SHARDA UNIVERSITY
Beyond Boundaries

School of Engineering and Technology

Department of Electronics and Communication Engineering

Lab Manual

For

Analog Electronics Circuit Lab

Mr.Rahul Kumar
(Lab Faculty, Lab In-charge)

SHARDA UNIVERSITY
Beyond Boundaries

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List of Experiment

1. To study the characteristics of BJT in CB configuration.
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3. Measurement of Operational Amplifier parameters- Common Mode Gain, Differential Mode Gain , CMMR.
4. Application of Op-Amp as Summing Amplifier.
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6. Applications of Op-amp as Integrator.
7. Applications of Op-amp as Differentiator.
8. To study positive feedback and negative feedback Amplifier
9. To study Phase Shift Oscillator.
10. To study Wein Bridge Oscillator.

To do in Laboratory

- **Be regular in the laboratory.**
- **Always follow proper dress in laboratory.**
- **Keep silence in laboratory.**
- **Know the theory behind the experiment which you are going to perform in laboratory.**
- **Identify the different leads or terminals or pins of the Transistor, IC making the connection.**
- **Know the biasing voltage required for different families of Transistor, ICs and connect the power supply voltage and ground terminals to the respective pins of Transistor, IC's.**
- **Know the current and voltage rating of Transistor, IC's before using them in experiment.**
- **Avoid unnecessary talking during the performing the experiment.**
- **Handle the Transistor or IC Kit properly and Mount the IC properly on the IC Ziff socket.**
- **Keep the table clean.**
- **After the completion of experiment switched off the power supply and return the apparatus.**
- **To make sign your every experiment after completion.**

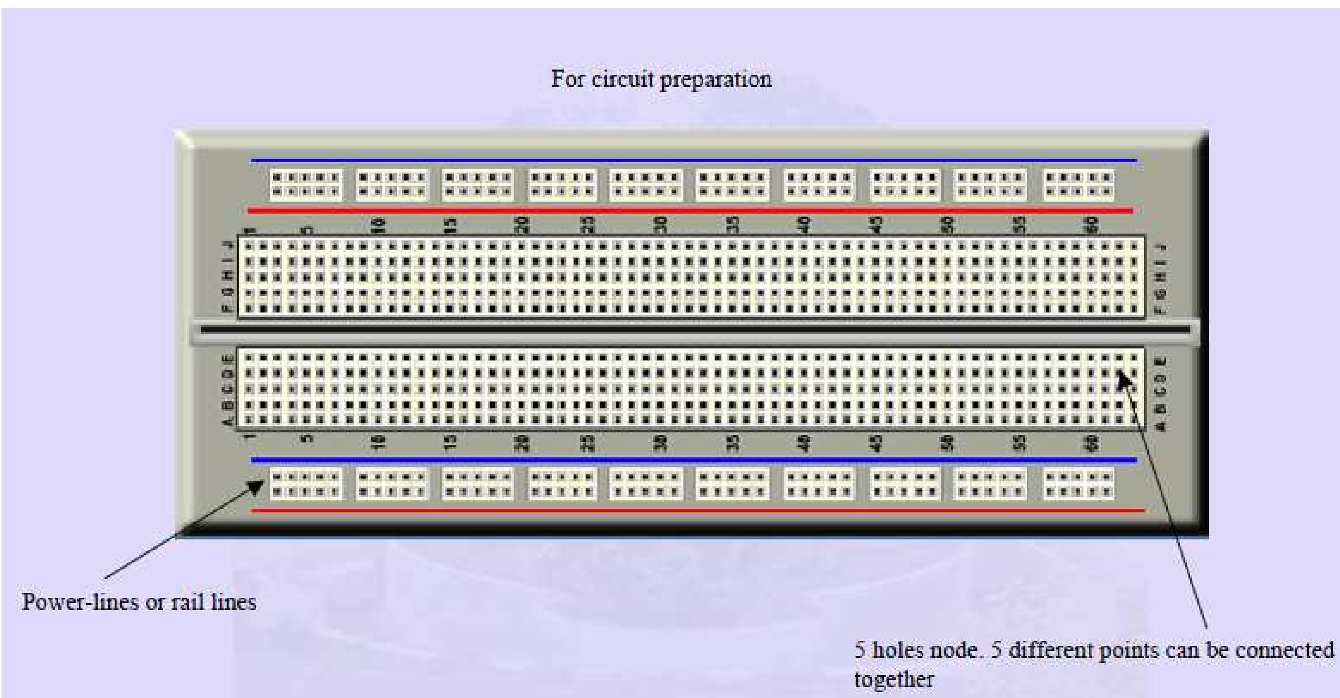
Not to do in Laboratory

- **Do not exceed the Voltage Rating.**
- **Do not alter the Transistor or IC's when you are performing the experiment.**
- **Avoid the loose connections and short circuits.**
- **Do not throw the connecting wires on the floor.**
- **Do not come late into the laboratory.**
- **Do not operate Transistor or IC Trainer kits unnecessarily.**
- **Do not so panic if you do not get desired output.**

Breadboard

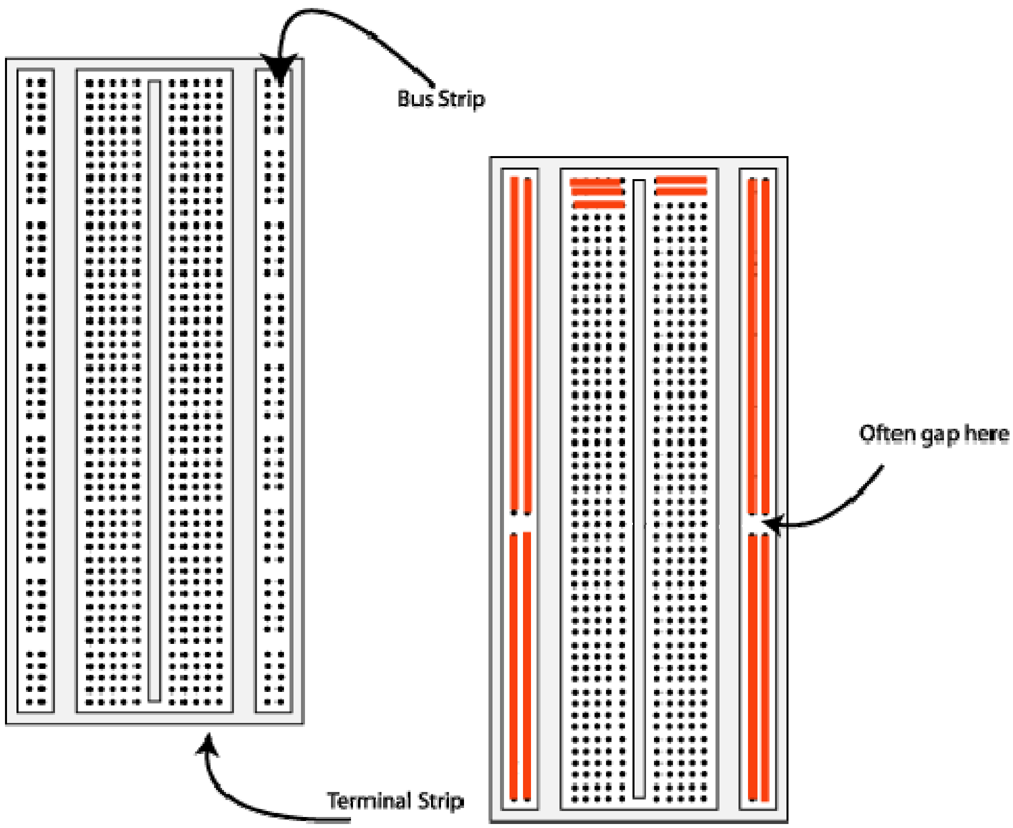
The breadboard consists of two terminal strips and two bus strips (often broken in the center). Each bus strip has two rows of contacts. Each of the two rows of contacts are a node. That is, each contact along a row on a bus strip is connected together (inside the breadboard). Bus strips are used primarily for power supply connections, but are also used for any node requiring a large number of connections. Each terminal strip has 60 rows and 5 columns of contacts on each side of the center gap. Each row of 5 contacts is a node.

You will build your circuits on the terminal strips by inserting the leads of circuit components into the contact receptacles and making connections with 22-26 gauge wire. There are wire cutter/strippers and a spool of wire in the lab. It is a good practice to wire +5V and 0V power supply connections to separate bus strips.



A breadboard is used to build and test circuits quickly before finalizing any circuit design. The breadboard has many holes into which circuit components like Transistor, ICs and resistors can be inserted.
The bread board has strips of metal which run underneath the board and connect the holes on the top of the board. The metal strips are laid out as shown below.

Note that the top and bottom rows of holes are connected horizontally while the remaining holes are connected vertically.



Working of Breadboard

The 5V supply must not be exceeded since this will damage the Transistor, ICs (Integrated circuits) used during the experiments. Incorrect connection of power to the ICs could result in them exploding or becoming very hot - with the possible serious injury occurring to the people working on the experiment! Ensure that the power supply polarity and all components and connections are correct before switching on power.

Bread boarding Tips

It is important to breadboard a circuit neatly and systematically, so that one can debug it and get it running easily and quickly. It also helps when someone else needs to understand and inspect the circuit. Here are some tips:

1. Always use the side-lines for power supply connections. Power the chips from the side-lines and not directly from the power supply.

2. Use black wires for ground connections (0V), and red for other power connections.
3. Keep the jumper wires on the board flat, so that the board does not look cluttered.
4. Route jumper wires around the chips and not over the chips. This makes changing the chips when needed easier.
5. You could trim the legs of components like resistors, transistors and LEDs, so that they fit in snugly and do not get pulled out by accident.

Common Causes of Problems

1. Not connecting the ground and/or power pins for all chips.
2. Not turning on the power supply before checking the operation of the circuit.
3. Leaving out wires.
4. Plugging wires into the wrong holes.
5. Driving a single gate input with the outputs of two or more gates
6. Modifying the circuit with the power on.

INDEX

Exp No.	Title of Experiment	Remarks	Date	Sign
1.	To study the characteristics of BJT in CB configuration.			
2.	To study the characteristics of BJT in CE configuration.			
3.	Measurement of Operational Amplifier parameters- Common Mode Gain, Differential Mode Gain, CMMR.			
4.	Application of Op-Amp as Summing Amplifier.			
5.	Application of Op-Amp as Difference Amplifier.			
6.	Applications of Op-amp as Integrator.			
7.	Applications of Op-amp as Differentiator.			
8.	To study positive feedback and negative feedback Amplifier.			
9.	To study Phase Shift Oscillator.			
10.	To study Wein Bridge Oscillator.			

Experiment No-1

OBJECT - To study the characteristics of BJT in common base configuration.

APPARATUS REQUIRED:

S.N.	APPARATUS NAME	QUANTITY	SPECIFICATION
1.	Trainer Kit (NPN Transistor)	1	
2.	Regulated power supply	1	
3.	Electronic Multimeter	1	
4.	Connecting wires		

THEORY: Transistor is a three layer semiconductor device. Layers are emitter, base, collector. Transistors are two types namely NPN and PNP. We use widely NPN type transistor because in NPN transistor majority charge carriers are electrons and they have greater mobility than holes. Transistors are widely used for the amplification of the signals. For amplification purpose transistor should work in active mode. In active mode, emitter-base junction is forward biased and collector base junction is reverse biased. There are three configuration of BJT in active mode:

1. BJT in CB Configuration
2. BJT in CE Configuration
3. BJT in CC configuration

COMMON BASE CONFIGURATION: If the transistor is connected as base terminal of BJT is common to both the input as well as output sides this circuit arrangement is known as CB configuration. Fig(1) depicts a CB configuration of a NPN transistor.

CIRCUIT DIAGRAM:

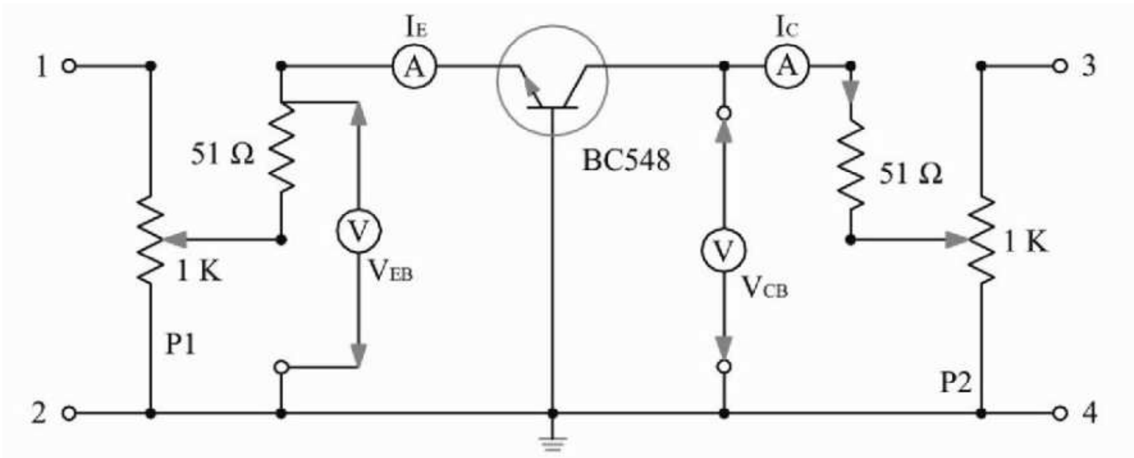


Fig.(1)

CB configuration of NPN transistor has two characteristics:

1- Input characteristics
2- Output characteristics

INPUT CHARACTERISTICS: The input characteristics relates an input current I_E to an input voltage V_{BE} for various levels of output voltage V_{CB} .

OUTPUT CHARATERISTICS: The output characteristics relates an output current I_C to an output voltage V_{CB} for various levels of input current I_E .

PROCEDURE:

For input characteristics:

1. Make the connections according to circuit diagram.

2. Firstly, set the output voltage V_{CB}.

3. Read the values of I_E increasing with V_{BE} and write in observation table.

4. Set the V_{CB} on different values and repeat the above process.

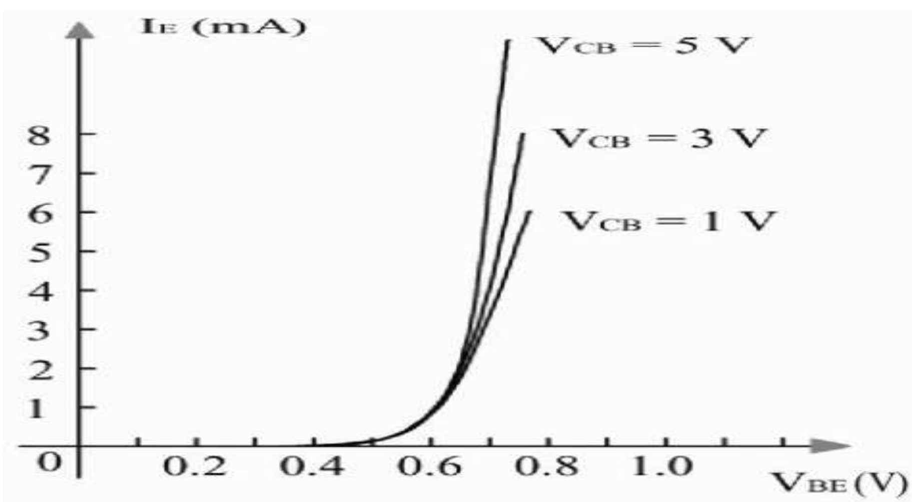
For output characteristics:

1. Make the connections according to circuit diagram.
2. Firstly, set the input current I_E .
3. Read the values of I_C, increasing with V_{CB} and write in observation table.
4. Set the I_E on different values and repeat the above process.

OBSERVATION TABLES:

FOR INPUT CHARACTERISTICS

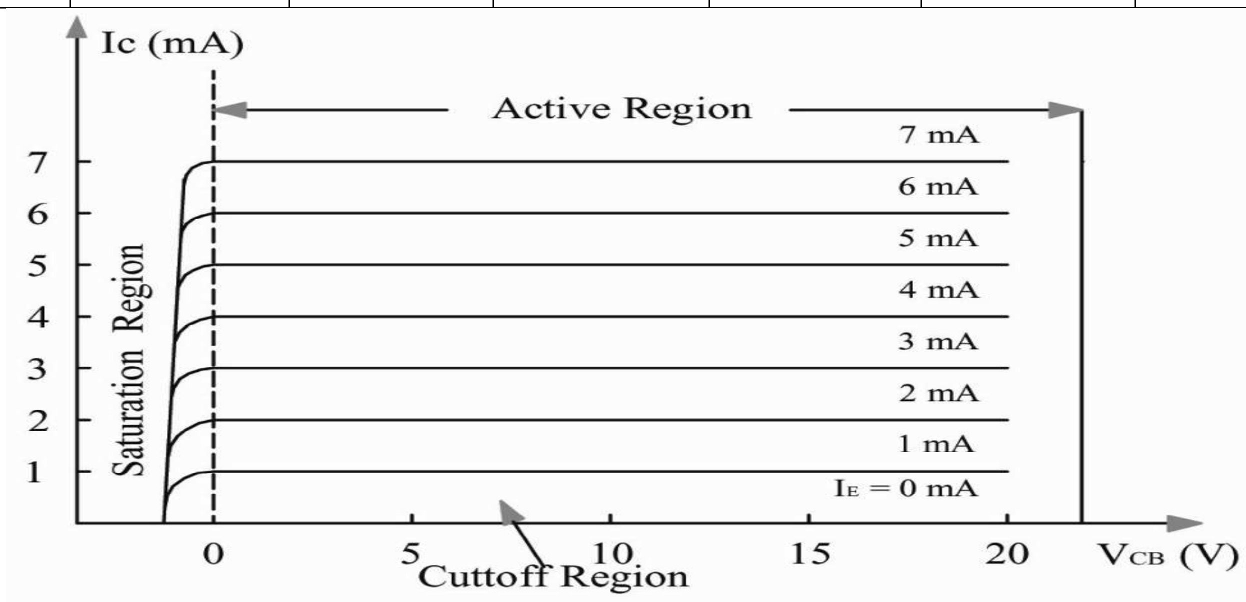
S.N	V_{CB} = 5 (V)		V_{CB}= 3 (V)	
	V_{BE} (V)	I_E (mA)	V_{BE} (V)	I_E (mA)
1.				
2.				
3.				
4.				



Input characteristics curve

FOR OUTPUT CHARACTERISTICS

S. N	I_E= 0(mA)		I_E=10(mA)		I_E=20(mA)		I_E=30(mA)		I_E=40(mA)		I_E=50(mA)	
	V_{CB}	I_C	V_{CB}	I_C	V_{CB}	I_C	V_{CB}	I_C	V_{CB}	I_C	V_{CB}	I_C
1.												
2.												
3.												
4.												



Output characteristics curve

CALCULATION:Transistor parameters

1.Input dynamic resistance

$r_i = \Delta V_{BE} / \Delta I_E \big|_{V_{CB}}$ = ………..Ω

2.Output dynamic resistance

$ro = \Delta V_{CB} / \Delta I_C \big|_{I_E}$ =……………Ω

3. Current gain

$\alpha = I_C/I_E$ =…………

RESULTS:

1. Draw the input & output characteristic on the graph paper
2. Input characteristics are quite similar to forward biased diode.
3. Output characteristics of this configuration are constant characteristics.

PRECAUTIONS:

1. All connections should be tight.
2. Terminal voltage should not exceed the break down voltage of transistor.
3. Do not touch any wire when you are performing the experiment.
4. Take reading carefully.

Experiment No-2

OBJECT - To study the characteristics of BJT in common emitter configuration.

APPARATUS REQUIRED:

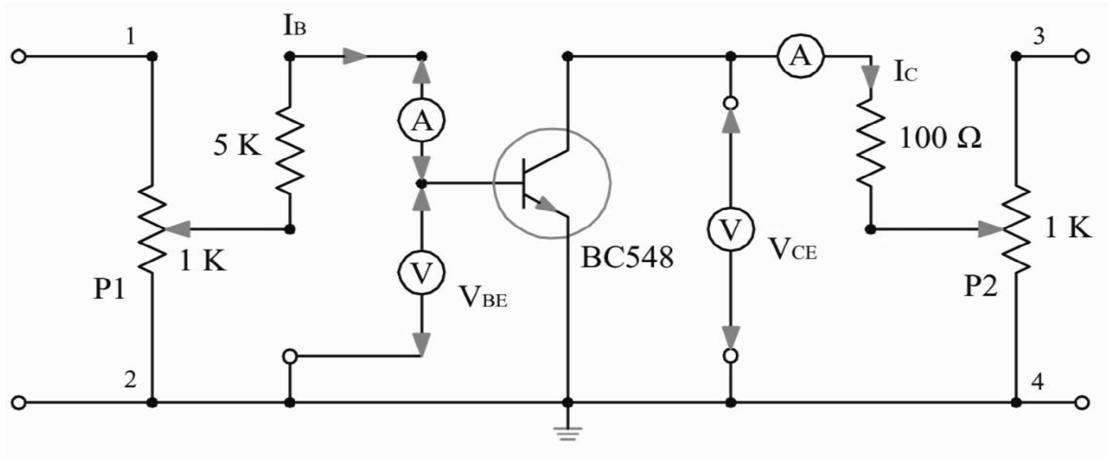
S.N.	APPARATUS NAME	QUANTITY	SPECIFICATION
1.	Trainer Kit (NPN Transistor)	1	
2.	Regulated power supply	1	
3.	Electronic Multimeter	1	
4.	Connecting wires		

THEORY: Transistor is a three layer semiconductor device. Layers are emitter, base, collector. Transistors are two types namely NPN and PNP. We use widely NPN type transistor because in NPN transistor majority charge carriers are electrons and they have greater mobility than holes mobility. Transistors are widely used for the amplification of the signals. For amplification purpose transistor should work in active mode. In active mode, emitter-base junction is forward biased and collector base junction is reverse biased. There are three configuration of BJT in active mode:

1. BJT in CB Configuration
2. BJT in CE Configuration
3. BJT in CC configuration

COMMON EMITTER CONFIGURATION: If the transistor is connected as emitter terminal of the transistor is common to both the input as well as output sides this arrangement is known as CE configuration. Fig(1) depicts a CE configuration of a NPN transistor.

CIRCUIT DIAGRAM:



Fig(1)

CE configuration of NPN transistor has two characteristics:

3- Input characteristics

4- Output characteristics

INPUT CHARACTERISTICS: The input characteristics relates an input current I_B to an input voltage V_{BE} for various levels of output voltage V_{CE} .

OUTPUT CHARATERISTICS: The output characteristics relates an output current I_C to an output voltage V_{CE} for various levels of input current I_B .

PROCEDURE:

For input characteristics:

1. Make the connections according to circuit diagram.

2. Firstly, set the output voltage V_{CE} .

3. Read the values of I_B , increasing with V_{BE} and write in observation table.

4. Set the V_{CE} on different values and repeat the above process.

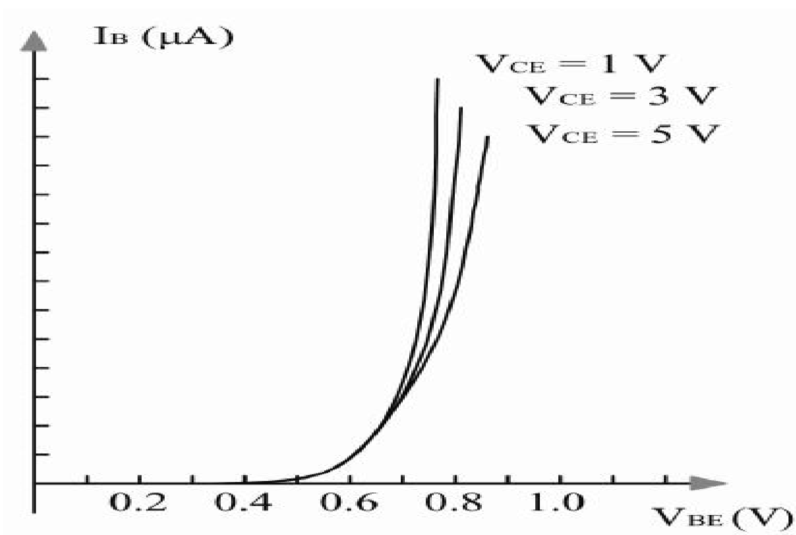
For output characteristics:

1. Make the connections according to circuit diagram.
2. Firstly, set the input current I_B .
3. Read the values of I_C, increasing with V_{CE} and write in observation table.
4. Set the I_B on different values and repeat the above process.

OBSERVATION TABLES:

FOR INPUT CHARACTERISTICS:

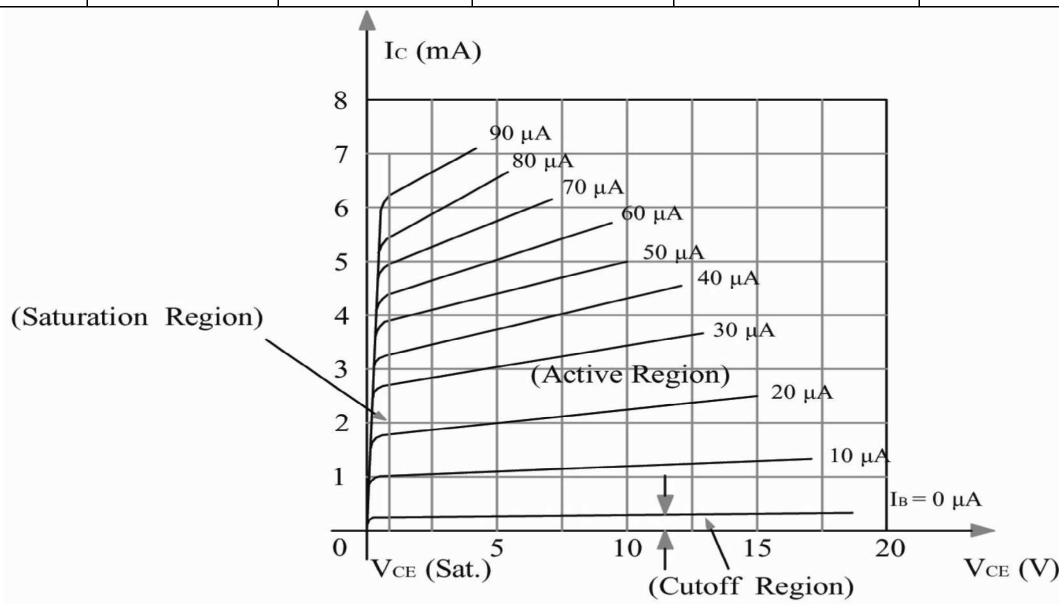
S.N	V_{CE} = 5 (V)		V_{CE}= 3 (V)	
	V_{BE} (V)	I_B (μA)	V_{BE} (V)	I_B (μA)
1.				
2.				
3.				
4.				



Input characteristics curve

FOR OUTPUT CHARACTERISTICS

S.N	I_B= 0(μA)	I_B=10(μA)	I_B=20(μA)	I_B=30(μA)	I_B=40(μA)	I_B=50(μA)
	V_{CB} I_C	V_{CB} I_C	V_{CB} I_C	V_{CB} I_C	V_{CB} I_C	V_{CB} I_C
1.						
2.						
3.						
4.						



Output characteristics curve

CALCULATION:

Transistor parameters

1. Input dynamic resistance

   $r_i = \Delta V_{BE} / \Delta I_B \big| V_{CE}$ = ...Ω

2. Output dynamic resistance

   $r_o = \Delta V_{CE} / \Delta I_C \big| I_B$ =..............Ω

3. Current gain

   $\beta = I_C/I_B$ =...........

RESULTS:

1. Draw the input & output characteristic on the graph paper
2. Input characteristics are quite similar to forward biased diode.
3. Output characteristics of this configuration are constant characteristics.

PRECAUTIONS:

1. All connections should be tight.
2. Terminal voltage should not exceed the break down voltage of transistor.
3. Do not touch any wire when you are performing the experiment.
4. Take reading carefully.

Experiment No-3

OBJECTIVE:- Measurement of Operational Amplifier parameters- Common Mode Gain, Differential Mode Gain, CMMR.

APPARATUS REQUIRED:

Power supply, CRO, Function Generator, Multi meter, Resistors, IC741 op-amp, Bread board and wires.

THEORY:

An op-amp is a high gain, direct coupled differential linear amplifier choose response characteristics are externally controlled by negative feedback from the output to input, op-amp has very high input impedance, typically a few mega ohms and low output impedance, less than 100Ω.Op-amps can perform mathematical operations like summation, integration, differentiation, logarithm, anti-logarithm, etc., and hence the name operational amplifier. Op-amps are also used as video and audio amplifiers, oscillators, in communication electronics, in instrumentation and control, in medical electronics, etc.

Circuit symbol and op-amp terminals:

The circuit schematic of an op-amp is a triangle as shown below in Fig. 1 op-amp has two input terminals. The minus input, marked (-) is the inverting input. The plus input, marked (+) is the non-inverting input. $+V_{CC}$ denotes the positive and negative power supplies. The use of the positive and negative supply voltages allows the output of the op-amp to swing in both positive and negative directions.

Op-amp input modes and CMRR:

In op-amp, a number of input signal combinations are possible:

• If an input signal is applied to either input with the other input connected to ground, the operation is referred to as single – ended.

• If two opposite polarity input signals are applied, the operation in referred to as double-ended.

• If the same input is applied to both inputs, the operation is called common mode

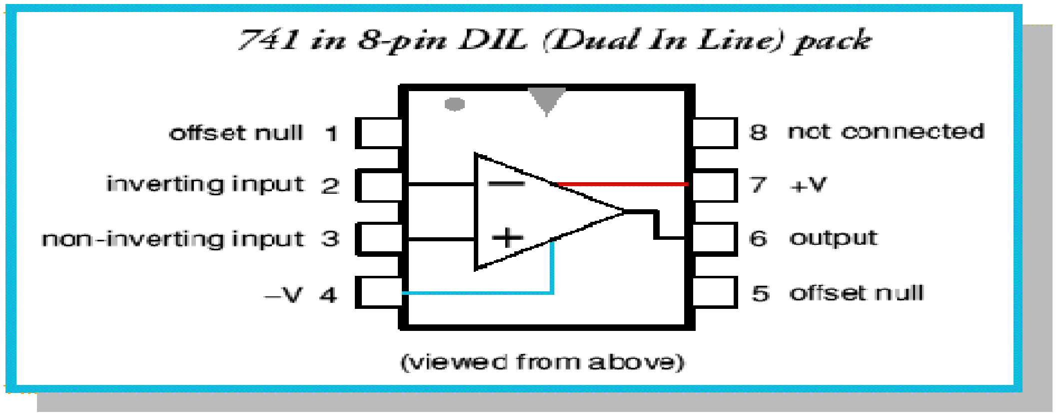


Fig:1

Differential gain, A_d

V_1 and V_2 are the two input signals and V_O is the output. In an ideal op-amp, V_O is proportional to the difference between the two signal voltages. $V_O \propto (V_1-V_2)$, $V_O = A_d\,(V_1-V_2)$ Where A_d is the constant of proportionality. A_d is called differential gain of the differential amplifier. The difference between the two inputs, $V_1 - V_2$ is generally called difference voltage and denoted as V_d.

$V_O = A_{d.}\,V_d$

Common mode gain, A_C

If we apply two input voltages which are equal in all respects to the differential amplifier, ie .if $V_1=V_2$, then ideally the output voltage, $V_O = A_d(V_1-V_2)$ must be zero. But the output voltage of the practical differential amplifier not only depends on the difference voltages, but also depends on the average common level of the two inputs. Such an average level of the two input signals is called common mode signal denoted as V_C. Practically, the differential amplifier produces the output voltage proportional to such common mode signal, also. The gain with which it amplifier the common mode signal to produce the output is called as common mode gain of the differential amplifier denoted as Ac. $V_O = A_C V_C$. So the total output of any differential amplifier can be expressed as
$V_O = A_d V_d + A_C V_C$

Common Mode Rejection Ratio (CMRR)

In an ideal different amplifier, A_d is infinite while A_C must be zero. However, in a practical differential amplifier; A_d is very large and A_C is very small. ie, the differential amplifier provides very large amplification for difference signals and very small amplification for common mode signals. Many disturbance signals/noise signals appear as a common input signal to both the input terminals of the differential amplifier. Such a common signal should be rejected by the differential amplifier.

"The ability of a differential amplifier to reject a common-mode signal is expressed by a ratio called **Common Mode Rejection Ratio (CMRR).**

CMRR is defined as the ratio of the differential voltage gain A_d to common mode voltage gain Ac.

CMRR $= A_d/Ac$

PROCEDUR:

Step 1.

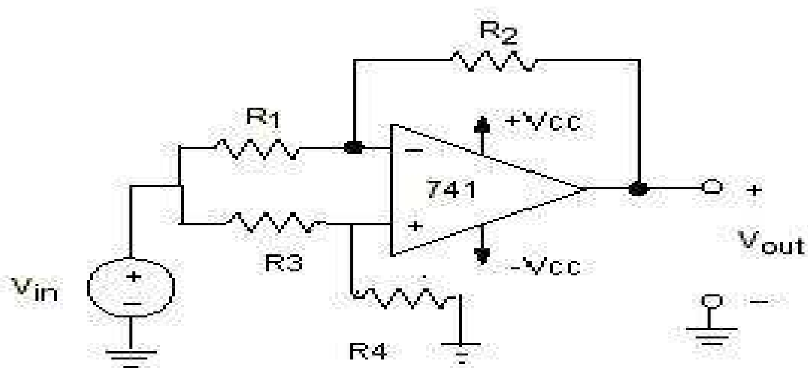
Connect the circuit as shown in figure. Input frequency should be 100 HZ.

Step 2.

Adjust the input voltage to be 2 V RMS.

Step 3.

Measure the output voltage. Calculate the common mode gain.



$R_1 = 100\ \Omega$, $R_2 = 100k\Omega$, $R_3 = 100\ \Omega$, $R_4 = 100\ k\Omega$

Differential gain $A_d = R_2/R_1$ or R_4/R_3

Common mode gain $A_C = V_o / V_I$

$CMRR = A_d/A_C$

CMRR in dB = $20 \log_{10} (CMRR)$

Repeat the experiment for different frequencies like 1kHz, 100 kHz

Results:-

Differential Mode Gain A_d =............

Common Mode Gain Ac =................

CMRR=..........................

Precautions:-

1. All connections should be tight.
2. Terminal voltage should not exceed the break down voltage of transistor.
3. Do not touch any wire when you are performing the experiment.
4. Take reading carefully.

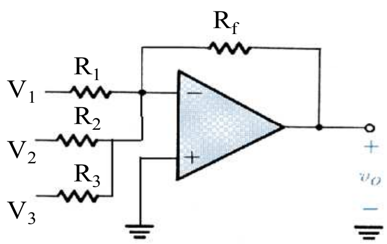
Experiment No-4&5

OBJECT: Applications of Op-amp as summing amplifier and differential amplifier .

APPARATUS REQUIRED: Power supply, CRO, Function Generator, Multi meter, Resistors, Capacitor , IC741 op-amp , Bread board and wires.

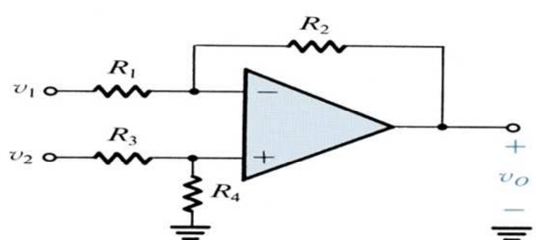
THEORY:

(1)Summing Amplifier: Amplifying the voltage sum betweenthe two inputs.



$V_o = -R_f(V_1 / R_1 + V_2 / R_2 + V_3 / R_3)$

Differential amplifier: Differential amplifier amplifying the voltage difference between the two inputs.



$$V_o = V_2\left(1+\frac{R_2}{R_1}\right)\left(\frac{R_4}{R_3+R_4}\right) - V_1\left(\frac{R_2}{R_1}\right)$$

If $R_1 = R_2 = R_3 = R$ $\quad V_o = V_2(1+1)\left(\frac{1}{2}\right) - V_1(1) = V_2 - V_1$

PROCEDURE:

(1) Make the connections according to circuit diagram.
(2) Taking all resistor same value like 1 k ohm
(3) Apply different voltage sources i.e V_1,V_2,V_3 .....
(4) Take differen-2 readings for different V_1,V_2,V_3
(5) Write the output reading in observation table

Observation Table For both

S.N	V_1 (V)	V_2 (V)	V_0 (V)
1.			
2.			
3.			

Results:- Verified the op-amp work as summing and difference amplifier

Precautions:-

1. All connections should be tight.
2. Terminal voltage should not exceed the break down voltage of transistor.
3. Do not touch any wire when you are performing the experiment.
4. Take reading carefully.

Experiment No-6&7

OBJECT: Applications of Op-amp as Differentiator and Integrator.

APPARATUS REQUIRED:

Power supply, CRO, Function Generator, Multi meter, Resistors, Capacitor , IC741 op-amp , Bread board and wires.

THEORY:

(1) DIFFERENTIATING AMPLIFIER:

The introduction of a capacitor into the input path of an op amp leads to time differentiation of the input signal. The circuit of Fig. 1 represents the simplest inverting differentiator involving an op amp. The circuit finds limited practical use, since high frequency noise can produce a derivative whose magnitude is comparable to that of the signal. In practice, high-pass filtering is utilized to reduce the effects of noise.

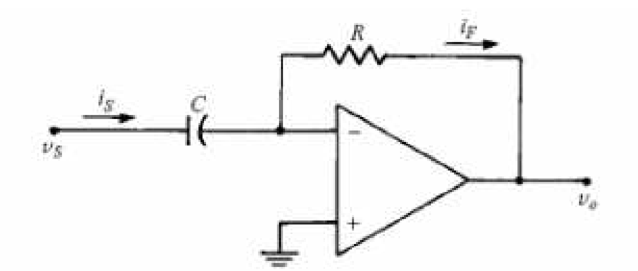


Fig. 1 Differentiating amplifier

Fig. 1, assuming the basic op amp is ideal. Since the op amp is ideal, $v_d \approx 0$ and the inverting terminal is a virtual ground. Consequently, v_S appears across capacitor C:

$$i_S = C\frac{dv_S}{dt}$$

But the capacitor current is also the current through R since $i_{in} = 0$. Hence,

$$v_o = -I_F R = -i_S R = -RC\frac{dv_S}{dt}$$

(2) INTEGRATING AMPLIFIER:

The insertion of a capacitor in the feedback path of an op-amp results in an output signal that is a time integral of the input signal. A circuit arrangement for a simple inverting integrator is given in Fig.2.

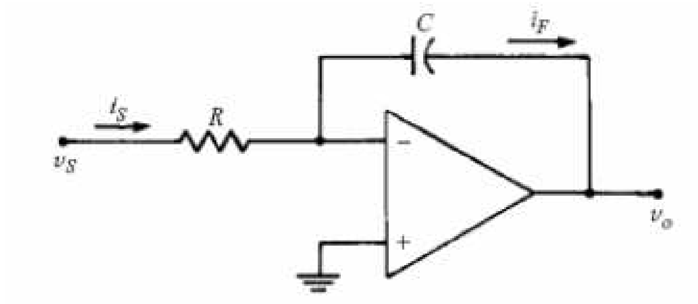


Fig. 2 Integrating Amplifier

If the op amp is ideal, the inverting terminal is a virtual ground, and v_S appears across R. Thus, $i_S = v_S/R$. But, with negligible current into the op amp, the current through R must also flow through C. Then

$$v_o = -\frac{1}{C}\int i_F\,dt = -\frac{1}{C}\int i_S\,dt = -\frac{1}{RC}\int v_S\,dt$$

PROCEDURE:

(1) Make the connections according to circuit diagram.
(2) Apply the input ac signal at inverting terminal by function generator.
(3) See the output waveform on CRO which is differentiation / integration of input ac signal.
(4) Apply different ac signal and check output signal.

RESULTS: Draw the output waveform on trace paper.

PRECAUTIONS:

1. All connections should be tight.
2. Terminal voltage should not exceed the break down voltage of transistor.
3. Do not touch any wire when you are performing the experiment.
4. Take reading carefully.

Experiment No-8

OBJECT: To study Positive feedback and Negative feedback Amplifier

APPARATUS REQUIRED:

Power supply, CRO, Function Generator, Multi meter, Resistors, IC741 op-amp , Bread board and wires.

Theory:

General Rules

The following two conditions define the rules that follow:

First, an amplifier "amplifies" the difference between its input voltages, ΔV_{in}

(1) $V_{out} = A\, \Delta V_{in}$ where $\Delta V_{in} \equiv V_{+} - V_{-}$

"A" is the "open loop gain" of the amplifier and for an ideal op amp is infinity and for a typical op amp is between 10^6 to 10^8.

Second since we are dealing with an actual physical device its output voltages can never exceed its supply voltages, V_{--} and V_{++}.

(2) $V_{--} < V_{out} < V_{++}$

Typical supply voltages are $V_{--} = -15V$ and $V_{++} = +15V$.

Applying these two conditions leads to 3 different cases:

2a: If $A\, \Delta V_{in} > V_{++}$ then $V_{out} = V_{++}$

2b: If $A\, \Delta V_{in} < V_{--}$ then $V_{out} = V_{--}$

2c: If $V_{--} < A\, \Delta V_{in} < V_{++}$ then $V_{out} = A\, \Delta V_{in}$

Additionally, op-amps approach nearly ideal input and output impedance conditions. For completeness, the following rules are added:

3a: $Z_{out} = 0$

3b: $Z_{in-} = \infty$; $Z_{in+} = \infty$.

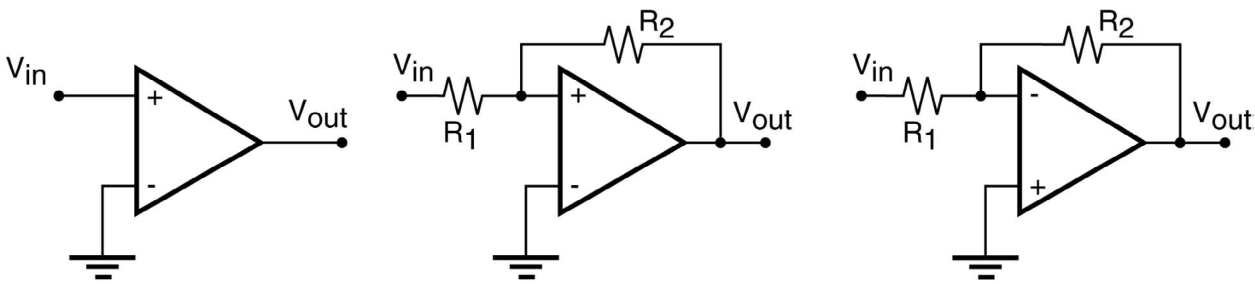
From 3b, it follows that:

3c: $I_{in-} = 0$; $I_{in+} = 0$.

For most applications these assumptions holds since typical input currents are 10-9 to 10-12 Amps and the input impedances are in the 10^6 to 10^9 Ω range.

Feedback:

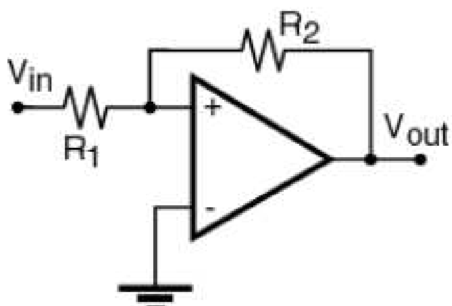
Feedback refers to connecting the output of the op-amp to its input, usually through resistors, and there are three basic ways to do that, shown below:



No Feedback Positive Feedback Negative Feedback

(1)Positive Feedback: Comparator with Hysteresis, Oscillators

The middle circuit in above Figures has positive feedback .The key in understanding this circuit will again be in calculating the voltages that cause its output to switch. The output will still be V_{++} or V_{--}, depending on whether $\Delta V > 0$ or $\Delta V < 0$. Switching of the output will occur when the value ΔV changes sign, i.e., at $\Delta V = 0$.



Positive Feedback circuit

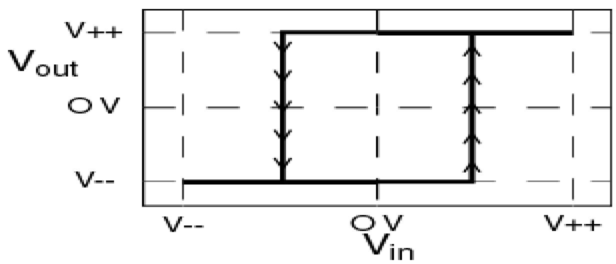
For the particular circuit above, $\Delta V = V_+$ since $V_- = 0$. So,

- if$V_+ > 0$,$V_{out} = V_{++}$,
- if$V_+ < 0$, $V_{out} = V_{--}$.

Since V_{out} change its state whenever V_+ crosses 0V, we need to find what value of V_{in} results in $V_+ = 0$. Since $V_+$is a voltage divider formed by R_1 and R_2between V_{in} and V_{out} it follows that:

• $V_+ = (V_{in} R_2 + V_{out}R_1)/(R_1 + R_2)$

Combining these equations and solving for $V_+ = 0$ yields $V_{in} = -V_{out} R_1/R_2$. Since V_{out} can only be either V_{++} or V_{--}, V_{out} switches from $V_{++}$to $V_{--}$when $V_{in} = -V_{++} R_1/R_2$ and it switches from V_{--} to V_{++} when $V_{in} = -V_{--}R_1 / R_2$.



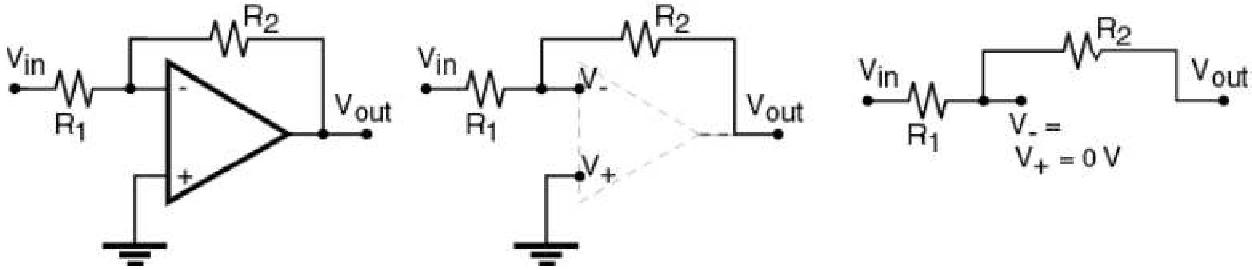
V_{out}vsV_{in} for the Positive Feedback Circuit

(2)Negative Feedback: Amplifiers

Only when negative feedback is applied to the op-amp it (may) act(s) as a linear amplifier. To be precise, it can only act as a linear amplifier as long as its output is not saturated, i.e., it does not exceed its supply voltages.

$V_+ \cong V_-$.

Steps for solving the –ive feedback circuit
1. Remove the op-amp altogether from your circuit
2. State that $V_+ = V_-$.
3. Solve.



Figure

Noting that the current through R_1 must be identical to the current through R_2 leads as immediately to the application of Ohm's law, namely:

• $(V_{in} – V_-)/R_1 = (V_- - V_{out})/R_2$

Since $V_- = 0$
• $V_{out} = (-R_2/R_1)$ Vin

RESULTS: Studied the positive feedback and negative feedback of op-amp.

PRECAUTIONS:

1. All connections should be tight.
2. Terminal voltage should not exceed the break down voltage of transistor.
3. Do not touch any wire when you are performing the experiment.
4. Take reading carefully.

Experiment No-9

OBJECT : To Study The Op-Amp as a Phase Shift Oscillator.

APPARATUS REQUIRED:

Component	Quantity
1. Resistance 10K	3
2. Capacitor 10nF	3
3. Pot 2.2M	1
4. Resistance 50K	1
5. IC741	1

THEORY:

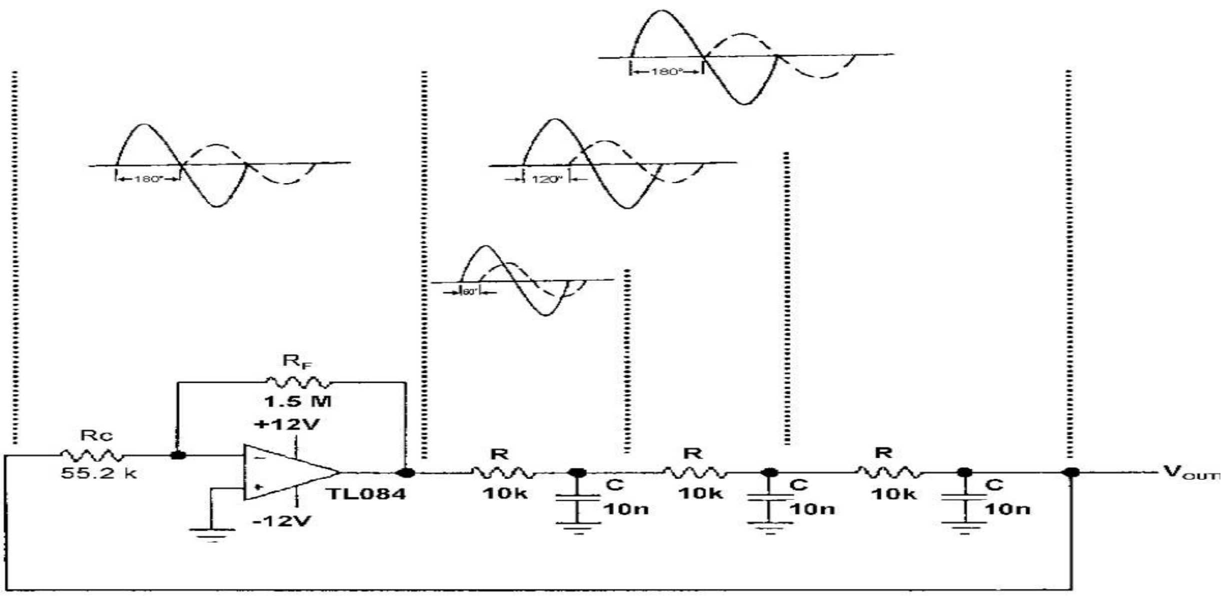
Phase Shift Oscillator :

The phase shift oscillator produces positive feedback by using an inverting amplifier and adding another 180° of phase shift with the three high-pass filter circuits. It produces this 180° phase shift for only one frequency. The operation of the RC Phase Shift Oscillator can be explained as follows. The starting voltage is provided by noise, which is produced due to random motion of electrons in resistors used in the circuit. The noise voltage contains almost all the sinusoidal frequencies. This low amplitude noise voltage gets amplified and appears at the output terminals. The amplified noise drives the feedback network which is the phase shift network. Because of this the feedback voltage is maximum at a particular frequency, which in turn represents the frequency of oscillation. Furthermore, the phase shift required for positive feedback is correct at this frequency only. The voltage gain of the amplifier with positive feedback is given by the above equation we can see that if $A_b=1$ $A_f = \infty$ The gain becomes infinity means that there is output without any input. i.e. the amplifier becomes an oscillator. This condition $A_b=1$ is known as the Barkhausen criterion of oscillation. Thus the output contains only a single sinusoidal frequency. In the beginning, as the oscillator is switched on, the loop gain A is greater than unity.

The oscillations build up. Once a suitable level is reached the gain of the amplifier decreases, and the value of the loop gain decreases to unity. So the constant level oscillations are maintained. Satisfying the above conditions of oscillation the value of R and C for the phase shift network is selected such that each RC combination produces a phase shift of 60°. Thus the total phase shift produced by the three RC networks is 180°. In the diagram, if $R_1 = R_2 = R_3 = R$, and $C_1= C_2 = C_3 = C$, then:

$f_{oscillation}=1/2\pi RC(6)^{1/2}$…………..(1)

Fig (1) The Op-Amp is used in the inverting mode; therefore, 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 networks. Thus the total phase shift around the loop is 360° (or 0°).



Procedure :

To observe the working of Phase Shift Oscillator

1. Calculate the value of frequency for given value of R & C by equation 1.

3. Connect the CR combination as shown in figure 2.

4. Rotate the potentiometer and set it at 29 times of the value of R i.e. R_F = 290K if R =10K.

5. Connect the oscilloscope CH I probe at terminal 1 or 'Vo' and observe the Vo.

6. If the output shows some distortion or imperfection vary the pot P till the perfect wave occurs.

7. Note the output frequency and verify it with measured output frequency.

RESULTS: The output wave form on trace paper.

PRECAUTIONS:

1. All connections should be tight.
2. Terminal voltage should not exceed the break down voltage of transistor.
3. Do not touch any wire when you are performing the experiment.
4. Take reading carefully.

Experiment No-10

OBJECT: To Study the Op-Amp as a Wien Bridge Oscillator.

APPARATUS REQUIRED:

Component	Quantity
1. Resistance 10K	2
2. Capacitor 10nF	2
3. Pot 10K	1
4. Resistance 2K	1
5. IC741	1

THEORY:

Wien Bridge Oscillator: Figure: (1) shows the basic Wien Bridge circuit configuration is the most commonly used audio-frequency oscillator. The Wien Bridge circuit is connected between the amplifier input terminals and the 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 0°. This condition occurs only when the bridge is balanced, that is at resonance. The frequency of oscillation F_O is exactly the resonant frequency generated by balanced Wien bridge oscillator.

$F_O = 1/2\pi RC = 0.159 / RC$ …….(1)

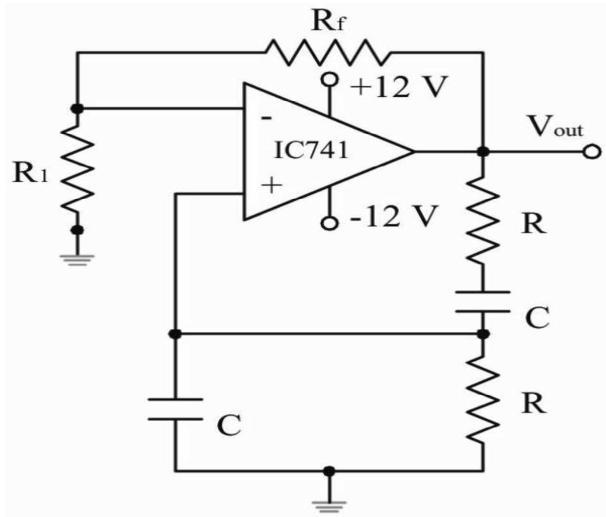


Fig. (1) Wien Bridge Oscillator

PROCEDURE :

To generate the sine wave by Wien bridge Oscillator.

1. Calculate the value of frequency for given value of R & C by equation 1.

2. Connect the Circuit as shown in the figure 1.

3. Rotate the potentiometer and set it at twice the value of R i.e. R_F = 2 K if R=1K.

4. Connect the oscilloscope CH I probe at 'V_{out}' and observe V_{out}.

5. If the output shows some distortion or imperfection vary the pot P till the perfect wave occurs.

6. Note the output frequency and verify it with measured output frequency.

7. Now check the potentiometer resistance the value of R_F should be twice of the resistance R.

8. Calculate the value of R for the frequency of 10 KHz, change the component.

9. Repeat the above steps from 4 to 10.

RESULTS: The output wave form on trace paper.

PRECAUTIONS:

1. All connections should be tight.
2. Terminal voltage should not exceed the break down voltage of transistor.
3. Do not touch any wire when you are performing the experiment.
4. Take reading carefully.

Mr.Rahul Kumar
(Lab Faculty,Lab IN charge)