PABNA UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department Of

Information and Communication Engineering

Faculty Of

Engineering and Technology

Course Title: Analog Electronics Sessional

Course Code: ICE-1202

Lab Report

Submitted to:	Submitted By:
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Index

Experiment NO	Experiment Name
01	To study the operational amplifier as Inverting and Non-Inverting amplifier
02	To design and construct an integrator and differentiator using IC-741 operational amplifier
03	To construct and study the characteristics of active low pass filter
04	To construct and study the characteristics of active low pass filter.
05	To design and study Astsble Multivibrator using timer IC-555.

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Experiment no:	01
Experiment name:	To study the operational amplifier as Inverting amplifier and non-inverting amplifier.

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Experiment name : To study the operational amplifier as Inverting amplifier and non-inverting amplifier.

Objectives :

1. Understand and comprehend working of OP Amp.
2. Design and build inverting and non-inverting amplifier to desired voltage gain using OP-Amp.
3. Establish relationship between input and output signal.
4. Use digital oscilloscope to debug / analyze the circuit.

Equipment :

1. IC-741.
2. Oscilloscope.
3. Bread-board.
4. DC Power supply.
5. Signal generator.
6. Multimeter.
7. Resistor.
8. Connecting wire.

Theory :

An inverting amplifier using op-Amp is a type of amplifier where the output waveform will be phase opposite to the input wave form. The input waveform will be amplified by the factor A_v (Voltage gain of the amplifier) in magnitude and it's phase will be inverted. In the inverting amplifier circuit the signal to be amplified is applied to the inverting input of the op-Amp through the input resistance R_i. R_f is the feedback resistor. R_f and R_{in} together determine the gain of the amplifier. Inverting optional amplifier gain can be expressed using the equation $A_v = -R_f/R_i$. Negative sign implies that the output signal is negated.

In non-inverting amplifier circuit the input signal is applied to the Positive or non-inverting input terminal of the operational amplifier and a Portion of the output signal is feedback to the negative input

terminal. Input voltage V_{in} and output voltage V_o.
Voltage gain of non-inverting amplifier $A_v = \frac{V_o}{V_i}$.

Experimental circuit:

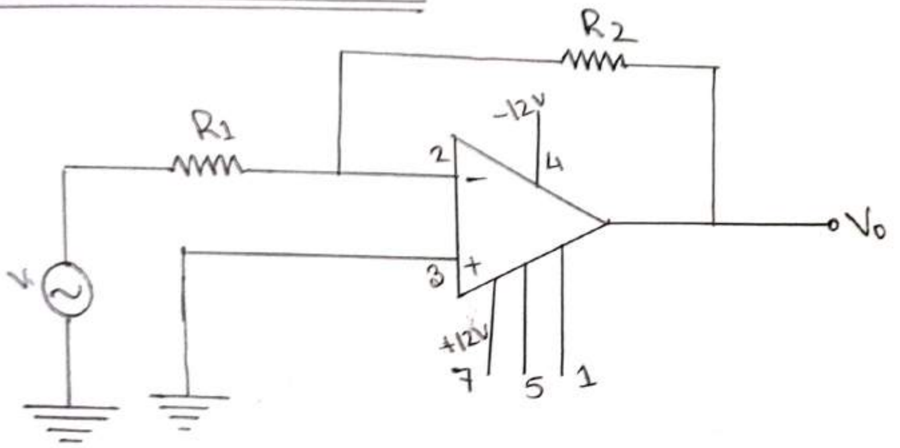

Figure-1: Experimental circuit for inverting amplifier

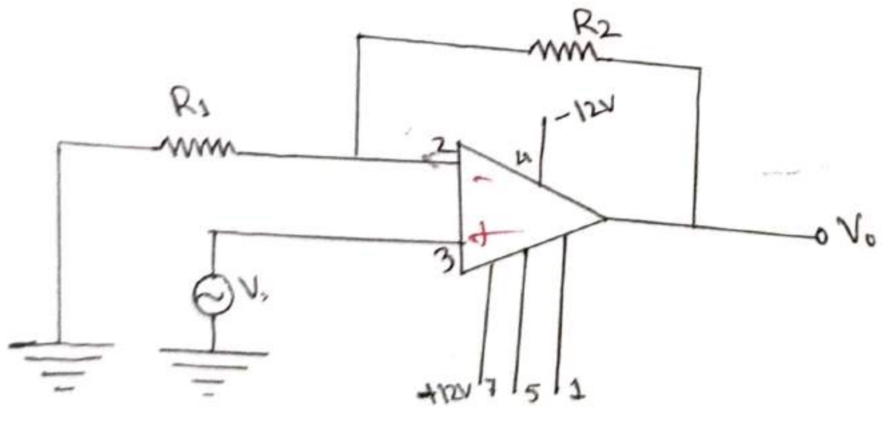

Figure-2: Experimental circuit for non-inverting amplifier.

Procedure :

1. Connect the circuit for inverting, non-inverting amplifier on a breadboard.

2. Connect the input terminal of the op-amp to function generator and output terminal to CRO

3. Feedback input from function generator and observe the output on CRO.

4. Draw the input and output waveforms on graph paper.

Experimental Table :

Table-1 : Experimental data for inverting amplifier

No of Observation	Input resistance R_L (kΩ)	Feedback Resistance R_f (kΩ)	Input voltage V_i (volt)	Output voltage V_o (volt)	measured voltage gain $A_v = -\frac{V_o}{V_i}$	Calculated voltage gain $A_v = -\frac{R_f}{R_i}$
01	1	10	0.4	3.86	−9.65	−10
02	1	10	0.7	6.71	−9.58	−10
03	1	10	0.9	8.89	−9.87	−10

Table-2 : Experimental data for non-inverting amplifier

No of Observation	Input resistance R_i (kΩ)	feedback resistance R_f (kΩ)	Input voltage V_i (volt)	Output voltage V_o (volt)	measured voltage gain $A_v = \frac{V_o}{V_i}$	Calculated voltage gain $A_v = 1 + \frac{R_f}{R_i}$
01	1	10	0.2	1.38	6.9	10
02	1	10	0.5	5.03	10.06	10
03	1	10	0.8	8.31	10.38	10

Result and Discussion :

During the experiment, when we tried to get the output sine wave form. we have encountered some Problems. The sine waveform didn't show up at the oscilloscope. After some trial and error, we found out that the source of the Problems are due to incorrect grounding. The connection of ground from bias voltage cannot be connected to the ground of the supply voltage. Thus, we have to make a new ground for each of bias voltages and supply voltages. Next, at DC bias voltage also have V+ and V- and both of it has been connected to Positive supply hence the flat sine waveform shown on the oscilloscope. To combat this, we made sure that the DC bias voltage V+ and V- are connected to the correct terminals which are the Positive and negative supply voltage.

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Experiment no:	02
Experiment name:	To design and construct an integrator and differentiator using IC-741 OP-Amp.

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Experiment name : To design and construct an integrator and differentiator using IC-741 OP-AMP.

Objectives : i) To study the working of op-amp using IC-741 as differentiator and integrator

ii) To construct differentiator and integrator using Op-Amp.

Equipment :

i) Resistors.

ii) Bread board.

iii) AVO meter.

iv) Connecting wire.

v) IC-741.

vi) capacitors.

vii) Oscilloscope.

viii) Calculator etc.

Theory :

For differentiator,

The basic Differentiator Amplifier circuit is the exact opposite to that of the Integrator operational amplifier circuit. Here, the position of the capacitor and resistor have been reversed and now the capacitor, C is connected to the input terminal of the inverting amplifier while the Resistor, Rf forms the negative feedback element across the operational amplifier. The circuit performs the mathematical operation of Differentiation that it is produces a voltage output which is proportional to the input voltage's rate of change and the current flowing through the capacitor. Or in other words the output voltage is a scaled version of the derivative of the input voltage. The capacitor blocks any DC content only allowing AC type signals to pass through and whose frequency is dependent on the rate of change of the input signal. At low frequencies the reactance of the capacitor is high resulting in a low gain (R_1/X_C) and low output voltage from the op-amp.

For Integrator,

In an integrator circuit, the output voltage is integral of the input signal. Here, the resistor is connected to the input terminal of the amplifier while the capacitor forms the negative feedback amplifier element across the operation amplifier. When a voltage is firstly applied to the input of an integrating amplifier, the unchanged capacitor C has very little resistance and acts a bit like a short circuit giving an overall gain of less than 1, thus resulting in zero output. The gain of an integrator at low frequency can be limited by connecting a resistor in shunt with capacitor. The circuit design generate triangular wave providing square wave as input to the integrator. Hence, the integrator circuit generates integral output with respect to the input waveform.

Experimental circuit :

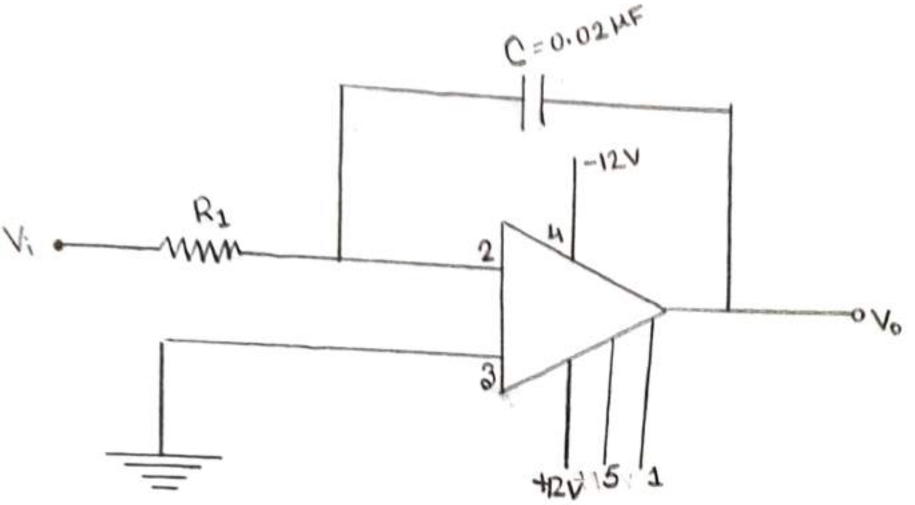

Figure 1: Experimental circuit for an integrator using IC-741 OP-amp

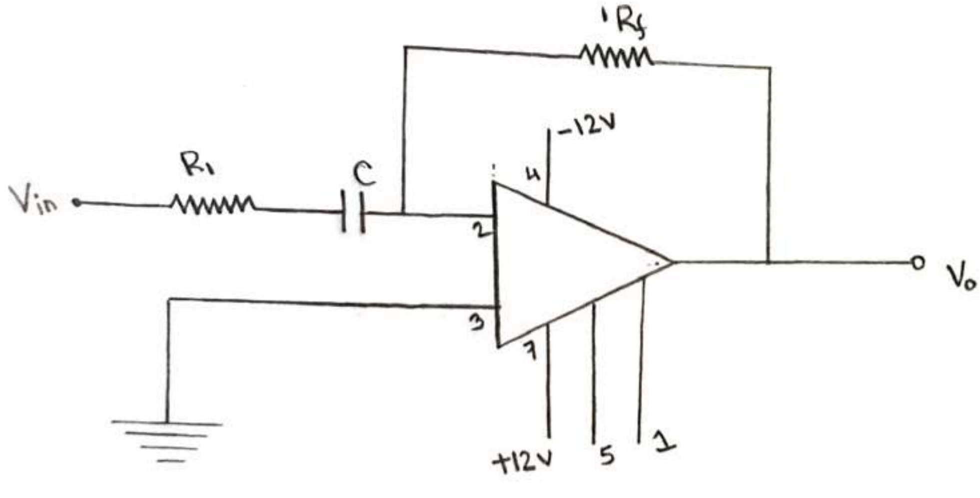

Figure-2: Experimental circuit for an differential using IC-741 OP-AMP.

Procedure :

Integrator :

1. Connect the circuit as shown in Figure-1.
2. Apply a symmetrical square wave of 1.14 V P-P amplitude and 1.094 KHz frequency.
3. Connect the input and output of the circuit to channel 1 and channel 2 of the CRO respectively and observe the waveforms.
4. Draw the waveforms along with the levels on a graph.
5. Compare the Practical values with theoretical values.
6. Repeat the same for sine-wave.

Differentiator :

1. Connect the circuit as shown in Figure-2.
2. Apply a symmetrical triangular wave of 1.10 VP-P amplitude and 1.106 KHz frequency.
3. Connect the input and output of the circuit to channel 1 and channel 2 of the CRO respectively and observe the waveforms.
4. Draw the waveforms along with the levels on a graph.

5. Compare the Practical values with theoretical values.

6. Repeat the same for the sine wave.

Experimental Table :

Table-1 : Experimental data for integrator :

No of observation	Input wave shape	Resistor (KΩ)	Capacitor (μF)	Voltage		Frequency		Output wave shape
				Input voltage	Output Voltage	Input frequency (KHz)	Output frequency (KHz)	
01		1	0.02	1.14	15.6	1.094	1.09	
02		1	0.02	1.16	9.40	2.11	2.09	
03		1	0.02	1.16	17.6	920 Hz	922 Hz	

Table-2 : Experimental data for differentiator :

No. of Observation	Input wave shape	Resistor (KΩ)	Capacitor (μF)	Voltage		Frequency		Output wave shape
				Input votage (V)	Output voltage (V)	Input frequency (KHz)	Output frequency (KHz)	
01		1	0.02	1.10	4.96	1.106	1.108	
02		1	0.02	1.08	8.08	1.818	1.816	
03		1	0.02	1.08	13.2	2.732	2.735	

Discussion:

From the result and table, our output wave shape is change from input wave shape. we get the same frequency from input and output. Integrator and differentiator, we also get changing wave shape and get some frequency. So we get accurate result.

Precaution:

1. We connect all the required component very carefully.
2. Connect oscilloscope and frequency generator very carefully and take value and saw wave shape carefully.
3. we take the value of frequency very carefully.

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Experiment no : 03

Experiment name : To construct and study the characteristicts of active low Pass filter

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Experiment name : To construct and study the characteristics of active low Pass filter.

Objectives:

1. To design a low Pass filter.
2. To obtain the frequency response of the active filter and examine the effect of the variation of the circuit component.

Equipment:

1. IC-741
2. Resistors.
3. Capacitor.
4. Oscilloscope.
5. Bread board
6. DC Power supply
7. Multimeter
8. Connecting wire
9. Signal generator

Theory :

A low pass filter allows only low frequency signal to pass. A low pass filter can be a combination of capacitor, inductor or resistor intended to produce attenuation above a specified frequency and little of no attenuation below that frequency. The frequency at which the transition occurs is called the cut-off frequency.

The most common and easily understood active filter is that active low pass filter its principle of operation and frequency response is exactly the same as those for the previously seen positive filter, the only difference this time is that it uses on OP-amp for amplification and gain control. The simplest format of low pass active filter is to connect an inverting or non-inverting amplifier, the same as those discussed in OP-amp.

Gain of a low pass filter :

$$\text{Voltage gain } (A_v) = \frac{V_{out}}{V_{in}}$$

$$A_v = \frac{A_F}{\sqrt{1+(f/f_c)^2}}$$

Where,

A_F = the Pass band gain of the filter $\left(1+\frac{R_2}{R_1}\right)$

f = frequency of the input signal in Hertz (Hz)

f_c = the cut-off frequency in Hertz (Hz)

Thus, the operation of a low Pass active filter can be verified from the frequency gain equation above as :

1. At very low frequencies, $f < f_c$.

$$\frac{V_{out}}{V_{in}} \cong A_F$$

2. At the cut-off frequency $f = f_c$

$$\frac{V_{out}}{V_{in}} \cong \frac{A_F}{\sqrt{2}}$$

3. At very high frequencies $f > f_c$.

$$\frac{V_{out}}{V_{in}} < A_F$$

The corner Frequency of the filter is,

$$f_c = \frac{1}{2\pi CR} \text{ Hertz}$$

Experimental circuit:

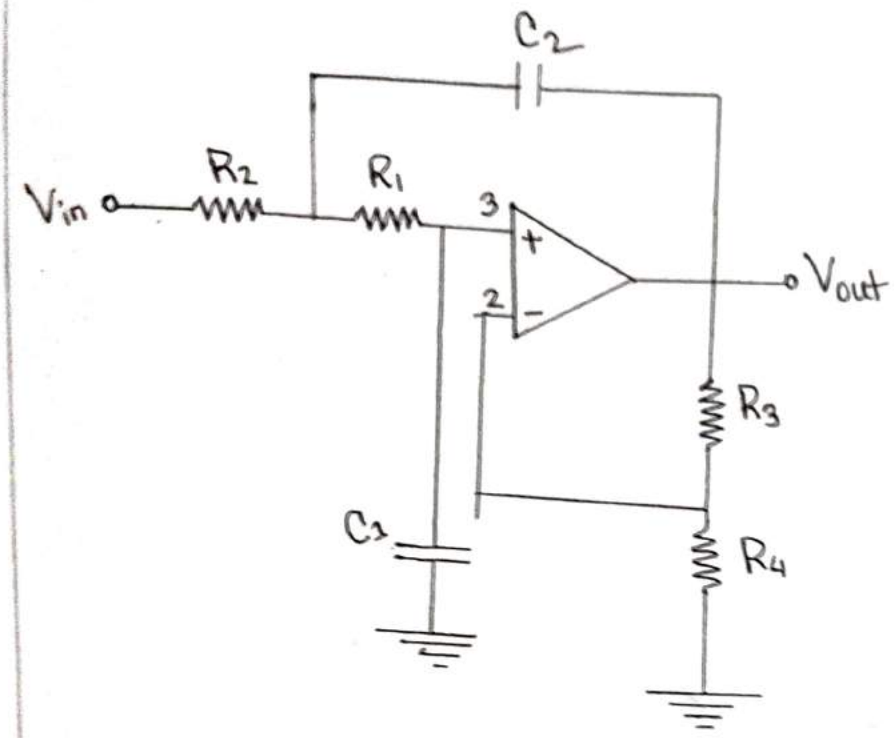


Figure: Circuit diagram for low Pass filter.

Procedure :

1. Firstly we set up all the required component in the bread board with their required values.

2. We give input into non-inverting terminal to ground by frequency generator. Input voltage Vin for active low pass filter.

3. Then we measure output voltage from Pin 6 with the help of oscilloscope.

4. By changing frequency we measure output.

5. From Vin and Vout we calculate gain Av and we calculate normalized gain Av.

6. Thus we complete the experiment and put all the values on the table.

7. From Vin and Vout we calculate gain Av and we also calculate normalized gain Av.

8. Then we complete graph from frequency and normalized voltage gain and put all the values on the data table.

Experimental data table:

Experimental data table for low pass filter:

$V_{in} = 2$ volt

No. of observation	Frequency f (Hz)	Output voltage V_o (P-P) (Volt)	Voltage gain $A_v = \frac{V_o}{V_{in}}$	Normalized voltage gain $A_N = \frac{A_v}{A_{v(max)}}$	Gain in dB = $10\log(A_N)$ dB
1	500	3.72	1.86	0.98	−0.087
2	700	3.72	1.86	0.98	−0.087
3	1000	3.76	1.88	1.00	0.00
4	1400	3.60	1.80	0.95	−0.22
5	1500	3.52	1.76	0.93	−0.32
6	1800	3.28	1.64	0.87	−0.61
7	2000	2.96	1.48	0.78	~~−2.36~~ −1.08
8	2200	2.60	1.30	0.69	−1.61
9	2500	2.20	1.10	0.58	−2.36
10	2700	1.96	0.98	0.52	−2.83
11	3000	1.60	0.80	0.42	−3.76
12	3300	1.16	0.68	0.36	−4.44
13	3500	1.20	0.60	0.32	−4.95
14	3700	1.06	0.53	0.28	−5.53
15	4000	0.9	0.45	0.24	−6.13
16	4700	0.64	0.32	0.17	−7.69

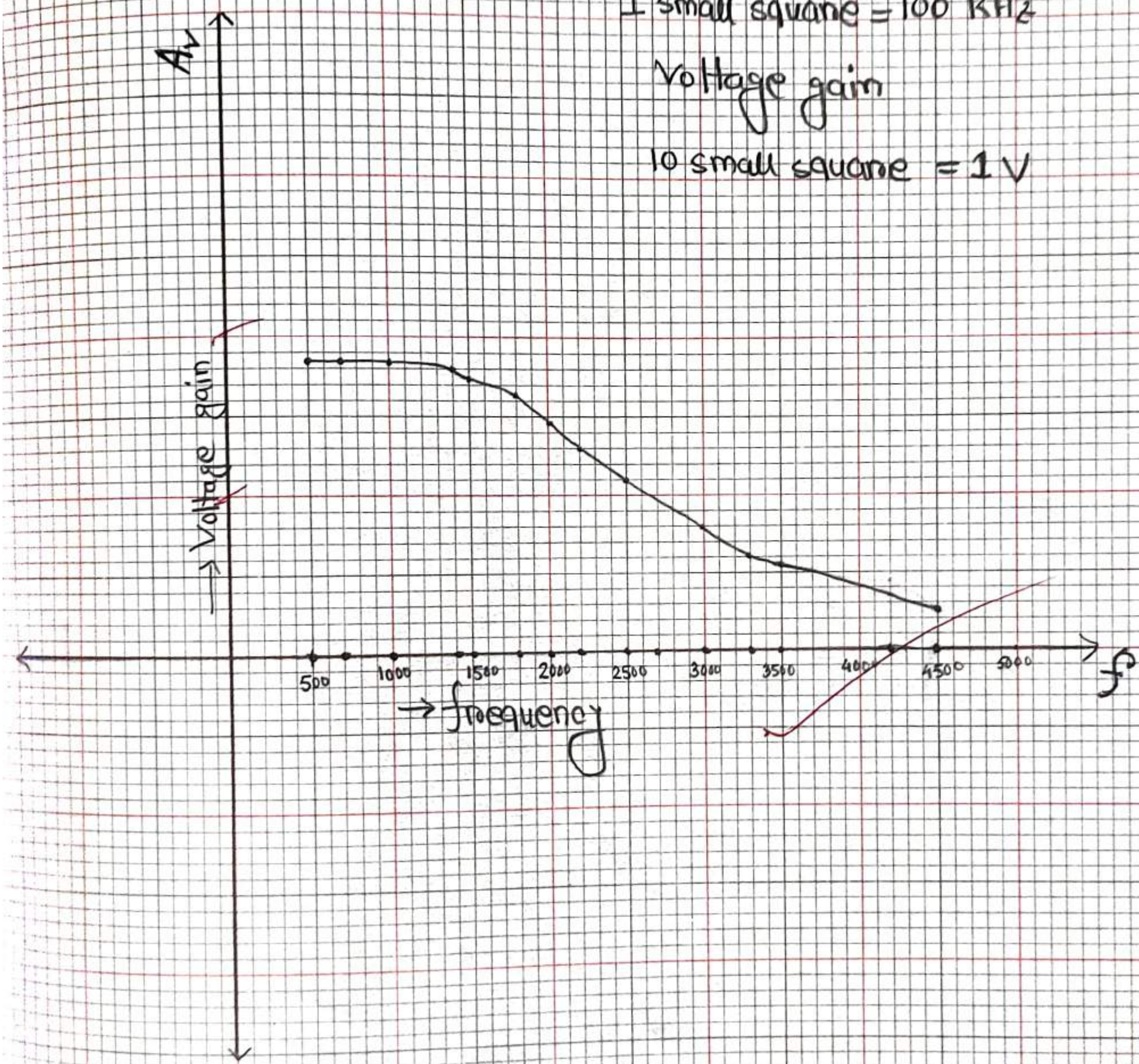
Roll No.

frequency

1 small square = 100 KHz

Voltage gain

10 small square = 1 V



Result and discussion :

From the data-table, we observe that frequency (input) is increasing from 0.5 KHz to 47 KHz. Input voltage $V_{in} = 2V$ (P-P) was fixed. We took input by frequency generator at Pin 2 and output was taken from oscilloscope at Pin 6. Output voltage was decreases with respect to frequency increases for low pass filter and at a time it is fixed. Then we get A_v from the ratio of output and input voltage and we also get normalized voltage gain from the ratio of A_v and $A_{v(max)}$. Then we plotted the value of frequency and normalized gain in graph paper. Thus we calculate all the values and complete the data table.

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Experiment no : 04

Experiment name : To construct and study the characteristics of active high Pass filter.

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Experiment name : To construct and study the characteristics of active high Pass filter.

Objectives :

1. To design a high Pass filter.
2. To obtain the frequency response of the active high Pass filter and examine the effect of the variation of the circuit component.

Equipment :

1. IC-741
2. Resistor
3. Capacitor
4. Oscilloscope
5. Bread board
6. DC Power supply
7. Multimeter
8. Connecting wire.
9. Signal generator.

Theory :

An active high Pass filter can be created by combining a Passive RC filter network with an operational amplifier to Produce a high Pass filter with amplification.

A first order (single Pole) Active high Pass filter as its name implies, attenuates low frequencies and Passes high frequency signals. The frequency response of the circuit is the same as that of the Passive filter, except that the amplitude of that signal is increased by the gain of the amplifier and for a non-inverting amplifier, the value of the Pass band voltage is gain is given as,

$$A_v = 1 + \frac{R_2}{R_1}$$

the same for the low Pass filter circuit.

Gain of a high Pass filter,

$$\text{Voltage gain } (A_v) = \frac{V_{out}}{V_{in}}$$

$$= \frac{A_F (f/f_c)}{\sqrt{1 + (f/f_c)^2}}$$

where,

A_F = the Pass band gain of the filter $(1+R_2/R_1)$

f = the frequency of the input signal in Hertz (Hz)

f_c = the cut-off frequency in Hertz (Hz)

Just like the low Pass filter, the operation of a high Pass active filter can be verified from the frequency gain equation.

1. At very low frequency, $f < f_c$

$$\frac{V_{out}}{V_{in}} < A_F$$

2. At the cut-off frequency, $f = f_c$

$$\frac{V_{out}}{V_{in}} = \frac{A_F}{\sqrt{2}} = 0.707 A_F$$

3. At very high frequency, $f > f_c$

$$\frac{V_{out}}{V_{in}} \cong A_F$$

The lower cut-off frequency can be found by using the formula,

$$f_c = \frac{1}{2\pi RC} \text{ Hertz}$$

Equi

Experimental circuit :

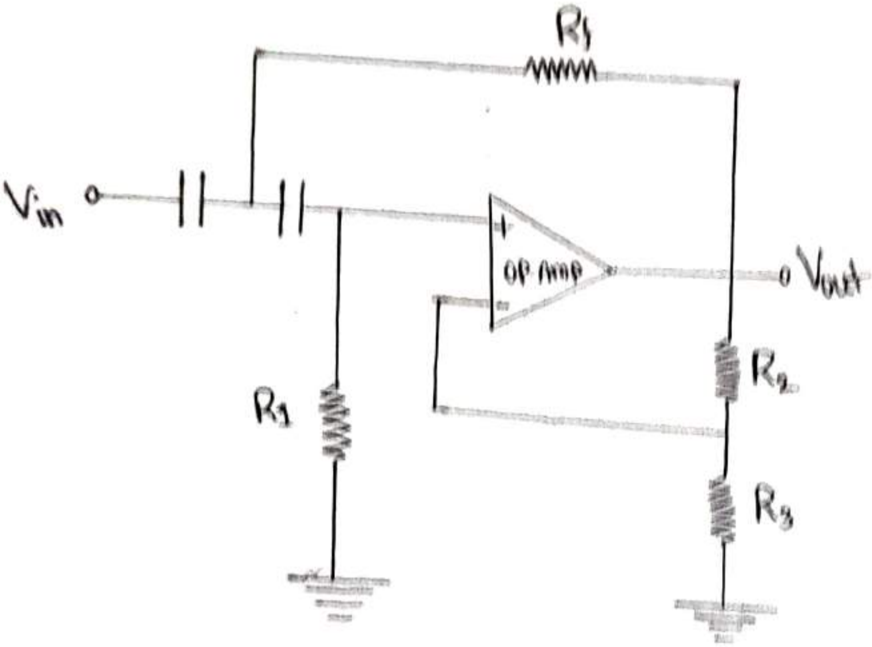

Figure : Active high Pass filter.

Procedure :

1. Firstly we set up all the required component on the bread board with their required values.

2. We take +12V to -12V from dc supply.

3. We give input into non-inverting terminal to ground by frequency generator. Input voltage,
$V_{in(P-P)} = 2V$ are fixed

4. We take output from terminal 6 to ground with oscilloscope and by changing frequency we measure output.

Experimental table :

Table: 2 Experimental data for active high pass filter

No of observation	Frequency f (Hz)	Output voltage $V_{o(p-p)}$ (volt)	Voltage gain $A_v = \frac{V_o}{V_{in}}$	Normalized voltage gain $A_N = \frac{A_v}{A_{v(max)}}$	Gain in dB $= 10 \log(A_N)$ dB
01	500	0.25	0.125	0.068	-11.67
02	700	0.48	0.24	0.132	-8.79
03	900	0.80	0.4	0.23	-6.38
04	1200	1.44	0.72	0.395	-4.03
05	1400	1.96	0.98	0.538	-2.69
06	1600	2.28	1.14	0.63	-2.00
07	1800	2.60	1.3	0.71	-1.49
08	2000	2.96	1.48	0.81	-0.91
09	2300	3.28	1.64	0.90	-0.46
10	2500	3.40	1.7	0.93	-.31
11	2800	3.52	1.76	0.96	-0.17
12	3000	3.56	1.78	0.98	-0.09
13	3300	3.60	1.8	0.99	-0.04
14	3500	3.60	1.8	0.99	-0.04
15	4000	3.64	1.82	1	0
16	4500	3.64	1.82	1	0
17	5000	3.60	1.8	0.99	-0.04
18					

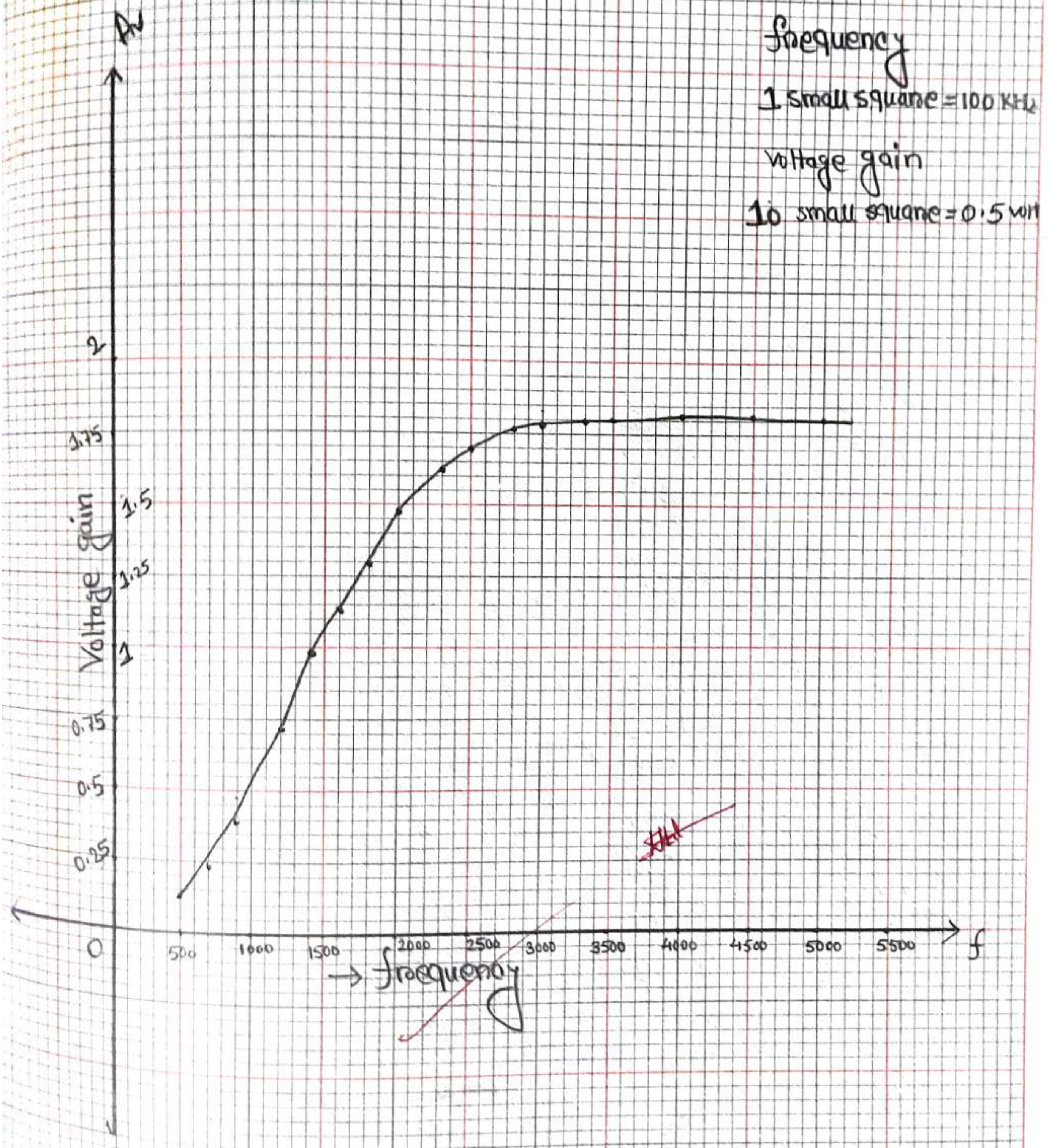

Figure : Graph of the high Pass filter.

Result and discussion :

From the table, we observe that frequency (input) is increasing from 0.5 KHz to 4.5 KHz. Input voltage $V_{in} = 2V$ (p-p) was fixed. We took input by frequency generator at Pin 2 and output was taken from Oscilloscope at Pin 6. Output voltage was increased with respect to frequency increase for high pass filter and at a time it was fixed. Then we get A_v from the ratio of output voltage and input voltage. We also get normalized voltage gain from the ratio of A_v and $A_{v(max)}$. $A_{v(max)} = 1.82$. Then we plotted the value of frequency and normalized gain (A_v) in graph paper. Then we calculate all the values and complete the data table.

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Experiment no : 05

Experiment name : to Design and study Astable Multivibrator using timer IC-555.

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Experiment name : To Design and study Astable multivibrator using timer IC-555.

Objectives :

1. To assemble the circuit of Astable multivibrator using timer 555.

2. To observe and plot the output voltage waveform (output voltage and voltage across capacitor) of Astable multivibrator.

Equipment :

i) IC-555.
ii) Bread board.
iii) Connecting wire.
iv) Avo-meter.
v) Resistor.
vi) Capacitor
vii) Oscilloscope.
viii) DC supply

Theory:

An astable multivibrator is often called as a free running multivibrator, it doesn't requires an external trigger to change the state of output hence it is called as free running. However, the time during which output is either high or ~~either~~ low is determined by two external resistors and a capacitor externally connected to the 555 timer.

As initially when output is high, capacitor C start charging towards V_{cc} through R_1 and R_2. However as soon as voltage across capacitor equals to $2/3\ V_{cc}$, threshold comparator triggers the F/F and output switches to low. Now capacitor starts discharging through R_2 and internal transistor. When voltage across C becomes less than or equal to $1/3\ V_{cc}$ trigger comparator output changes the state of F/F and output goes high. This cycle repeats again and rectangular waveform is observed at the output of timer.

The time during which the capacitor charges from $1/3\ V_{cc}$ to $2/3\ V_{cc}$ is equal to the time the output is high and is given by.

$$t_1 = 0.69(R_A + R_B)C_T$$

Similarly, the time during which the capacitor discharges from $1/3\ V_{cc}$ to $2/3\ V_{cc}$ is equal to the time the output is low and is given by.

$$t_2 = 0.69(R_B)C_T$$

The total Period of output waveform is given by.

$$T = t_1 + t_2 = 0.69(R_A + 2R_B)C$$

Hence the output frequency of oscillation is given by.

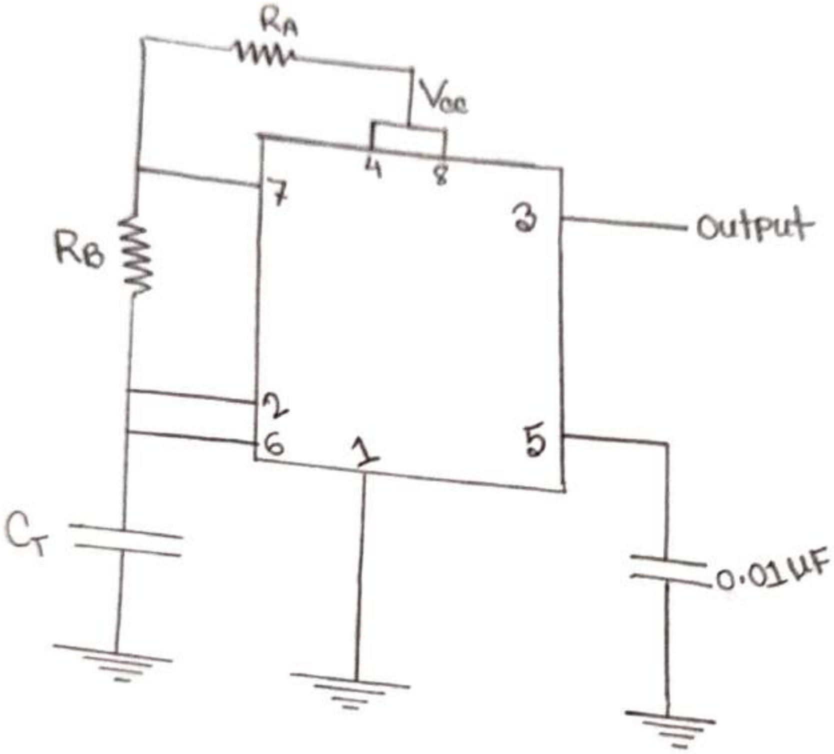
$$f_0 = \frac{1}{T} = \frac{1.45}{(R_A + 2R_B)C_T}$$

Duty cycle is the ratio of on time to total time of the waveform and is given by.

$$D = \frac{t_1}{T} = \frac{0.69(R_A + R_B)C_T}{0.69(R_A + 2R_B)C_T}$$

$$= \frac{R_A + R_B}{R_A + 2R_B}$$

Experimental circuit :



FB !

Figure : Astable multivibrator using IC-555 timer.

Experimental Table :

Experimental data for Astable Multivibrator using timer IC-555.

No of observation	Resistor R_A (KΩ)	Resistor R_B (KΩ)	Capacitor C_T (μF)	Measured: Charging time t_1 (sec)	Measured: Dis-Charging time t_2 (sec)	Measured: Frequency $f = \frac{1}{t_1+t_2}$ (Hz)	Calculated: Charging time $t_1 = 0.693 C_T (R_A+R_B)$ (sec)	Calculated: Discharging time $t_2 = 0.693 C_T \times R_B$ (sec)
1	54	45.8	0.02×10^{-6}	0.0015	0.0007	454.54	0.00138	0.00063
2	54	330	0.02×10^{-6}	0.006	0.005	90.90	0.00536	0.00461
3	54	350	0.02×10^{-6}	0.006	0.0055	86.95	0.00559	0.000634

$f \rightarrow ?$

Procedure :

1. Refer the Pin diagram of IC-555 and assemble the Astable multivibrator circuit as per circuit diagram on the breadboard.

2. Set the DC Power supply to provide $+V_{CC} = 5V$ and apply V_{CC} at respective Pin of IC 555.

3. Connect output Pin 3 of 555 to channel 1 of CRO and Pin (6/2) to Channel 2 of CRO with respect to ground.

4. Observe the output waveforms (i.e. output voltage and voltage across capacitor) on CRO/DSO.

5. Measure the output voltage, voltage across capacitor t_1, t_2, T, f. Note the readings in the observation table.

6. Calculate the theoretical values of above measured Parameters.

7. Plot the output voltage waveforms for output voltage and voltage across capacitor.

Result and discussion :

Astable multivibrator using IC-555 timer is a simple oscillator circuit that generates continuous pulse. The frequency of the circuit can be controlled by shifting the values of Resistors R_A, R_B and capacitors. The designing and working of astable multivibrator using 555 timer IC is done by using resistors, capacitors and a operational amplifiers.

Firstly, we design the circuit using IC-555 timer and measured the value of resistors and capacitors (0.01 μF and 0.02 μF). Then we measure charging time and discharging time and also calculate the charging and discharging time as,

$$t_1 = 0.693\, C_T (R_A + R_B)$$

$$t_2 = 0.693\, C_T \times R_B$$

And we also ~~cal~~ measure frequency. ~~d~~ Next, we change the value of R_B and again take the values of ~~table~~ t_1 and t_2 again and put the values in the table.