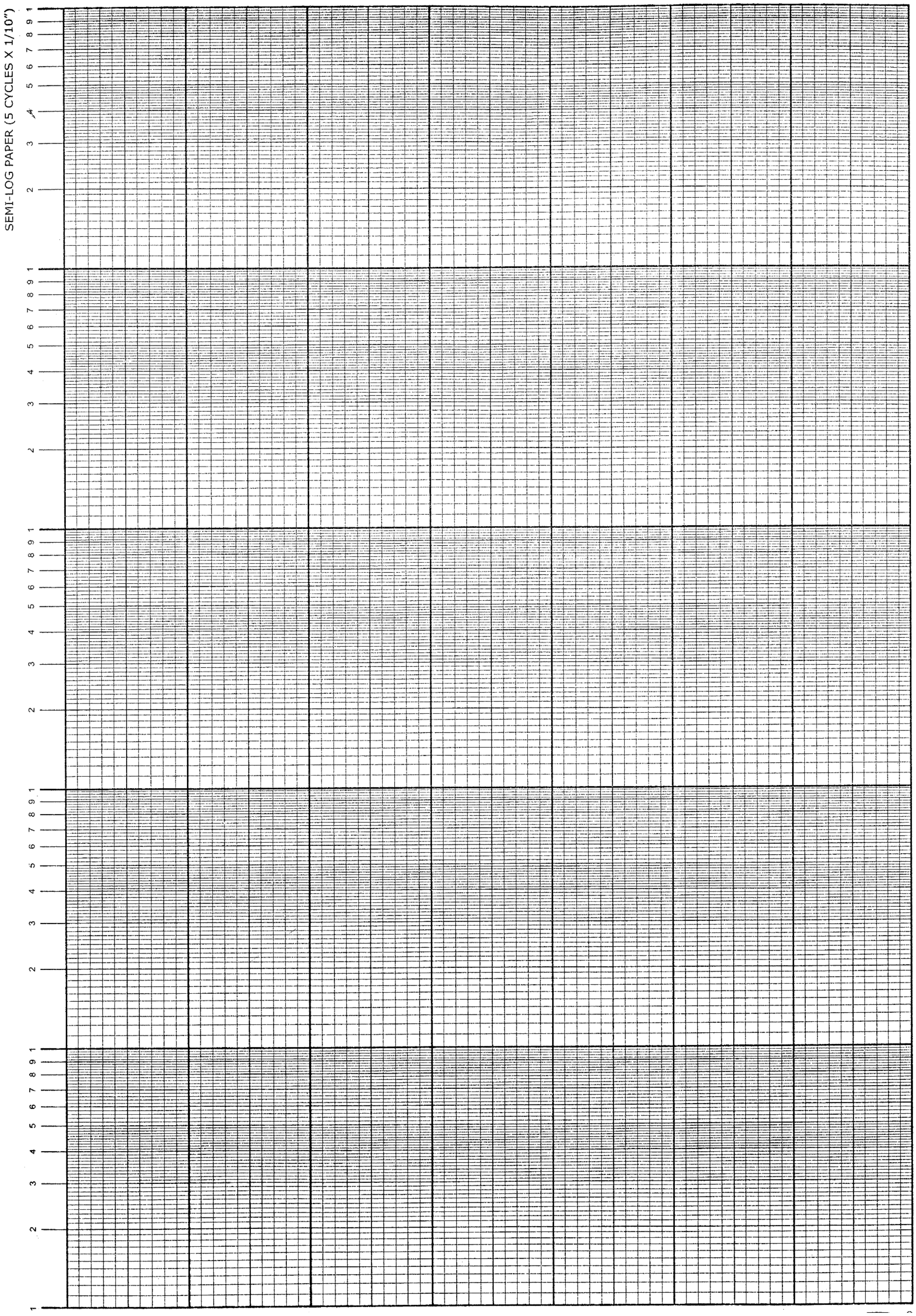
XVIII References / Suggestions for further reading

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

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

Marks Obtained			**Dated signature of Teacher**
Process related (15)	**Product related (10)**	**Total (25)**	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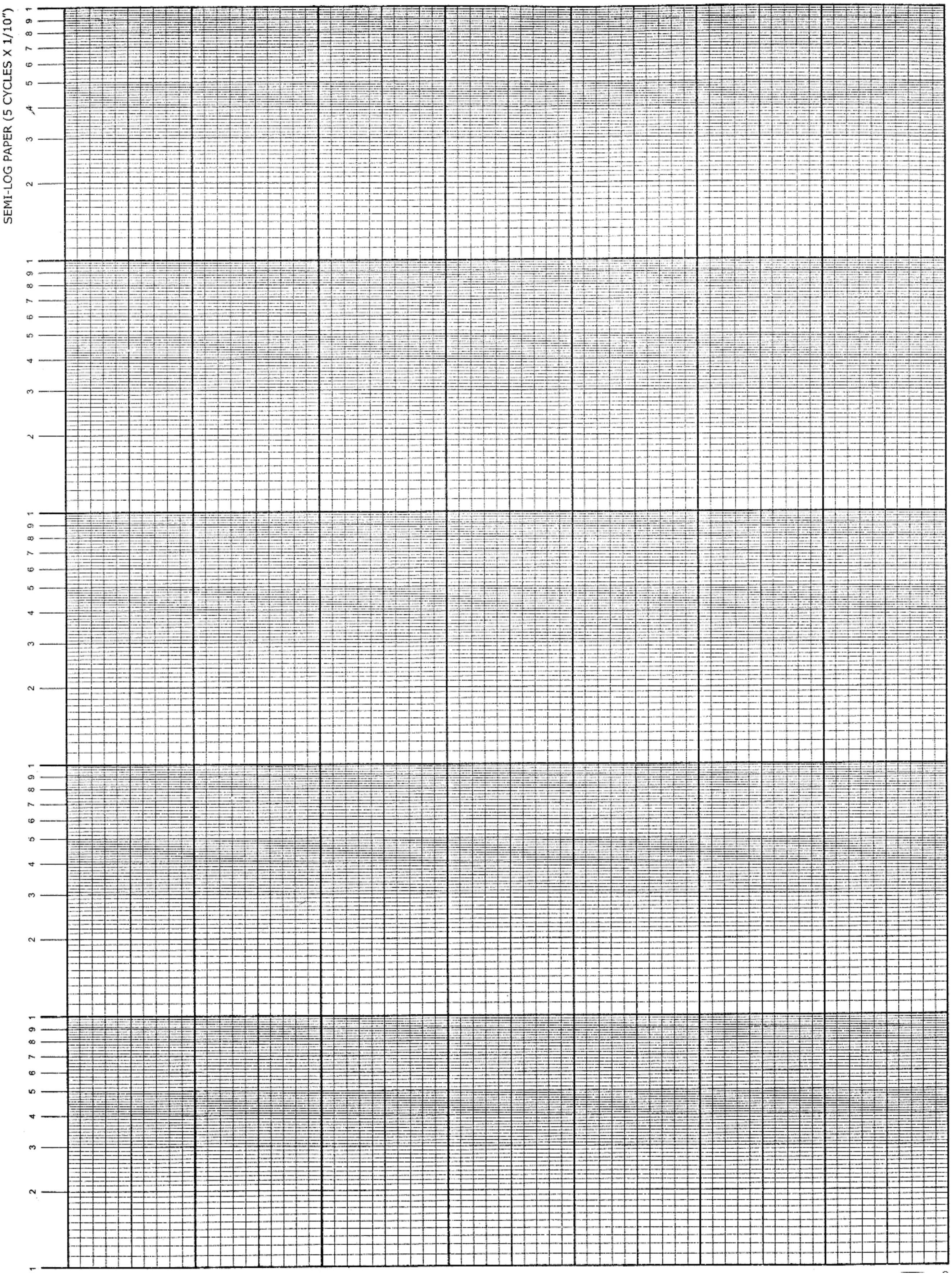
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Practical No. 7: Build / Test adder and circuit consist of IC 741.

I Practical Significance

In adder and circuit the input signal can be added and subtracted to the desired value by selecting appropriate values for the external resistors. These arithmetic functions are 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 voltages each multiplied by a constant gain factor. This practical will enable student to add and subtract signals using IC 741

II Industry/Employer Expected Outcome(s)

Maintain analog electronic circuits.

Student will be able to mount the electronic component on breadboard as per the given sample circuit diagram.
Select relevant electronic components IC 741 and resister value for specified gain.

III Course Level Learning Outcome

Use various configurations of Op-Amp for different applications

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IV Laboratory Learning Outcome(s):

Select the proper range of multimeter to measure the voltage.
Measure output voltage of adder circuit consist of IC 741.

V Relevant Affective Domain related outcome(s)

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

VI Relevant Theoretical Background

Adder circuit using Op Amp is used to perform arithmetic operations like addition, s. It is always used in close loop mode with negative feedback and the voltage gain is controlled by external components R_1 and R_F. 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 the inverting configuration of an op-amp if more than one input is given to the inverting terminal then resultant circuits work as a summing amplifier or adder.
Output expression:

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

a) **Circuit diagram/Laboratory layout:**

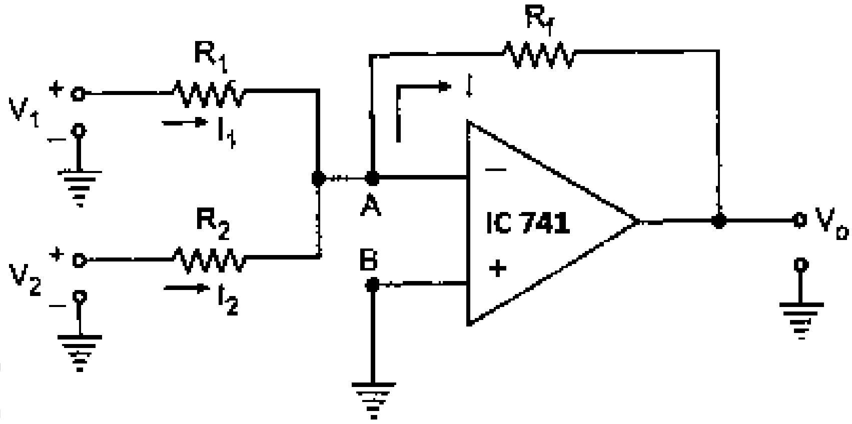

Fig. 7.1: Inverting Adder

(https://www.eeeguide.com/wp-content/uploads/2016/08/Summing-Amplifier-002.jpg)

b) **Sample Experimental set up**

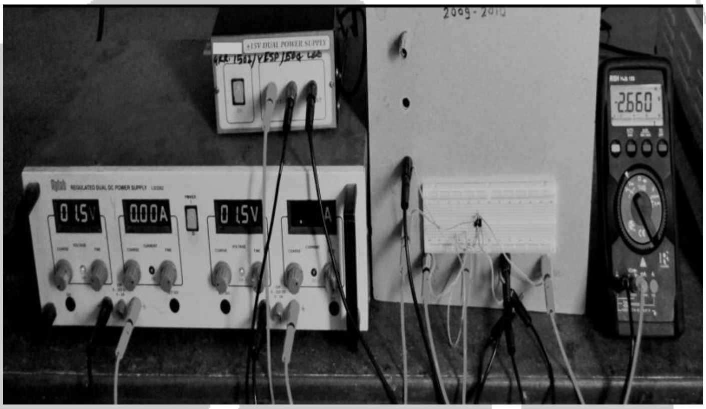

Fig. 7.2: Adder experimental setup

c) **Actual Experimental set up**

VII 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 , 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

VIII 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.

IX Procedure

Inverting Adder

1. Test and mount the IC on the breadboard.
2. Make connections as per circuit diagram.
3. Connect dual power supply.
4. Apply input voltages V_1 and V_2 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 V_1 and V_2 using regulated power supply.
8. Calculate ($V_1 + V_2$) and the theoretical output voltage using the formula
9. Vout = $-(R_F/R) * (V_1 + V_2)$ <u>Note:</u> $R = R_1 = R_2$
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.

X Resources Used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity

XI Actual Procedure

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XII Observation:

Table No. 7.1: 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.						

Note: $R_1 = R_2 = R_F = R$

XIII Calculations:

Inverting Adder:

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

XIV Result(s)

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XV Interpretation of results

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XVI Conclusion and recommendation

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XVII Practical related questions

Note: Below are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identifying CO.

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 $Vo = 2(V_1 + V_2 + V_3)$.

[Space for Answers]

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XVIII 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://dec-iitkgp.vlabs.ac.in/exp/functions-inverting adder(Virtual Lab Link)
3. https://youtu.be/c_a8eA52zKU?si=vxfGAI-RFZTuSedV.

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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

Practical No. 8: Build / Test subtractor circuit consists of IC 741.

I Practical Significance

In subtractor circuit the input signal can be subtracted to the desire value by selecting appropriate values for the external resisters. This circuit can be used to subtract ac or dc signals. This circuit provides an output voltage proportional to or equal to the difference of two input signals each multiplied by a constant gain factor. This practical will enable student to subtract signals using IC 741.

II Industry/Employer Expected Outcome(s)

Student will be able to mount circuits on bread board and test output using multimeter.
Select relevant electronic components IC 741 and resister value for specified gain.

III Relevant Course Learning Outcome(s):

Construct various configurations of Op-Amp for different applications.

IV Laboratory Learning Outcome(s):

- Select the proper range of multimeter to measure the voltage.
- Measure output voltage of subtractor circuit consisting of IC 741.

V Relevant Affective domain related Outcome(s)

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

VI Theoretical Background Relevant:

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 Potentiometer between pin 1 and 5 and connecting wiper to pin 4.

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

$Vout = (R_F / R) * (V_1 - V_2)$

VII Circuit diagram/Laboratory layout:

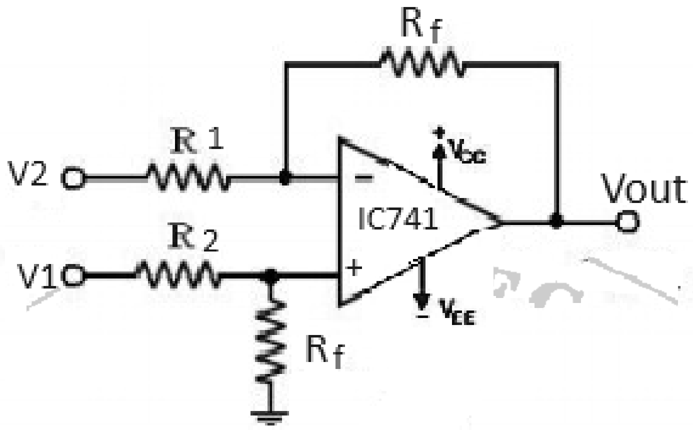

Fig. 8.1: Circuit diagram Subtractor

Actual Experimental set up

VIII 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 , 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

IX 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.

X Procedure

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 = R_F / R* (V1 - V2) Note: R=R1=R2= R_F
10. Using DMM, measure Vo 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.

XI Resources Used

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

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

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

Table No. 8.1: 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:

Subtractor

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

XIV Results

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

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XVI Conclusions and Recommendation

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

1. Why it is necessary to null the offset voltage before using the OPAMP?

2. Draw the circuit diagram of non-inverting subtractor.
3. Draw the circuit for the defined output equation $V_o = 2(V_1 - V_2 - V_3)$
4. Suggest the circuit and value of input and feedback resistor for given output equation $V_o = -3(V_a - V_b)$

[Space for Answers]

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XVIII 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 Op-Amp.
3. Ramakant A. Gayakwad, *Op-Amps and linear Integrated Circuits*, Prentice -Hall India,3rdedition, 2001, ISBN NO: 81-203-0807-7.
4. K. R. Botkar, *Integrated Circuits*, Khanna publication,10th edition,2005, ISBN NO :81- 7409-208-0.

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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

Practical No. 9: Build / Test Integrator circuit consist of IC741.

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I Practical Significance

Operational amplifiers 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 Industry/Employer Expected Outcome(s)

Maintain analog electronic circuits.

Select relevant electronic components IC 741 and resistor and capacitor value for specified gain.

Student will be able to build, test and understand the concept as well as functionality of an Integrator circuit using IC-741.

III Course Level Learning Outcome(s)

Construct various configurations of Op-Amp for different applications.

IV Laboratory Learning Outcome(s):

Use function generator.

Interpret input and output waveforms of integrator circuit consist of IC 741.

V Relevant Affective Domain related outcome(s)

Follow safe practices.

Demonstrate working as a leader/a team member.

Follow ethical practices

VI Relevant Theoretical Background

An integrator is a circuit that performs a mathematical operation called integration. Integration is a process of continuous 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 an 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 generators, in filters, analog computers etc.

$$V_O = -\frac{1}{RC}\int V_i\,dt$$

VII a) Circuit diagram/Layout of Laboratory

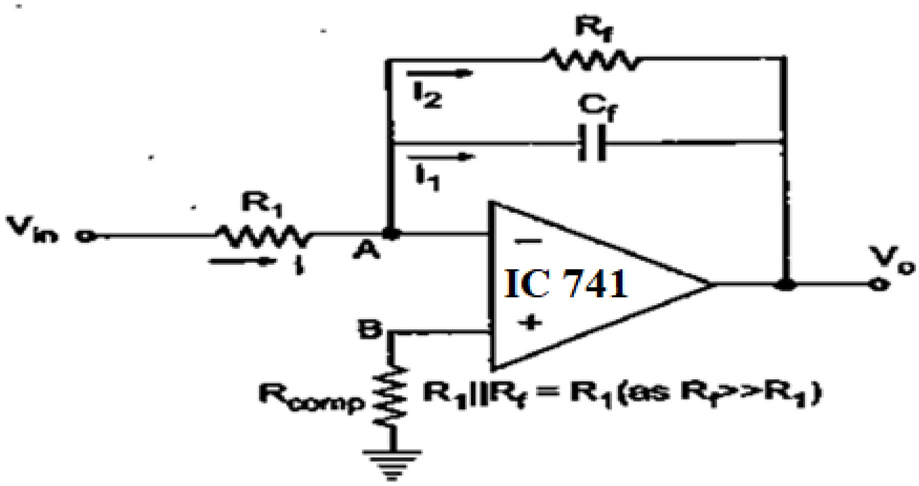

Fig 9.1: Integrator using IC 741

(https://www.eeeguide.com/wp-content/uploads/2016/08/Integrators-19.jpg)

b) Actual Experimental set up

VIII Resources Required

Sr. No.	Name of Resource	Suggested Broad 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	0.1μF	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

IX 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.

X Procedure

1. Assemble the circuit on the 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 the observation table.
8. Plot the graph gain vs. frequency on semi log paper. Calculate gain for different input frequency in decibels.

XI Resources Used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity

XII Actual Procedure

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XIII Observation and Calculation

Table No: 9.1 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 KHz		
11.	2 KHz		
12.	3 KHz		
13.	4 KHz		
14.	5 KHz		
15.	6 KHz		
16.	7 KHz		
17.	8 KHz		
18.	9 KHz		
19.	10 KHz		

Calculations:

i. Voltage Gain: Vo/Vi
ii. Voltage Gain in dB: $20 \log_{10} (Vo / Vi)$
iii. 3 dB Bandwidth, $B/W = F_H - F_L$

XIV Result(s)

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XV Interpretation of results

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XVI Conclusion and recommendation

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XVII Practical related questions

Note: Below are few sample questions for reference. Teacher must design more such questions to ensure the achievement of identifies CO.

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.Define instrumentation amplifier. State need of it
3. Can integrator act as low pass filter? Justify it with the help of frequency response.
4. Draw circuit diagram of Schmitt trigger.

[Space for Answers]

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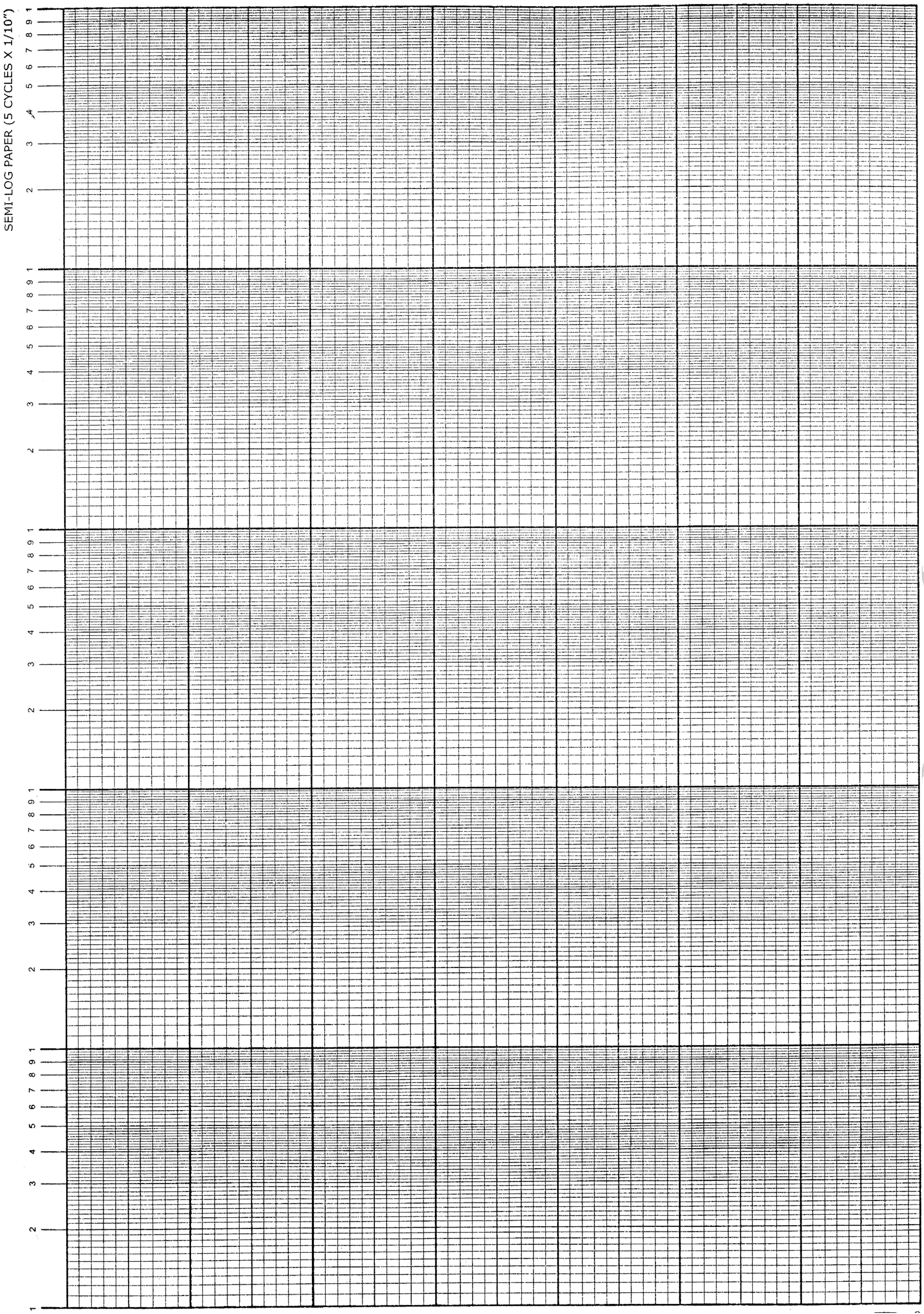
XVIII References/Suggestions for further reading

1. https://youtu.be/pf4PteIKJrY?si=y3_XVpFGIj7p1XdH
2. https://youtu.be/1B4O5gy6A6U?si=kc7B-1iMECU4oa2K

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

Marks Obtained			Dated signature of Teacher
Process related (15)	**Product related (10)**	**Total (25)**	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Practical No. 10: Build /Test Differentiator circuit consists of IC 741.

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 differentiation 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 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 Industry/Employer Expected Outcome(s)

Student will be able to mount circuits on breadboard and test output using multimeter.
Select relevant electronic components IC741, resistor and capacitor value for specified gain.

III Relevant Course Learning Outcome(s)

Construct various configurations of Op-Amp for different applications.

IV Laboratory Learning Outcome(s):

- Use function generator.
- Interpret input and output waveforms of Differentiator circuit consisting of IC 741.

V Relevant Affective domain related Outcome(s)

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

VI Theoretical Background Relevant:

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 R_1 is replaced by a capacitor C_1.

The expression for the output voltage can be obtained as the output Vo is equal to R_F C_1 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_o with respect to the input signal. Since the differentiator performs the reverse of the integrator function.

$$V_O = - RC\, dv_i/dt$$

VII Circuit diagram/Laboratory layout:

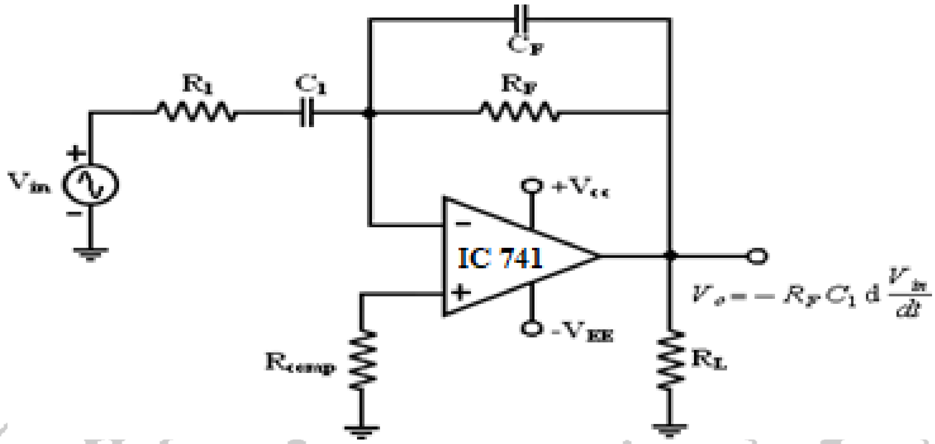

Fig. 10.1: Active differentiator

Actual Experimental set up

VIII 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

IX 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.

X Procedure

1. Assemble the circuit on the 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 10.1
8. Plot the graph gain vs. frequency on semi log paper. Calculate gain for different input frequency in decibels.

XI Resources Used

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

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

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

Table No. 10.1: 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 KHz		
11.	2 KHz		
12.	3 KHz		
13.	4 KHz		
14.	5 KHz		
15.	6 KHz		
16.	7 KHz		

Sr. No.	Input Frequency (Hz)	Output Voltage, Vo (Volts)	Gain in dB 20 $\log_{10}$(Vo/Vi)
17.	8 KHz		
18.	9 KHz		
19.	10 KHz		

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

XIV Results

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

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XVI Conclusions and Recommendation

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

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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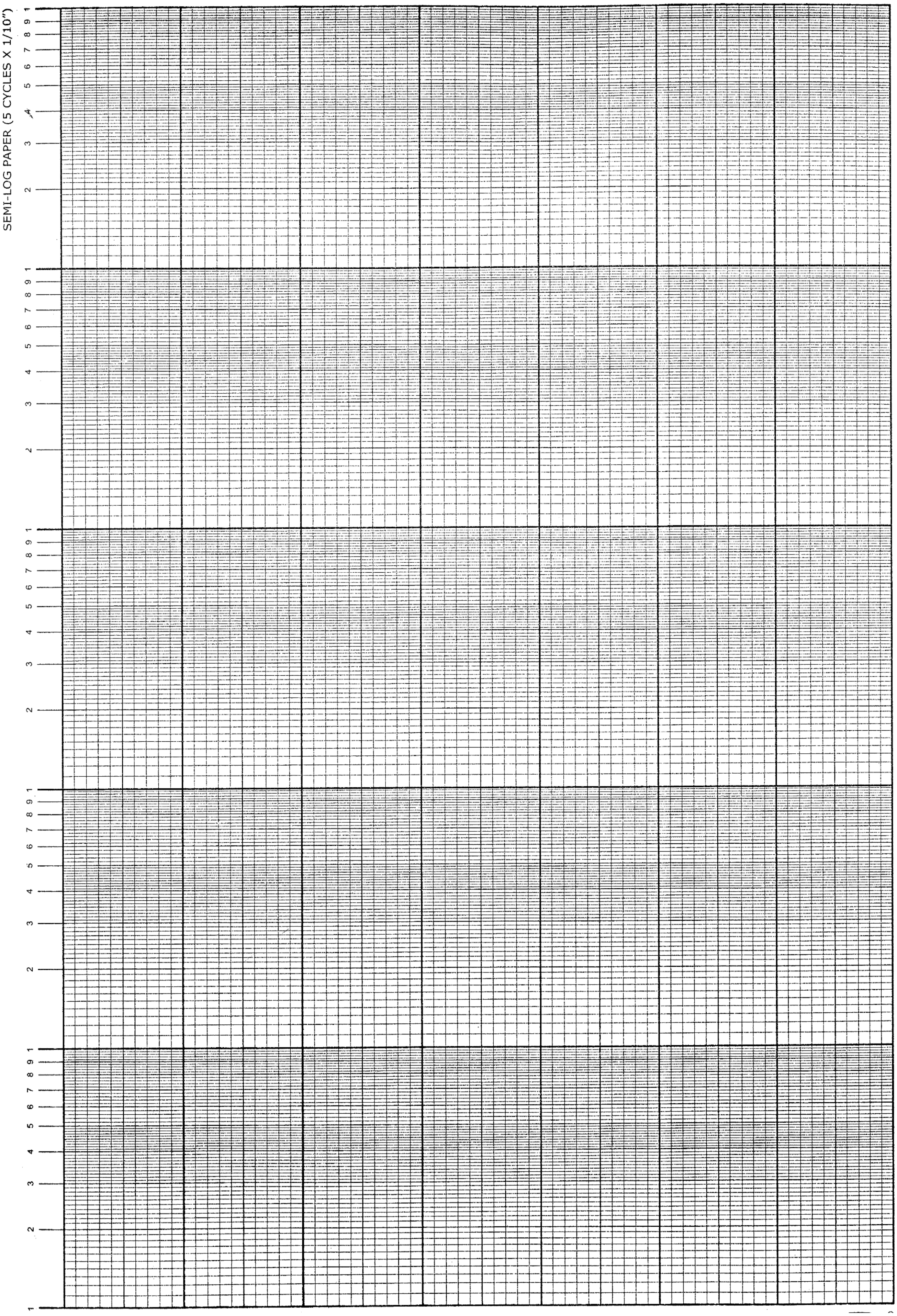
XVIII References / Suggestions for further reading

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.

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	60 %
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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


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

Practical No. 11: Build / Test Voltage to Current 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.

II Industry/Employer Expected Outcome(s)

Maintain analog electronic circuits.

Select relevant electronic components IC 741 and resistor value for specified gain.

Mounting of the electronic component on breadboard as per circuit diagram.

III Course Level Learning Outcome(s)

Construct various configurations of Op-Amp for different applications.

IV Laboratory Learning Outcome(s):

Measure output current of V to I converter circuit using IC 741.

V Relevant Affective Domain related outcome(s)

Follow safe practices.

Demonstrate working as a leader/a team member.

Follow ethical practices

VI Relevant Theoretical Background

Voltage to current convertor in which load resistor R_L 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 R_1 depends on the output current Io and is in series with the input difference voltage Vid.

$$Io = (Vo - Vin) / R_1$$

VII a) Sample Experimental set up

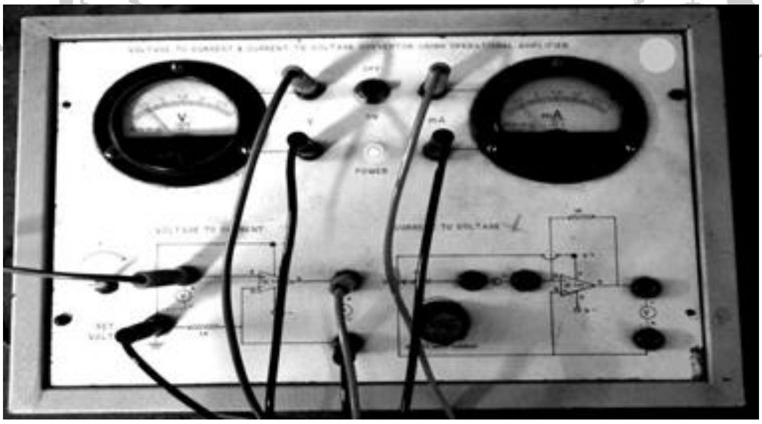


Fig. 11.1: V/I converter kit

b) Circuit diagram / Layout of Laboratory:

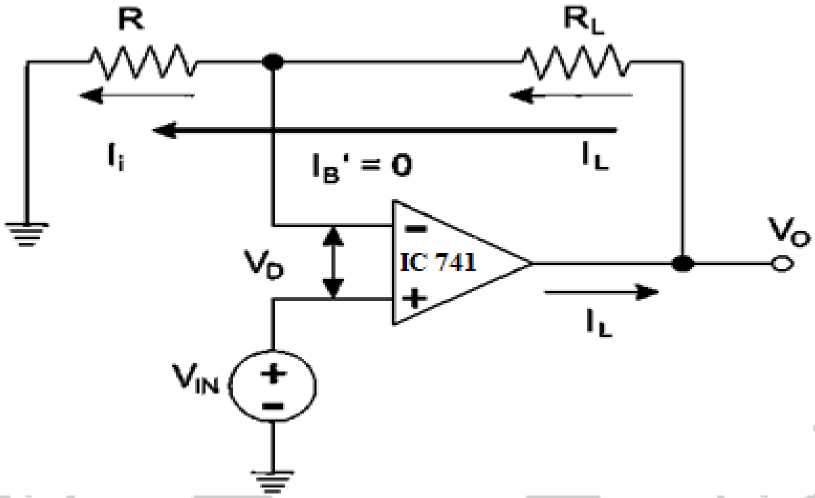


Fig. 11.2: Voltage to current converter

(https://ae-iitr.vlabs.ac.in/exp/voltage-current-converter/images/VC1.png)

c) Actual Experimental set up

VIII Resources Required

Sr. No.	Name of Resource	Suggested Broad 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

IX 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

X Procedure

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 11.2.
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) /R_1.
7. Compare theoretical current and practical current values.

XI Resources Used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity

XII Actual Procedure

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

Table No. 11.1: Observation Table for voltage to current converter

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

Calculations:

$$Io = (Vo-Vin) / R_1$$

XIV Result(s)

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XV Interpretation of results

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XVI Conclusion and recommendation

XVII Practical related questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identifying CO.

1. Give output expression for V to I converter with grounded load and draw diagram.
2. Draw I/V converter and write output expression.
3. Write application of Log amplifier and antilog amplifier.
4. Draw diagram of multiplier and write output expression.
5. Draw a sample and hold the circuit and waveform of it.

[Space for Answers]

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XVIII References/Suggestions for further reading

1. https://www.youtube.com/watch?v=5Bo-PR5Zoso
2. https://www.youtube.com/watch?v=9R0qsP-MpvM&t=27s

XIX Assessment Scheme

Performance Indicators		Weightage
Process Related: 15 Marks		**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

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

Practical No. 12: Build the circuit of zero crossing detector and test the output.

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 Vo is driven into negative saturation when an input signal Vin crosses zero volts in negative direction the output Vo is driven into positive saturation. This practical will enable students to measure phase value of input signal using IC 741.

II Industry / Employer Expected Outcome(s)

Student will be able to mount circuits on breadboard and test output using multimeter. Maintain analog electronic circuits.

III Relevant Course Learning Outcome(s)

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

IV Laboratory Learning Outcome(s):

- Interpret output voltage waveform of zero crossing detector.

V Relevant Affective domain related Outcome(s)

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

VI Theoretical Background Relevant:

A 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 a square wave converter.

VII Circuit diagram/Laboratory layout:

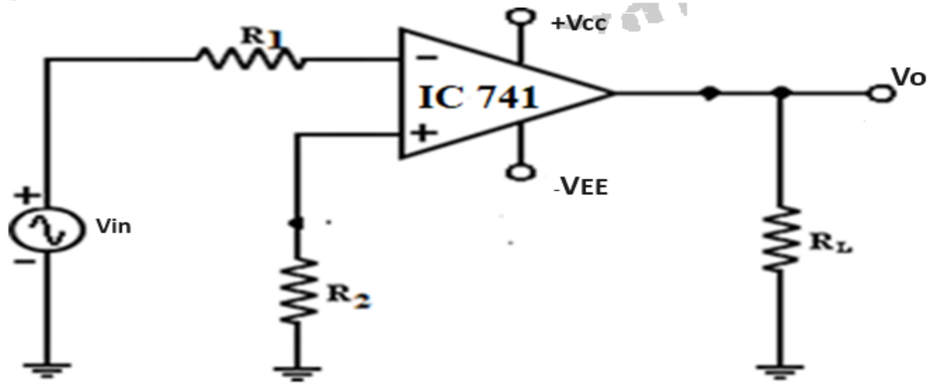

Fig. 12.1: Zero crossing detector

Actual Experimental set up

VIII 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.	Function generator	02 Hz to 2 MHz	1 No
7.	CRO	0 to 20 MHz	2 No
8.	Analog IC tester	Suitable to test analog IC	1 No.
9.	Breadboard	5.5 cm X 17cm	2 No.
10.	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

IX 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.

X 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. Apply input signal Vin from function generator to input pin No.2 and vary upto value as per variation given in observation table no. 12.1.

6. Observe input and output (pin No. 6) waveforms on CRO.
7. Plot the graph for input and output waveforms observed on CRO.

XI Resources Used

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

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

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

Table No: 12.1 Observation Table for Zero crossing detector

Sr. No.	Apply Input Voltage (Volts)	Applied Voltage (Vin)	Difference Voltage, Vid=V_1-V_2 (Volts)	Output Voltage, Vo (Volts)
1.	Vin = 0			
2.	Vin > 0			
3.	Vin < 0			

XIV Results

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

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XVI Conclusions and Recommendation

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

1. Apply the given input signal to non-inverting terminal of Op-Amp and compare it with inverting zero crossing detectors.
2. Why is comparator sometimes also called voltage level detector?
3. What is the drawback in zero crossing detectors?

[Space for Answers]

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XVIII 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 Op-Amp.

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	60 %
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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

Scale

X-axis -

Y-axis -

Practical No. 13: Use transistor to build / test voltage series feedback amplifier with feedback.

I Practical Significance

As negative feedback is used for stability. This configuration is the most stable one and used in most discrete amplifier systems. This practical will help to develop practical skill of the students to use appropriate feedback connection in the amplifier

II Industry/Employer Expected Outcome(s)

Maintain analog electronic circuits.

Select relevant components, mount it on breadboard as per the circuit diagram.

III Course Level Learning Outcome(s)

Maintain different waveform generator circuits.

IV Laboratory Learning Outcome(s):

Check the performance of feedback on the output voltage of amplifier.

V Relevant Affective Domain related outcome(s)

Follow safe practices.

Maintain tools and equipment.

Demonstrate working as a leader/a team member

VI Relevant Theoretical Background

The feedback circuit is connected in shunt with the output in such a way that it decreases the output impedance and increases the input impedance. In this circuit, it is placed in a shunt with the output but in series with respect to the input signal. Voltage-Series feedback, the input impedance of the amplifier is increased, and the output impedance is decreased. Noise and distortions are reduced considerably. The most advantage of the negative feedback is that by proper use of this, there is significant improvement in the frequency response and in the linearity of the operation of the amplifier. The following figure shows the block diagram of voltage series feedback, by which it is evident that the feedback circuit is placed in shunt with the output but in series with the input.

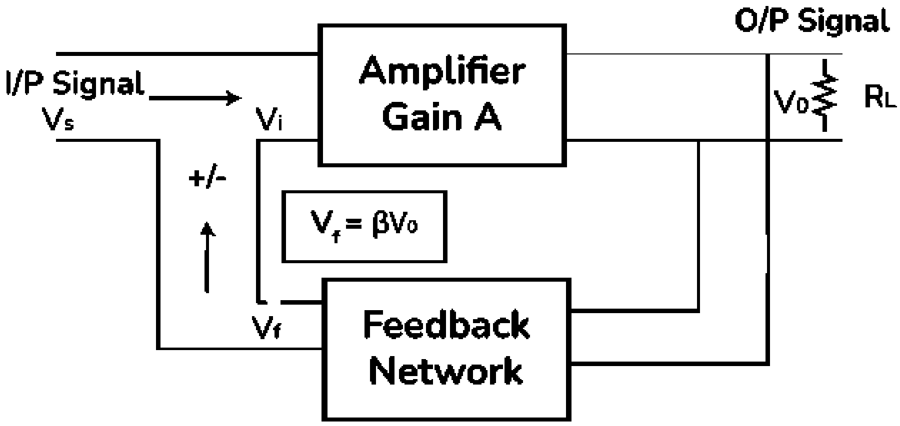

Fig. 13.1: Block Diagram of Voltage Series Feedback amplifier

VII Circuit diagram/ Laboratory layout

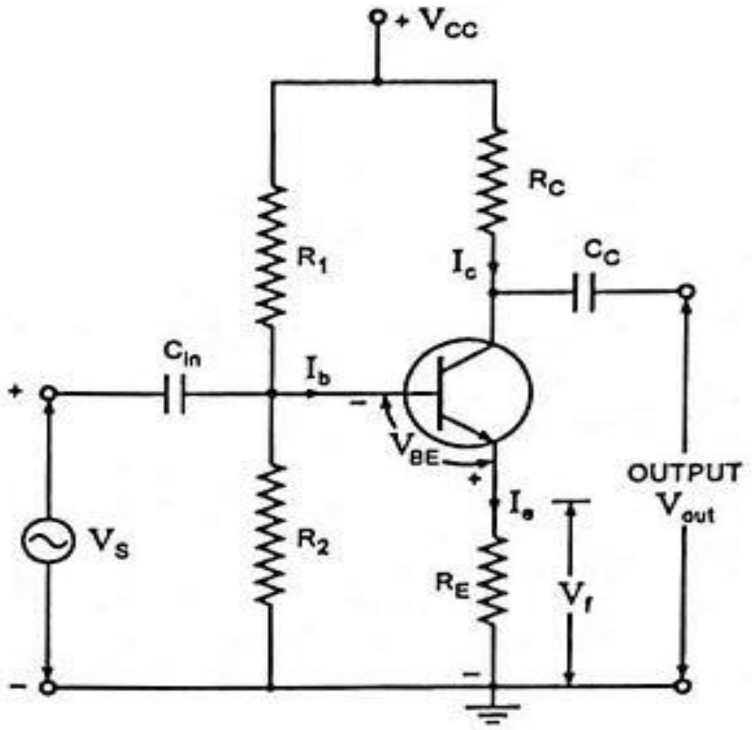

Fig. 13.2: Circuit Diagram of voltage series feedback amplifier

(Courtesy:https://www.tutorialspoint.com/amplifiers/classA_power_amplifier.htm)

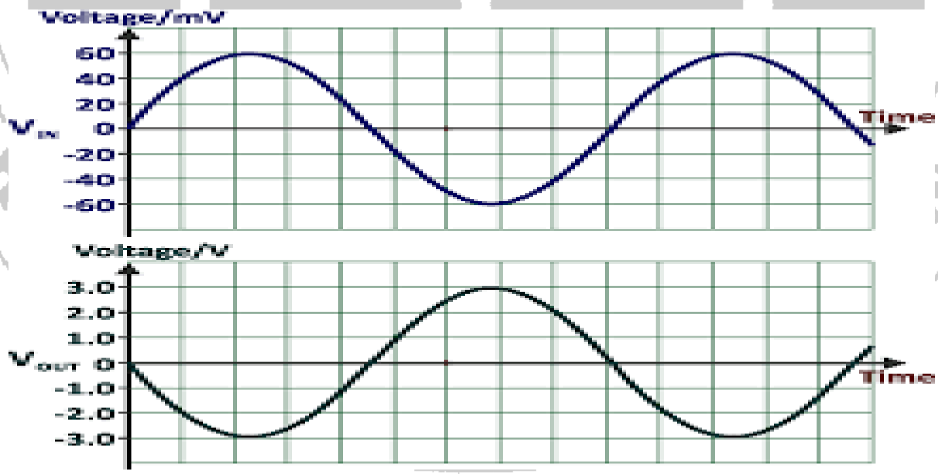

Fig. 13.3: Input and Output waveform

Actual Experimental set up used in laboratory:

VIII Resources Required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Cathode Ray Oscilloscope (Analog type)	20/30/100 MHz Frequency	1No.
2.	Regulated DC Power Supply	0-30V, 2Amp SC protection Vcc=12 volt	1No.
3.	Function Generator	(0-3) MHz	1 No.
4.	Transistor	BC558 or CLl00 or BDl15	1No.
5.	Resistors	R_1=33kΩ, R_2=3.3Ω, R_C=l.5KΩ R_E=330Ω, R_L=lKΩ,	1No.
6.	Capacitors	Cin=10µF, Cc=10µF CE=l0µF	1No.
7.	Breadboard	5.5 CM X 17CM	1No.
8.	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

IX 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 proper settings of function generator and CRO before use.

X Procedure

1. Build circuit on breadboard as per circuit diagram.
2. Connect function generator output to CRO and observe input signal on CRO.
3. Switch ON DC Power Supply, function generator and CRO
4. Keep the input voltage constant, vary the frequency from 10 Hz to MHz in regular steps and note down the corresponding output voltage on CRO.
5. Remove the emitter bypass capacitor and repeat Step 4 and observe the effect of feedback on the gain of the amplifier.
6. Note down the value of output voltage for each frequency. The voltage gain is in db.
7. Calculated by using expression $Av = 20 \log (V_O / Vi)$ dB

XI Resources Used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity

XII Actual Procedure

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

Observation Table 13.1

Input Voltage in mV (To be kept Constant), Vi = ...

Sr. No.	Input Frequency (Hz)	Output Voltage, Vo' (with feedback) (Volts)	Output Voltage, Vo (without feedback) (Volts)	Gain in dB (with feedback)	Gain in dB (without feedback)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

Calculations:

i. Voltage Gain: Vo/Vi

ii. Bandwidth (with feedback) (B.W) F = FH -FL

iii. Bandwidth (without feedback) (B.W) = FH -FL

XIV Result(s)

1. Bandwidth (with feedback) (B.W) =.......................

2. Bandwidth (without feedback) (B.W) =.....................

XV Interpretation of results

XVI Conclusion and recommendation

XVII Practical related questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identifying CO.

1. State the significance of the value of the bypass capacitor.
2. Compare Voltage series feedback and voltage shunt feedback.
3. Suggest the changes in circuit to form voltage shunt feedback amplifier.

[Space for Answers]

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XVIII References/Suggestions for further reading

1. http://www.becbapatla.ac.in/ece/lab/EC%2026 l%20EC-l %20Lab%20Manual.pdf
2. https://www.youtube.com/watch?v=JTwmVEKQc-0

XIX Assessment Scheme

Performance Indicators		Weightage
Process Related: 15 Marks		**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

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

Practical No. 14: Use transistor to build/test voltage shunt feedback amplifier with feedback.

I Practical Significance

As negative feedback is used for stability. This configuration is the most stable one and used in most discrete amplifier systems. Voltage shunt feedback connection decreases output resistance. It is one of the important features of an amplifier. This practical will help the students to use appropriate feedback connection in the amplifier.

II Industry/Employer Expected Outcome(s)

Maintain analog electronic circuits.

Student will be able to mount circuits on breadboard and test output on CRO.

III Course Level Learning Outcome(s)

Maintain different waveform generator circuits.

IV Laboratory Learning Outcome(s):

Check the performance of feedback on the output voltage of amplifier.

V Relevant Affective Domain related outcome(s)

Follow safe practices.

Maintain tools and equipment.

Demonstrate working as a leader/a team member

VI Relevant Theoretical Background

The feedback circuit is connected in shunt with the output in such a way that it decreases the output impedance and increases the input impedance. The most advantage of the negative feedback is that by proper use of this, there is significant improvement in the frequency response and in the linearity of the operation of the amplifier.

Voltage shunt feedback operates as a current - voltage controlled feedback system. In the Voltage shunt feedback configuration, the signal fed back is in parallel with the input signal. The output voltage is sensed, and the current is subtracted from the input current in shunt. The following figure shows the block diagram of voltage shunt feedback, by which it is evident that the feedback circuit is placed in series with the output but in shunt with the input.

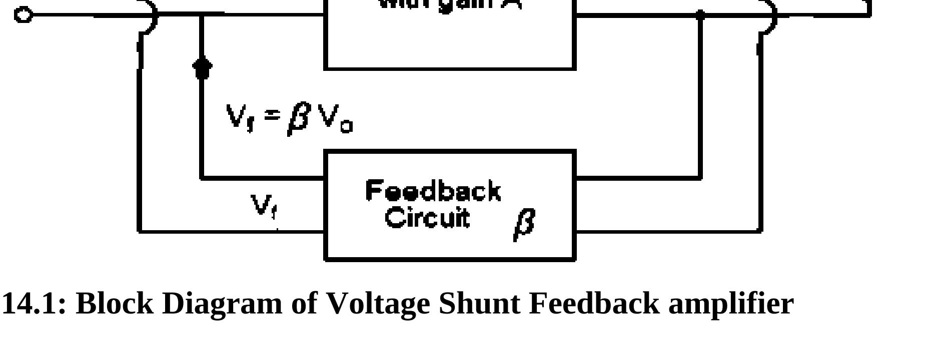

Fig. 14.1: Block Diagram of Voltage Shunt Feedback amplifier

VII Circuit diagram / Laboratory layout

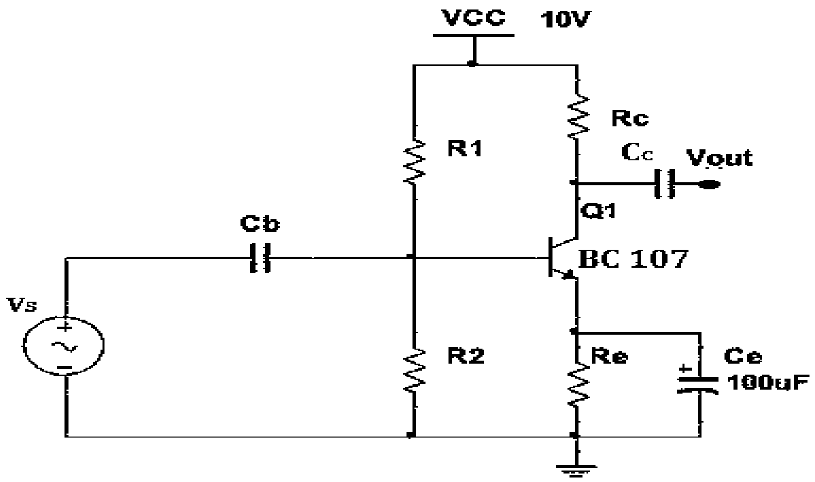

Fig. 14.2: Circuit Diagram of Voltage Shunt Feedback amplifier

Actual Experimental set up used in laboratory:

VIII Resources Required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Cathode Ray Oscilloscope (Analog type)	20/30/100 MHz Frequency	1No.
2.	Regulated DC Power Supply	0-30V, 2Amp SC protection V_{CC} = 12 volt	1No.
3.	Function Generator	(0-3) MHz	1 No.
4.	Transistor	BC558 or CLl00 or BDl15	1No.
5.	Resistors	R_1=33kΩ, R_2=3.3Ω, R_C=l.5KΩ R_E=330Ω, R_L=1KΩ.	1No.
6.	Capacitors	C1=10μF C2=10μF CE=l0μF	1No.
7.	Breadboard	5.5 CM X 17CM	1No.
8.	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

IX 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 proper settings of function generator and CRO before use.

X Procedure

1. Build circuit on breadboard as per circuit diagram.
2. Connect function generator output to CRO and observe input signal on CRO.
3. Switch ON DC Power Supply, function generator and CRO
4. Keep the input voltage constant, vary the frequency from 10 Hz to 1 MHz in regular steps and note down the corresponding output voltage on CRO.
5. Remove the emitter bypass capacitor and repeat Step 4 and observe the effect of feedback on the gain of the amplifier.
6. Note down the value of output voltage for each frequency. The voltage gain is in db.
7. Calculated by using expression Av = 20log (Vo *I* Vi) dB
8. Plot frequency response on semi log paper.

XI Resources Used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.			
2.			
3.			
4.			

XII Actual Procedure followed

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

Table No.: 14.1 Observation Table

Input Voltage in mV (To be kept Constant), Vi = ...

Sr. No.	Input Frequency (Hz)	Output Voltage, Vo' (with feedback) (Volts)	Output Voltage, Vo (without feedback) (Volts)	Gain in dB (with feedback)	Gain in dB (without feedback)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

Calculations:

i. Voltage Gain: Vo / Vi

ii. Bandwidth (with feedback) (B.W) F = $F_H - F_L$

iii. Bandwidth (without feedback) (B.W) = $F_H - F_L$

XIV Result(s):

1. Bandwidth (with feedback) (B.W.) =.......................

2. Bandwidth (without feedback) (B.W.) =.....................

XV Interpretation of results

XVI Conclusion and recommendation

XVII Practical related questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identifying CO.

1. State the effect of change in value of feedback resistance.
2. Compare Current shunt feedback and voltage shunt feedback.
3. List the specifications of the transistor used in circuit from the datasheet.

[Space for Answers]

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XVIII References/Suggestions for further reading

1. https://www.electronics-tutorials.ws/systems/feedback-systems.html
2. Laboratory Manual for Introductory Electronics Experiments, Maheshwari, L.K.; Anand, M.M.S., New Age International Pvt. Ltd. New Delhi; ISBN: 9780852265543
3. Transistor Database User Guide, 2016
4. http ://www.becbapatla.ac.in/ece/lab/EC%20261 %20EC-1 %2 OLab%20Manual.pdf

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	**60%**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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

Practical No. 15: Test the effect of positive and negative feedback on the output voltage of given amplifier.

I Practical Significance

Positive or regenerative feedback has the tendency of making an amplifier circuit unstable, so that it produces oscillations (AC). Negative or degenerative feedback has the tendency of making an amplifier circuit more stable, so that its output changes less for a given input signal than without feedback. This practical will help the students to develop skills to test the effect of positive and negative feedback on the given amplifier.

II Industry/Employer Expected Outcome(s)

Maintain analog electronic circuits.

III Course Level Learning Outcome(s)

Maintain different waveform generator circuits.

IV Laboratory Learning Outcome(s):

Check the performance of amplifier for positive and negative feedback.

V Relevant Affective Domain related outcome(s)

Follow safe practices.

Maintain tools and equipment.

Demonstrate working as a leader/a team member.

VI Relevant Theoretical Background

Feedback is the coupling of an amplifier's output to its input. Depending upon whether the feedback signal increases or decreases the input signal, there are two types of feedback in amplifier.

1. Positive or Regenerative feedback
2. Negative or Degenerative feedback.

Positive or Regenerative feedback: If the feedback signal is applied in phase with the input signal and thus increases output signal amplitude, then it is called positive feedback. It is also called regenerative or direct feedback.

a. It increases gain of amplifier
b. It produces excessive distortion
c. It is used in oscillators.

Negative or Degenerative feedback: If the feedback signal is applied out of phase with the input signal and thus decreases the output signal amplitude, it is called negative feedback.

a. It reduces the gain of the amplifier.
b. It improves the amplifier performance.
c. It is used in small and large signal amplifier circuits.

VII Circuit diagram / Laboratory layout

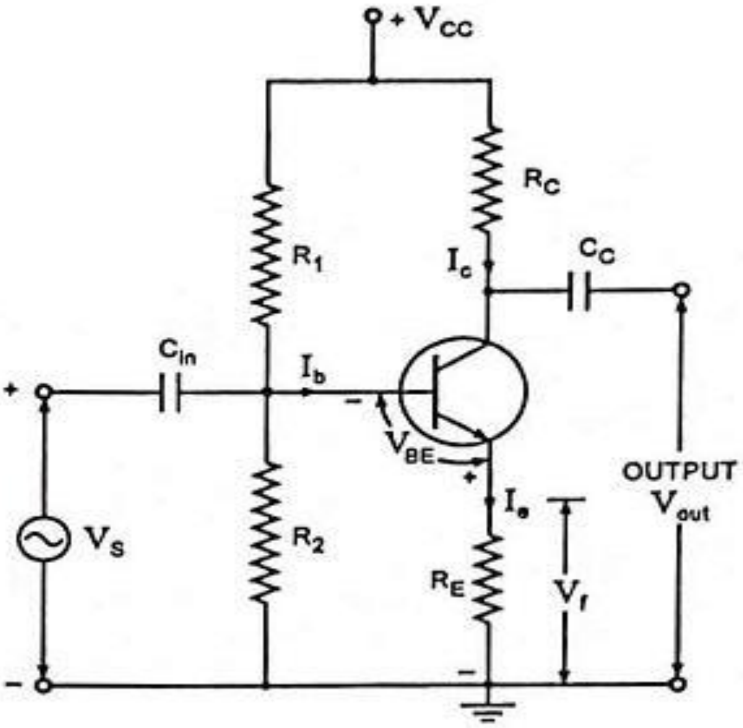

Fig. 15.1: Circuit Diagram of negative feedback amplifier

Courtesy: https:/lwww.scribd.com/doc/l l 9790927/Voltage-Series-

Feedback-Amplifier

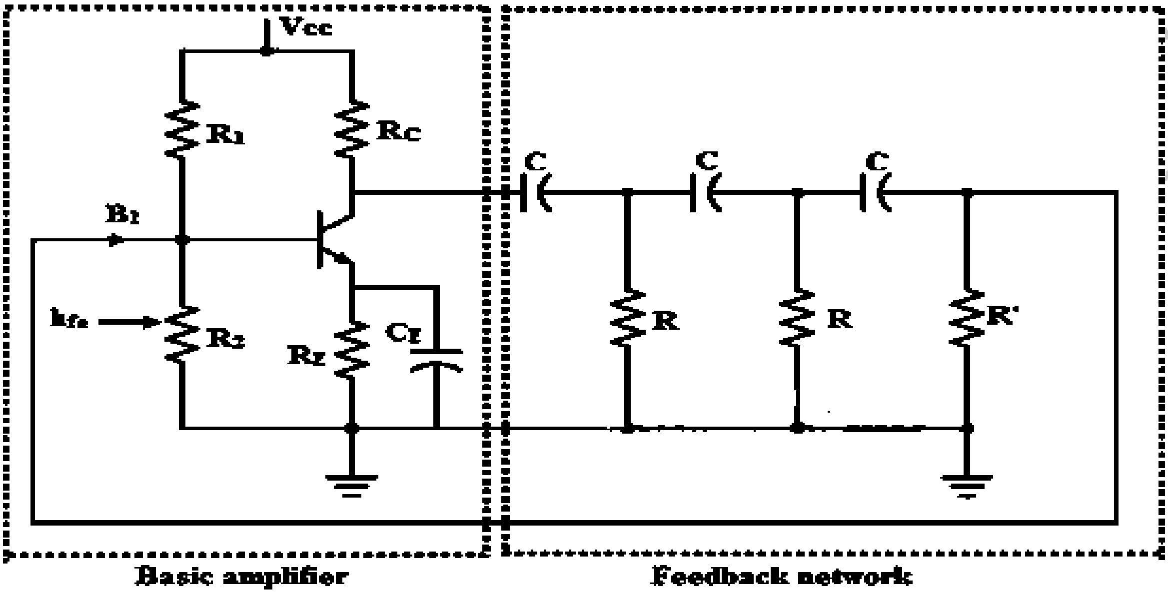

Fig. 15.2: Circuit diagram of RC phase shift oscillator (positive feedback amplifier)

(http:l/bhagwantuniversi fy.ac.in/wp-content/uploads/2016/01/ELECTRONICS-LAB-l l-SEM-IV.pdf)

Actual Circuit diagram used in laboratory with equipment specifications.

VIII Resources Required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Cathode Ray Oscilloscope (Analog type)	20/30/100 MHz Frequency	1No.
2.	Regulated DC Power Supply	0-30V, 2Amp SC protection V_{CC} = 12 volt	1No.
3.	Function Generator	(0-3) MHz	1 No.
4.	Transistor	BC107 or BC548	1No.
5.	Resistors	For figure 15.1 R_1=33kΩ, R_2=3.3Ω, R_E=330Ω, R_L=1KΩ.	1No.
		For figure 15.2 R_1=683kΩ, R_2=12Ω, R_C=1KΩ, R_E=1KΩ, R_L=1KΩ.	
6.	Capacitors	For figure 15.1 C1=1µF C2=1µF CE=l0µF For figure 15.2 CE = 100 µF, C=0.1µF	1No.
7.	Breadboard	5.5 CM X 17CM	2No.
8.	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

IX 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 proper settings of function generator and CRO before use.

X Procedure

1. Build circuit of negative feedback amplifier on breadboard as per Figure 15.1.
2. Select appropriate amplitude (10 mV to 20 mV) and frequency (10 KHz) of sine wave input signal on function generator.
3. Connect function generator output to CRO and observe input sine wave signal on CRO.
4. Connect function generator at input terminals and CRO at output terminals of circuit.
5. Switch on DC Power Supply and Observe output waveform on CRO.
6. Note down output voltage from CRO with and without bypass capacitor CE.
7. Build circuit of positive feedback (RC phase shift oscillator) on breadboard as per Figure 15.2.
8. Connect DC Power Supply to the circuit and CRO at output terminals.
9. Switch ON power supply, Set VEE = 12V.
10. Switch on CRO and Observe output on CRO.
11. Note down Output voltage from CRO.
12. Change the value of resistor R in the RC network and observe the change in output.
13. Note down Output voltage from CRO.

XI Resources Used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity

XII Actual Procedure

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XIII Observations and Calculations

Table No: 15.1 Observation Table (Negative feedback amplifier)

Sr. No.	Input Voltage Vi	Output Voltage without feedback (Vo')	Output Voltage with feedback (Vo)	Gain without feedback (Av= Vo'/Vi)	Gain with feedback (Av= Vo/Vi)
1					
2					

Table No: 15.2 Observation Table (Positive feedback amplifier)

Sr. No.	Input Voltage (Vi) (at base of transistor)			Output Voltage (Vo) (at the collector)			5Gain Av=Vo/Vi		
	RC N/W 1	RC N/W 2	RC N/W 3	RC N/W 1	RC N/W 2	RC N/W 3	RC N/W 1	RC N/W 2	RC N/W 3
1									
2									

XIV Result(s)

1. Gain with Negative feedback =.......................
2. Gain with positive feedback =.......................

XV Interpretation of results

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XVI Conclusion and recommendation

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XVII Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. Write the difference between gain with and without negative feedback.
2. State the effect on output voltage with change in capacitor of RC network.
3. State the specifications of transistors used in circuit from the datasheet.

[Space for Answers]

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XVIII References/Suggestions for further reading

1. https://en.wikiped ia.org/wiki/Negative-feed back_amplifier
2. https://www.electronics-tutorials.ws/systems/feedback-systems.html
3. https://en.wikipedia.org/wiki/Positive _feedback

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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

Practical No. 16: Test the circuit to measure the frequency of oscillation of the given RC phase shift oscillator consist of IC 741.

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 Industry/Employer Expected Outcome(s)

- Student will be able to mount circuits on breadboard and test output using multimeter.
- Select and test proper components value with their specifications.

III Relevant Course Learning Outcome(s)

- Maintain different waveform generator circuits.

IV Laboratory Learning Outcome(s):

- Measure the output frequency of RC phase shift oscillator based on IC 741.

V Relevant Affective domain related Outcome(s)

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

VI Theoretical Background Relevant:

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 appearing at the inverting terminal is shifted by the 180° at the output. An additional 180° phase shift required for oscillation is provided by a 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.

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

$$R_F = 29R_1$$

VII Circuit diagram/Laboratory layout:

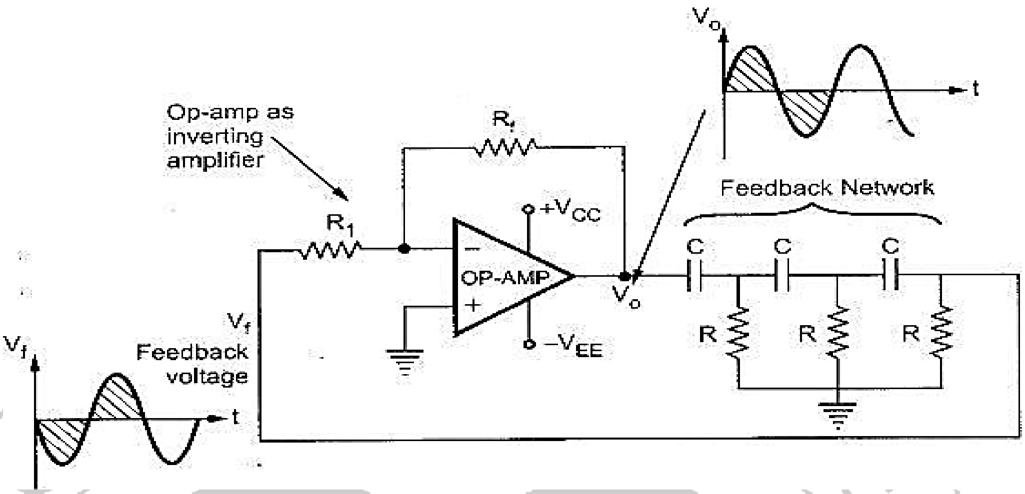

Fig. 16.1: Circuit diagram of RC phase shift oscillator

Actual Experimental set up

VIII 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.

Sr. No.	Instrument /Components	Specification	Quantity
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

IX 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.

X Procedure

1. Test and mount the IC 741 on breadboard.
2. Connect the circuit as per the circuit diagram as shown in figure 16.1.
   Apply voltage using V_{CC} = + 15 V and V_{EE} = -15V DC power supply to pin no 7 and pin no. 4 of IC 741 respectively.
3. Connect CRO at the output terminals of the circuit (Pin no. 6 of IC 741).
4. Vary potentiometer to get stable sine wave output.
5. Observe the sine wave output on CRO.
6. Measure the frequency of sine wave output on CRO.
7. Calculate the frequency of sine wave theoretically using formula:
   $$F = \frac{1}{2\pi RC\sqrt{6}}$$
8. Compare theoretical and practical frequency of sine wave output.
9. After the completion of practical switch off the supply, remove the connections and submit wires and equipment.

XI Resources Used

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

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

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

Table No: 16.1 Observation table for Frequency of RC phase shift oscillator

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

Calculations:

Output frequency

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

XIV Results:

1. Output frequency = ……………………

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

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………

XVI Conclusions and Recommendation

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

1. Give the values of slew rate of IC: LM 318, LM 351 and LM741 (Refer Data sheet)
2. Design RC phase shift oscillator using Op-Amp for F=1KHz.
3. ……………………………………………………………………………………………..

[Space for Answers]

……….
……….
……….
……….
……….
……….

XVII 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.

XVIII Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	60 %
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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

TEXAS INSTRUMENTS

LM118-N, LM218-N, LM318-N

www.ti.com

SNOSBS8C – MARCH 1998 – REVISED MARCH 2013

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

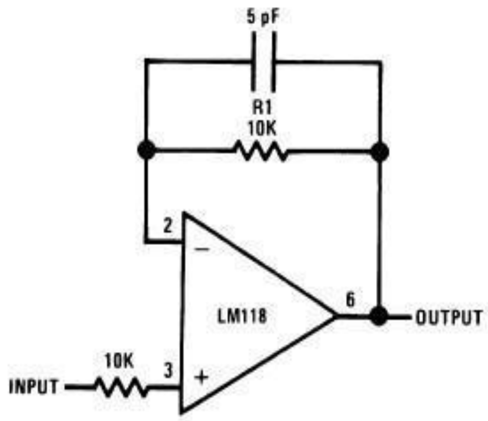
The LM118 series are precision high speed operational amplifiers designed for applications requiring wide bandwidth and high slew rate. They feature a factor of ten increase in speed over general purpose devices without sacrificing DC performance.

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)

Practical No.17: Test the circuit of Crystal Oscillator consist of crystal and IC 741.

I Practical Significance

It is a linear electronic circuit that produces a sine wave output. The use of crystal oscillator in military and aerospace is to establish an efficient modulation, for the navigation purpose, electronic warfare, in the guidance systems. This practical will help the students to develop skills to build crystal oscillator using IC741 and measure the generated frequency using CRO.

II Industry/Employer Expected Outcome(s)

Maintain analog electronic circuits.

III Course Level Learning Outcome(s)

Maintain different waveform generator circuits.

IV Laboratory Learning Outcome(s):

Measure the output frequency of Crystal Oscillator consist of crystal and IC 741.

V Relevant Affective Domain related outcome(s)

Follow safe practices.

Maintain tools and equipment.

Demonstrate working as a leader/a team member

VI Relevant Theoretical Background

Crystal oscillator gives most stable oscillations. It is widely used in microcontroller applications to provide clock signal. There are different types of piezoelectric resonators, but typically, quartz crystal is used in oscillators. Selecting crystals for a specific application will often be dependent on three factors: size (footprint area, height), performance (accuracy over temperature, lifetime) and cost (for example, higher performance and smaller package = higher price). Crystals are available with leads or without leads. The quartz crystal oscillator circuit diagram consists of series resonance and parallel resonance, i.e., two resonant frequencies.

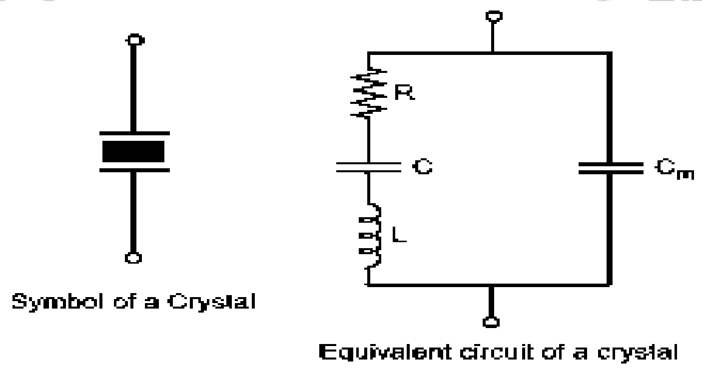


Fig. No. 17.1: Equivalent circuit of Quartz Crystal

$$fs = \frac{1}{2\pi\sqrt{L1C1}}$$

(fs = Series resonant frequency)

$$fp = \frac{1}{2\pi\sqrt{L1(\frac{C2C1}{C2+C1})}}$$

(fp =Parallel resonant circuit)

a) Circuit diagram/Laboratory layout:

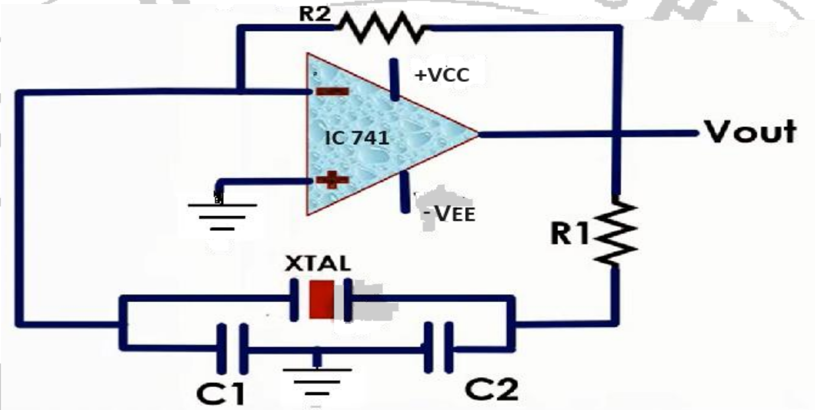


Fig No. 17.2: Crystal Oscillator

(https://www.circuitbasics.com/wp-content/uploads/2020/09/opamp_osc.png)

VII Actual Experimental set up used in laboratory:

VIII Resources Required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Cathode Ray Oscilloscope (Analog type)	20/30/100 MHz Frequency	1 No.
2	Dual Power supply	± 15 V 2A Dual tracking power supply	1 No.
3	IC-741C	Dual-In-Line or S.O. Package	1 No.
4	Crystal	1 MHz or equivalent	1 No.
5	Resistors	R1=47KΩ, R2=100KΩ, R4=10K	1 No.
6	Capacitors	30pf	2 No.
7	Breadboard	5.5 CM X 17CM	1 No.
8	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

IX 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 proper settings of function generator and CRO before use.
4. Test the transistor before use

X Procedure

1. Build circuit on breadboard as per circuit diagram.
2. Connect DC Power Supply to the circuit and CRO at output terminals.
3. Switch ON dual power supply, Set Vcc = 12V.
4. Switch on CRO and Observe output on CRO.
5. Measure amplitude and time period from CRO.
6. Calculate frequency of oscillation by the formula F = 1 / T.

XI Resources Used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity

XII Actual Procedure

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………
………
………

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

Observation Table 17.1

Keep Vcc = 12 volt

Sr. No.	Amplitude(V) of output signal in volts	Time period (T) of output signal in msec.
1		

Calculations:

i. Practical Frequency (F) = 1 / T

XIV Result(s)

Practical Frequency (F) = ...

XV Interpretation of results

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………
………

XVI Conclusion and recommendation

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XVII Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. Identify the crystal available on different microprocessor and microcontroller kit and state it frequency.
2. State the characteristic and frequency range of the crystal oscillator.

3. From the crystal datasheet state parameter values such as package number, resistance, capacitance, frequency, temperature tolerance.
4. ....

[Space for Answers]

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……

XVIII References/Suggestions for further reading

1. https://www.youtube.com/watch?v=jyZQdZF6KIE
2. Laboratory Manual for Introductory Electronics Experiments, Maheshwari, L.K.; Anand, M.M.S., New Age International Pvt. Ltd. New Delhi; ISBN: 978085226554
3. Transistor Database User Guide, 2016.

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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

Practical No. 18: Test the Hartley Oscillator based on IC 741.

I Practical Significance

The Hartley oscillator is an electronic oscillator circuit in which the oscillation frequency is determined by the tuned circuit consisting of capacitors and inductors, i.e. an LC oscillator. This practical will help the students to view Hartley oscillators generated oscillations of certain frequency.

II Industry/Employer Expected Outcome(s)

- Maintain analog electronic circuits.

III Relevant Course Learning Outcome(s)

- Maintain different waveform generator circuits.

IV Laboratory Learning Outcome(s):

Measure the output frequency of Hartley Oscillator consist of IC 741.

V Relevant Affective domain related Outcome(s)

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

VI Theoretical Background Relevant:

Hartley oscillator is inductively coupled; variable frequency oscillators where the oscillator may be a series or shunt fed. A Hartley oscillator is the advantage of having one tuning capacitor and one center tapped inductor. The transistor provides amplification along with inversion to amplify and correct the signal generated by the tank circuit. The mutual inductance between L_l and L_2 provides the feedback of energy from the collector-emitter circuit to the base-emitter circuit. The frequency of oscillations in this circuit is

. Frequency = $1 / 2\pi \sqrt{L_T C}$

Where $L_T = L_1 + L_2$

(L_T total inductance of the series inductors) and C is the capacitance of the feedback capacitor.)

VII Sample Circuit diagram/Laboratory layout:

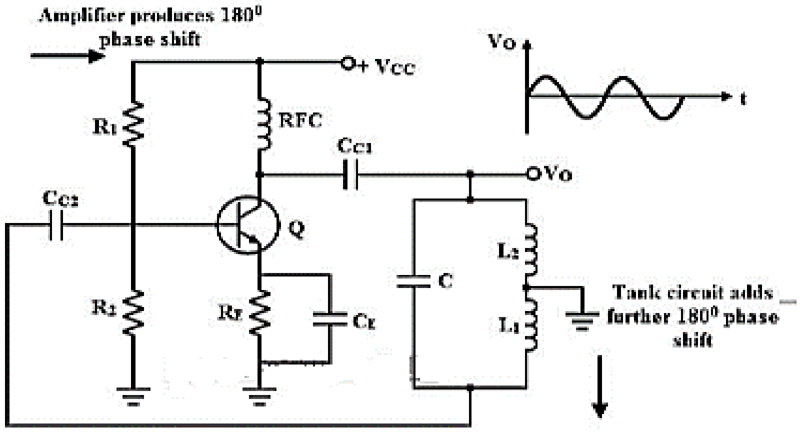

Fig. 18.1 Circuit diagram of Hartley oscillator

Sample Circuit diagram/Laboratory layout:

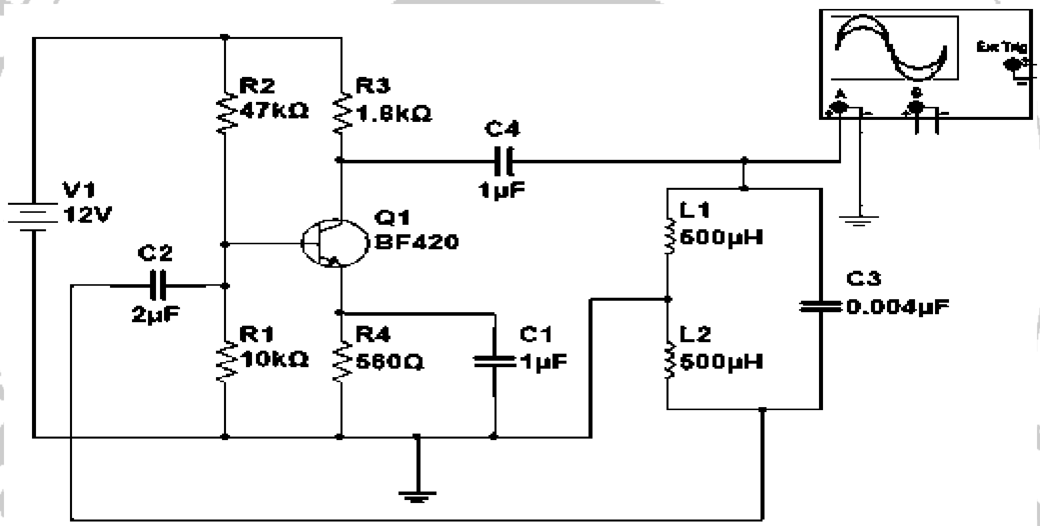

Fig. 18.2 Circuit diagram of Hartley oscillator

Actual Experimental set up

VIII Resources Required

Sr. No.	Instrument /Components	Specification	Quantity
1.	Cathode Ray Oscilloscope (Analog type)	20/30/100 MHz Frequency	1No.
2.	Regulated DC Power Supply	0-30V, 2Amp SC protection Vcc=12 volt	1No.
3.	Function Generator	(0-3) MHz	1 No.
4.	Transistor	BC420	1No.
5.	Resistors	R1=10KΩ, R2=47KΩ, R3=1.8KΩ, R4= 560Ω	1No.
6.	Inductors	L1=500uH, L2= 500uH,	1 No.
7.	Capacitors	C1=1uF,C2=2uF, C3=0.004uF,C4=1uF	4 No.
8.	Breadboard	5.5 CM X 17CM	2 No.
9.	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

IX 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.

X Procedure

1. Place the components on a breadboard according to the circuit diagram.
2. Make sure the connections are secure and correctly placed.
3. Connect the power supply to the circuit.
4. Power up the circuit and observe the output signal at the collector or the output tap of the oscillator using an oscilloscope.
5. Verify that the circuit oscillates at the desired frequency.

XI Resources Used

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

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

Table No: 18.1 Observation table for Frequency of Hartley oscillator

Sr. No.	Time T (sec)	Practical Frequency F= 1 / T (Hz)	Theoretical Frequency (Hz)	Remark
1.				

Calculations:

i) Practical Frequency F= 1/T

ii) Theoretical Frequency F:

Frequency = $1 / 2\pi \sqrt{L_T C}$

Where $L_T = L1 + L_2$

XIV Results

i). Practical Frequency =………………...

ii) Theoretical Frequency= ……………………

iii) Amplitude of output voltage Vo= …………………….

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

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XVI Conclusions and Recommendation

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

1. State the applications of Hartley Oscillator.
2. State the difference between positive and negative feedback.
3. State different types of oscillators.

[Space for Answers]

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XVIII References / Suggestions for further reading

1. https://www.youtube.com/watch?v=GUTvr9gJtgI
2. Applied Electronics by R. S. Shedha, S. Chand Publication.
3. https://www.youtube.com/watch?v=3B_sBX_11Zw

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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

Practical No. 19: Simulate the working of Hartley Oscillator using Multisim or relevant software.

I Practical Significance

The Hartley oscillator is an electronic oscillator circuit in which the oscillation frequency is determined by the tuned circuit consisting of capacitors and inductors, i.e. an LC oscillator. This practical will help the students to develop skills to build Hartley oscillator using appropriate EDA tool.

II Industry/Employer Expected Outcome(s)

Maintain analog electronic circuits.

III Course Level Learning Outcome(s)

Maintain different waveform generator circuits.

IV Laboratory Learning Outcome(s):

Observe the output waveform of Hartley Oscillator.

V Relevant Affective Domain related outcome(s)

Follow safe practices.

Maintain tools and equipment.

Demonstrate working as a leader/a team member

VI Relevant Theoretical Background

Hartley oscillator is inductively coupled; variable frequency oscillators where the oscillator may be a series or shunt fed. A Hartley oscillator is the advantage of having one tuning capacitor and one center tapped inductor. The transistor provides amplification along with inversion to amplify and correct the signal generated by the tank circuit. The mutual inductance between L_l and L_2 provides the feedback of energy from collector-emitter circuit to the base-emitter circuit.

The frequency of oscillations in this circuit is,

.

$$\text{Frequency} = \frac{1}{2\pi\sqrt{L_T C}}$$

Where $L_T = L_1 + L_2$

VII Circuit diagram/Laboratory layout:

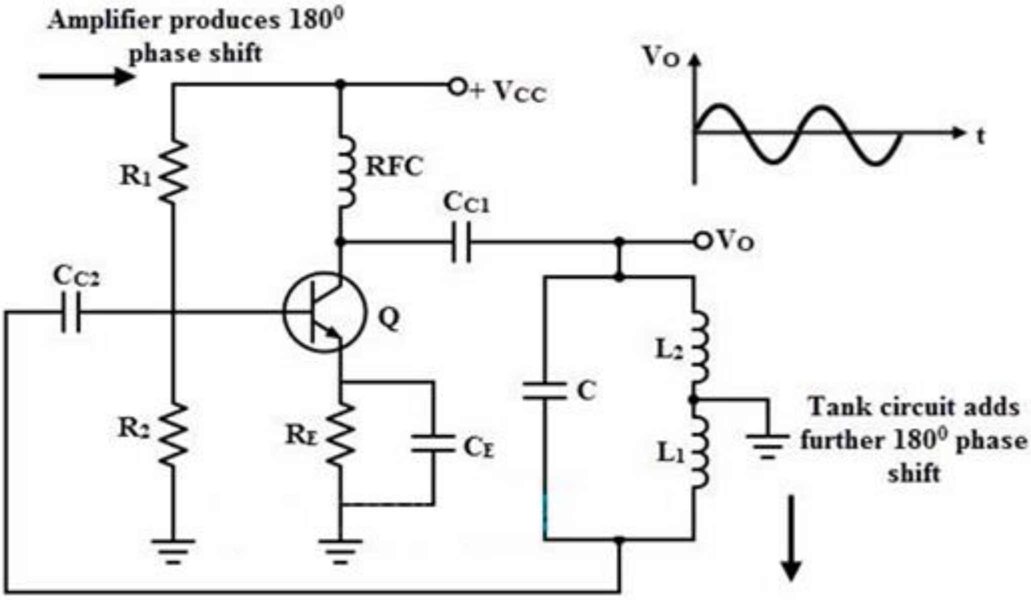


Fig. No. 19.1: Circuit diagram of Hartley Oscillator

Actual Experimental set up used in laboratory:

VIII Resources Required

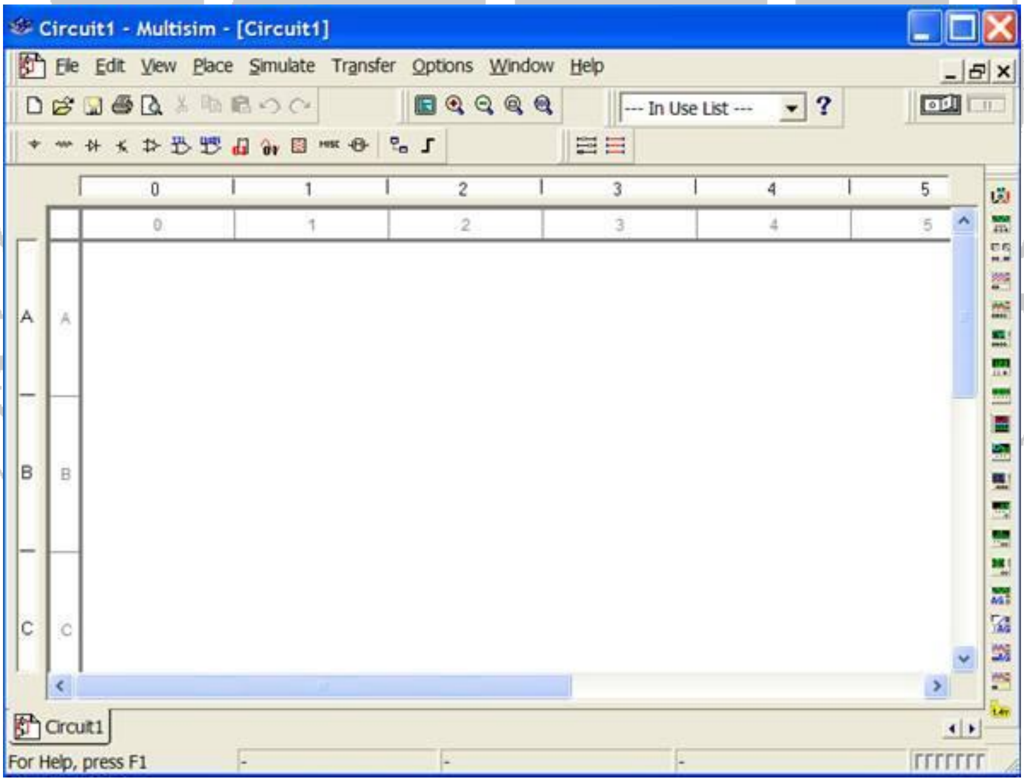
Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Computer with desired Configuration	Latest Processor	1No.
2.	Simulation software	LT Spice /Lab view/H Spice / P Spice /HS Spice / Multisim / Proteus or any other relevant open source software	1No.

IX Precautions to be followed

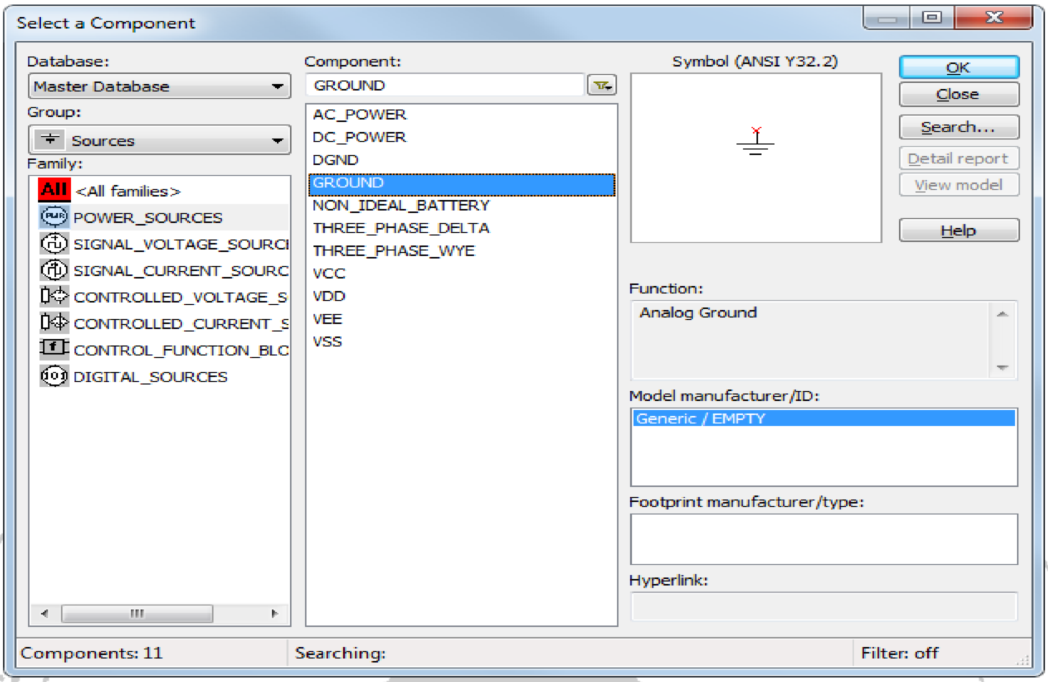
1. Ensure proper earthing to the computer system.
2. Ensure compatibility of computer system with software.
3. Ensure proper installation of simulation software.

X Procedure

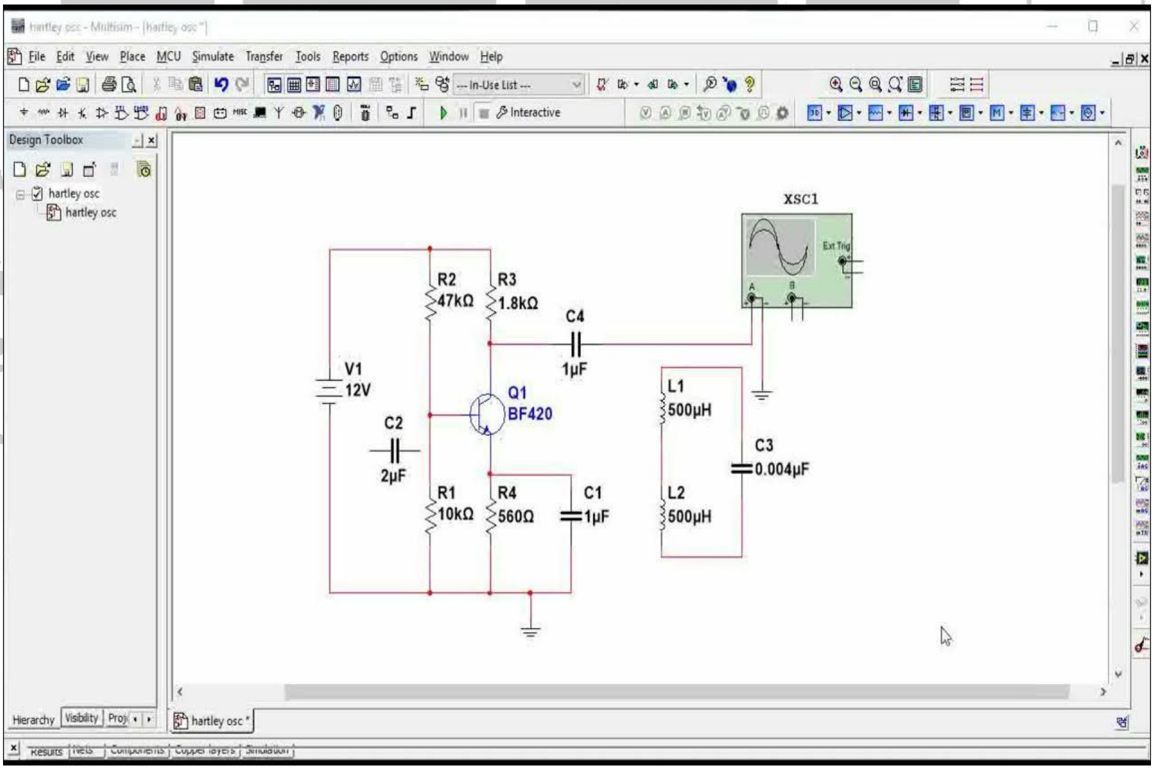
1. Perform step by step Installation process of simulation software.



2. Select relevant electronic components from the software library.



3. Build the Hartley Oscillator in simulation software as per diagram



XI Resources Used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity

XII Actual Procedure

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

Observation Table 19.1

Amplitude of Waveform Vo = -------

Sr. No.	Time 'T' (sec)	Practical Frequency F = l / T (Hz)	Theoretical Frequency (Hz)	Remark
1.				

Calculations:

Practical Frequency: F = l / T

Theoretical Frequency Fr:

$$Frequency = \frac{1}{2\pi\sqrt{L_T\, C}}$$

Where, $L_T = L_1 + L_2$

XIV Results

1. Practical Frequency F =.......................
2. Theoretical Frequency Fr =...................
3. Amplitude of Output Vo = ...

XV Interpretation of results

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XVI Conclusion and recommendation

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XVII Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. State the configuration of transistor used in Hartley oscillator circuit?
2. Suggest the changes required to simulate Colpitts oscillator.
3. Which type of feedback is used in oscillator circuit?
4. If transistor is replaced by Op-Amp then draw the circuit of Hartley oscillator

[Space for Answers]

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XVIII References/Suggestions for further reading

1. https://www.youtube.com/watch?v=GUTvr9gJtgI
2. https://www.youtube.com/watch?v=FQjQsOz5XUs

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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

Practical No. 20: Build and test the circuit of first order low pass 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 before certain cut off frequency.

II Industry/Employer Expected Outcome(s)

- Student will be able to mount circuits on breadboard and test output using multimeter.
- Testing of relevant active and passive electronic components required to assemble the first order low pass (LPF) Butterworth filter.

III Relevant Course Learning Outcome(s)

- Analyze active filters used in various electronic circuits.

IV Laboratory Learning Outcome(s):

- Measure bandwidth and cut off frequency of low pass filter.
- Plot the frequency response of low pass filter.

V Relevant Affective domain related Outcome(s)

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

VI Theoretical Background Relevant:

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. Depending on the Roll of Rate of the LPF it is classified as first order, second order filters and so on. The 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 filter gain roll of at -20dB/decade. In second order Low pass filter gain roll of at -40dB/decade.

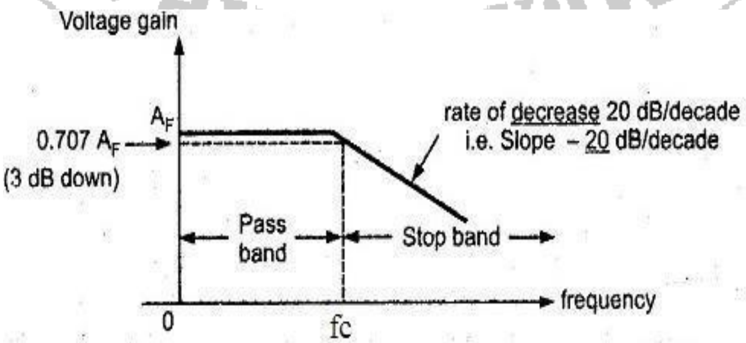

Fig. 20.1: Frequency response of First order Low pass filter

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

$$\frac{V_O}{V_{in}} = \frac{A_F}{1+j(\frac{f}{f_C})}$$

The pass band gain of the first order Low pass filter is given by

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

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

F = frequency of the input signal (Hz)

Magnitude of the voltage gain is given by

$$\text{Voltage Gain (Av)} = \frac{V_{Out}}{V_{in}} = \frac{A_F\,(\frac{f}{f_C})}{\sqrt{1+j[\frac{f}{f_C}]^2}}$$

VII Circuit diagram/Laboratory layout:

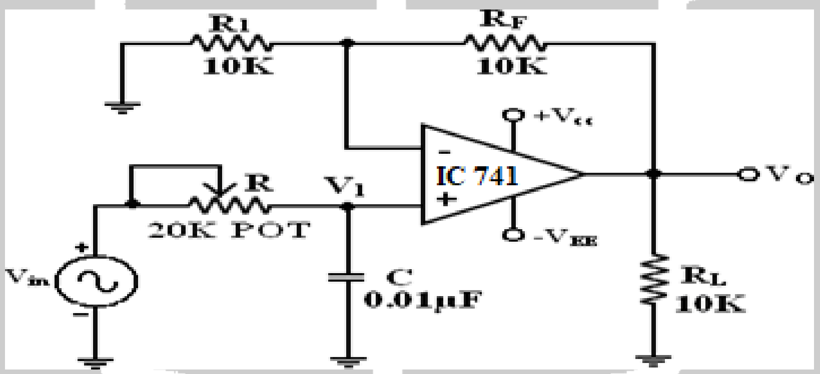

Fig. 20.2: Circuit diagram of First order Low pass filter

Actual Experimental set up

VIII Resources Required

Sr. No.	Instrument / Components	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

IX 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.

X Procedure

1. Test and mount the IC741 on breadboard.
2. Connect the circuit as per the circuit diagram show in fig. 20.2.
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 the 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 = 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.

XI Resources Used

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

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XIII 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			

Sr. No.	Input Frequency (Hz)	Output Voltage, Vo (Volts)	Voltage Gain (A= Vo/Vi)	Gain in dB = 20 log (Vo/Vi)
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 $\log_{10}$ $(\frac{V_O}{V_{in}})$ = ------------------------- dB.

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

iv. Bandwidth =…………………………

XIV Results

1. Cutoff Frequency =…………………...

2. Roll of rate =…..……………………

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

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XVI Conclusions and Recommendation

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

1. Design LPF at a cutoff frequency of 1 KHz and pass band gain of 2. Assume C=0.01μF.
2. Give some examples of electronic circuits where low pass filter is used?
3. Derive the formula of cut-off frequency $F_c = 1/(2\pi RC)$ for a first order active Butterworth high pass filter.
4. What do you mean by cut off frequency (Fc) of a filter?

[Space for Answers]

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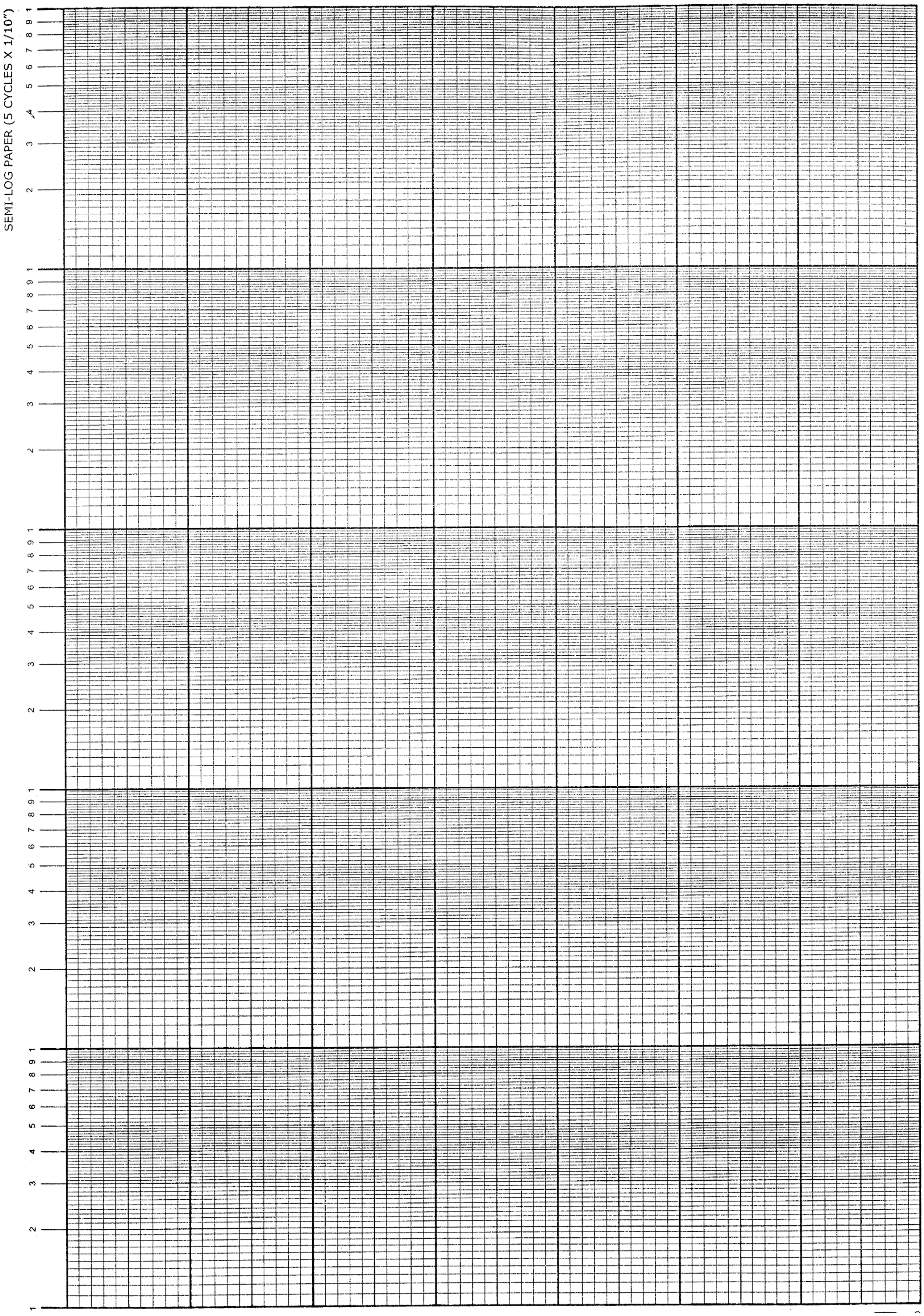
XVIII References / Suggestions for further reading

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.

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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


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

Practical No. 21: Build and test the circuit of first order high pass 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 Industry/Employer Expected Outcome(s)

Testing of relevant active and passive electronic components required to assemble first order high pass (HPF)

III Course Level Learning Outcome(s)

Analyze active filters used in various electronic circuits.

IV Laboratory Learning Outcome(s):

Measure bandwidth and cutoff frequency of high pass filter.
Plot the frequency response of high pass filter.

V Relevant Affective domain related Outcome(s)

Follow safe practices.

Demonstrate working as a leader/a team member

Maintain tools and equipment's

VI Relevant 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

$$\frac{Vo}{Vi} = \frac{Af\left(\frac{f}{fc}\right)}{\sqrt{1+(f/fc)^2}}$$

Where $A_F = 1 + R_F/Ri$

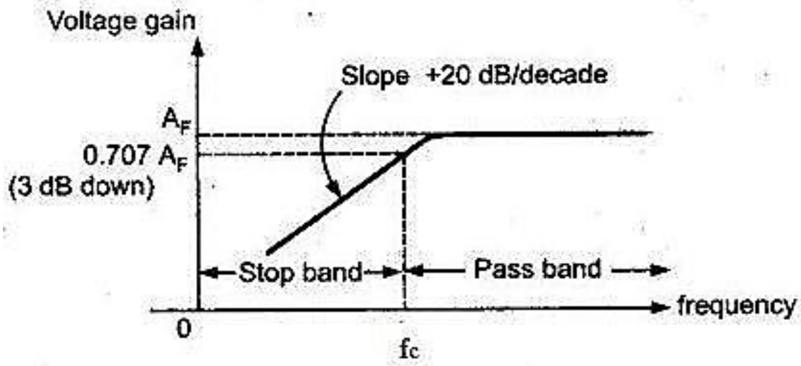


Fig. 21.1: Frequency response of First order High pass Butterworth filter
(Courtesy:http://www.eeeguide.com/wp-content/uploads/2016/09/First-Order-High-Pass-Butterworth-Filter-9.jpg)

VII Sample Circuit diagram/Laboratory layout:

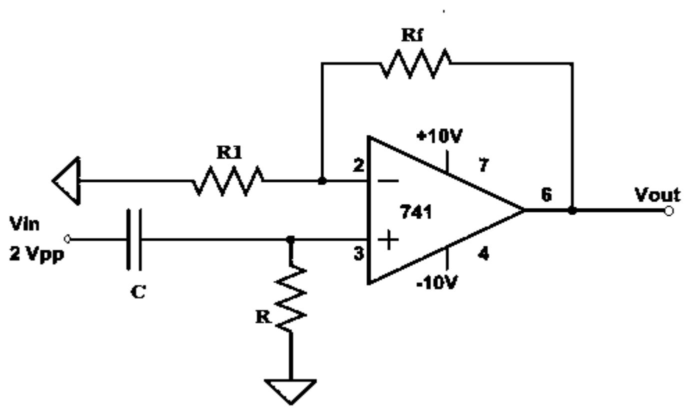


Fig. 21.2: High pass filter
(https://www.eeeguide.com/wp-content/uploads/2016/09/First-Order-High-Pass-Butterworth-Filter-001.jpg)

a) Sample experimental setup:

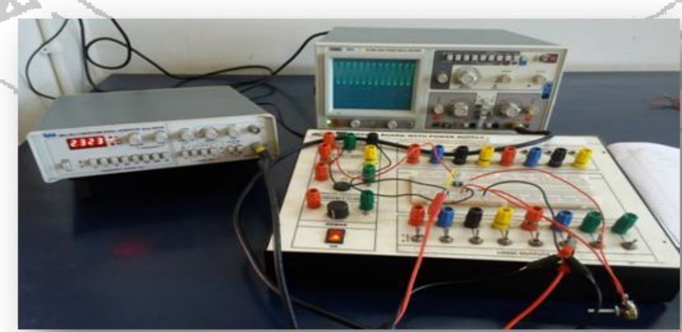


Fig. 21.3: First order high pass Butterworth filter

Actual Experimental set up

VIII 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, 2 Amp 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, RL=1KΩ	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

IX 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.

X **Procedure**

1. Test and mount the IC741 on the breadboard.
2. Connect the circuit as per the circuit diagram shown in fig 21.2
3. Apply voltage V_{CC} = +15 V and V_{EE} = -15V using DC power supply to pin no 7 and pin no. 4 respectively.
4. Connect the (1 volt peak to peak, 100Hz) sine wave input from function generator.
5. and observe the corresponding output of pin number 6 on CRO.
6. Measure the output voltage of HPF on CRO for the applied signal as in step 4.
7. Vary input signal frequency step by step as shown in the observation table and note down the corresponding output voltage.
8. Repeat steps 4 to 6 up to frequency 1MHz.
9. Calculate gain in decibels using formula: Gain in dB = 20 $\log_{10}\left(\frac{V_O}{V_{in}}\right)$.
10. Calculate the cutoff frequency theoretically using formula: $F_C = \frac{1}{2\pi RC}$
11. Plot the frequency response on semi log paper for frequency on x axis and gain in dB on y-axis.

XI **Resources Used**

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.			
2.			
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XII **Actual Procedure Followed (use blank sheet provided if space not sufficient)**

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

Table No: 21.1 Observation table for Gain of HPF

Input Voltage in Volts (To be kept Constant), Vi = 1 Volt 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 $\log_{10}$ $(\frac{V_O}{V_{in}})$ = ------------------------- dB.

XIV Results

1. Cutoff Frequency = …………………...
2. Gain in dB = …………………...

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

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XVI Conclusions and Recommendation

XVII Practical Related Questions

1. Design first order HPF at a cutoff frequency of 1 KHz and pass band gain of 1. Assume C = 0.1µF.
2. List types of filters. Draw an ideal frequency response of each filter.
3. Write advantages of active filter over passive filter.
4. Difference between active filter and passive filter.

[Space for Answers]

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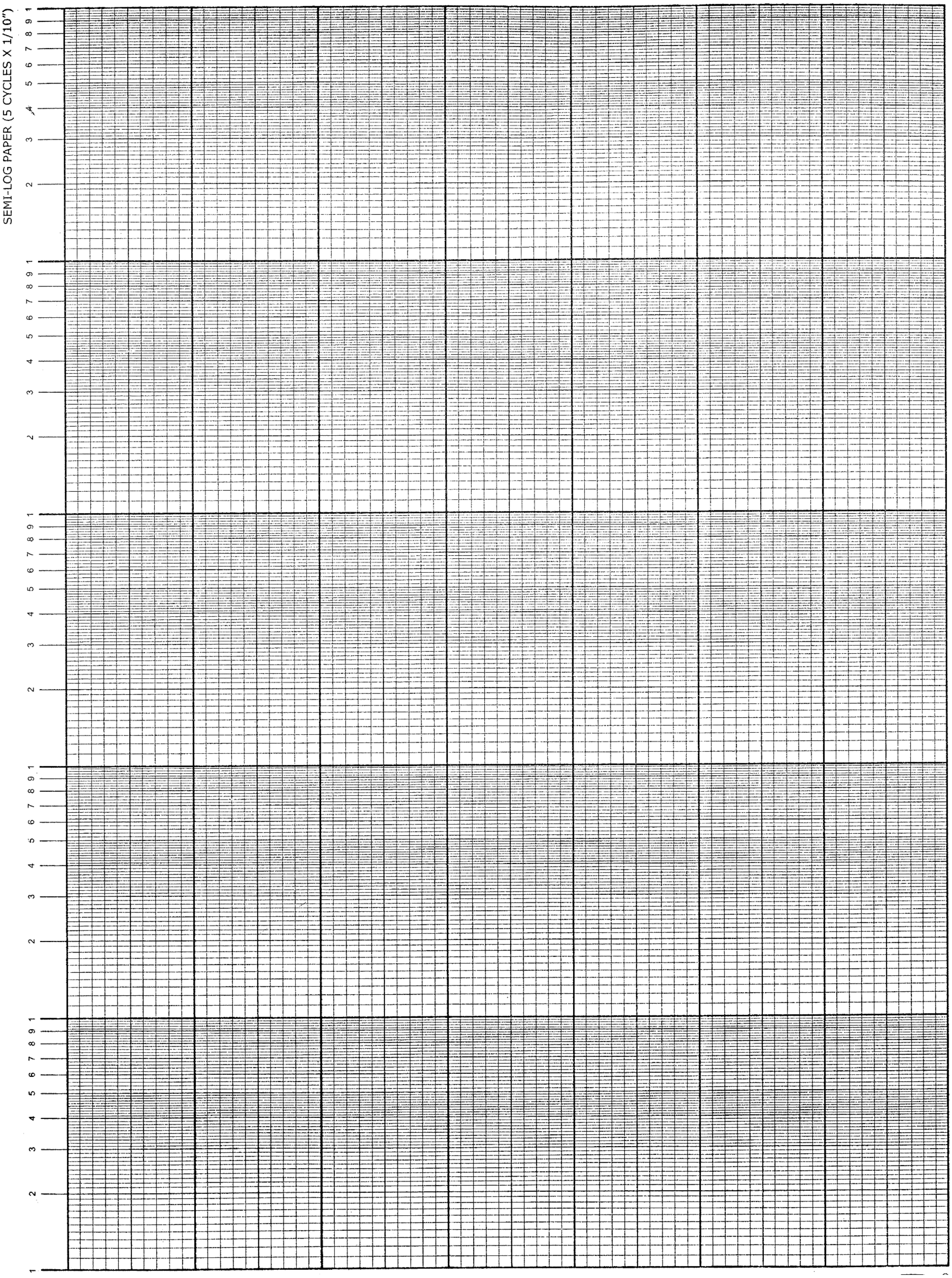
XVIII References/Suggestions for further reading

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

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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


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

Practical No. 22: Simulate the working of high pass filter consist of IC 741 using Multisim or relevant software.

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 simulate HPF exhibit high gain after certain cut off frequency.

II Industry/Employer Expected Outcome(s)

- Student will be able to mount circuits on breadboard and test output using multimeter.
- Testing of relevant active and passive electronic components required to assemble first order high pass (HPF) filter.

III Relevant Course Learning Outcome(s)

- Analyze active filters used in various electronic circuits.

IV Laboratory Learning Outcome(s):

- Observe the output waveform of high pass filter.

V Relevant Affective domain related Outcome(s)

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

VI Theoretical Background Relevant:

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 filter is given by,

$V_O = [1+(R_F / R_1)] \times [(j2\pi f\, RC / (1+j2\pi f\, RC)] \times Vin.$

Where, $A_F = 1+ (R_F / R_1)$

F = frequency of the input signal (Hz)

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

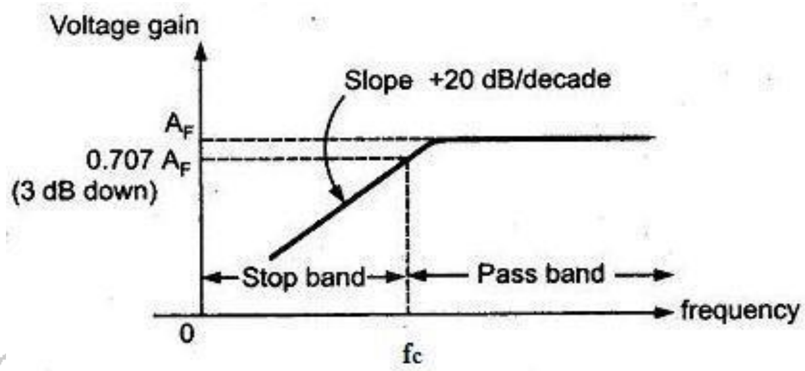


Fig. 22.1: Frequency response of First order High pass filter

VII Circuit diagram/Laboratory layout:

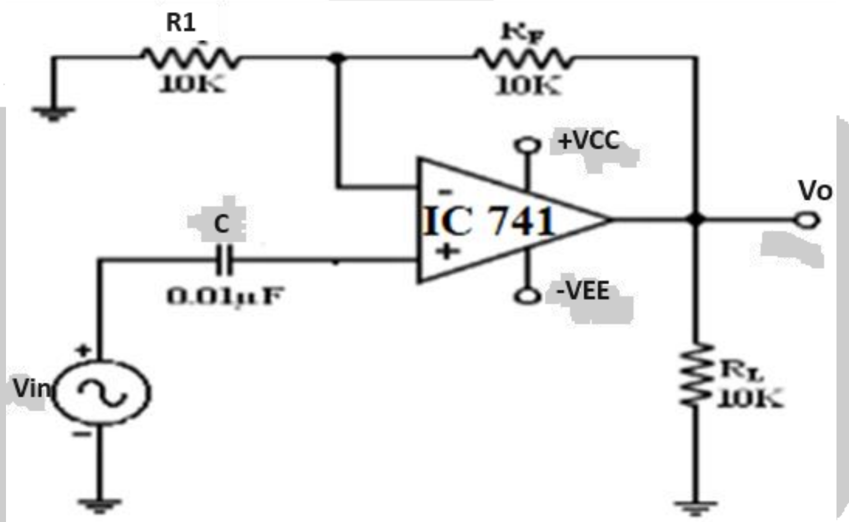


Fig. 22.2: Circuit diagram of First order High pass filter

Actual Experimental set up

VIII Resources Required

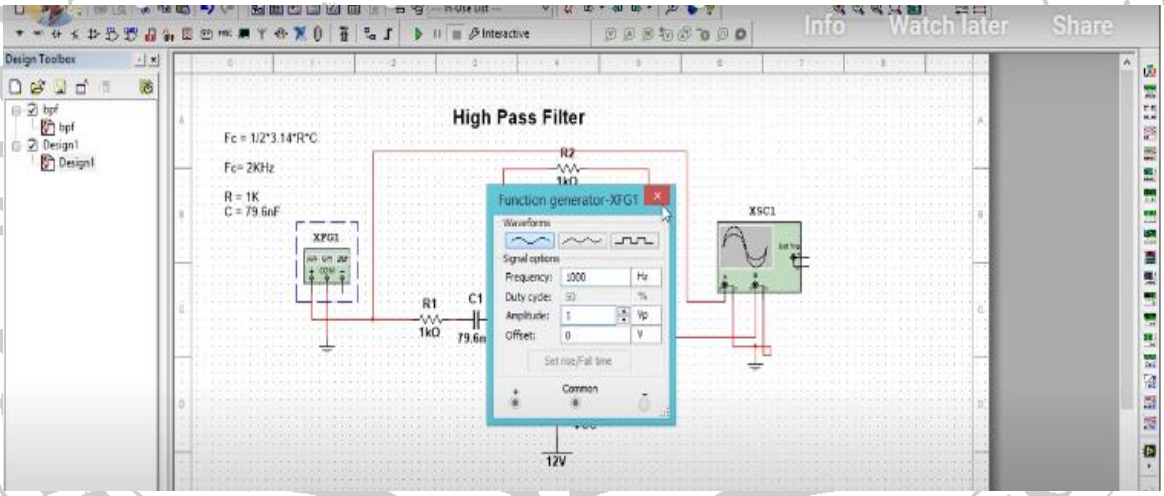
Sr. No.	Instrument / Components	Specification	Quantity
1.	Computer with advanced Configuration.	Latest Processor	1 No.
2.	Simulation Software	LT space/ Lab view/ Multisim/ Proteus / Octeva or any other relevant open source software.	1 No.

IX Precautions to be Followed

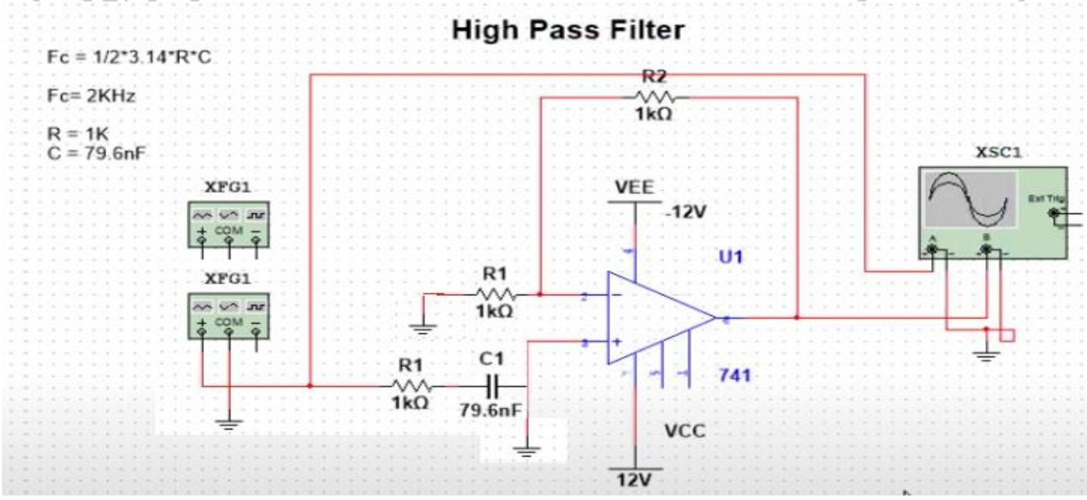
1. Ensure proper earthing to the computer system.
2. Ensure compatibility of computer system with software.
3. Ensure proper installation of simulation software.

X Procedure

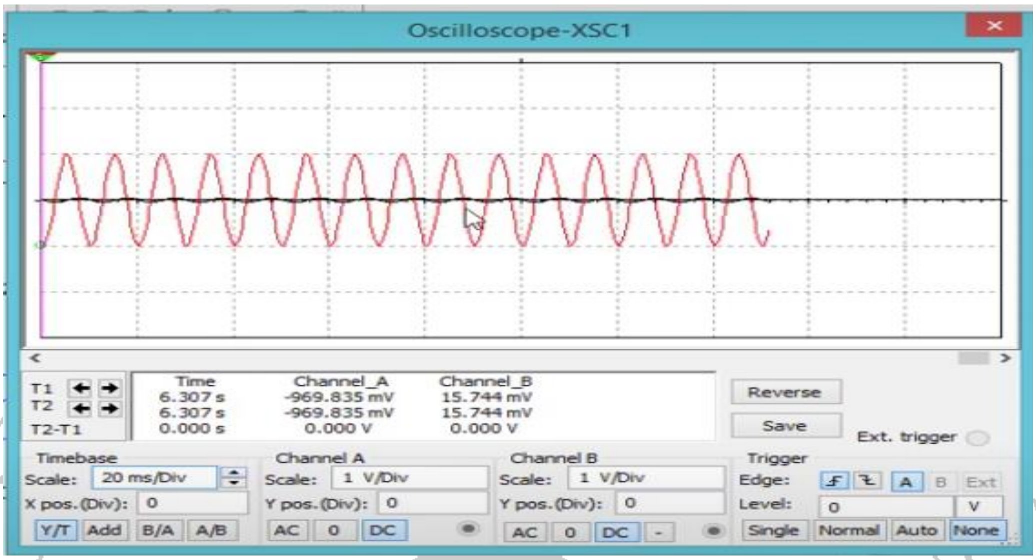
1. Perform step by step Installation process of simulation software.



2. Build the High pass filter circuit in simulation software as per diagram.



3. Apply Input signal sine wave to the circuit.
4. Simulate/run the circuit.
5. Note down output voltage for input frequency (100Hz to 1MHz)



6. Take printouts of simulated circuit and frequency response on A-4 paper.

XI Resources Used

Sr. No.	Instrument / Components	Specification	Quantity
1.			
2.			
3.			
4.			
5.			
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XII Actual Procedure Followed (use blank sheet provided if space not sufficient)

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

Table No: 10.1 Observation table for Gain of HPF

Input Voltage in Volts (To be kept Constant), Vi = 1 Volt 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 $\log_{10}$ $(\frac{V_O}{V_{in}})$ = ------------------------- dB.

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

iv. Bandwidth =…………………………

XIV Results

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

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

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XVI Conclusions and Recommendation

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

1. Design a 4KHz active High pass filter.
2. Design first order HPF at a cutoff frequency of 1 KHz and pass band gain of 1. Assume C=0.1μF.

[Space for Answers]

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XVIII 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

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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

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

Practical No. 23: Build / test astable multivibrator using IC 555 for the specific duty cycle.

I Practical Significance

Astable multivibrator is a rectangular wave generating circuit. It has two quasi stable states. 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 student will be able to construct astable multivibrator on bread board and measure % duty cycle of the output waveform.

II Industry/Employer Expected Outcome(s)

Maintain analog electronic circuits.

III Course Level Learning Outcome(s)

Use specific analog IC to develop various applications.

IV Laboratory Learning Outcome(s):

Select the proper value of R and C for generating waveform of specific duty cycle.

V Relevant Affective Domain related outcome(s)

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

VI Relevant Theoretical Background

Astable multivibrator is also called a 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.

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

$$Ton = 0.693(R_A + R_B) * C$$

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

$$T_{Off} = 0.693(R_B)C$$

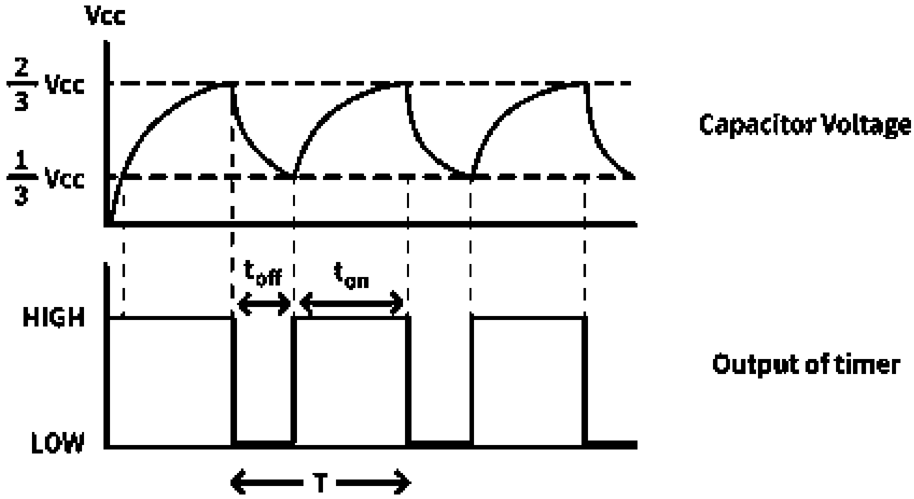

Fig 23.1: Waveforms of Astable multivibrator using IC 555
[Courtesy:https://www.electronicshub.org/wp-content/uploads/2015/06/Waveforms-in-Astable-mode-of-operation.jpg]

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

$$T = T_{on} + T_{Off}$$

$$T = 0.693(R_A + 2R_B) * C$$

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

$$\%D = (T_{on} / T_{Off})*100$$

$$= \frac{(RA + RB)}{((RA + 2RB)}*100$$

Then frequency is given by,

$$F = \frac{1.45}{(R_A + 2R_B)C} \text{ Hz}$$

VII Circuit diagram/Laboratory layout:

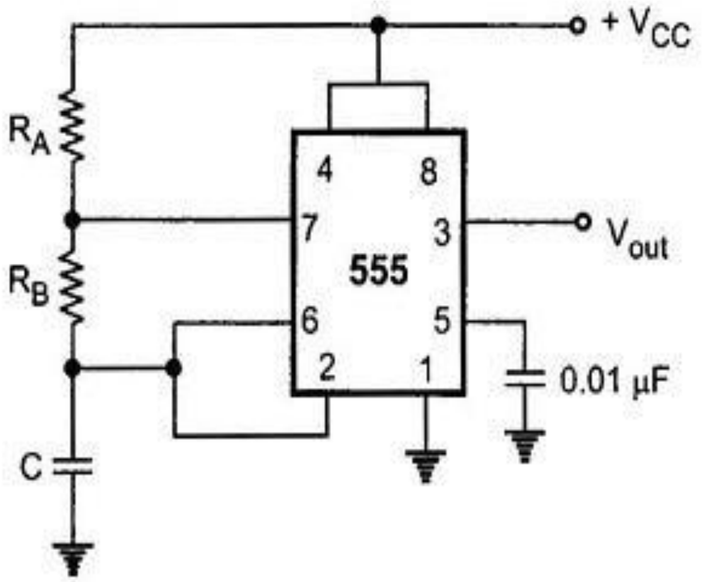

Fig. 23.2: Circuit Diagram of Astable multivibrator
(https://www.electronicshub.org/wp-content/uploads/2021/04/Astable-Multivibrator-using-555-Timer-IC.png)

Actual Experimental set up

VIII Resources Required

Sr. No.	Name of Resource	Suggested Broad 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 and 12KΩ, R_B=10KΩ	1No.
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

IX 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

X Procedure

1. Test and mount the IC 555 in breadboard and make the connections as shown in fig. 23.2.
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 R_A = 15KΩ).
9. After the completion of practical switch off the supply, remove the connections and submit wires and equipment.

XI Resources Used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity

XII Actual Procedure

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

Table No: 23.1 Observation Table for Duty cycle

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

Calculations:

- Ton = $0.693(R_A + R_B)C$
- $T_{Off} = 0.693(R_B)C$

  $T = Ton + T_{Off}$
- $T = 0.693(R_A + 2R_B)C$
- Percentage Duty Cycle %D= (Ton / T_{Off})*100
- Output frequency $F = \frac{1.45}{(RA + 2RB)C}$

XIV Results:

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

XV Interpretation of results

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XVI Conclusion and recommendation

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XVII Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifying CO.

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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XVIII References/Suggestions for further reading

1. https://ae-iitr.vlabs.ac.in/exp/astable-monostable-multivibrator/procedure.html)
2. Ramakanth A. Gayakwad, "OP-amps and Linear Integrated Circuits", PHI, Fourth Edition, 2010.

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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

Practical No.24: Build / test monostable multivibrator using IC 555 for the specific duty cycle.

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 student will be able to construct monostable multivibrator on bread board and measure pulse width of the output waveform.

II Industry/Employer Expected Outcome(s)

Testing of relevant active and passive electronic components required to assemble Monostable Multivibrator.
Maintain analog electronic circuits.

III Course Level Learning Outcome(s)

Use specific analog IC to develop various applications.

IV Laboratory Learning Outcome(s):

Measure the time period of monostable multivibrator using IC 555.

V Relevant Affective Domain related outcome(s)

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

VI Relevant 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 $T_{ON} = 1.1\ R_T{*}C_T$

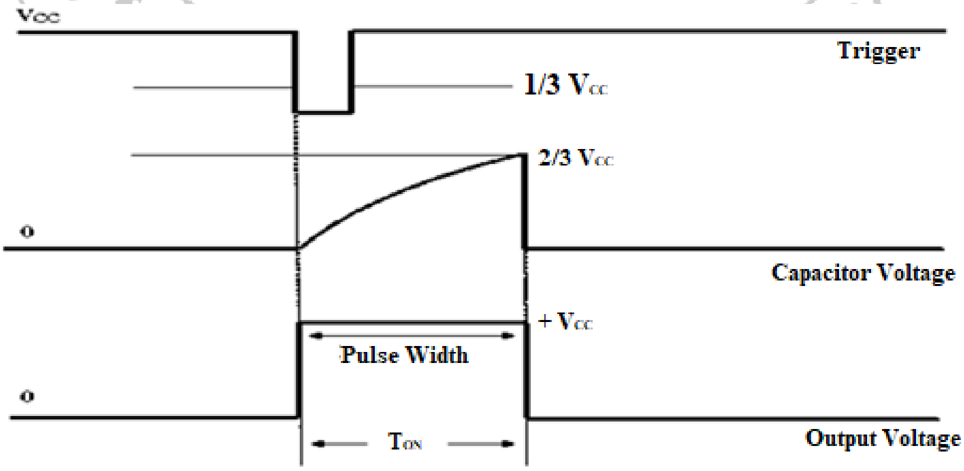

Fig. 24.1: Waveform of Monostable multivibrator using IC 555

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.

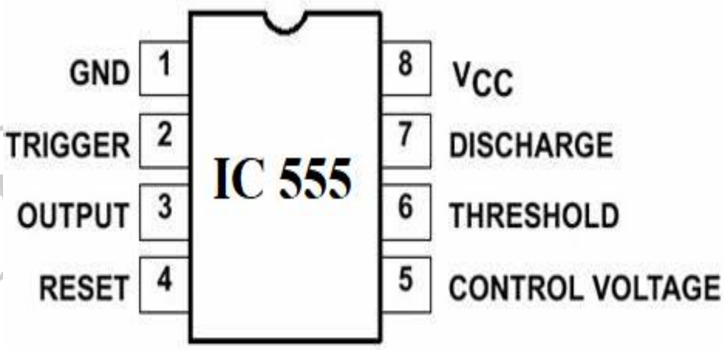

Fig 24.2 Pin diagram of IC 555

Table No: 24.1 Pin Functions of IC555

Pin No.	Name	I / O	Description
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 reference voltage of 2/3
7	Discharge	I	Connected to open collector of a transistor which discharge a capacitor between intervals
8	V_{CC} Supply	I	Supply voltage

VII Circuit diagram/Laboratory layout:

a) Sample Circuit diagram

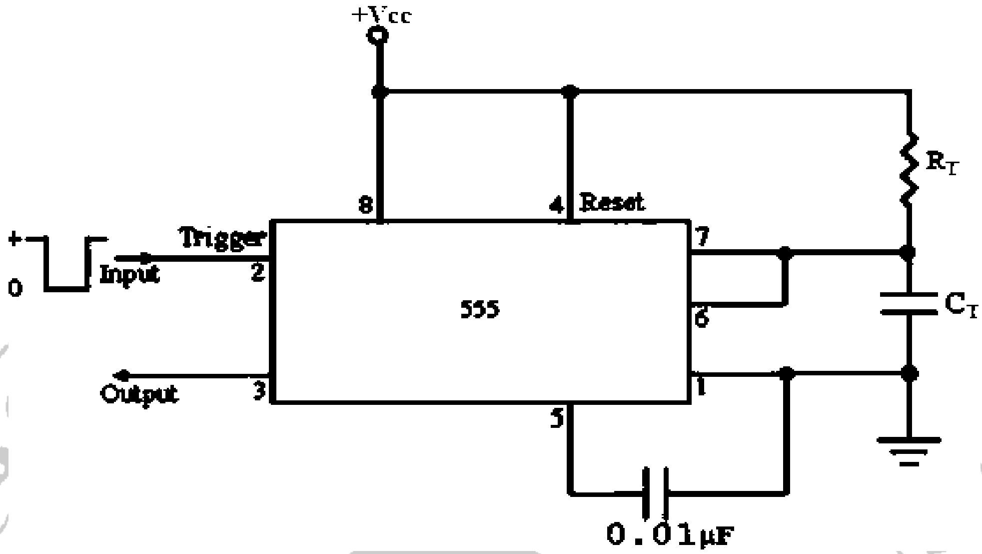

Fig 24.3: Circuit Diagram of Monostable multivibrator using IC 555

Actual Experimental set up

VIII Resources Required

Sr. No.	Name of Resource	Suggested Broad 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.

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
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

IX 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

X Procedure

1. Test and mount the IC 555 in breadboard
2. Connect the circuit as per the circuit diagram shown in fig 24.3.
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.

XI Resources Used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity

XII Actual Procedure

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

Table No: 24.2 Observation table for Pulse Width

Sr. No.	R_T in (KΩ)	T_{ON}	
		Practical	Theoretical $T_{ON} = 1.1\ R_T * C_T$
1.			
2.			

Sample calculation:

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

XIV Results

1. Pulse Width =………………….

XV Interpretation of results

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XVI Conclusion and recommendation

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XVII Practical related questions

1. Find the range of supply voltage for IC SE555(refer datasheet).
2. Design a Monostable multivibrator 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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XVIII 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

XIX Assessment Scheme

Performance Indicators		Weightage
Process Related: 15 Marks		**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

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

Scale

X-axis -

Y-axis -

Practical No.25: Simulate the working of monostable multivibrator using IC 555 using Multisim or relevant software.

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 Industry/Employer Expected Outcome(s)

Maintain analog electronic circuits

III Course Level Learning Outcome(s)

Use specific analog IC to develop various applications.

IV Laboratory Learning Outcome(s)

Observe the output waveform of monostable multivibrator.

V Relevant Affective Domain related outcome(s)

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

VI Relevant 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 output of the monostable multivibrator using 555 timer remains in its stable state until it gets a trigger. In monostable 555 multivibrator, when both the transistor and capacitor are shorted then this state is called a stable state. When the voltage goes below at the second pin of the 555 IC, the o/p becomes high. This high state is called quasi stable state. When the circuit activates then the transition from a stable state to quasi stable state. Then the discharge transistor is cut off and capacitor starts charging to V_{CC}. Charging of the capacitor is done via the resistor R_1 with a time constant R_1C_1. Hence, the voltage of the capacitor increases and finally exceeds 2/3 Vcc, it will change the internal control flip flop, thereby turning off the 555 timer IC. Thus, the o/p goes back to its stable state from an unstable state.

The pulse width of the output rectangular pulse is

$T_{ON} = 1.1\ R_T * C_T$

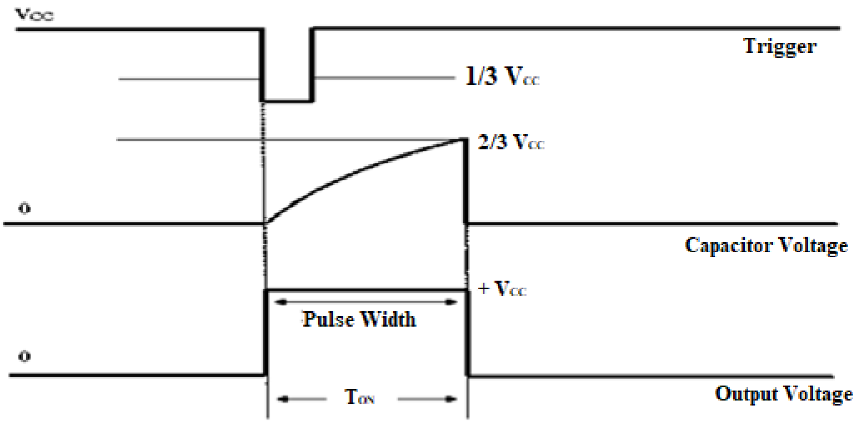


Fig. 25.1: Waveform of Monostable multivibrator

VII Circuit diagram / Laboratory layout:

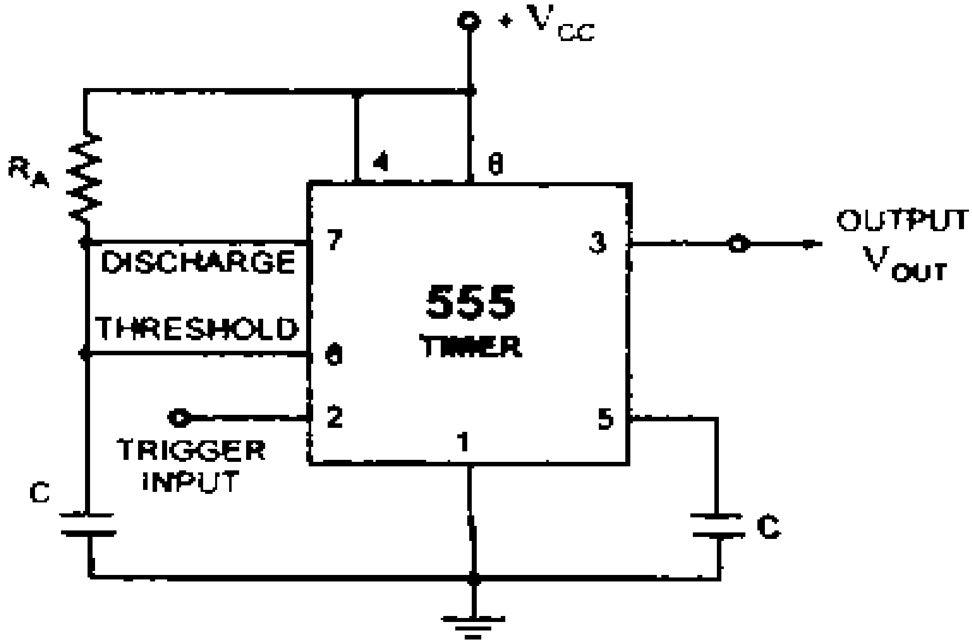


Fig. 25.2: Schematic diagram of Monostable multivibrator

VIII Resources Required

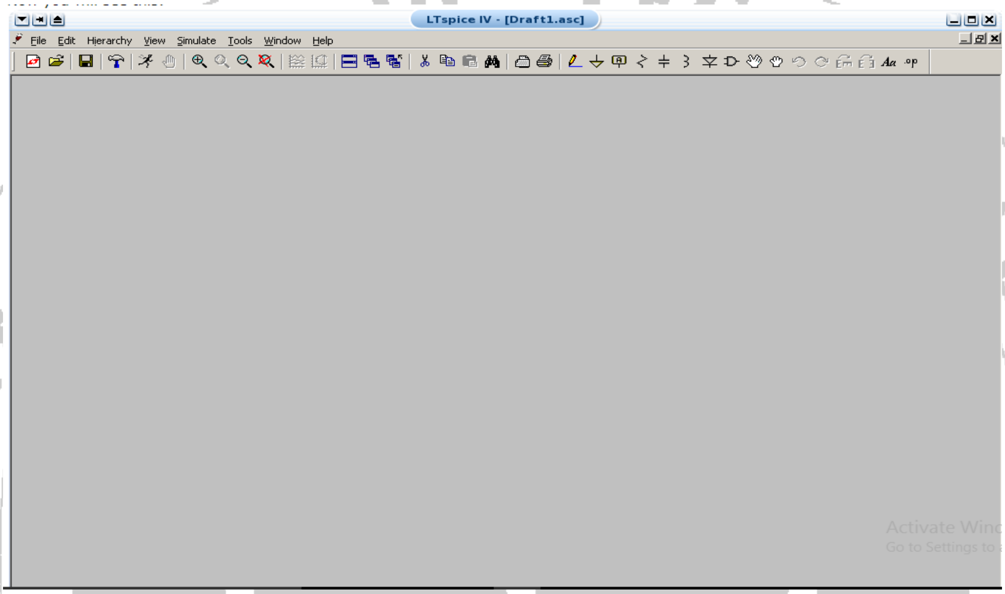
Sr. No.	Instrument / Components	Specification	Quantity
1.	Computer with advanced Configuration	Latest Processor	1 No.
2.	Simulation software	LT Spice / Lab view / H Spice *I* P Spice /HS Spice *I* Multisim/ Proteus / Octave or any other relevant open source software	1 No.

IX Precautions to be followed

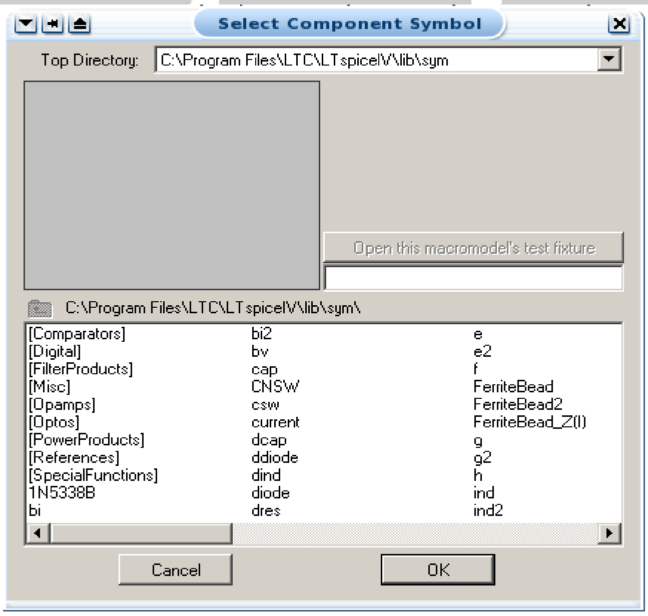
1. Ensure proper earthing to the computer system.
2. Ensure compatibility of computer system with software.
3. Ensure proper installation of simulation software

X Procedure

1. Perform step by step Installation process of simulation software.

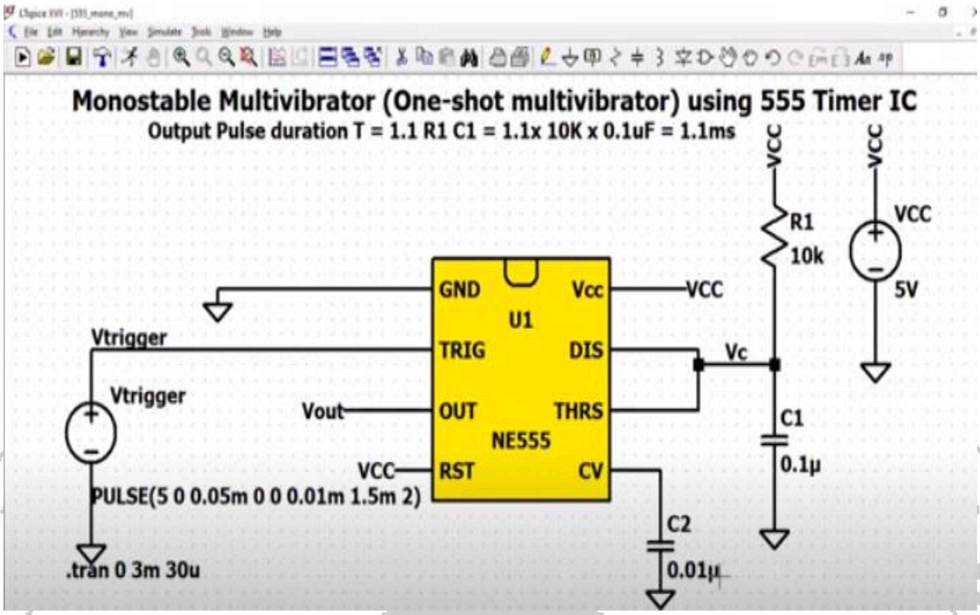


2. Select relevant electronic components from software library.



- Some common parts are:
  - res - resistor
  - cap - capacitor
  - ind - inductor
  - diode - diode
  - voltage - any kind of power supply or battery

3. Build the Monostable multivibrator in simulation software as per diagram



4. Simulate /run the circuit.
5. Observe output waveform on PC screen
6. Take printouts of circuit diagram and waveforms on A-4 Paper.

XI Resources Used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity

XII Actual Procedure

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

Table No: 25.1 Observation table for Pulse Width

Sr. No.	R_T in (KΩ)	T_{ON}	
		Practical	Theoretical Ton =1.1 R_A C
1			
2			

Calculation:

1. Pulse width Ton = 1.1 R_A C

XIV Results

1. Pulse Width =…………………

XV Interpretation of results

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XVI Conclusion and recommendation

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XVII Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. Find the range of supply voltage for IC SE555 (refer datasheet).
2. Design a Monostable multivibrator 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 names and give their IC number also.

[Space for Answers]

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XVIII References/Suggestions for further reading

1. http://vlabs.iitkgp.ac.in/psac/newlabs2020/vlabiitkgpAE/exp3/monostable_multivibrator.html.
2. https://ae-iitr.vlabs.ac.in/exp/astable-monostable-multivibrator/simulation.html.

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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

Practical No.26: Build/ Test Voltage Controlled Oscillator using IC 555.

I Practical Significance

A voltage controlled oscillator is an oscillator whose frequency is controlled by an input voltage.

Basically, the voltage input into the VCO chip controls how many times a digital signal will oscillate in a given time period. In this experiment students will learn how we can build a voltage controlled oscillator (VCO) with a 555 timer chip.

II Industry/Employer Expected Outcome(s)

Maintain analog electronic circuits.

III Course Level Learning Outcome(s)

Use specific analog IC to develop various applications.

IV Laboratory Learning Outcome(s):

Check the performance of Voltage Controlled Oscillator using IC 555.

V Relevant Affective Domain related outcome(s)

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

VI Relevant Theoretical Background

Voltage Controlled Oscillator is an oscillator which produces oscillating signals (waveforms) with variable frequency. The frequency of this waveform varies by varying the magnitude of the Input voltage.

Often a circuit requires a voltage-controlled oscillator, that is, an oscillator whose frequency depends on an input voltage. The frequency of the astable multivibrator above depends only on the values of R_A, R_B and C. By using a voltage-controlled current source to charge C, one can adjust the charging rate and hence the frequency. If a current source charges the capacitor with a constant current I, as in the circuit below, the time for the capacitor to charge from V_{Th} to V_{Tr} is,

$$t_{ch} = C\,(V_{Th} - V_{Tr})\,/I = C*V_{cc}\,/\,(3I).$$

The circuit below will discharge virtually instantaneously, so the frequency of oscillation will be

$$F_{osc} = 1\,/(t_{ch} + t_{dis}) = 1/\,t_{ch} = 3I/\,(C*V_{cc}).$$

VII Circuit diagram/Laboratory layout:

a) Sample Circuit diagram

b)

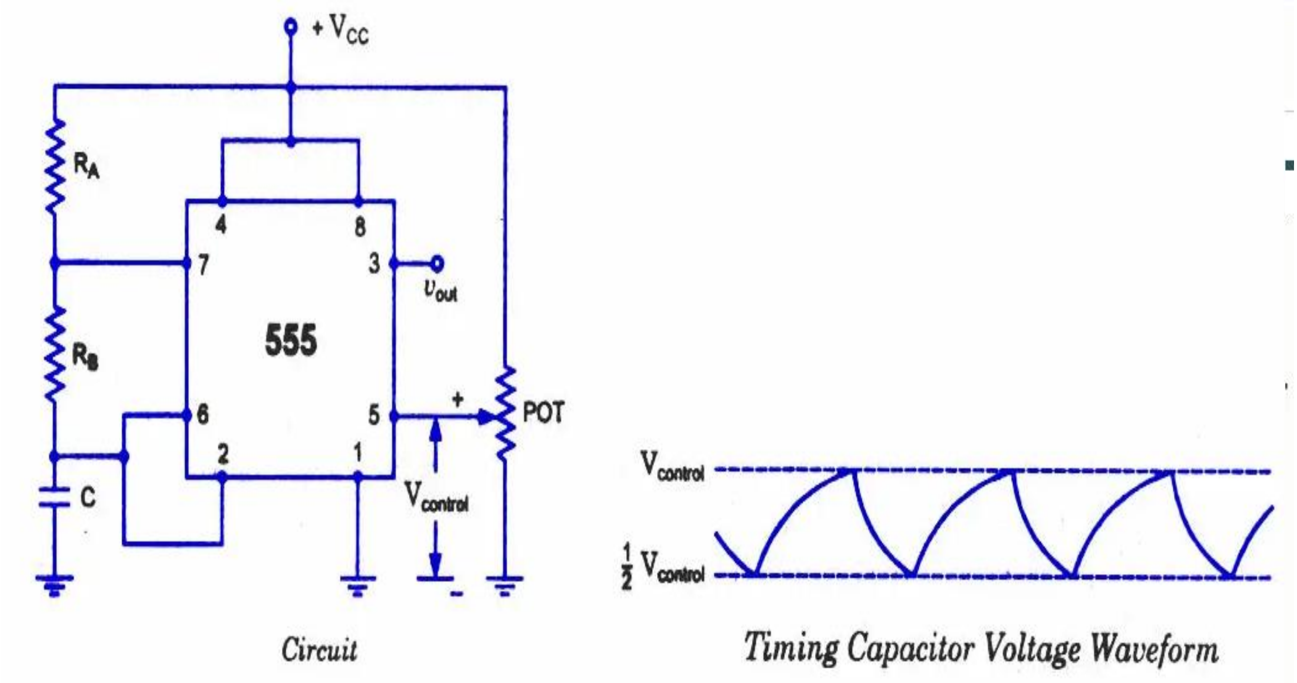

Fig. 26.1: Circuit Diagram of voltage-controlled oscillator using IC 555
(https://www.scribd.com/document/252728982/Voltage-Controlled-Oscillator)

c) Actual Experimental set up

VIII Resources Required

Sr. No.	Name of Resource	Suggested Broad 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=0.01µF,	2 No.
4.	IC-555	8 Pin, DIP	1 No.
5.	Resistors	R_1 =10KΩ R2=100KΩ , R3=10k pot	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

IX 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

X Procedure

1. Test and mount the IC 555 in breadboard
2. Connect the circuit as per the circuit diagram shown in Fig 26.1.
3. Return V_{CC} to 5 V for the 555 timer.
4. Select R such that the frequency of oscillation will vary from 5 kHz to 10 kHz as Vc (Pin no. 5) is varied from 1V to 10V. Test the current source with a resistive load of 1 k.
5. Analyze the relationship between the control voltage and the frequency output to understand the VCO behavior of the circuit.
6. Vary the input voltage between 1V and 10V with step size of 0.5V. Record and plot F_{osc} vs. V_{CC}.

XI Resources Used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity

XII Actual Procedure

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

Table No: 26.1 Observation table for voltage controlled oscillator

Sr. No.	Varying input control voltage (Vc)	Time period of output (Tout)	Frequency output Fout= 1/Tout
1.	1		
2.	2		
3.	2.5		
4.			
5.			
6.			
8.			
9.			
10.			

Calculations:

Theoretical Frequency:

$$t_{ch} = C\,(V_{Th} - V_{Tr}) / I = C\,V_{CC} / (3\,I).$$

$$F_{osc} = 1/\,t_{ch}$$

XIV Results

1. Frequency of oscillations =………………….

XV Interpretation of results

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XVI Conclusion and recommendation

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XVII Practical related questions

1. What is the purpose of using a voltage-controlled oscillator (VCO)?
2. Design a Voltage controlled oscillator using IC55 for a frequency of 10KHz
3. How does the frequency of a VCO vary with changes in the control voltage?
4. Discuss the advantages and limitations of using the IC 555 timer for VCO applications.

[Space for Answers]

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XVIII 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.

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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

Scale

X-axis -

Y-axis -

Practical No. 27: Build/ test the circuit of frequency multiplier using PLL IC 565.

I Practical Significance

The phase locked loop (PLL) is a very useful RF building block. The PLL uses the concept of minimizing the difference in phase between two signals: a reference signal and a local oscillator to replicate the reference signal frequency. Using this concept, it is possible to use PLLs for many applications from frequency synthesizers to FM demodulators, and signal reconstitution. In this experiment students are able to design PLL as FM multiplier using IC 565.

II Industry/Employer Expected Outcome(s)

Maintain analog electronic circuits

III Course Level Learning Outcome(s)

Use specific analog IC to develop various applications.

IV Laboratory Learning Outcome(s):

Measure the output frequency of multiplier circuit consist of IC565.

V Relevant Affective Domain related outcome(s)

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

VI Relevant Theoretical Background

Frequency multiplier using the 565 PLL- The frequency divider is inserted between the VCO and the phase comparator. Since the output of the divider is locked to the input frequency fin, the VCO is actually running at a multiple of the input frequency. The desired amount of multiplication can be obtained by selecting a proper divide by N network, where N is an integer. For example, to obtain the output frequency F_{OUT} = 5 fin, a divide by N = 5 network is needed. The 4 bit binary counter (7490) is configured as a divide by 5 circuits. The transistor Q is used as a driver stage to increase the driving capability of the NE 565. C3 is used to eliminate possible oscillation. C2 should be large enough to stabilize the VCO frequency.

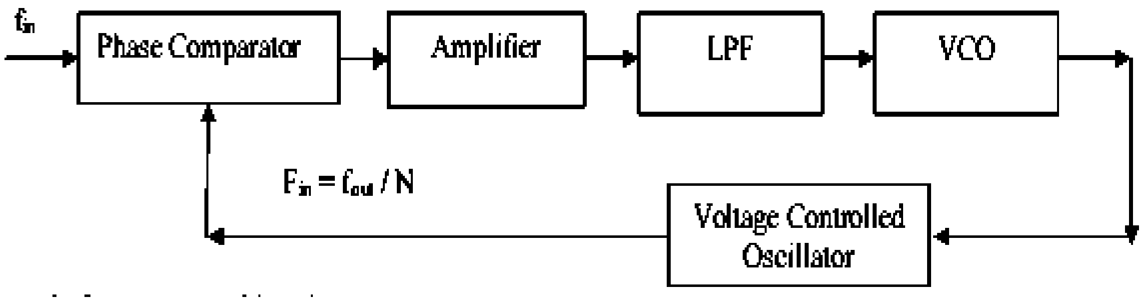

Fig. 27.1: Block diagram of PLL as FM multiplier

(https://stannescet.ac.in/cms/staff/qbank/ECE/Lab_Manual/EC8462-LINEAR%20INTEGRATED%20CIRCUITS%20LAB-1430566332- EC%208462%20LIC%20LAB%20MANUAL.pdf)

The output frequency of the VCO can be rewritten as

$$Fo = 0.25 / (R_T * C_T) \text{ Hz.}$$

Where R_T and C_T are the external resistor and capacitor connected to pin 8 and pin 9. A value between 2K and 20K is recommended for R_T. The VCO free running frequency is adjusted with RT and CT to be at the center for the input frequency range.

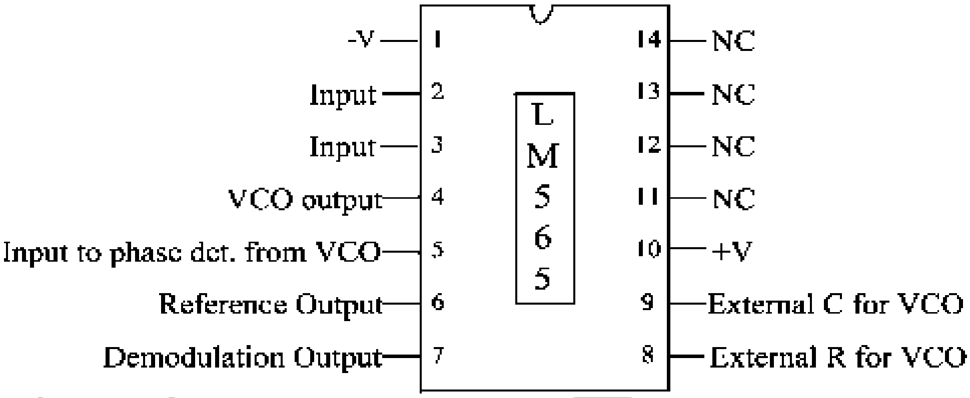

Fig. 27.2: Pin diagram of IC 565

(https://www.electronics-tutorial.net/wp-content/uploads/2015/09/PLL1.png)

VII Circuit diagram/Laboratory layout:

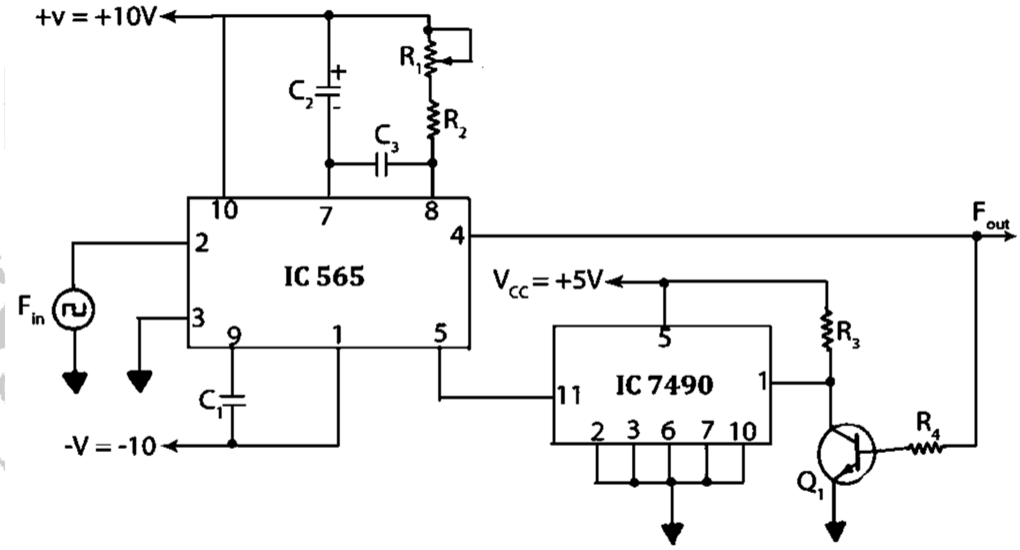

Fig 27.3: Circuit Diagram of FM multiplier

(https://grt.edu.in/ECEinnovate/LAB%20MANUAL/LIC%20LAB%20MANUAL.pdf)

Actual Circuit diagram

VIII Resources Required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Cathode Ray Oscilloscope (Analog type)	20/30/100 MHz Frequency	1 No.
2.	Regulated DC Power Supply	0-30V, 2Amp SC protection Vcc=5 volt	1 No.
3.	Function Generator	0-2 MHz with Sine, square and triangular output with variable frequency and amplitude	1No.
4.	IC	LM 565/NE SE565 and IC 7490.	1 No.
5.	Resistors	R_1=20 KΩ + 2.2KΩ, R_2=4.7KΩ(3N), R_3=10KΩ	3No.
6.	Capacitors	C_1=0.01uF, C_2=10uF, C_3=0.001uf (3N)	3No.
7.	Breadboard	5.5 CM X 17CM	1 No.
8.	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

IX 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

X Procedure

1. The connections are given as per the circuit diagram.
2. The circuit uses a 4- bit binary counter 7490 used as a divide-by-5 circuit.
3. Measure the free running frequency of VCO at pin 4, with the input signal Vi set equal to zero. Compare it with the calculated value = 0.25 / (RT CT).
4. Now apply the input signal of 1 VPP square wave at 500 Hz to pin 2.
5. Vary the VCO frequency by adjusting the 20kΩ potentiometer till the PLL is locked. Measure the output frequency. It should be 5 times the input frequency.
   F1 is the lower ends of the capture range.
   F2 is gives the upper end of the lock range.
   F3 is the upper end of the capture range.
   F4 is gives the lower end of the lock range.
6. Repeat steps 4,5 for input frequency of 1 kHz and 1.5 kHz.

XI Resources Used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1			
2			
3			
4			
5			

XII Actual Procedure

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XIII Observation:

Table 27.1 Observation table for FM multiplier

(Vm = 1Vpp square wave at 1KHz)

Sr. No.	Fo (Hz)	F1 (Hz)	F2 (Hz)	F3 (Hz)	F4 (Hz)	F_L (Hz)		Fc (Hz)	
						TH	PR	TH	PR
1	**0 Hz**								
2	**500Hz**								
3	**1 KHz**								
4	**1.5 KHz**								

Calculations:

i) The output frequency of the VCO can be rewritten as (for input voltage Vm =0V)

$Fo = 0.25 / (R_T C_T)$ Hz. =..............................

Practical Theoretical

ii) Lock range frequency F_L = $(F_2 – F_4)$ F_L= 7.8*Fo /12

=..................................... .= ....

iii) Capture range frequency Fc = $(F_3 – F_1)$ $Fc = [F_L / (2)(3.6)(\mathbf{10^3})C]^{1/2}$

= ……………………… =………………………………

XIV Result(s)

Fo =..

F_L =...

F_C =...

XV Interpretation of results

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XVI Conclusion and recommendation

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XVII Practical related questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identifying CO.

1. Define capture range, lock range, sensitivity of PLL.
2. What is the significance of the bandwidth of the LPF in the phase locked loop?
3. Draw diagram of FM modulator using PLL.

[Space for Answers]

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XVIII References/Suggestions for further reading

1. https://www.youtube.com/watch?v=16IK7K6_4wI
2. https://www.youtube.com/watch?v=j1_D704Mh3s

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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

Practical No. 28: Check the performance of PLL as FM demodulator (IC 565).

I Practical Significance

The phase locked loop (PLL) is a very useful RF building block. The PLL uses the concept of minimizing the difference in phase between two signals: a reference signal and a local oscillator to replicate the reference signal frequency. Using this concept, it is possible to use PLLs for many applications from frequency synthesizers to FM demodulators, and signal reconstitution. In this experiment students can be able to design PLL as FM demodulator using IC 565.

II Industry/Employer Expected Outcome(s)

Maintain analog electronic circuits

III Course Level Learning Outcome(s)

Use specific analog IC to develop various applications.

IV Laboratory Learning Outcome(s):

Interpret input and output waveform of FM demodulator circuit contains PLL (IC 565).

V Relevant Affective Domain related outcome(s)

Follow safe practices.

Maintain tools and equipment.

Demonstrate working as a leader/a team member

VI Relevant Theoretical Background

When the input signal frequency increases, then the output signal voltage decreases. However, when the input signal frequency decreases, the output signal voltage will increase, therefore, we can utilize the relationship between the voltage of PLL and frequency to design the FM demodulator.

In an FM signal, the instantaneous frequency varies in accordance with the modulating signal. For a sinusoidal modulating signal, the frequency deviation in an FM signal is sinusoidal, and it is proportional to the modulating, amplitude.

Suppose the center frequency of the FM signal is fc, and it lies within the hold-in range of PLL the VCO is locked to fc, by applying an demodulated carrier at the input of the phase detector. When VCO is locked to fc, the error signal is zero, and therefore, the control signal that changes the VCO frequency is also equal to zero. If an FM signal is applied to the phase detector, there will be a difference in the phases of the VCO output and the input FM signal. The control signal is produced in proportion to the phase difference at an instance of time. This control voltage will modify the VCO frequency, which is again compared with the incoming frequency. In this way, the current incoming frequency is compared with the previously attained value of the VCO frequency, which is the previously attained frequency of the FM Signal.

The VCO, therefore, tries to track the instantaneous frequency of the applied FM signal. The control signal is produced in proportion to the difference between the VCO frequency and the instantaneous frequency of FM signal. In other words, the control signal so produced is proportional to the frequency deviation in the FM signal. Since the frequency deviation is proportional to the modulating signal, the control signal appearing at the output of LPF is the modulating signal. Therefore, the FM signal is demodulated by PLL.

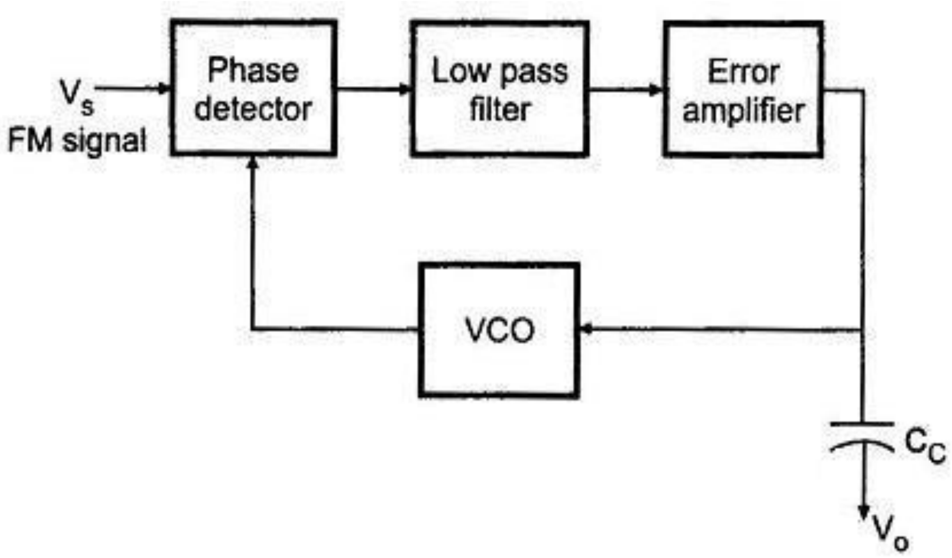

Fig. 28.1: Block diagram of PLL as FM demodulator
(https://www.eeeguide.com/wp-content/uploads/2016/09/PLL-FM-Detector-Circuit-or-Demodulator-001.jpg)

VII Circuit diagram/Laboratory layout:

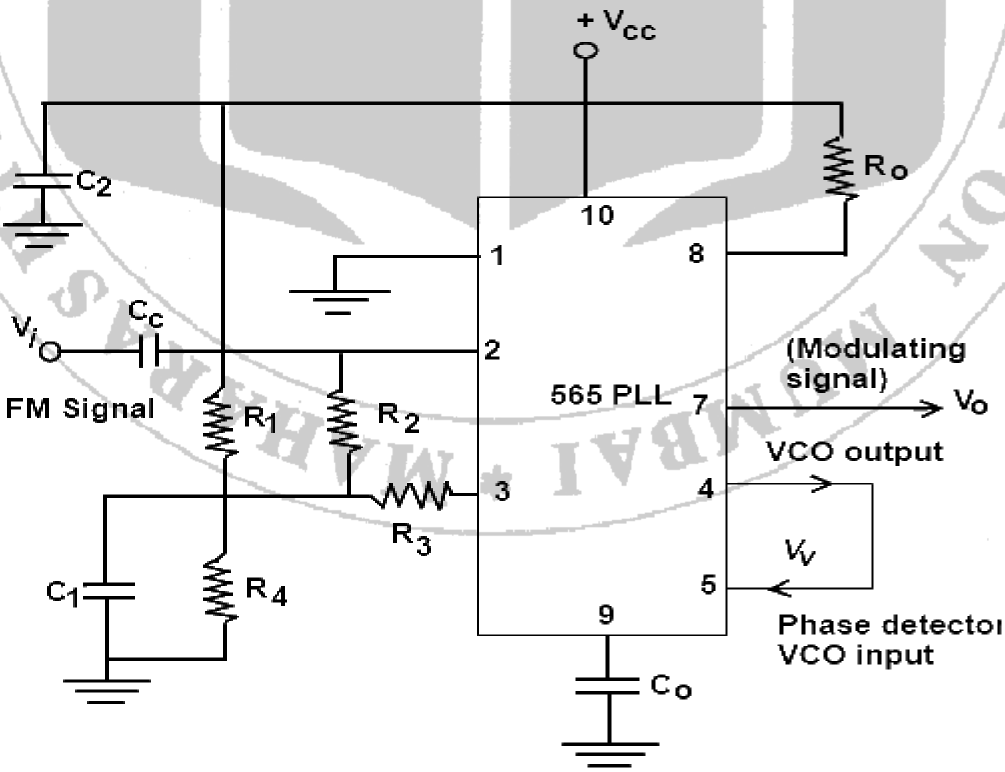

Fig. 28.2: Circuit Diagram of FM demodulator

Actual Circuit diagram

VIII Resources Required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Cathode Ray Oscilloscope (Analog type)	20/30/100 MHz Frequency	1 No.
2.	Regulated DC Power Supply	0-30V, 2Amp SC protection Vcc=5volt	1 No.
3.	Function Generator	0-2 MHz with Sine, square and triangular output with variable frequency and amplitude	1No.
4.	IC	LM 565/NE SE565, LM 311	1 No.
5.	Resistors	R1=5KΩ, Ro =10KΩ(3N), Rin=600Ω(2N)	1No.
6.	Capacitors	C1=0.05uF, C2=0.2uF, C_0 = 1.5 nF (2N)	1No.
7.	Breadboard	5.5 CM X 17CM	1 No.
8.	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

IX 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

X Procedure

1. Implement the circuit of figure 28.2 and disconnect pins 4 and 5 of the PLL (short-circuited with a wire). Observe the free-running frequency of the VCO in pin 4. Modify the potentiometer resistance (R0) to make this frequency about 1 kHz or slightly superior.
2. Connect pins 4 and 5 again. Observe the phase comparator output (after amplifier) in pins 6 and compare each of these signals with the demodulated signal in the output pin of the comparator (pin 7 of integrated circuit LM311).
3. Compare the output signals of the VCO with the FSK signal at the PLL input. Finally, compare the retrieved modulation signal (at the comparator output) with the original modulation signal of the signal generator.

XI Resources Used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity

XII Actual Procedure

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XIII Observation:

Observation Table 27.1
(Vm = 500 mV, Fo = 20 KHz)

Audio signal frequencies	FM input	Audio output
1 KHz		
2 KHz		

Calculations

i) Free-running frequency (Fo):

$F_O = 0.3 / R_o * C_o =$

ii) Hold-in range:

$F_H = \pm 8 * Fo / Vc =$

XIV Result(s)

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XV Interpretation of results

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XVI Conclusion and recommendation

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XVII Practical related questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identifying CO.

1. Define capture range, lock range, sensitivity of PLL.
2. What is the significance of the bandwidth of the LPF in the phase locked loop?
3. Draw diagram of FM modulator using PLL.

[Space for Answers]

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XVIII References/Suggestions for further reading

1. https://www.youtube.com/watch?v=16IK7K6_4wI
2. https://www.youtube.com/watch?v=j1_D704Mh3s

XIX Assessment Scheme

	Performance Indicators	Weightage
	Process Related: 15 Marks	**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

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