

रैखिक एकीकृत सर्किट प्रयोगशाला

Linear Integrated Circuits Lab

(EC 226)

(बी टेक IV सेमेस्टर / B Tech IV Semester)

(प्रयोगशाला मैनुअल)

Lab Manual

(2024-25)



इलेक्ट्रॉनिक्स एवं संचार अभियांत्रिकी विभाग
Department of Electronics and Communication Engineering

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रैखिक एकीकृत सर्किट प्रयोगशाला

Linear Integrated Circuits Lab

(प्रयोगशाला मैनुअल)

Lab Manual

कार्यक्रम : प्रौद्योगिकी में स्नातक

Program : Bachelor of Technology

विशेषज्ञता : इलेक्ट्रॉनिक्स और संचार अभियांत्रिकी

Specialization : Electronics and Communication Engineering

सेमेस्टर : IV

Semester : IV

पाठ्यक्रम कोड : EC 226

Course Code : EC 226

डॉ. राहुल कुमार चौरसिया (प्रयोगशाला समन्वयक) द्वारा तैयार

Prepared by Dr. Rahul Kumar Chaurasiya (Laboratory Coordinator)

इलेक्ट्रॉनिक्स एवं संचार अभियांत्रिकी विभाग
Department of Electronics and Communication Engineering
रैखिक एकीकृत सर्किट प्रयोगशाला (EC-226)
Linear Integrated Circuits Lab (EC-226)
प्रयोगों की सूची
List of Experiments

क्रमांक S.N.	प्रयोग Experiment	पृष्ठ संख्या Page No.
1	ऑपरेशनल एम्प्लीफायर (Op-Amp) का उपयोग करके एक सक्रिय फ़िल्टर डिज़ाइन करें Design an active filter using Op-Amp	
2	ऑपरेशनल एम्प्लीफायर (Op-Amp) का उपयोग करके सिग्नल तुलनित्र डिज़ाइन करें Design a signal comparator using Op-Amp.	
3	ऑपरेशनल एम्प्लीफायर (Op-Amp) का उपयोग करके इसे शून्य बनाने के लिए इनपुट ऑफसेट वोल्टेज डिज़ाइन करें Design input offset voltage of making it zero using Op-Amp	
4	ऑपरेशनल एम्प्लीफायर (Op-Amp) का उपयोग करके एकीकरण कर्ता वा विभेदक परिपथ डिज़ाइन करें Design Integrator & Differentiator Circuits using Op-Amp	
5	ऑपरेशनल एम्प्लीफायर (Op-Amp) का उपयोग करके योजक वा घटाव परिपथ डिज़ाइन करें Design adder and subtractor Circuits using Op-Amp	
6	ऑपरेशनल एम्प्लीफायर (Op-Amp) का उपयोग करके एक फ़ंक्शन जेनरेटर डिज़ाइन करें Design a Function Generator using Op-Amp	
7	ऑपरेशनल एम्प्लीफायर (Op-Amp) का उपयोग करके शिमिट ट्रिगर परिपथ डिज़ाइन करें Design a Schmitt trigger circuit using Op-Amp	
8	ऑपरेशनल एम्प्लीफायर (Op-Amp) का उपयोग करके एक अनवस्थित मल्टी-वाइब्रेटर डिज़ाइन करें Design an Astable multi-vibrator using Op-Amp	
9	ऑपरेशनल एम्प्लीफायर (Op-Amp) का उपयोग करके एक द्वि-स्थिर मल्टी-वाइब्रेटर डिज़ाइन करें Design a Bistable multi-vibrator using Op-Amp	
10	ऑपरेशनल एम्प्लीफायर (Op-Amp) का उपयोग करके दूसरे क्रम का बटरवर्थ फ़िल्टर डिज़ाइन करें Design second order Butterworth filter using Op-Amp	
11	ऑपरेशनल एम्प्लीफायर (Op-Amp) का उपयोग करके बफर सर्किट डिज़ाइन करें Design buffer circuit using Op-Amp	
12	ऑपरेशनल एम्प्लीफायर (Op-Amp) का उपयोग करके परिशुद्ध दिष्टकारी डिज़ाइन करें Design a precision rectifier using Op-Amp	
13	ऑपरेशनल एम्प्लीफायर (Op-Amp) का उपयोग करके फेजशिफ्ट आर०सी०ऑसिलेटर सर्किट डिज़ाइन करें Design and setup a RC phase shift oscillator using Op - Amp 741	
14	ऑपरेशनल एम्प्लीफायर (Op-Amp) का उपयोग करके वेनब्रिजऑसिलेटर सर्किट डिज़ाइन करें Design and construct a Wien bridge oscillator using Op-Amp 741	

मौलाना आजाद राष्ट्रीय प्रौद्योगिकी संस्थान भोपाल

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	प्रयोग 1 Experiment 1		
विभाग Department	इलेक्ट्रॉनिक्स एवं संचार अभियांत्रिकी Electronics & Communication Engineering	सत्र Session:	2024-25
शिक्षक का नाम Name of Teacher	डॉ. राहुल कुमार चौरसिया Dr. Rahul Kumar Chaurasiya	कार्यक्रम Program	बी टेक B Tech
विषय Subject	रैखिक एकीकृत सर्किट प्रयोगशाला (EC-226) Linear Integrated Circuits Lab (EC-226)	सेमेस्टर Semester	IV

Objective: Design an active filter using Op-Amp

Theory:

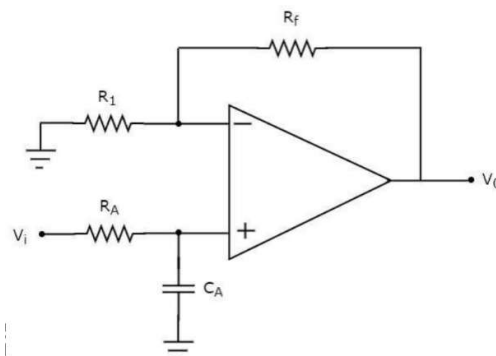
Active Filter (low pass filter)

A filter is a frequency selective circuit that allows only a certain band of frequency component of an input signal to pass through and blocks other frequency components. An active filter network is obtained by interconnecting passive elements and active element. Op-amps are used in active filters to provide amplification and gain control. A low pass filter allows only low frequency signals and suppresses high frequency signals. The range of frequency varies from dc to cut off frequency f_L . The frequency range below cut off frequency is called pass band and frequency range beyond f_L is called stop band.

Components Required: There are following main components:

- 741 Op-amp
- Resistors (designed values), $\frac{1}{4}$ W
- Capacitors (designed values)
- 0-30 V, 1A dc dual regulated power supply
- MHz Function Generator
- 30 MHz Oscilloscope
- Digital Multimeter
- Breadboard

Circuit Diagram:



Design:

First order low pass filter→

Upper cut-off frequency, $f = 1 \text{ kHz}$, Choose R & C accordingly

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

Pass band gain, Keep $A_o = 2$, choose R_f and R_1 accordingly

$$A_o = 1 + \frac{R_f}{R_1}$$

Procedure:

- 1 Construct the circuit as per the diagram.
- 2 Apply 1 V peak-peak sinusoidal signal at the output.
- 3 Observe simultaneously the input and output waveforms on the oscilloscope.
- 4 Vary the frequency of the input signal from 10Hz to 100 kHz. Measure the output amplitude corresponding to different frequencies and compute the gain.
- 5 Plot the frequency response on a semi-log sheet with gain in dB on y-axis and frequency in Hz on x-axis.

Precautions:

1. Make null adjustment before applying the input signal.
2. Maintain proper V_{cc} levels.

Observation:

Input Signal Frequency(in Hz)	V_o (Volts)	Gain(dB)

Result:

मौलाना आजाद राष्ट्रीय प्रौद्योगिकी संस्थान भोपाल

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	प्रयोग 2 Experiment 2		
विभाग Department	इलेक्ट्रॉनिक्स एवं संचार अभियांत्रिकी Electronics & Communication Engineering	सत्र Session:	2024-25
शिक्षक का नाम Name of Teacher	डॉ. राहुल कुमार चौरसिया Dr. Rahul Kumar Chaurasiya	कार्यक्रम Program	बी टेक B Tech
विषय Subject	रैखिक एकीकृत सर्किट प्रयोगशाला (EC-226) Linear Integrated Circuits Lab (EC-226)	सेमेस्टर Semester	IV

Objective: Design a signal comparator using Op-Amp.

Theory:

Comparator:

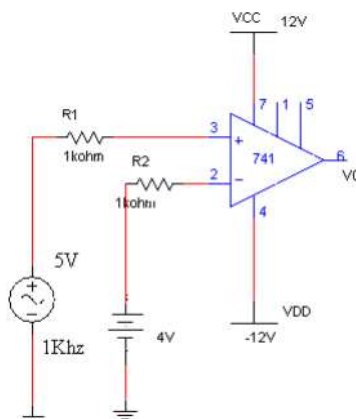
A comparator is a circuit which compares a signal voltage applied at one input of an op amp with a known reference voltage at the other input. It is basically an open loop op-amp with output $\pm V_{sat}$ as in the ideal transfer characteristics. It is clear that the change in the output state takes place with an increment in input V_i of only 2mv. This is the uncertainty region where output cannot be directly defined. There are basically 2 types of comparators. Non inverting comparator and Inverting comparator.

The applications of comparator are zero crossing detectors, window detector, and time marker generator and phase meter.

Components Required: There are following main components:

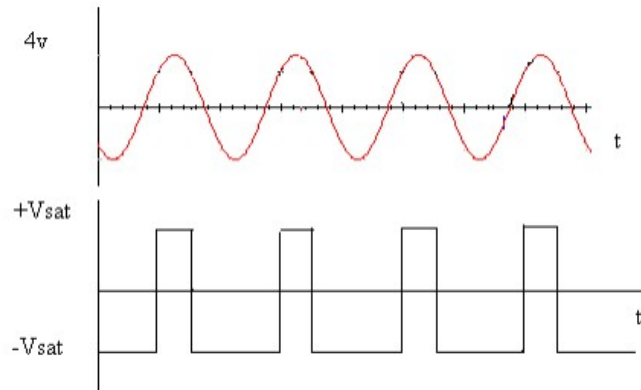
1. IC 741
2. Resistors
3. Function generator
4. Regulated power supply
5. IC bread board trainer
6. CRO
7. Patch cards and CRO probes

Circuit Diagram:



Observation:

Voltage input	Vref	Observed square wave amplitude

Model Graph:**Procedure:**

1. Connections are made as per the circuit diagram.
2. Select the sine wave of 10V peak to peak , 1K Hz frequency.
3. Apply the reference voltage 2V and trace the input and output wave forms.
4. Superimpose input and output waveforms and measure sine wave amplitude with reference to Vref.
Repeat steps 3 and 4 with reference voltages as 2V, 4V, -2V, -4V and observe the waveforms.
5. Replace sine wave input with 5V dc voltage and $V_{ref} = 0V$.
6. Observe dc voltage at output using CRO.
7. Slowly increase V_{ref} voltage and observe the change in saturation voltage.

Precautions:

1. Make null adjustment before applying the input signal.
2. Maintain proper V_{cc} levels.

Results:

मौलाना आजाद राष्ट्रीय प्रौद्योगिकी संस्थान भोपाल

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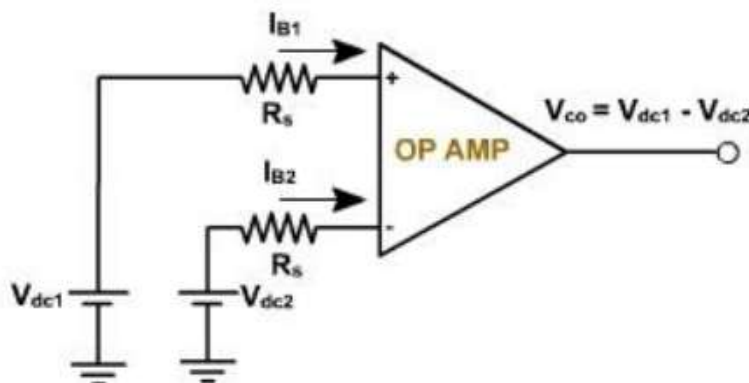
	प्रयोग 3 Experiment 3		
विभाग Department	इलेक्ट्रॉनिक्स एवं संचार अभियांत्रिकी Electronics & Communication Engineering	सत्र Session:	2024-25
शिक्षक का नाम Name of Teacher	डॉ. राहुल कुमार चौरसिया Dr. Rahul Kumar Chaurasiya	कार्यक्रम Program	बी टेक B Tech
विषय Subject	रैखिक एकीकृत सर्किट प्रयोगशाला (EC-226) Linear Integrated Circuits Lab (EC-226)	सेमेस्टर Semester	IV

Objective: Design input offset voltage of making it zero using Op-Amp

Theory:

Input Offset Voltage:

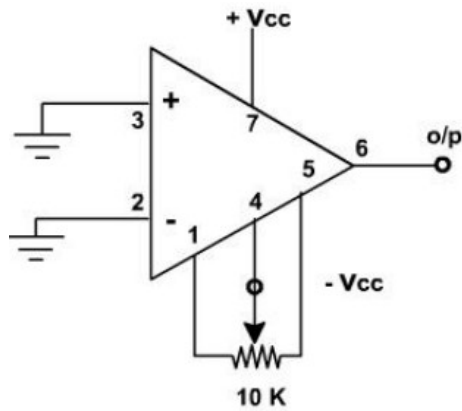
Input offset voltage is the voltage required to be applied at the input for making output voltage to zero volts. Ideally, the output voltage should be zero when the voltage between the inverting and non inverting inputs is zero. In reality, the output voltage may not be zero with zero input voltage. This is due to un-avoidable imbalances, mismatches, tolerances, and so on inside the op-amp. In order to make the output voltage zero, we have to apply a small voltage at the input terminals to make output voltage zero.



$$V_{io} = V_{dc1} - V_{dc2}$$

Components Required: There are following main components:

1. IC 741
2. Resistors
3. Potentiometer/Rheostat
4. Function generator
5. Regulated power supply
6. IC bread board trainer
7. CRO
8. Patch cards and CRO probes

Circuit Diagram:**Observation:**

Offset value	Resistance Value of Potentiometer	

Procedure:

1. Connections are made as per the circuit diagram.
2. Pin 2 and pin 3 are grounded.
3. Calculate output voltage between pin 6 and ground.
4. Potentiometer of 10 K ohm is connected between pin 1 and pin 5.
5. Rotate Potentiometer and record the value at which output voltage become zero.

Precautions:

1. Maintain proper V_{CC} levels.
2. Proper wire connection should be made to avoid short circuit of IC.

Results :

मौलाना आजाद राष्ट्रीय प्रौद्योगिकी संस्थान भोपाल

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	प्रयोग 4 Experiment 4		
विभाग Department	इलेक्ट्रॉनिक्स एवं संचार अभियांत्रिकी Electronics & Communication Engineering	सत्र Session:	2024-25
शिक्षक का नाम Name of Teacher	डॉ. राहुल कुमार चौरसिया Dr. Rahul Kumar Chaurasiya	कार्यक्रम Program	बी टेक B Tech
विषय Subject	रैखिक एकीकृत सर्किट प्रयोगशाला (EC-226) Linear Integrated Circuits Lab (EC-226)	सेमेस्टर Semester	IV

Objective: Design Integrator & Differentiator Circuits using Op-Amp

Theory: Differentiator Circuit using Op-Amp

It is an opamp circuit which performs the mathematical operation of differentiation. That is the output waveform is the derivative or differential of the input voltage. That is

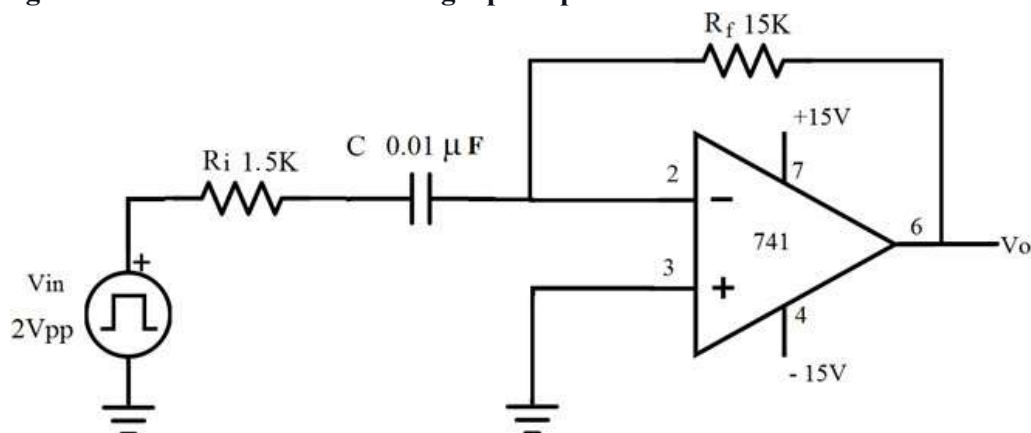
$$V_o = -R_f C d(V_{in})/dt.$$

The differentiator circuit is constructed from basic inverting amplifier by replacing the input resistance R_i with capacitor C . This circuit also works as high pass filter.

Components Required: There are following main components:

1. Dual power supply +/- 15V
2. Function generator (0- 1MHz)
3. Oscilloscope
4. Bread board
5. IC 741C
6. Resistor
7. Capacitor
8. Probes and connecting wires

Circuit Diagram Differentiator Circuit using Op-Amp



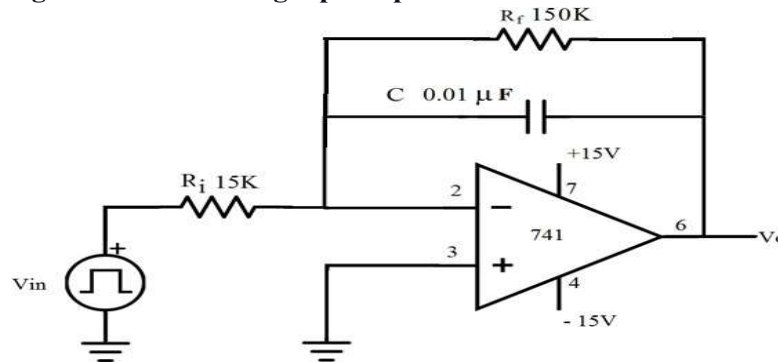
Theory Integrator Circuit using Op-Amp

It is a closed loop op-amp circuit which performs the mathematical operation of integration. That is the output waveform is the integral of the input voltage and is given by

$$V_o = (-1/R_f C) \int V_{in} dt.$$

The integrator circuit is constructed from basic inverting amplifier by replacing the feedback resistance R_f with capacitor C . This circuit also works as low pass filter.

Circuit Diagram Integrator Circuit using Op-Amp



Procedure

1. Check the components.
2. Setup the circuit on the breadboard and check the connections.
3. Switch on the power supply.
4. Keep the oscilloscope in AC coupling mode.
5. Give $V_i = 2V_{pp}$, 1KHz square wave.
6. Observe input and output on two channels of the oscilloscope simultaneously.
7. Note down and draw the input and output waveforms on the graph.

Observation:

The time period and amplitude of the output waveform of differentiator and Integrator circuit

Precautions:

1. Maintain proper V_{cc} levels.
2. Proper wire connection should be made to avoid short circuit of IC.
3. Make null adjustment before applying the input signal.

Results :

मौलाना आजाद राष्ट्रीय प्रौद्योगिकी संस्थान भोपाल

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	प्रयोग 5 Experiment 5		
विभाग Department	इलेक्ट्रॉनिक्स एवं संचार अभियांत्रिकी Electronics & Communication Engineering	सत्र Session:	2024-25
शिक्षक का नाम Name of Teacher	डॉ. राहुल कुमार चौरसिया Dr. Rahul Kumar Chaurasiya	कार्यक्रम Program	बी टेक B Tech
विषय Subject	रैखिक एकीकृत सर्किट प्रयोगशाला (EC-226) Linear Integrated Circuits Lab (EC-226)	सेमेस्टर Semester	IV

Objective: Design adder and subtractor Circuits using Op-Amp

ADDER Circuit using Op-Amp

Theory: Adder Circuit using Op-Amp

Op-amp can be used to design a circuit whose output is the sum of several input signals. Such a circuit is called a summing amplifier or an adder. Summing amplifier can be classified as inverting & non-inverting summer depending on the input applied to inverting & non-inverting terminals respectively. Circuit Diagram shows an inverting summing amplifier with 2 inputs. Here the output will be amplified version of the sum of the two input voltages with 180° phase reversal.

$$V_o = - (R_f / R_i)(V_1 + V_2)$$

Theory: Subtractor Circuit using Op-Amp

A difference amplifier is a circuit that gives the amplified version of the difference of the two inputs, $V_o = A(V_1 - V_2)$, Where V_1 and V_2 are the inputs and A is the voltage gain. Here input voltage V_1 is connected to non-inverting terminal and V_2 to the inverting terminal. This is also called as differential amplifier. Output of a differential amplifier can be determined using super position theorem. When $V_1 = 0$, the circuit becomes an inverting amplifier with input V_2 and the resulting output is $V_{o2} = -R_f / R_i (V_2)$. When $V_2 = 0$, the circuit becomes a non-inverting amplifier with input V_1 and the resulting output is $V_{o1} = R_f / R_i (V_1)$.

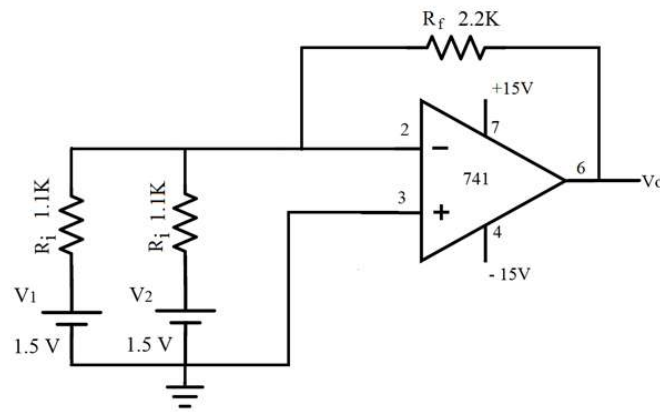
Therefore the resulting output according to super position theorem is

$$V_o = V_{o1} + V_{o2} = R_f / R_i (V_1 - V_2)$$

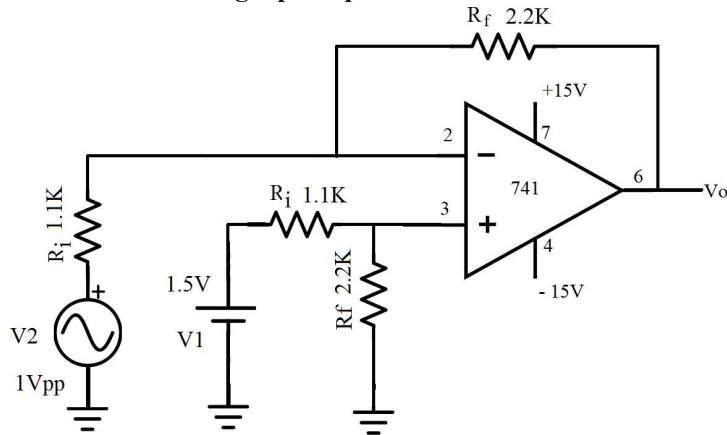
Components Required: There are following main components:

1. Dual power supply $\pm 15V$
2. DC power source $1.5V$
3. Function generator (0- 1MHz)
4. Oscilloscope
5. Bread board
6. IC 741C
7. Resistor
8. Probes and connecting wires

Circuit Diagram: Adder Circuit using Op-Amp



Circuit Diagram: Subtractor Circuit using Op-Amp



Procedure: Adder Circuit using Op-Amp

1. Check the components.
2. Setup the circuit on the breadboard and check the connections.
3. Switch on the power supply.
4. Give $V_1 = V_2 = +1.5\text{V}$ DC with polarity as shown in fig.1.
5. Make sure that the CRO selector is in the D.C. coupling position.
6. Observe input and output on two channels of the oscilloscope simultaneously.
7. Note down and draw the input and output waveforms on the graph.
8. Verify that the output voltage
9. Repeat the procedure with $V_1 = 1\text{Vpp} / 1\text{ KHz}$ sine wave and $V_2 = +1.5\text{Vdc}$
10. Verify the output .

Procedure: Subtractor Circuit using Op-Amp

1. Check the components.
2. Setup the circuit on the breadboard and check the connections.
3. Switch on the power supply.
4. Give $V_1 = +1.5\text{V}$ DC with polarity as shown.
5. Give $V_2 = 1\text{Vpp} / 1\text{ KHz}$ sine wave.
6. Make sure that the oscilloscope coupling selector is in the D.C. position.
7. Observe input and output on oscilloscope simultaneously.
8. Note down and draw the input and output waveforms on the graph

Observation: Adder Circuit using Op-Amp**Part1:**

$V_1 = 1.5 \text{ DC}$

$V_2 = 1.5 \text{ DC}$

Then $V_o = ?$

Part2:

$V_1 = 1 \text{ Vpp sine wave}$

$V_2 = 1.5 \text{ DC}$

Then $V_o = ?$

Observation: Subtractor Circuit using Op-Amp

$V_1 = 1.5 \text{ DC}$

$V_2 = 1 \text{ Vpp sine wave}$

Then $V_o = ?$

Precautions:

1. Maintain proper V_{cc} levels.
2. Proper wire connection should be made to avoid short circuit of IC.
3. Make null adjustment before applying the input signal.

Results :

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	प्रयोग 6 Experiment 6		
विभाग Department	इलेक्ट्रॉनिक्स एवं संचार अभियांत्रिकी Electronics & Communication Engineering	सत्र Session:	2024-25
शिक्षक का नाम Name of Teacher	डॉ. राहुल कुमार चौरसिया Dr. Rahul Kumar Chaurasiya	कार्यक्रम Program	बी टेक B Tech
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Objective: Design a Function Generator using Op-Amp

Theory:

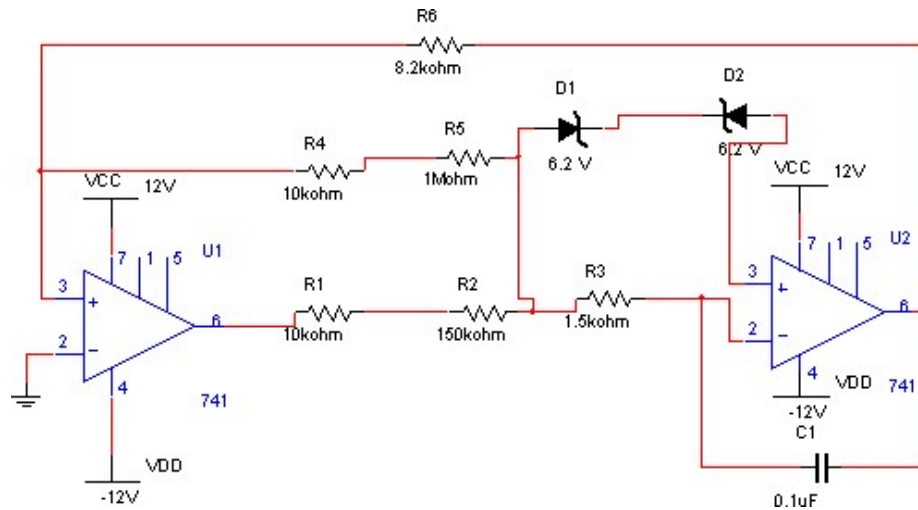
The function generator consists of a comparator U1 and an integrator A2. The comparator U2 compares the voltage at point P continuously with the inverting input i.e., at zero volts. When voltage at P goes slightly below or above zero volts, the output of U1 is at the negative or positive saturation level, respectively.

To illustrate the circuit operation let us set the output of U1 at positive saturation $+V_{sat}$ (approximately $+V_{cc}$). This $+V_{sat}$ is an input to the integrator U2. The output of U2, therefore will be a negative going ramp. Thus, one end of the voltage divider R2-R3 is the positive saturation voltage $+V_{sat}$ of U1 and the other is the negative going ramp of U2. When the negative going ramp attains a certain value $-V_{ramp}$, point p is slightly below zero volts; hence the output of U1 will switch from positive saturation to negative saturation $-V_{sat}$ (approximately $-V_{cc}$). This means that the output of U2 will now stop going negatively and will begin to go positively. The output of U2 will continue to increase until it reaches $+V_{ramp}$. At this time the point P is slightly above zero volts. The sequence then repeats. The frequencies of the square wave function of the d.c supply voltage. Desired amplitude can be obtained by using approximate zener sat the output of U1.

Components Required: There are following main components:

1. Op-Amp IC 741 –2 Nos
2. Bread board IC trainer
3. Capacitor $0.1\mu F$
4. Zener diodes (6.2V)—2 Nos
5. Resistors— $10K\Omega$, $150K\Omega$, $1.5K\Omega$, $1M\Omega$, $8.2K\Omega$ CRO
6. Patch cards
7. Connecting wires

Circuit Diagram:



Procedure:

1. The circuit is connected as shown in circuit diagram.
2. The output of the comparator U1 is connected to the CRO through channel 1, to generate a square wave.
3. The output of the comparator U2 is connected to the CRO through channel 2, to generate a triangular wave.
4. The time periods of the square wave and triangular waves are noted and they are found to be equal.

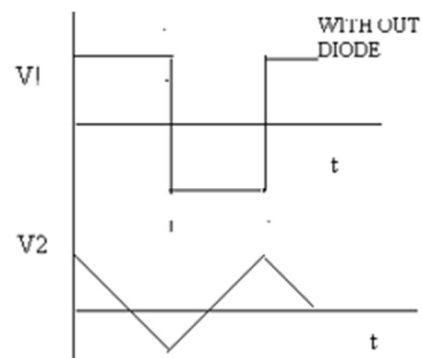
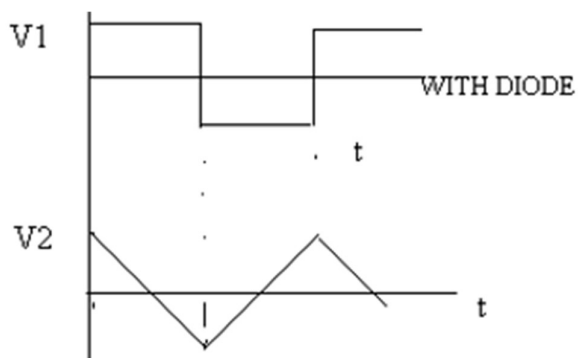
Observation:

Time periods of triangular wave=

Time periods of square wave=

Positive peak ramp=

Voltage of square wave=



Graph :

Precautions:

1. Maintain proper Vcc levels.
2. Proper wire connection should be made to avoid short circuit of IC.
3. Make null adjustment before applying the input signal.

Results :

मौलाना आजाद राष्ट्रीय प्रौद्योगिकी संस्थान भोपाल

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	प्रयोग 7 Experiment 7		
विभाग Department	इलेक्ट्रॉनिक्स एवं संचार अभियांत्रिकी Electronics & Communication Engineering	सत्र Session:	2024-25
शिक्षक का नाम Name of Teacher	डॉ. राहुल कुमार चौरसिया Dr. Rahul Kumar Chaurasiya	कार्यक्रम Program	बी टेक B Tech
विषय Subject	रैखिक एकीकृत सर्किट प्रयोगशाला (EC-226) Linear Integrated Circuits Lab (EC-226)	सेमेस्टर Semester	IV

Objective: Design a Schmitt trigger circuit using Op-Amp

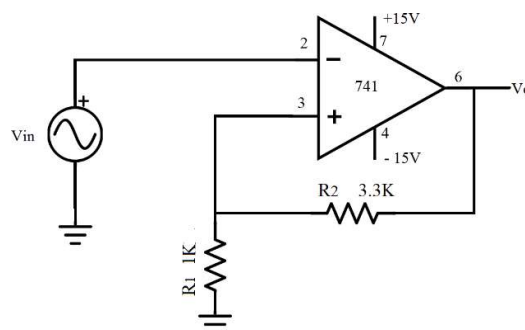
Theory:

It is a regenerative comparator or it is a comparator with hysteresis. This circuit uses positive feedback and the op-amp is operated in saturation. The output can take two values $+V_{sat}$ and $-V_{sat}$. When output = $+V_{sat}$, the voltage appearing at the non-inverting terminal is V_{UT} or $UTP = +V_{sat} (R_1/R_1 + R_2)$ called the upper threshold point. Similarly When output = $-V_{sat}$, the voltage appearing at the non-inverting terminal is V_{LT} or $LTP = -V_{sat} (R_1/R_1 + R_2)$ called the lower threshold point. When V_{in} is greater than UTP, the output will switch from $+V_{sat}$ to $-V_{sat}$. Similarly When V_{in} is less than LTP; the output will switch from $-V_{sat}$ to $+V_{sat}$ which is shown in the graph. The difference between UTP-LTP is called hysteresis. Hysteresis avoids false triggering of the circuit by noise. Hysteresis curve is the plot of V_o versus V_{in} . It is used to convert any irregular wave into square wave.

Components Required: There are following main components:

1. Dual power supply $\pm 15V$
2. Function generator (0- 1MHz)
3. Oscilloscope
4. Bread board
5. IC 741C
6. Resistor
7. Probes and connecting wires

Circuit Diagram:



Design:

$$UTP = +V_{sat} (R_1/R_1+R_2)$$

Let $UTP = +3V$

$$LTP = -3V, V_{sat}=+13V$$

$$UTP, +3 = +13 (R_1/R_1+R_2)$$

Let $R_1 = 1 K\Omega$

Then $R_2 = 3.3K\Omega$

.

Procedure:

1. Check the components.
2. Setup the circuit on the breadboard and check the connections.
3. Switch on the power supply.
4. Give $V_i = 10 V_{pp} / 1KHz$ sine wave.
5. Observe input and output on two channels of oscilloscope simultaneously.
6. Note down and draw the input and output waveforms on the graph.

Observation:

UTP =

LTP =

Precautions:

4. Maintain proper V_{cc} levels.
5. Proper wire connection should be made to avoid short circuit of IC.
6. Make null adjustment before applying the input signal.

Results :

मौलाना आजाद राष्ट्रीय प्रौद्योगिकी संस्थान भोपाल

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	प्रयोग 8 Experiment 8		
विभाग Department	इलेक्ट्रॉनिक्स एवं संचार अभियांत्रिकी Electronics & Communication Engineering	सत्र Session:	2024-25
शिक्षक का नाम Name of Teacher	डॉ. राहुल कुमार चौरसिया Dr. Rahul Kumar Chaurasiya	कार्यक्रम Program	बी टेक B Tech
विषय Subject	रैखिक एकीकृत सर्किट प्रयोगशाला (EC-226) Linear Integrated Circuits Lab (EC-226)	सेमेस्टर Semester	IV

Objective: Design an Astable multi-vibrator using Op-Amp

Theory:

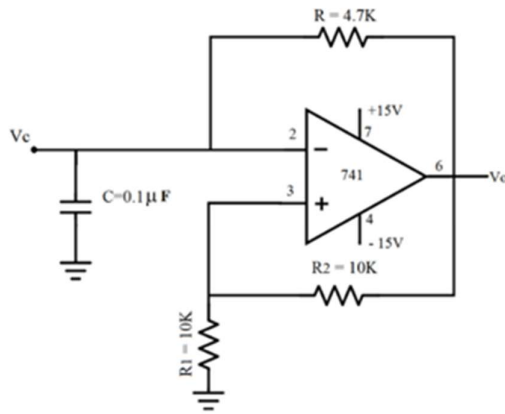
In this circuit, the opamp is operated in saturation mode and the output swings between $+V_{sat}$ and $-V_{sat}$ giving square wave output. This circuit is also called free running oscillator or square wave generator. A positive feedback with feedback factor

$\beta = R_1 / (R_1 + R_2)$ is provided to the non-inverting terminal. When $V_o = +V_{sat}$, the capacitor C starts to charge to $+V_{sat}$ through R . when the capacitor voltage crosses $+\beta V_{sat}$, output switches from $+V_{sat}$ to $-V_{sat}$. Now the voltage appearing at the non-inverting terminal is $-\beta V_{sat}$ and capacitor discharges through R towards $-V_{sat}$. When the capacitor voltage crosses $-\beta V_{sat}$, the output switches from $-V_{sat}$ to $+V_{sat}$ and this process continues to generate square wave output with time period $T = T_{on} + T_{off} = 2RC \ln[(1+\beta)/(1-\beta)]$. In asymmetrical astable multivibrators, the charging and discharging time of capacitor is made unequal to get asymmetrical square wave with different T_{on} and T_{off} .

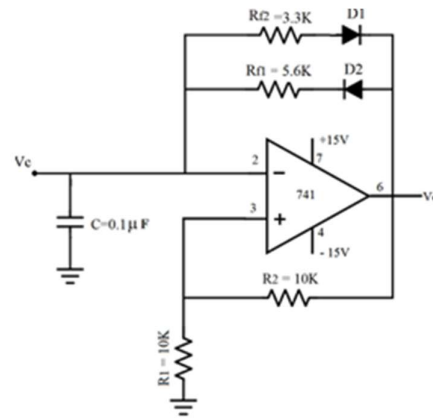
Components Required: There are following main components:

1. Dual power supply $\pm 15V$
2. Function generator (0- 1MHz)
3. Oscilloscope
4. Bread board
5. IC 741C
6. Resistor
7. Capacitor $0.1\mu F$
8. Diode 1N4001
9. Probes and connecting wires

Circuit Diagram:



Symmetrical Astable Multivibrator



Asymmetrical Astable Multivibrator

Design: Symmetrical Astable Multivibrator

Given $f = 1 \text{ KHz}$
So $T = 1/f = 1 \text{ ms}$
And $\beta = R_1 / (R_1 + R_2)$
Let $R_1 = 10 \text{ K}\Omega$, and $R_2 = 10 \text{ K}\Omega$
Then $\beta = 0.5$
Therefore $T = 2.2RC = 1 \text{ ms}$
Let $C = 0.1 \mu\text{F}$ Then
 $R = 4.7 \text{ K}\Omega$

Design: Asymmetrical Astable Multivibrator

Given $f = 1 \text{ KHz}$
So $T = T_{\text{on}} + T_{\text{off}} = 1/f = 1 \text{ ms}$
Also Duty cycle $= T_{\text{on}} / (T_{\text{on}} + T_{\text{off}}) = 0.66$ or 66% Solving above two equations, $T_{\text{on}} = 0.66 \text{ ms}$
 $T_{\text{off}} = 0.33 \text{ ms}$
For $\beta = 0.5$,
 $T_{\text{on}} = 1.1 R_{f1} C = 0.66 \text{ ms}$
Let $C = 0.1 \mu\text{F}$
Then $R_{f1} = 6.2 \text{ K}\Omega = 5.6 \text{ K}\Omega$ (Std)
Similarly $T_{\text{off}} = 1.1 R_{f2} C = 0.33 \text{ ms}$
Then $R_{f2} = 3 \text{ K}\Omega = 3.3 \text{ K}\Omega$ (Std)

Procedure:

1. Check the components.
2. Setup the symmetric astable multivibrator circuit on the breadboard and check the connections.
3. Switch on the power supply.
4. Observe output and capacitor voltage on two channels of the oscilloscope simultaneously.
5. Draw the waveforms on the graph.
6. Measure the frequency of oscillation and duty cycle.
7. Repeat the procedures for asymmetric astable multivibrator..

Observation:**a) Symmetrical astable multivibrators** $V_o(p-p) =$ $f =$

Duty cycle =

b) Asymmetrical astable multivibrators $V_o(p-p) =$ $f =$

Duty cycle =

Precautions:

- a. Maintain proper V_{cc} levels.
- b. Proper wire connection should be made to avoid short circuit of IC.
- c. Make null adjustment before applying the input signal.

Results :

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	प्रयोग 9 Experiment 9		
विभाग Department	इलेक्ट्रॉनिक्स एवं संचार अभियांत्रिकी Electronics & Communication Engineering	सत्र Session:	2024-25
शिक्षक का नाम Name of Teacher	डॉ. राहुल कुमार चौरसिया Dr. Rahul Kumar Chaurasiya	कार्यक्रम Program	बी टेक B Tech
विषय Subject	रैखिक एकीकृत सर्किट प्रयोगशाला (EC-226) Linear Integrated Circuits Lab (EC-226)	सेमेस्टर Semester	IV

Objective: Design a Bistable multi-vibrator using Op-Amp

Theory:

An operational amplifier can be used as a bistable multivibrator. An incoming waveform is converted into short pulses and these are used to trigger the operational amplifier to change between its two saturation states. To prevent small levels of noise triggering the circuit, hysteresis is introduced into the circuit.

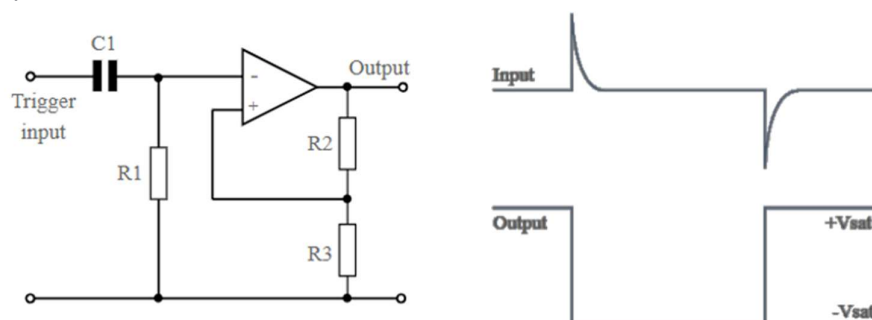
The bistable circuit has two stable states. These are the positive and negative saturation voltages of the operational amplifier operating with the given supply voltages. The circuit can then be switched between them by applying pulses. A negative going pulse will switch the circuit into the positive saturation voltage, and a positive going pulse will switch it into the negative state.

The positive going pulses need to be greater than V_{O-Sat} through the potential divider, i.e. $-V_{sat} \times R_3 / (R_2 + R_3)$, and similarly the negative going pulses will need to be greater than $+V_{sat}$ through the potential divider, i.e. $+V_{sat} \times R_3 / (R_2 + R_3)$. If they are not sufficiently large then the bistable will not change state.

Components Required: There are following main components:

1. Op-Amp IC 741
2. Bread board IC trainer
3. Capacitor
4. Resistors
5. Patch cards
6. Connecting wires

Circuit Diagram:



Bistable Multivibrator Circuit

Procedure:

1. The circuit is connected as shown in circuit diagram.
2. Select appropriate value of R_1 , C_1 , R_2 and R_3 .
3. Apply Input at inverting terminal
4. Observe output waveform at CRO.
5. Record result..

Observation:**Precautions:**

1. Maintain proper V_{cc} levels.
2. Proper wire connection should be made to avoid short circuit of IC.
3. Make null adjustment before applying the input signal.

Results :

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	प्रयोग 10 Experiment 10		
विभाग Department	इलेक्ट्रॉनिक्स एवं संचार अभियांत्रिकी Electronics & Communication Engineering	सत्र Session:	2024-25
शिक्षक का नाम Name of Teacher	डॉ. राहुल कुमार चौरसिया Dr. Rahul Kumar Chaurasiya	कार्यक्रम Program	बी टेक B Tech
विषय Subject	रैखिक एकीकृत सर्किट प्रयोगशाला (EC-226) Linear Integrated Circuits Lab (EC-226)	सेमेस्टर Semester	IV

Objective: Design second order Butterworth filter using Op-Amp

Theory:

An additional RC network connected to the first order Butterworth filter gives a second order low pass filter. This second order low pass filter has an advantage that the gain rolls-off very fast after the cut-off frequency, in the stop band.

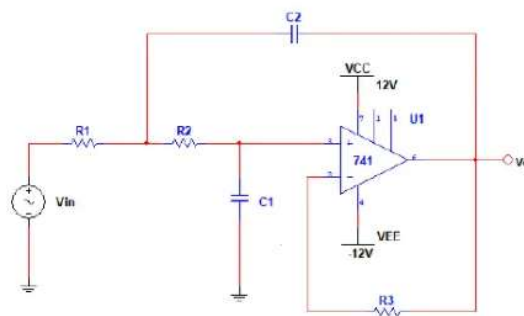
In this second order filter, the cut-off frequency value depends on the resistor and capacitor values of two RC sections. The cut-off frequency is calculated using the below formula.

$$f_c = 1 / (2\pi\sqrt{R^2C^2})$$

Components Required: There are following main components:

1. Op-Amp IC 741
2. Bread board IC trainer
3. Capacitor
4. Multimeter
5. Resistors
6. DSO/CRO
7. Patch cards
8. Connecting wires

Circuit Diagram:



Second Order Butterworth LPF

Procedure:

1. Test the components and build the filter circuit as per circuit diagram.
2. Obtain the frequency response of the filter.
3. Plot the the frequency response of the filter on semi log graph sheet.
4. Find cut-off frequency of the filter using frequency response

Design:

Sl.No.	Steps	Working
1.	Cut off frequency required	$f =$
2.	Choose C_1	$C_1 =$
3.	Choose C_2 such that $C_2 \geq 2C_1$	$C_2 =$
4.	Calculate R_1 and R_2 $R_1 = \frac{\sqrt{2}C_2 - \sqrt{2C_2^2 - 4C_1C_2}}{4\pi f C_1 C_2}$ $R_2 = \frac{\sqrt{2}C_2 + \sqrt{2C_2^2 - 4C_1C_2}}{4\pi f C_1 C_2}$	$R_1 =$ $R_2 =$
5.	Calculate R_3 $R_3 = R_1 + R_2$	$R_3 =$
6.	Calculate cut off frequency $f_L = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}$	$f_L =$

Observation:

Input voltage $V_i(p-p) =$ _____

Frequency	$V_o(p-p)$	Gain $G = \frac{V_{o(p-p)}}{V_{i(p-p)}}$	Gain in dB $G_{dB} = 20\log_{10}(G)$
10Hz			

LPF

Designed cut off frequency: _____

Obtained cut off frequency: _____

Roll off: _____

Precautions:

1. Maintain proper V_{cc} levels.
2. Proper wire connection should be made to avoid short circuit of IC.
3. Make null adjustment before applying the input signal.

Results :

मौलाना आजाद राष्ट्रीय प्रौद्योगिकी संस्थान भोपाल

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	प्रयोग 11 Experiment 11		
विभाग Department	इलेक्ट्रॉनिक्स एवं संचार अभियांत्रिकी Electronics & Communication Engineering	सत्र Session:	2024-25
शिक्षक का नाम Name of Teacher	डॉ. राहुल कुमार चौरसिया Dr. Rahul Kumar Chaurasiya	कार्यक्रम Program	बी टेक B Tech
विषय Subject	रैखिक एकीकृत सर्किट प्रयोगशाला (EC-226) Linear Integrated Circuits Lab (EC-226)	सेमेस्टर Semester	IV

Objective: Design buffer circuit using Op-Amp

Theory:

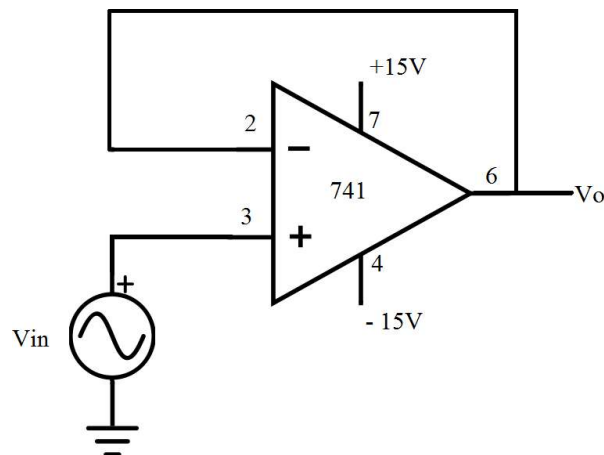
A **voltage buffer**, also known as a **voltage follower**, or a **unity gain amplifier**, is an amplifier with a gain of 1. It's one of the simplest possible op-amp circuits with closed-loop feedback.

Even though a gain of 1 doesn't give any voltage amplification, a buffer is extremely useful because it prevents one stage's input impedance from loading the prior stage's output impedance, which causes undesirable loss of signal transfer.

Components Required: There are following main components:

1. Dual power supply +/- 15V
2. Function generator (0- 1MHz)
3. Oscilloscope
4. Bread board
5. IC 741C
6. Probes and connecting wires

Circuit Diagram:



Buffer Circuit

Design:

The voltage follower is a non-inverting amplifier with unity gain.

$$A = 1 + R_f / R_i = 1$$

Or

$$R_f / R_i = 0$$

Therefore

$$R_f = 0$$

.

Procedure:

1. Check the components.
2. Setup the circuit on the breadboard and check the connections.
3. Switch on the power supply.
4. Give 2V_{pp}/ 1 KHz sine wave as input.
5. Observe input and output on the two channels of the oscilloscope simultaneously.
6. Note down and draw the input and output waveforms on the graph.
7. Verify that the input and output waveforms are same in magnitude and phase.

.

Observation:

V_i =

V_o =

Voltage Gain →

V_o / V_i =

Phase difference between input and output waveforms

Precautions:

1. Maintain proper V_{cc} levels.
2. Proper wire connection should be made to avoid short circuit of IC.
3. Make null adjustment before applying the input signal.

Results :

मौलाना आजाद राष्ट्रीय प्रौद्योगिकी संस्थान भोपाल

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	प्रयोग 12 Experiment 12		
विभाग Department	इलेक्ट्रॉनिक्स एवं संचार अभियांत्रिकी Electronics & Communication Engineering	सत्र Session:	2024-25
शिक्षक का नाम Name of Teacher	डॉ. राहुल कुमार चौरसिया Dr. Rahul Kumar Chaurasiya	कार्यक्रम Program	बी टेक B Tech
विषय Subject	रैखिक एकीकृत सर्किट प्रयोगशाला (EC-226) Linear Integrated Circuits Lab (EC-226)	सेमेस्टर Semester	IV

Objective: Design a precision rectifier using Op-Amp

Theory:

In a normal diode rectifier, the cut in voltage across the diode will result in reduction of output voltage and inaccuracy of rectification.

If ideal rectifier is needed in an application, a precision rectifier may be used.

In the circuit, when the input is greater than zero, D1 will conduct and D2 is OFF, so the output is zero because the other end of R2 is connected to the virtual ground and there is no current through R2.

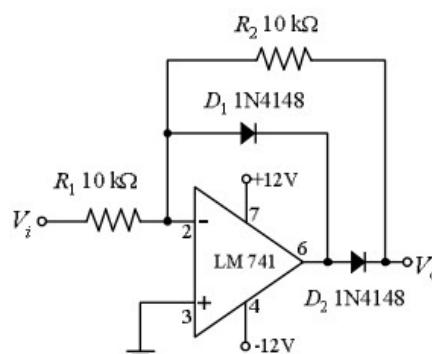
When the input is less than zero, D2 is on, and D1 is off, and the output is similar to that of an inverting amplifier with gain = $-R_1/R_2$

The value of R1 and R2 are selected in such a way that the circuit has reasonable level of input impedance and the gain is unity. Diode D1 and D2 are signal diodes

Components Required: There are following main components:

1. Op-Amp IC 741
2. Dual power supply,
3. CRO,
4. function generator,
5. bread board
6. diodes
7. resistors.
8. Connecting wires

Circuit Diagram:

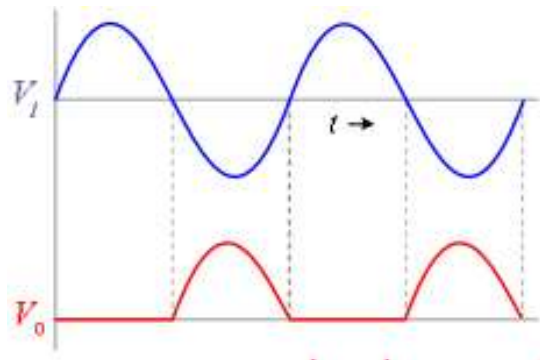


Procedure:

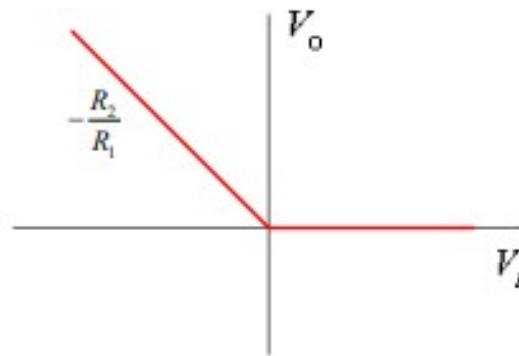
1. Set up the circuit as shown in circuit diagram
2. Give a sine wave of $\pm 5\text{V}$ peak magnitude and 1 kHz frequency at the input and observe the input and output simultaneously on CRO
3. Put the CRO into X-Y mode and connect input signal to X and output signal to Y. Select suitable volt per division in both channels.
4. Observe the characteristics.

Observation:

A) Input and Output waveforms:



B) Transfer Characteristics:

**Precautions:**

1. Maintain proper V_{cc} levels.
2. Proper wire connection should be made to avoid short circuit of IC.
3. Make null adjustment before applying the input signal.

Results:

	प्रयोग 13 Experiment 13		
विभाग Department	इलेक्ट्रॉनिक्स एवं संचार अभियांत्रिकी Electronics & Communication Engineering	सत्र Session:	2024-25
शिक्षक का नाम Name of Teacher	डॉ. राहुल कुमार चौरसिया Dr. Rahul Kumar Chaurasiya	कार्यक्रम Program	बी टेक B Tech
विषय Subject	रैखिक एकीकृत सर्किट प्रयोगशाला (EC-226) Linear Integrated Circuits Lab (EC-226)	सेमेस्टर Semester	IV

Objective: Design and setup a RC phase shift oscillator using Op - Amp 741

Theory:

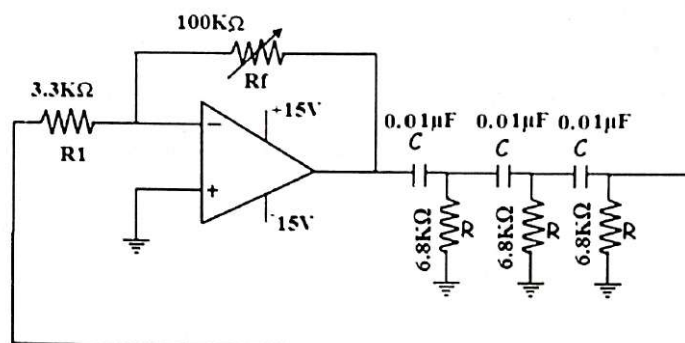
RC phase shift oscillator uses op-amp, in inverting amplifier mode and the circuit generates its own output signal. It consists of an op-amp as an amplifier and 3 RC cascaded network as the feedback circuit. Since the op-amp is used in the inverting mode, any signal that appears at the inverting terminal is shifted by 180° at the output. An additional 180° phase shift required for oscillation is provided by the cascaded RC network. Thus the total phase shift around the circuit is 360° or 0° . At some specific frequency, the phase shift of the cascaded RC network is exactly 180° and feedback factor is $1/29$. If the gain of the amplifier is 29, the total loop gain of the circuit becomes 1. The circuit will oscillate at this specific frequency and is given by

$$f_{\text{oscillation}} = \frac{1}{2\pi RC\sqrt{6}}$$

Components Required: There are following main components:

1. Op-Amp IC 741
2. Dual power supply,
3. CRO,
4. Function generator,
5. Bread board
6. Resistors.
7. Capacitors
8. Connecting wires and Probe

Circuit Diagram:



Procedure:

- 1 Check the components.
- 2 Setup the RC phase shift oscillator circuit on the breadboard and check the connections
- 3 Switch on the power supply.
- 4 Observe output voltage on oscilloscope.
- 5 Draw the waveforms on the graph
- 6 Measure the frequency of oscillation

Observation:

Let $f = 1 \text{ KHz}$

$C = .01 \mu\text{F}$

$R = 6.8 \text{ K}\Omega$

If

$R_1 = 3.3 \text{ K}\Omega$

$R_f = 95.7 \text{ K}\Omega$

Use $100 \text{ K}\Omega$ pot

Measured frequency of oscillation is =

Precautions:

1. Maintain proper V_{cc} levels.
2. Proper wire connection should be made to avoid short circuit of IC.
3. Make null adjustment before applying the input signal.

Results:

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	प्रयोग 14 Experiment 14		
विभाग Department	इलेक्ट्रॉनिक्स एवं संचार अभियांत्रिकी Electronics & Communication Engineering	सत्र Session:	2024-25
शिक्षक का नाम Name of Teacher	डॉ. राहुल कुमार चौरसिया Dr. Rahul Kumar Chaurasiya	कार्यक्रम Program	बी टेक B Tech
विषय Subject	रैखिक एकीकृत सर्किट प्रयोगशाला (EC-226) Linear Integrated Circuits Lab (EC-226)	सेमेस्टर Semester	IV

Objective: Design and construct a Wien bridge oscillator using Op-Amp 741

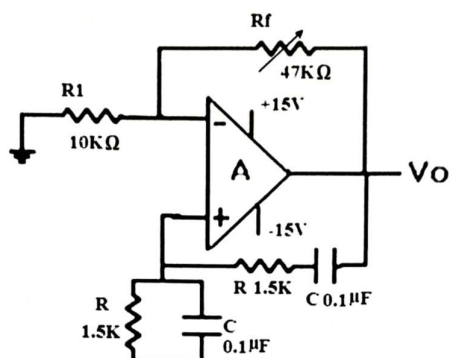
Theory:

It is the commonly used audio frequency oscillator which employs both positive and negative feedback. The feedback signal is connected in the non-inverting input terminal so that the amplifier is working in non-inverting mode. The Wien bridge circuit is connected between amplifier input terminal and output terminal. The bridge has a series RC network in one arm and a parallel RC network in the adjoining arm. In the remaining two arms of the bridge, resistor R_1 and R_f are connected. The phase angle criterion for oscillation is that the total phase shift around the circuit must be zero. This condition occurs when bridge is balanced. At resonance, the frequency of oscillation is exactly the resonance frequency of balanced Wien bridge and is given by $f_0 = 1 / (2\pi RC)$. At this frequency, the gain required for sustained oscillation is 3. It is provided by the non-inverting amplifier with $\text{Gain} = 1 + (R_f / R_1) = 3$

Components Required: There are following main components:

1. Op-Amp IC 741
2. Dual power supply,
3. CRO,
4. Function generator,
5. Bread board
6. Resistors.
7. Capacitors
8. Connecting wires and Probe

Circuit Diagram:



Procedure:

- 7 Check the components.
- 8 Setup the RC phase shift oscillator circuit on the breadboard and check the connections
- 9 Switch on the power supply.
- 10 Observe output voltage on oscilloscope.
- 11 Draw the waveforms on the graph
- 12 Measure the frequency of oscillation

Observation:

Let

$$f = 1 \text{ KHz}$$

$$C = .01 \mu\text{F}$$

$$R = 1.5 \text{ K}\Omega$$

$$\text{GAIN} = 3$$

If $R_1 = 10\text{K}\Omega$, $R_f = 20\text{K}\Omega$ Use $47\text{K}\Omega$ pot

Measured frequency of oscillation is =

Precautions:

- 1 Maintain proper V_{cc} levels.
- 2 Proper wire connections should be made to avoid short circuit of IC.
- 3 Make null adjustment before applying the input signal.

Results: