Pest LAB - 1 (Sarvan Jha)

Experiment 1: Diode Characteristics

Objective:

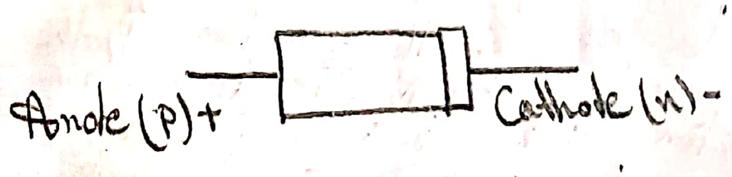
Measure the I-V Characteristics of diode.

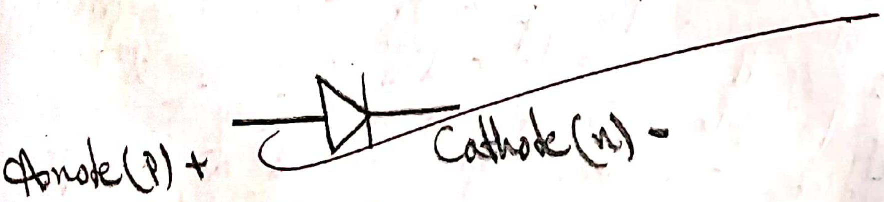
Materials Required

1. Breadboard
2. Equipment: DC power supply and Benchtop Digital Multimeter
3. Components:
   - Diode: One - 1N4007 (Diode voltage drop $V_D = 0.7\,v$).
   - Resistance: One - 100 Ω.

Structure of P-N junction diode

The diode is a device formed from a junction of n-type and p-type semiconductor material. The lead connected to the p-type material is called the anode and the lead connected to the n-type material is cathode. In general the cathode of a diode is maked by a solid line on the diode.





Biasing of PN junction Diode :

Forward bias Operation

The P-N junction supports uni-directional current flow. If +ve terminal of the input supply is connected to P side and -ve terminal is connected to n-side, then diode is said to be forward biased condition. In this condition the height of the potential barrier at the junction is lowered by an amount equal to given forward biasing voltage. Both the holes from P side and electrons from n side cross the junction simultaneously thereby decreasing the depleted region. This constitutes through the diode to be very large, the diode can be approximated as short-circuit switch. Diode offers a very small resistance called forward resistance.

Reverse bias Operation

If negative terminal of the input supply is connected to P-side and +ve terminal is connected to a n-side then the diode is said to be reverse biased. In this condition an amount equal to reverse biasing voltage increases the height of the potential barrier at the junction. Both the holes on P-type and electrons on N-side tend to move away from the junction thereby increasing the depleted region. However the process cannot continue indefinitely, thus a small current called reverse saturation current continues to flow in the diode. This current is negligible; the diode can be approximated as a open circuited switch it offers a very high resistance called reverse resistance.

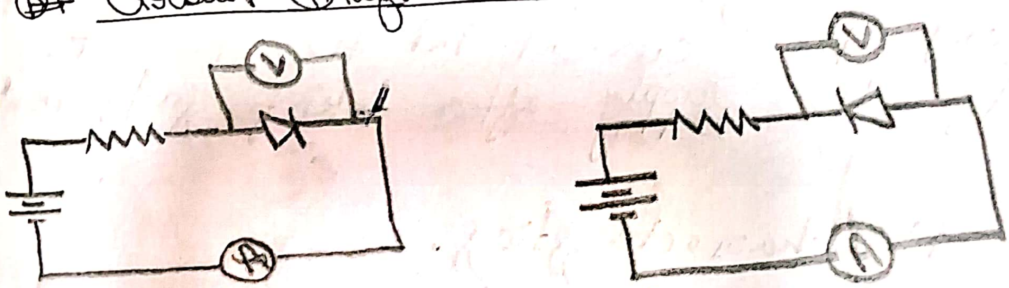
Diode Characteristics:

The nonlinear characteristics of diodes are used extensively in the design of digital and analog circuits. The terminal current voltage (IV) characteristic of diode is described by Shockley's equation and is given by

$$I_D = I_S\left(e^{\frac{qV_D}{nKT}} - 1\right)$$

Where I_D is the diode current, V_D is diode voltage, I_S is the diode saturation current, n is the ideality factor, K is Boltzmann's constant, and T is the absolute temperature.

Circuit Diagram



Forward Biasing   Reverse Biasing

Fig 1 (a) forward Bias (b) ~~Reverse Bias~~

Procedure:

Before you proceed, identify the p and n-side of the diode in order to connect properly in forward and reverse bias mode.

Forward bias Characteristics:

1. Assemble the circuit on your breadboard as shown in fig 1(a). Connect to the 0-30V dc power supply. 2. Switch on the power supply. Slowly increase the supply voltage in steps of 0.1 volt using the fine adjustment knob and note down the corresponding of diode current. When you find the change in current is large, increase the supply voltage in steps of 0.5 to note down current. 3. Using multimeters in appropriate modes, measure voltage drop across the diode and the current in the circuit. Switch off the supply after taking sufficient readings.

4. Plot the IV characteristics.

Reverse Bias Characteristics:

1. Assemble the circuit on your breadboard as shown in Fig 1(b), Connect to the 0-30V dc power supply.

2. Switch on the supply. Increase the supply voltage in steps of 0.5 volt to note down the diode current.

3. Use multimeter for voltage and current measurements. Keep in mind the magnetude of current flowing in the circuit will be very small, so chose current range properly. Switch off the supply after taking sufficient readings.

4. Plot the IV characteristics and estimate the reverse saturation current.

Forward bias			Reverse bias		
Voltage Applied (V)	Voltage, V_D (V)	Current, I_D (mA)	Voltage Applied (V)	Voltage, V_D (mV)	Current, I_D (µA)
0	-0.19 mV	-0.001 mA	0	-0.142 mV	0
0.1	99.84 mV	0.003 mA	0.1	-99.891 mV	0
0.2	199.712 mV	0.043 mA	0.2	-199.805 mV	0
0.3	0.299 V	0.532 mA	0.3	-300 mV	0
0.4	0.392 V	6.87 mA	0.4	-400 mV	0
0.5	0.457 V	41.98 µA	0.5	-499 mV	0
0.6	0.494 V	105 µA	0.6	-600 mV	0
0.7	0.518 V	185.93 µA	0.7	-699 mV	0
0.8	0.535 V	0.236 mA	0.8	-798 mV	0
0.9	0.549 V	0.355 mA	0.9	-898 mV	0
1	0.559 V	0.466 mA	1	-998 mV	0
2	0.614 V	0.421 mA	2	-1999 mV	0
3	0.639 V	0.424 mA	3	-2999 mV	0
4	0.656 V	0.438 mA	4	-3998 mV	0
5	0.668 V	0.544 mA	5	-4997 mV	0

Exercise

1. Write the values of the resistance (in Ω, kΩ or MΩ) having the following colour bands:

(a) Green, Blue, Black, Gold: 56Ω ± 5%

(b) Red, Red, Red, Silver: 2200Ω ± 10%

(c) Yellow, violet, Red, Gold: 4700 Ω ± 5%

(d) Brown, Black, Green, Silver: 1000000 ± 10%

2. Answer the following questions on a separate sheet and attach it to this sheet.

(a) Write the colour code used to specify the value of a resistance.

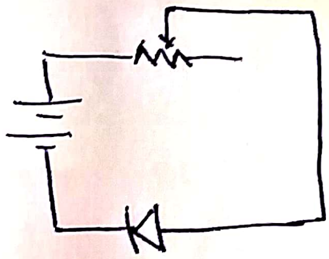
Ans:→

Colour	Digit	Multiplier	Tolerance
Black	0	1	
Brown	1	10	±1%
Red	2	100	±2%
Orange	3	1000	
Yellow	4	10,000	
Green	5	100,000	±0.5%
Blue	6	1,000,000	0.25%
Violet	7	10,000,000	0.1%
Grey	8	~~100000000~~	0.05%
White	9	~~1000000000~~	
Gold			± 5%
Silver			±10%

cathode and and anode are generally indicated on a
?
On a physical diode, you will notice two terminal
from a tin can shape in the middle. One
the positive terminal called the anode. The other
is the negative end, called the cathode.

t does the notch on a transistor indicate?
In a practical transistor, there is a notch present
ne emitter lead for identification.

aw a circuit diagram to generate a variable
from 0-5V using a potentiometer and a
power supply of 5V.

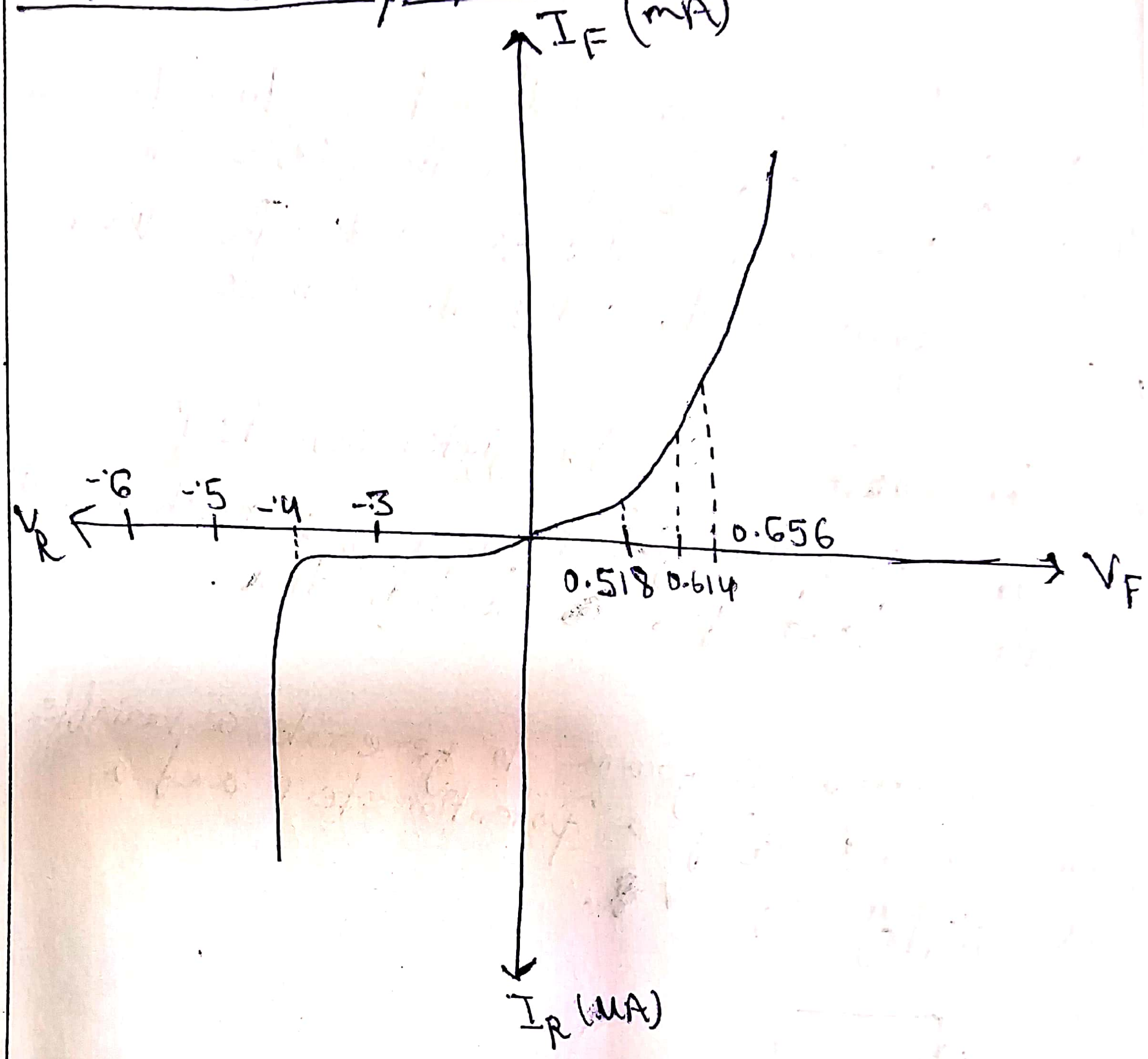


onclusion

From this experiment, we learnt
about the IV characteristics of a diode

30/1/24.

IV characteristics



Experiment - 2 (POST-LAB) (ABHISHEK)

Half Wave and Full Wave Rectifier Circuits

Objective :-

Design and analysis of half wave and full wave rectifier circuits.

Materials Required :-

- ~~Breadboard.~~
- Equipment function generator and oscilloscope.
- Components :
  - Transformer : One - 230 V to 12 - 0 - 12 V
  - Diode : Two - 1N4007 (Diode voltage drop $V_D = 0.7V$)
  - Resistors : 1 KΩ , 2.2 KΩ

General guidelines / precautions :-

- Connect the diode with correct polarity. Check the diode voltage first to confirm if the diode is working.
- Keep ground terminals of oscilloscope probes and function generator output connected throughout the experiment.
- In an oscilloscope, for higher precision, increase vertical sensitivity (i.e. lower value of volt / div), especially while measuring small ~~ampli~~ amplitude levels (e.g. ripple voltage). You may need to switch to ac coupling while doing so.

4- In the case full wave rectifier, swi[tch] on the mains supply to the transformer only after you have made all other connections (in order to avoid electric shock.

5- Also, while making any changes in the circuit, switch off the mains supply to the transformer.

6- Use "line" as the source of triggering in the oscilloscope. Put the oscilloscope in CHOP mode.

7- Make sure that the power lines in breadboard given on the top and bottom for the power supply must be used all from there you connect to the other parts of the circuit.

8- Switch off the supply to all the equipment before you make any changes in the circuits.

11 Half Wave and FULL Wave Rectifier :->

One the very important applications of diode is as a rectifier to convert AC into DC power supply is required for the operation of most of the electronic and circuits (For example: Television, co radio, telephone, mobile as well as meas instruments like multi-meter, oscillators, ...

iers etc.). Now a days, alomost all electro-
nic equipment includes a circuit that converts
AC supply into DC supply. The first block
of DC power supply is rectifier. Rectifier may
be defined as an electronic device used to
convert AC Voltage or current into undire-
ctional voltage or current. Since a diode p-n
junction conducts in one direction but not in
the reverse direction, diodes can be used
as a rectifier. Rectifier broadly divided into
two categories: Half wave rectifier and
Full wave rectifier.

Part A : Half Wave Rectifier

In positive half cycle, diode D is forward
biased and conducts. Thus, the output voltage
is same as the input voltage. In the nega-
tive half cycle, D is reverse biased, and
therefore output voltage is zero.

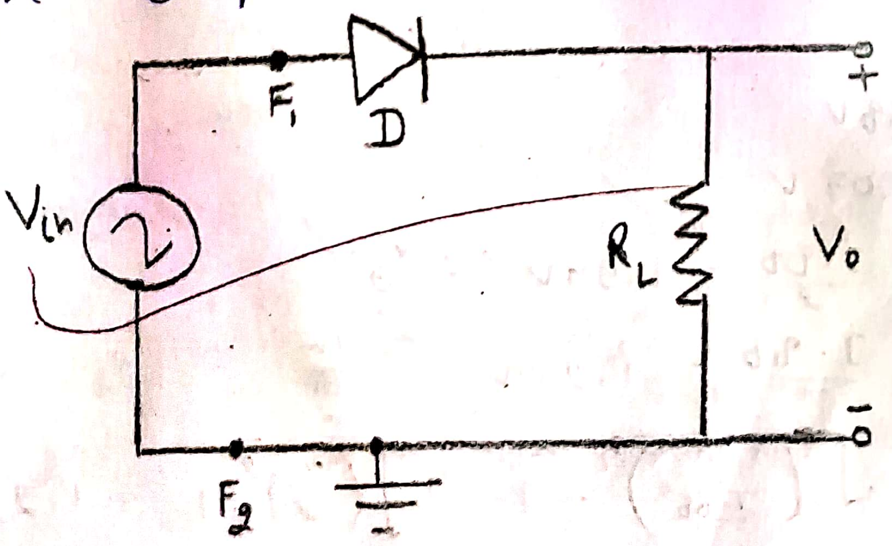


Figure 4 Half wave Rectifier Circuit

1- Determine the average value V_{dc} and maximum efficiency.

2- Set the function generator to obtain lov peak to-peak sine wave at 500 Hz frequency. Do not connect any circuit to the function generator. Keep DC offset equal to 0. Observe the function generator output on the oscilloscope and verify sine wave generation.

3- Set up the circuit as shown in Fig. 4(a) taking $R_L = 2.2K\Omega$.

4- Now, connect the function generator to circuit at points F1 & F2 as shown Fig. 4.

5- Display V_i and V_o simultaneously on the oscilloscope. Sketch V_i and V_o below the other with identical time and amplitude axes.

HWR →

$V_m = 3.88V$

$V_{pp} = 4.07V$

$V_{rms} = \frac{3.88}{2} = 1.94V = \frac{V_m}{2}$

$V_{dc} = \frac{3.88}{\pi} = 1.23V = \frac{V_m}{\pi}$

$R.F. = \sqrt{\left(\frac{\frac{3.88}{2}}{\frac{3.88}{\pi}}\right)^2 - 1} = \sqrt{\left(\frac{\pi}{2}\right)^2 - 1} = 1.208$

$\eta = \left(\frac{2}{\pi}\right)^2 \times 100 = 40.52\% = \left(\frac{V_{dc}}{V_{rms}}\right)^2 \times 100$

put → 10

0

put →

8.8V

0

RT B:

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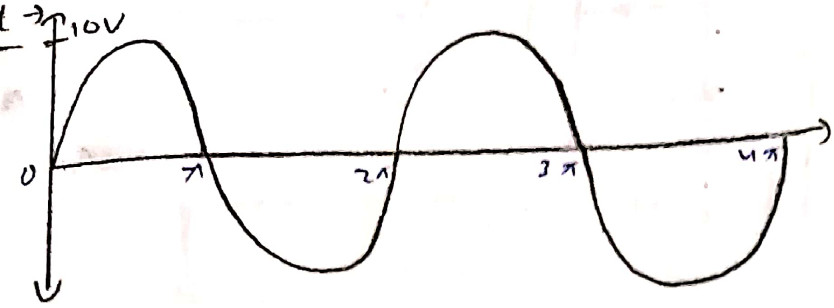

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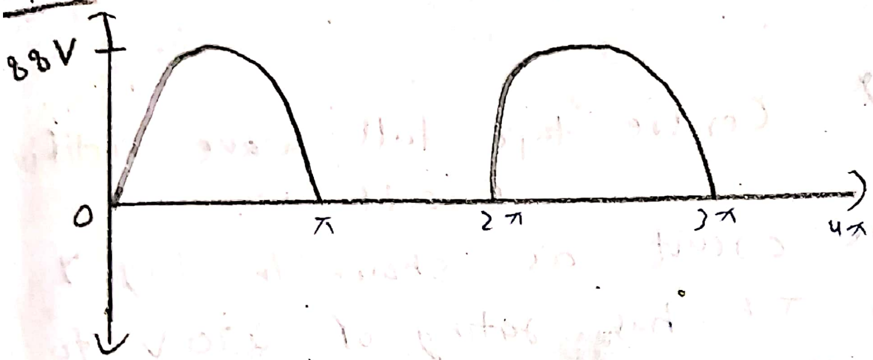


RT B: Full Wave Rectifier

centre tapped full wave rectifier that uses
wo diodes connected to the secondary of
a centre tapped transformer as shown in Fig.
y. The centre tap is usually considered as
the ground point or the zero-voltage refe-
rence point. As shown in Fig. 2 an AC input
voltage is applied to the primary coils of
the transformer. The input makes the seco-
ndary ends A and B become positive and
negative alternatively. For the positive half of
the AC signal, the secondary point A is posi-
tive, ground point will have zero voltage
and B will be negative. At this instant Dio-
de D1 will be forward biased and diode
D2 will be reverse biased.

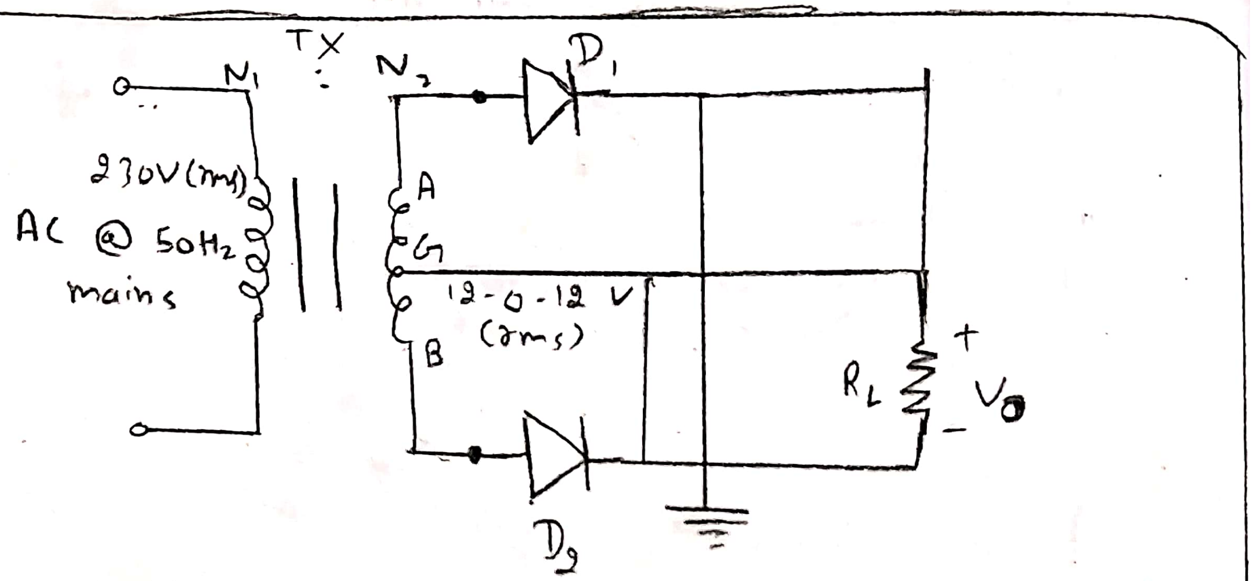


Figure 2: Centre tape full wave Rectifier Circuit

1. Set up the circuit as shown in Fig. 2. The transformer TX has rating of 230 V to 12-0-12 V, 2 A. Take $R_L = 2\,k\Omega$. Connect transformer primary to the mains and switch on the mains.

   Display the secondary voltages V_{AG} and V_{BG} (V_{AG} to Ch-1 ; V_{BG} to Ch-2) on the oscilloscope. Make sure that both the "Probe grounds" are connected to the circuit ground. Sketch the waveforms overlapping, with the same time and amplitude axes. They should be 180° out of phase. Measure the output voltage (V_m & V_{p-p}) of the transformer in the oscilloscope.

2. Display and sketch the full-wave rectified output V_o across RL. Measure the peak voltages in both halves.

FWR →

$V_{BG} = 16.8V$

$V_{AG} = 17.2V$

$V_{PP} = 34V$

$V_m = 16.1V$

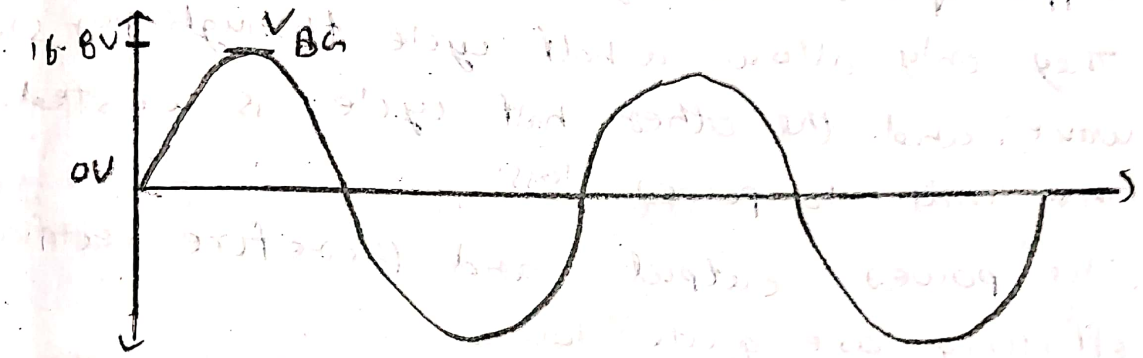
$V_{p.p} = 16.3V$

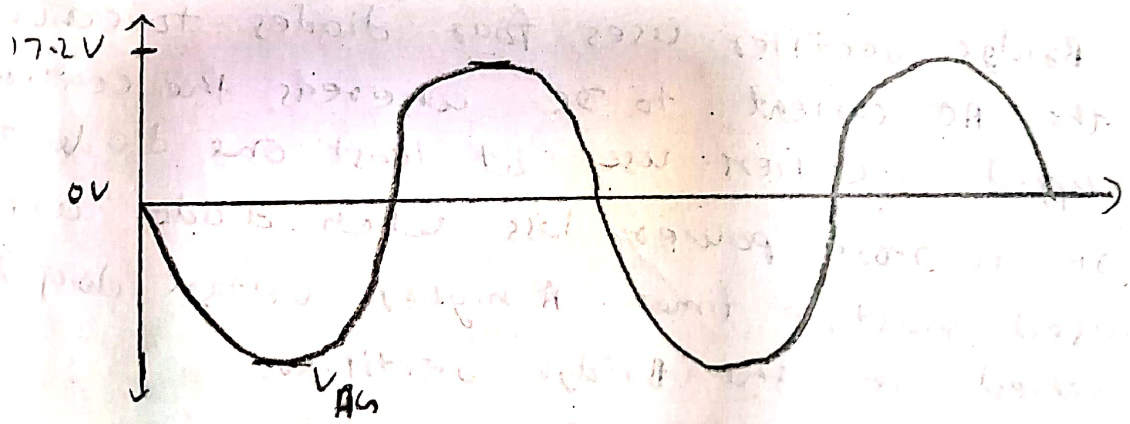
$\frac{V_m}{\sqrt{2}} \in V_{rms} = \frac{16.1}{\sqrt{2}} = 11.38V$

$\frac{2V_m}{\pi} \in V_{dc} = 10.94V$

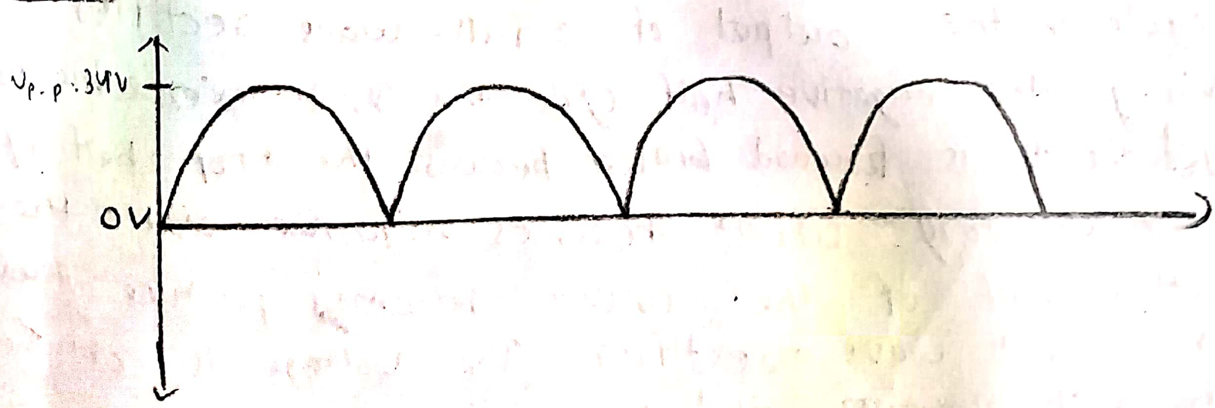
$\sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1} \in R.F. = \sqrt{\left(\frac{11.38}{10.94}\right)^2 - 1} = 0.45$

$\frac{V_{dc}}{V_{rms}} \times 100 \quad \eta = \left(\frac{10.94}{11.38}\right)^2 \times 100 \approx 80\%$





Output →



Note :-> If the peak amplitudes are not equal, what could be the reason?

Questions :->

1- What is the disadvantage of
a) A half wave rectifier
b) Bridge circuit rectifier as compared to the cent. re tape rectifier.

-> a) Disadvantage of half wave rectifier :->

① The transformer utilisation factor is zero.
② They produce a low output voltage.
③ Ripple factor is high.
④ They only allow a half cycle through per sine wave, and the other half cycle is wasted. This leads to power loss.
⑤ The power output and therefore rectification efficiency are quite low.

b) Bridge rectifier uses four diodes to convert the AC current to DC whereas the centre-tapped rectifiers uses at least one diode. There is more power loss when diodes are used multiple times. A higher voltage drop is sensed in the Bridge rectifiers.

2- How is the negative cycle got inverted to positive cycle in the output of a full-wave rectifier?

-> During the negative half cycle, the D_1 is reverse biased and the D_2 is forward biased because the top half of the secondary circuit becomes negative and the bottom half of the circuit becomes positive. Thus in a full wave rectifier. DC voltage is obtained for both positive and negative half cycle.

Experiment-3 (POST LAB REPORT) [MAYANK]

Half wave and full wave Rectifier circuits with filter

Objective: Design and analysis of half wave and full wave rectifier circuits with filter.

Materials Required:

1.) Breadboard

2.) Equipment : Function generator and oscilloscope.

3.) Components.

a) Transformer : One - 230V to 12 0 12 V

b) Diode : Two - IN4007 (Diode voltage drop $V_D = 0.7$ V)

c) Resistance : six - 1kΩ and 22kΩ

d) Capacitance : Two - 22 μF, 100 μF

General Guidlines / Prequations:

1.) Connect the capacitor with the correct polarity. The capacitor being of electrolytic type, it is polarized and will be damaged if connected with incorrect polarity. Similarly, confirm the polarity of diodes before connecting.

2.) Keep ground terminals of oscilloscope proves and function generator output connected together throughout the experiment.

3) In an oscilloscope, for higher precision, increase vertical sensativity (i.e - lower value of volt/div.), espacially while measuring small amplitude levels (e.g. ripple voltage). You may need to switch to ac coupling while doing so.

4.) In the case full wave rectifier, switch on the main supply to the transformer only after you have made all other connections c in order to avoid electric shock.

5.) Also, while making any changes in the circuit, switch off the mains supply to the transformer.

6.) Make sure that the power lines in the breadboard given on the top and bottom for the power supply must be used and connect to the other parts of the circuit.

7.) Switch off the supply to all the equipments before you make any changes in the circuit.

Half wave rectifier with capacitor filter:-

1.) Now connect a capacitor ($C = 22\mu F$) in the circuit with correct polarity as shown in fig. 1(a)

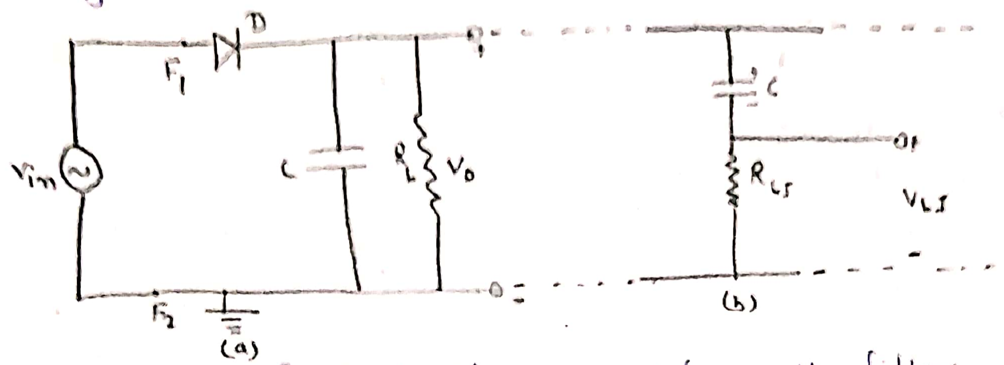


Fig 1: Half wave rectifier with filter

2.) Now display V_i and V_o simultaneously on the oscilloscope. Sketch V_i and V_o overlapping with the same time and amplitude axes.

3.) Measure peak to peak ripple voltage on oscilloscope by enlarging V_o to the maximum extent. you may have to put the input coupling in the ac mode while doing this experiment. See the guidelines given and the end. Repeat steps 2 and 3 for $R_L = 1k\Omega$ and $4.7k\Omega$. Comment on the output waveforms and ripple voltages.

4.) Connect a $RL_1 = 5\Omega$ resistance in series with C of Fig 1(b). The points across this RL_1 are marked as p and q. Note: The resistance 5Ω is chosen small enough not to affect the overall performance of the circuit and at the same time to ensure an appreciable voltage across it. This voltage represents the current flowing through the capacitor.

5.) Display and sketch V_o and V_{RL} (i.e. Voltage across RL_1 between 'p' and 'q') are below the other with identical time axes. Mark the ground reference line.

Full wave rectifier with capacitor filter:-

1.) Setup the circuit as shown in fig. 2 with the capacitor C. The transformer TX has rating of 230V to 12 0 12V, 1A Take $RL = 1k\Omega$. Connect transformer primary to the mains and switch on the mains. Display the secondary voltages V_{AG} and V_{BG} (V_{AG} to Ch-1, V_{BG} to ch-2) on oscilloscope. Make sure that both the "Probe grounds" are connected to the circuits ground. Sketch the waveforms overlapping, with the same time and amplitude axes. They should be 180° out of phase. Measure the output voltage (V_m and V_{p-p}) of the transformer in the oscilloscope.

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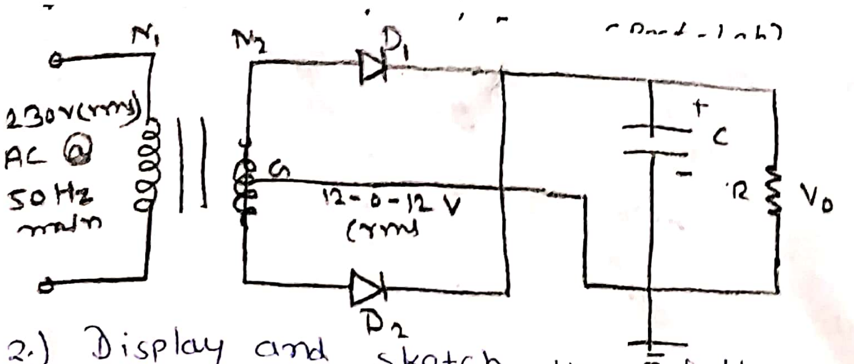


Fig-2: Full wave rectifier with filter.

2.) Display and sketch the full-wave rectified output V_o across R_L. Measure the peak voltages in both halves. Note: If the peak amplitudes are not equal, what could be the reason)

3.) Now connect $C = 100\mu F$ as shown in Fig.2 (Read the guideline 3). Sketch V_o and measure V_r (Peak-to-Peak ripple voltage). Set the oscilloscope channel to AC coupling and increase vertical sensitivity (decrease V/div) while measuring V_r.

4.) Calculate ripple factor by using the formulas

$$\text{Ripple factor} = \frac{1}{4\sqrt{3}f.C.r}$$

Observations :-

1) For half wave rectifier :-

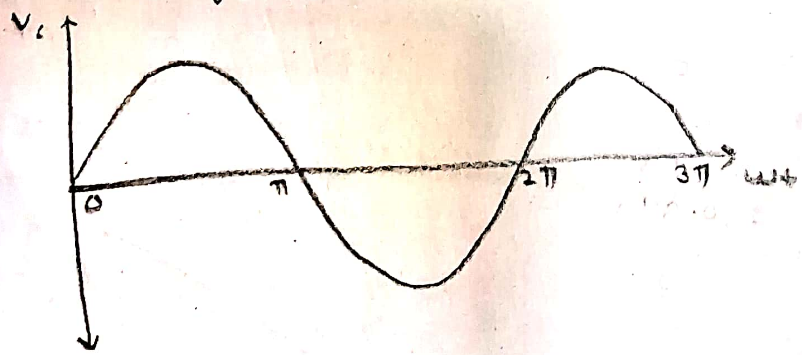
Input :-

$V_{pp} = 9.60$ V

$V_m = 4.40$ V

frequency = 500 Hz

Input wave forms:-



Output :-

$V_r(p\text{-}p) = 200$ mV

$$V_r(rms) = \frac{V_r(p\text{-}p)}{2\sqrt{3}}$$

$$= 0.57 \text{ V}$$

$$r = \frac{1}{2\sqrt{3} \times 500 \times 1000 \times 22 \times 10^{-6}}$$

$$r = \frac{1}{2\sqrt{3}\, fRC}$$

$$= \frac{1}{2.2\sqrt{3}}$$

$$= 0.0262$$

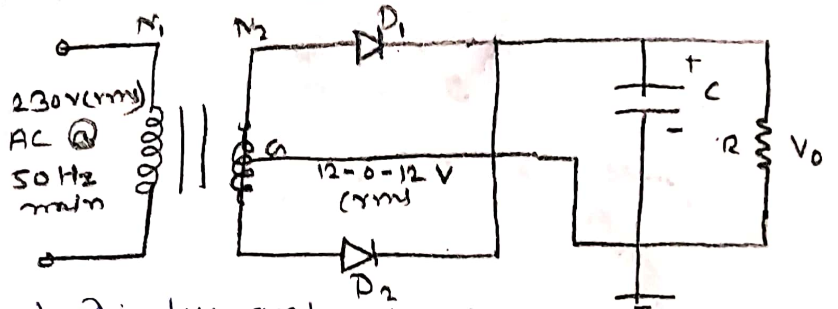


Fig-2:
Full wave rectifier with filter.

2.) Display and sketch the full-wave rectified output V_0 across R_L. Measure the peak voltages in both halves. Note: If the peak amplitudes are not equal, what could be the reason?

3.) Now connect $C = 100\mu F$ as shown in fig.2 (Read the guideline 3). Sketch V_0 and measure V_r (Peak-to-Peak ripple voltage). Set the oscilloscope channel to AC coupling and increase vertical sensitivity (decrease V/div) while measuring V_r.

4.) Calculate ripple factor by using the formulas

Ripple factor $= \dfrac{1}{4\sqrt{3} f . C . r}$

Observations :-

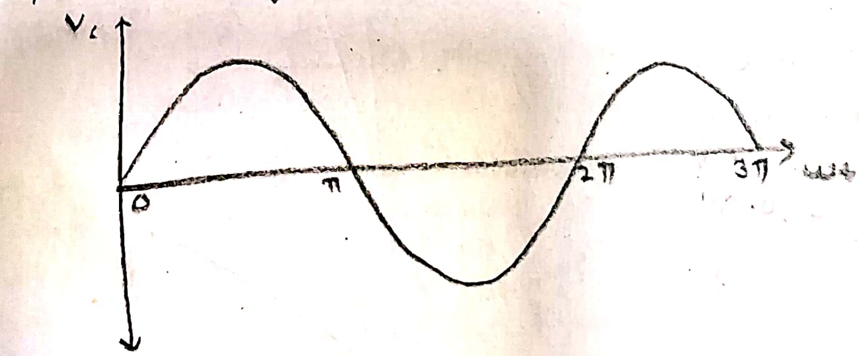
1) For half wave rectifier :-

Input :- $V_{pp} = 9.60\ V$

$V_m = 4.40\ V$

frequency $= 500\ Hz$

Input wave forms:-



Output :-

$V_{r(p-p)} = 200 mV$

$V_{r(rms)} = \dfrac{V_{r(p-p)}}{2\sqrt{3}}$

$= 0.57 V$

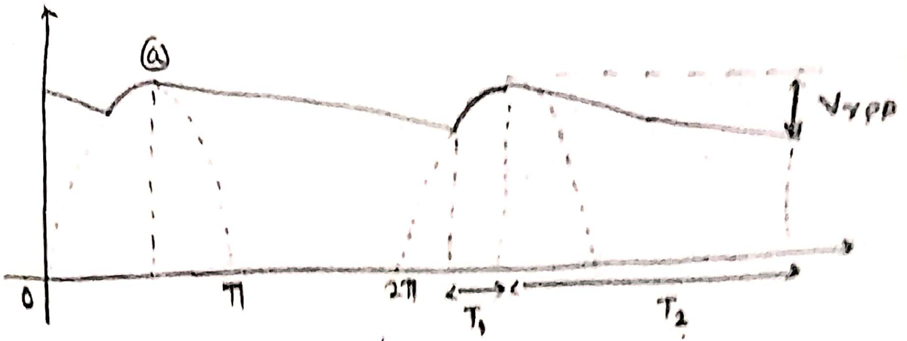
$r = \dfrac{1}{2\sqrt{3} \times 500 \times 1000 \times 22 \times 10^{-6}}$

$r = \dfrac{1}{2\sqrt{3}\, f R C}$

$= \dfrac{1}{22\sqrt{3}}$

$= 0.0262$

Output wave form:-



2.) For full wave rectifier:-

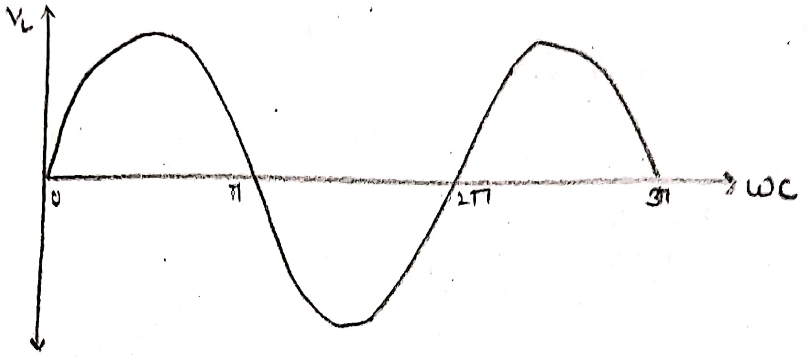
Input :

$V_{A\,a(rm)} = 16.4\ V$

$V_{B\,a\,m} = 16.4\ V$

$V_{pp} = 32.8\ V$

Input wave form:-



Output:-

$V_r\,(p\text{-}p) = 1.18\ V$

$V_r\,(rms) = \dfrac{1.18}{2\sqrt{3}}$

$= 0.34\ V$

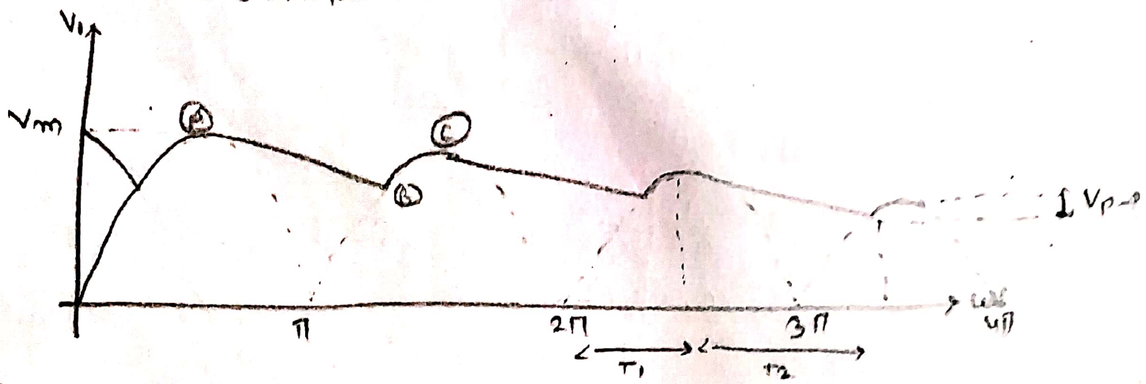
$V_m = 14.3\ V$

$r = \dfrac{1}{4\sqrt{3}\,fRC}$

$= \dfrac{1}{4\sqrt{3} \times 1000 \times 100 \times 10^{-6} \times 50}$

$= 0.028$

Output wave form:-



Experiment - 5 (Post-lab) → Abhishek

POST LAB QUESTIONS :-

Que.1. Define peak inverse voltage (PIV)? And write its value for full wave rectifier?

Ans. The peak inverse voltage is either the specified maximum voltage that a diode rectifier can block or alternatively, the maximum voltage that a rectifier needs to block in a given circuit. PIV for full wave rectifier is $2V_{max}$.

Que.2. What is the necessity of the transformer in the rectifier circuit?

Ans. 1.) It is used to change the voltage level from the 115V AC to another level, either higher to lower, to accomadate the needs of the rest of the circuit.

2.) It provides isolation between the power mains and the circuit power for safety reasons.

Que.3. Explain how capacitor helps to improve the ripple factor?

Soln:- The ripple can be reduced by smoothing capacitors which converts the ripple voltage into a smoother dc voltage. Aluminium electrolytic capacitors are widely used for this and have capacitances of 100μF or more. The repeated dc pulses charges the capacitor to peak voltage.

Conclusion:-

In this experiment, we have learnt design and analysis of half wave and full wave reactifier circuits with filter in depth. We lernt about their functions, mechanism and at what input what output will going to be coming and also tested their mechanics and structure clearly.

Kalambe 6/12/24

Sarvan.

Experiment 4: Clipping and Clamping Circuits

Objective: Design and analysis of wave shaping circuits.

Materials Required

1. Breadboard.
2. Equipment: function generator and oscilloscope.
3. Components:
   - Diode: Two - 1N4007 (Diode voltage drop $V_D = 0.7V$)
   - Zener Diode: One - (Zener voltage $V_Z = 3.9V$)
   - Resistance: Three - $1K\Omega$, $2.2K\Omega$, $100K\Omega$.
   - Capacitor: One - $22\mu F$.

I General Precautions:

1. Connect the capacitor with correct polarity. The Capacitor being of electrolytic type, it is polarised, and will be damaged if connected with incorrect polarity. Similarly, confirm the polarity of the diodes before connecting.

2. Keep ground terminals of oscilloscope probes and function generator output connected together throughout the experiment.

3. Make sure that the power lines in the breadboard given on the top and bottom for the power supply must be used and from their you connect to the other parts of the circuit.

4. Switch off the supply to all the equipments before you make any changes in the circuit.

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II PART A : Clipping Circuits

Clippers are the circuit that employ diodes to remove a portion of an input signal without distorting the remaining part of the applied waveform. A clipper can serve as a protective measure, preventing a signal from exceeding the clip limits. A practical application of a clipper is to prevent an amplified speech signal from overdriving a radio transmitter. Over driving the transmitter generates spurious radio signals which causes interference with other station. The clipper is a protective measure.

II.I Clipping Circuit - Positive Clipping

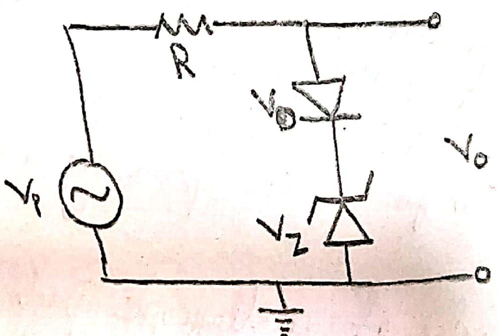


Fig. 1 : Positive Clipper

1. Connect the circuit as shown in fig. 1 with $R = 2.2K\Omega$
2. Set the function generator to get 20V peak-to-peak sine wave at 500HZ frequency. Observe the function generator output on the oscilloscope and verify sine wave generation.
3. Connect the function generator output to the circuit as shown fig. 1.
4. Display and sketch V_i and V_o one below the other with identical time and amplitude axes.
5. Superimpose the two waveforms V_i and V_o and observe.

6. Set the oscilloscope in X-Y mode (V_i to Ch2: X-input and V_o to Ch1 to Y-input) and sketch V_o versus V_i with equal x and y scales. Label the graph and ticks on the axes.

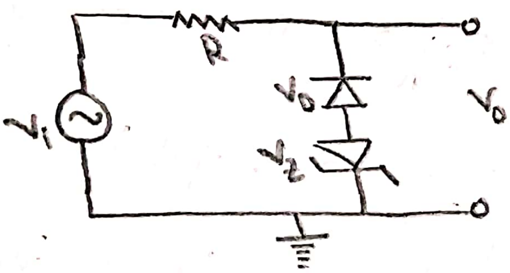
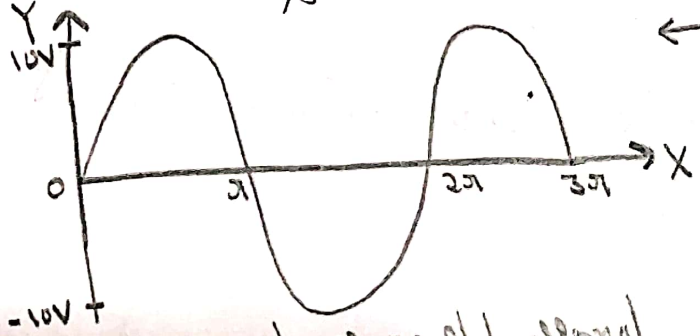


Fig 1.2: Negative Clipper

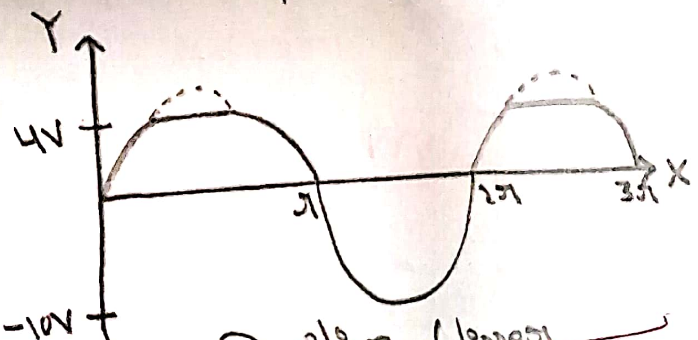
Expected wave forms at step no. 4



← Input

$f = 500HZ$,
$V_{pp} = 20V$

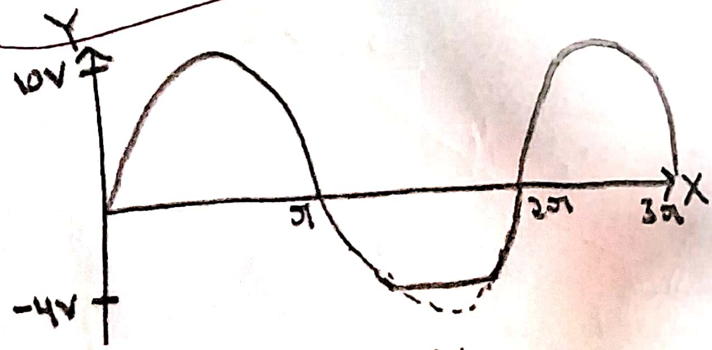
Input sinusoidal signal



← Output

$f = 500HZ$
$V_{pp} = 14V$

Positive Clipper



← Output

$f = 500HZ$
$V_{pp} = 14V$

Negative Clipper

II.I.1 Symmetrical Clipping Circuit

1. Connect the circuit as shown in fig. 2 with $R_1 = 1K\Omega$.
2. Set the function generator to get 20V peak-to-peak sine wave at 500Hz frequency. Observe the function generator output on the oscilloscope and verify sine generation.
3. Connect the function generator output to the circuit as shown fig. 2.
4. Display and sketch v_i and v_o one below the other with identical time and amplitude axes.
5. Superimpose the two waveforms v_i and v_o and observe.

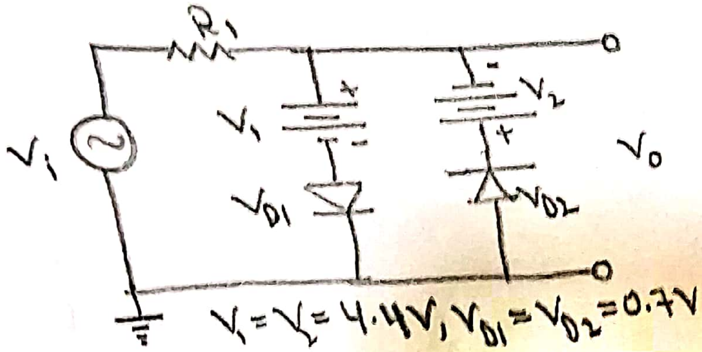
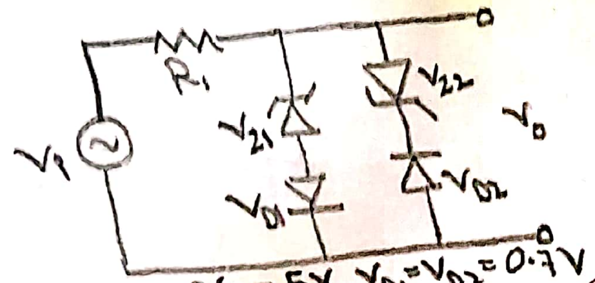


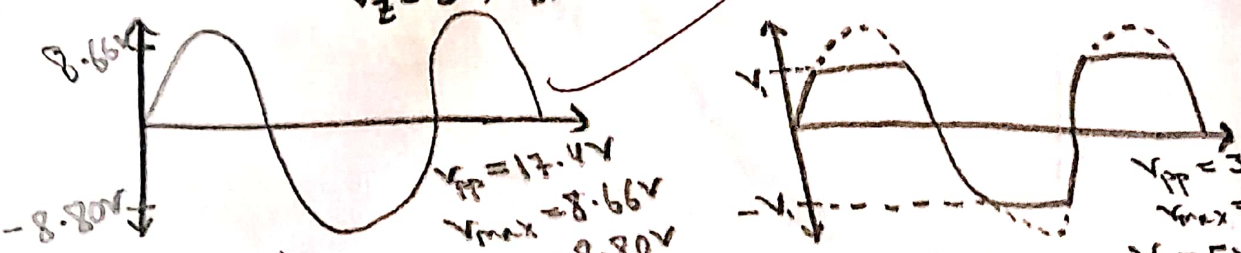
fig 2: Symmetrical Clipper

$V_1 = V_2 = 4.4V, V_{D1} = V_{D2} = 0.7V$



Symmetrical Clipper using Zener diode

$V_Z = 5V, V_{D1} = V_{D2} = 0.7V$



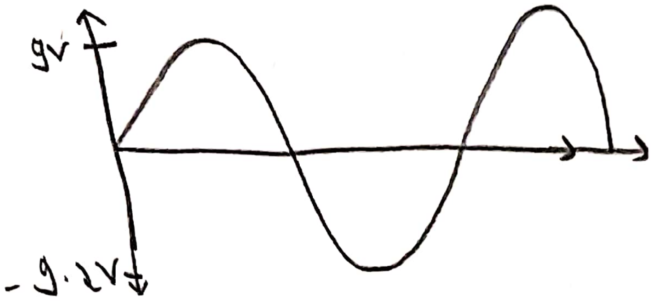
$V_{pp} = 17.4V$
$V_{max} = 8.66V$
$V_{min} = 8.80V$

Input

$V_{pp} = 3.04V$
$V_{max} = 1.52V$
$V_Z = 5V$
$V_{min} = -1.52V$

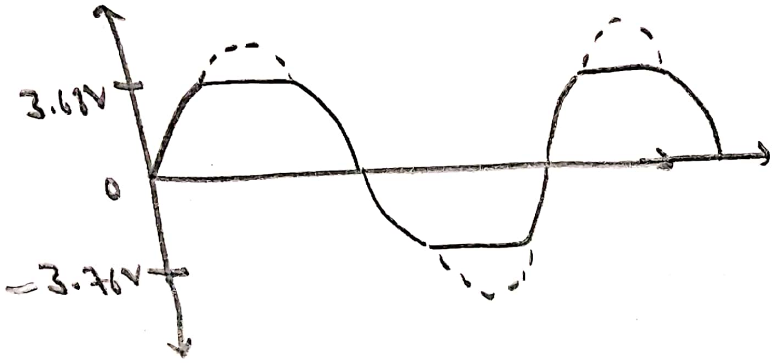
Output

Input :→



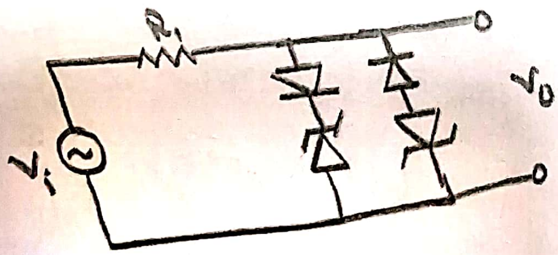
$V_{pp} = 18.2V$
$V_{max} = 9V$
$V_{min} = 9.2V$

Output :→

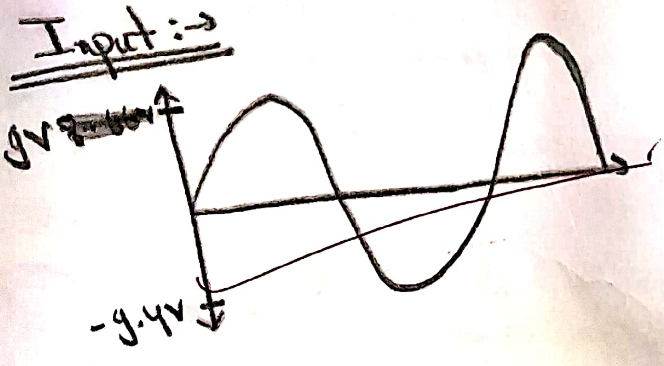


$V_{pp} = 7.44V$
$V_{max} = 3.88V$
$V_{min} = -3.76V$

Zener Reverse :→

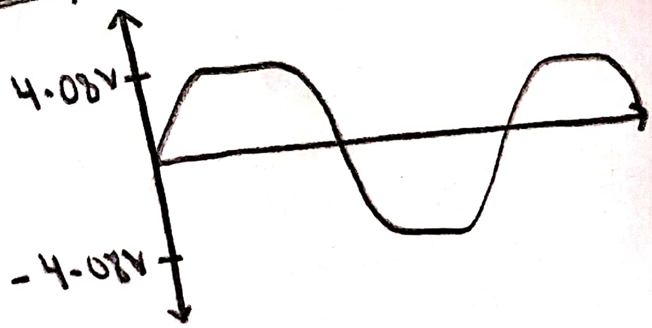


Input :→



$V_{pp} = 18.4V$
$V_{max} = 9V$
$V_{min} = -9.4V$

Output :→



$V_{pp} = 8.16V$
$V_{max} = 4.08V$
$V_{min} = -4.08V$

III Clamper Circuits –

Clamping is a process of introducing a dc level into a signal. Clamper circuit consist of diode and capacitor that shifts the input waveform to different dc level, without changing the appearance of the applied wave form.

1. When the diode is forward biased, it will conduct and charge the capacitor. The output voltage across the diode is zero.

2. The capacitor is charged to peak input voltage quickly because of small time constant of the circuit.

3. Connect the circuit as shown in fig. 3 with $R_L = 100k\Omega$.

4. During the -ve cycle when diode is reverse bias, the diode becomes to its off state. In this case, the output voltage is equal to the sum of the input voltage and the voltage across the terminals of the capacitor which have the same polarity with each other.

5. Set the function generator to get 20V peak-to-peak square with a period of 2ms. Observe the function generator output ~~of~~ on the oscilloscope and verify square wave generation.

6. Connect the function generator output to the circuit as shown fig. 3

7. Display and sketch V_i and V_o one below the other with identical time and amplitude axes.

8. Superimpose the two waveforms V_i and V_o and observe.

Negative →

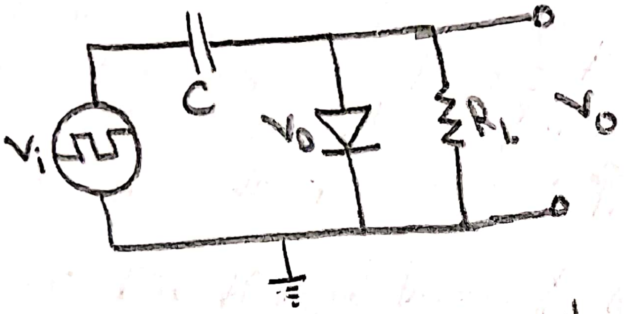
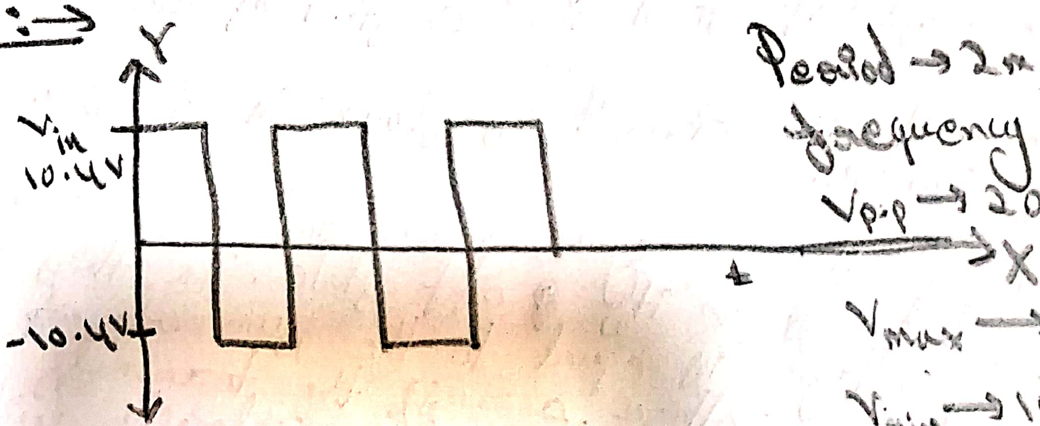


fig 3: Clamping Circuit

Input :→



Period → 2ms

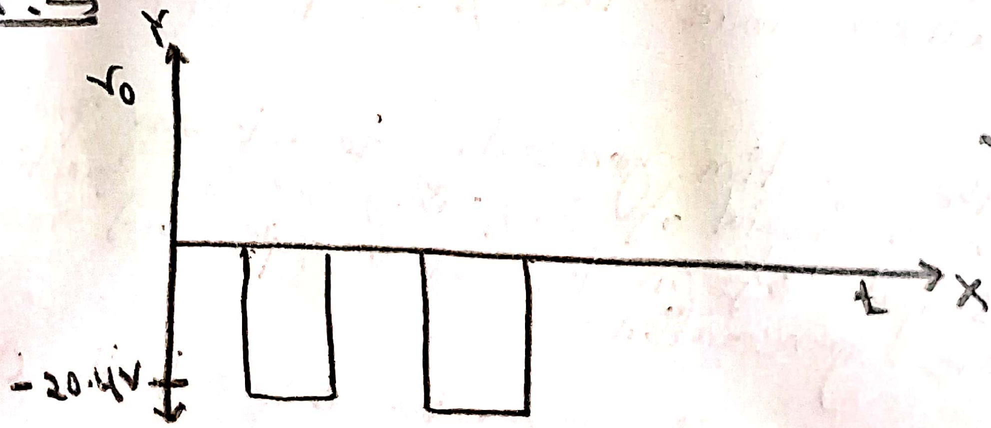
frequency → 500HZ

$V_{p\text{-}p}$ → 20.8V

V_{max} → 10.4V

V_{min} → 10.4V

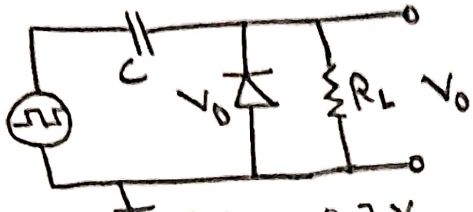
Output :→



$V_{p\text{-}p}$ = 20.4V

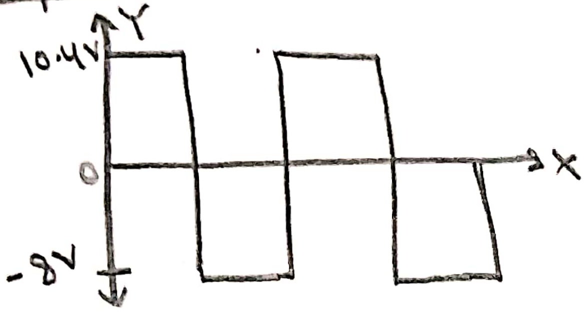
V_{max} = 800mV

Positive Clamper



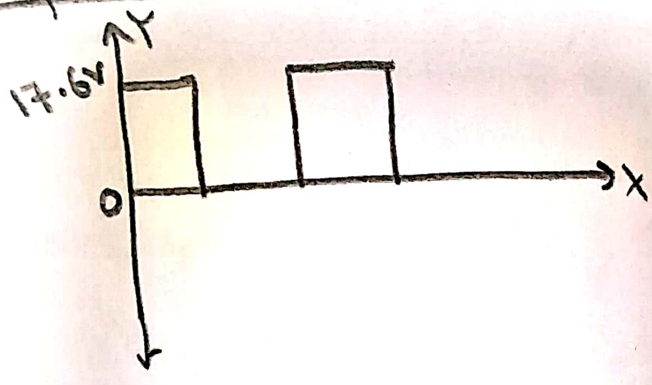
$V_D = 0.7V$

Input:→



$f = 500Hz$
$V_{pp} = 18.4V$
$V_{max} = 10.4V$
$V_{min} = 8V$

Output:→



$f = 500Hz$
$V_{pp} = 18.8V$
$V_{max} = 17.6V$
$V_{min} = 1.2V$

Conclusion:→

Clippers reduce the amplitude while clamper shift the DC level. Both are relevent circuits in various high-level applications of electronics as well as communication. Clippers are used in communication circuits such as transmitters and receivers.

Experiment-5 (Post-Lab) → Abhishek

Operational Amplifier

Objective →

Analyzing of inverting and non-inverting Op-Amp circuits.

Material Required →

1- Bread board

2. Equipment : Multi-output DC power supply, Function Generator, Oscilloscope.

3- Components :

- Op-Amp : One - LM741.
- Resistance : Five - 1 kΩ (4 no), 10 kΩ (1 no), 12 kΩ (2 nos), 100 kΩ (4 no).

I General Guidelines / Prequations :

1- The op-amp generally works on split power supply (e.g. ±12V). Both positive and negative power supplies must be present whenever op-amp is powered. The range of power supply is from ±5V to ±15V. Do not forget to connect the common terminal of the power supply to the ground on the breadboard.

2- Connecting only one side of power supply or interchanging positive and negative power supplies damages the op-amp.

3- For connecting power supply, you have to follow the procedure as given below.

(a) Disconnect the power supply to op-amps.

(b) Switch on the power supply.

(c) Set the output voltage as required (e.g. ±12V).

(d) Switch off the power supply.
(e) Connect the power supply to op-amps.
(f) Switch on the power supply.

4. For any IC, never exceed the input voltage beyond the power supply limits.

5. Keep ground terminals of the oscillo scope probes and function generator output and power supply common connected together through out the experiment.

6. Make sure that the power lines in the breadboard given on the top and bottom for the power supply must be used and from their you connect to the other parts of the circuit.

7. Switch off the supply to all the equipments before you make any changes in the circuit.

II Operational Amplifier

→ An operational amplifier is a very high gain amplifier having very high input impedance (2MΩ for LM741), low output impedance (less than 100Ω) high open loop gain (200000 for LM741) and high unity gain band width (1.5 MHz for LM741). The two op-amp circuits are most widely used, one is non-inverting amplifier and the other one is inverting amplifier. The inverting op-amp will have V_o is equal to minus KV_i, where the minus sign comes because of the phase inversion. The output will be inverted by 180 degrees.

The inverting amplifier is the most basic op-amp circuit. It uses the simple resistive feedback network to stabilize the overall voltage gain. The gain of the non-inverting amplifier is positive i.e. V_o is equal to KV_i.

II.I PART A : Inverting Applier

→ obtain theoritical values of V_o/V_i for step 5 of Part A. Do this for Part B also.

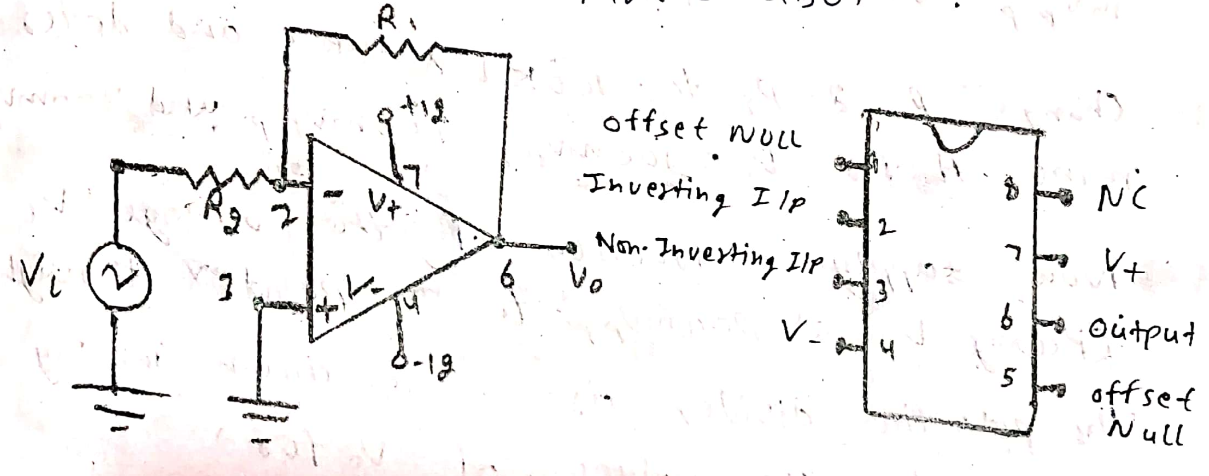


Fig. 1 : Inverting Amplifier

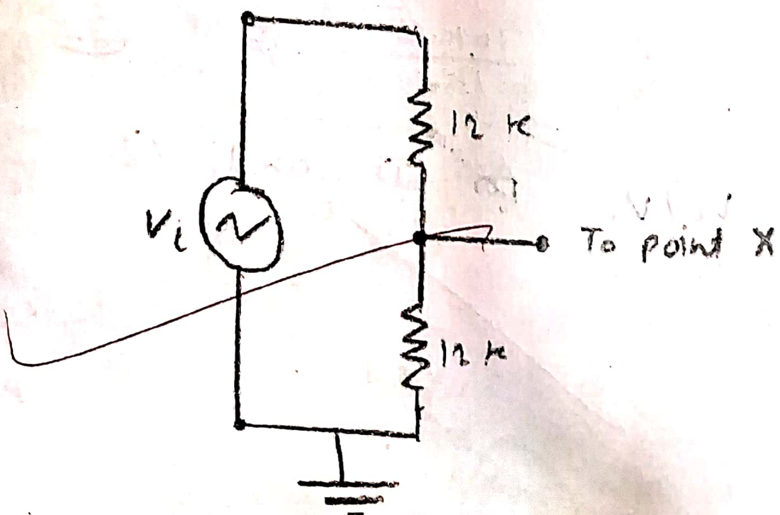


Fig. 2 : Voltage Divider.

1- Assemble the circuit shown in Fig 1 with $R_1 = 10 k\Omega$ and $R_2 = 1 k\Omega$. make sure the power supply ground is connected to the circuit ground.

2. Apply 200 mV_{p-p} 1 KHz sine wave at V_i from the function generator and see the output in the oscillo scope.

3. Observe V_o and V_i, and determine voltage gain $A = V_o / V_i$, Also obtain A for $V_i = 100$ mV_{p-p} and 300 mV_{p-p}

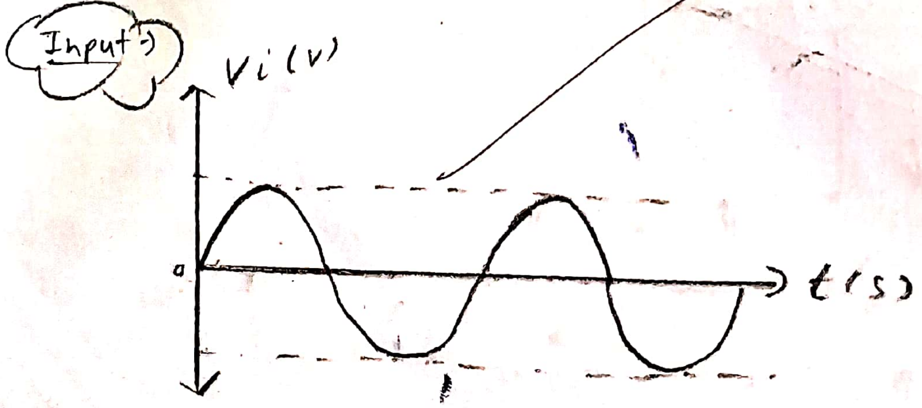
4- Change R_1 & R_2 to $100 K\Omega$ & $10 K\Omega$ and determine A for $V_i = 100 mV_{p-p}$, $200 mV_{p-p}$ and $300 mV_{p-p}$

5- Now supply a fraction of the voltage V_i (Keeping V_i at $200 mV_{p-p}$) to the point X through the potential divider circuit as shown in Fig. 2 and note the values of V_o for →

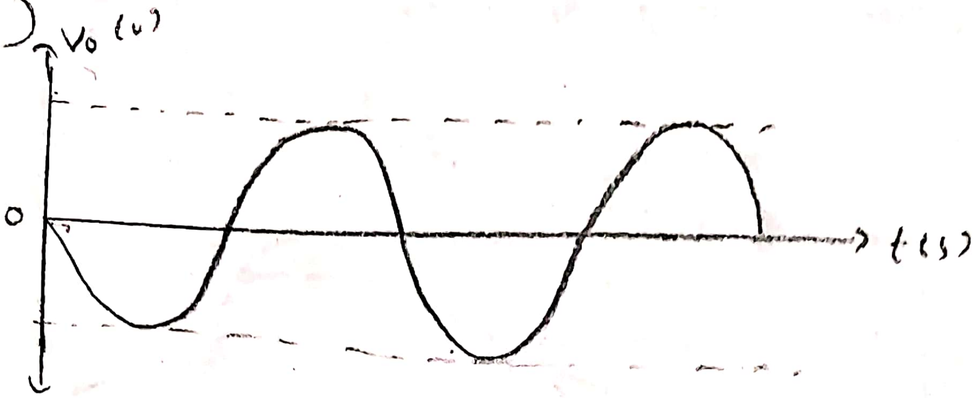
$$\frac{R_1}{R_2} = \frac{100 K\Omega}{10 K\Omega} \quad — ①$$

$$\frac{R_1}{R_2} = \frac{10 K\Omega}{1 K\Omega} \quad — ②$$

Compute V_o / V_i for ① and ②



Output →



Results →

① $R_1 = 10\,k\Omega$, $R_2 = 1\,k\Omega$

	V_{p-p} Input	V_{p-p} Output	$A = \frac{V_o}{V_i}$
100mV →	86mV	880mV	10.1
200mV →	168mV	1.7V	10.1
300mV →	250mV	2.52V	10.1

→ $\simeq 10$

② $R_1 = 100\,k\Omega$, $R_2 = 10\,k\Omega$

V_{p-p} Input	V_{p-p} Output	$A = \frac{V_o}{V_i}$
100mV	1.08V	10.8
200mV	2.08V	10.4
300mV	3.08V	10.2

→ $\simeq 10$

Using Voltage divider →

① $R_1 = 100\,k\Omega$, $R_2 = 10\,k\Omega$

$V_i = 216\,mV$, $V_o = 664\,mV$, $A = \frac{664}{216} = 3.11$

② $R_1 = 10\,k\Omega$, $R_2 = 1\,k\Omega$

$V_i = 212\,mV$, $V_o = 158\,mV$, $A = \frac{158}{212} = 0.74$

PART 'B': Non- Inverting Amplifier

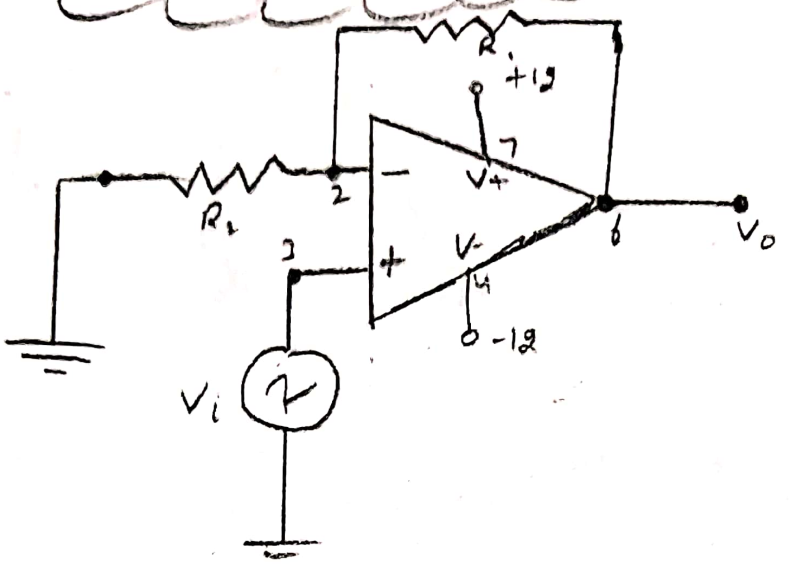


Fig. 3: ~~sym~~ Non- Inverting Amplifier

1- Assemble the circuit shown in Fig-3 with $R_1 = 10k\Omega$ and $R_2 = 1k\Omega$, make sure the power supply ground is connected to the circuit ground.

2- Apply 200 mVp-p, 4 KHz sine wave at V_i from the function generator and see the output in the oscilloscope.

3- Observe V_o and V_i, and determine voltage gain $A = V_o / V_i$, Also obtain A for $V_i = 100$ mVp-p and 300 mVp-p.

4- Change R_1 & R_2 to $100k\Omega$ & $10k\Omega$ and determine A for $V_i = 100$ mVp-p, 200 mVp-p and 300 mVp-p.

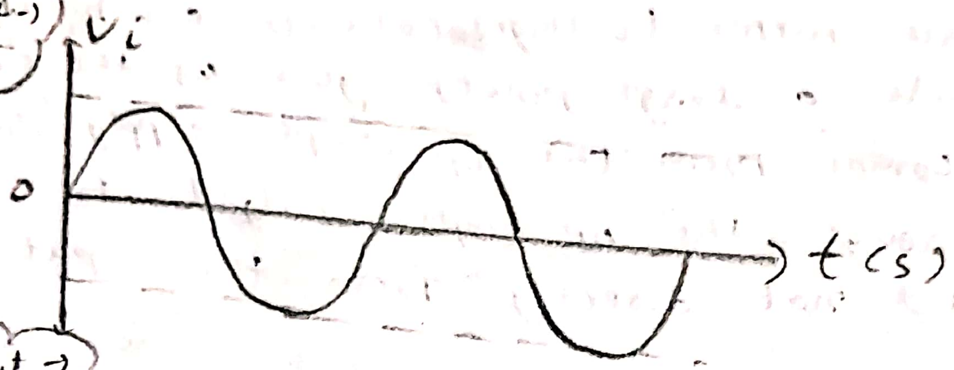
~~5 - Now apply a fraction of the voltage V_i (keeping V_i at 200 mVp-p) to the point X through the potential divider circuit as shown in Fig. 2 and note the values of V_o for~~

$$\frac{R_1}{R_2} = \frac{100k\Omega}{10k\Omega} \quad — \quad (3.)$$

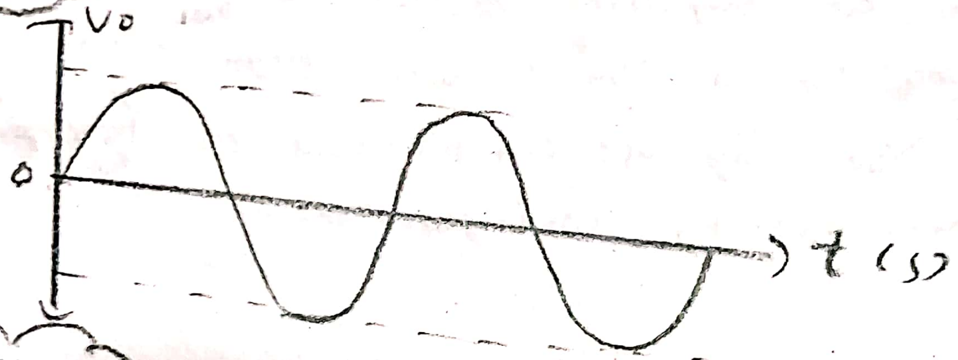
$$\frac{R_1}{R_2} = \frac{10k\Omega}{1k\Omega} \quad — \quad (4.)$$

Compute V_o/V_i for (1) and (4)

Input →



Output →



Results →

(1) $R_1 = 10k\Omega$, $R_2 = 1k\Omega$

V_i	V_o	$A = \frac{V_o}{V_i}$
108mV	1.2V	10.8
208mV	2.32V	10.6
304mV	3.4V	10

→ $\simeq 10$

(2.) $R_1 = 100k\Omega$, $R_2 = 10k\Omega$

V_i	V_o	$A = \frac{V_o}{V_i}$
112mV	1.16V	10.35
204mV	2.29V	10.9
308mV	3.4V	10.7

→ $\simeq 10$

Note :-

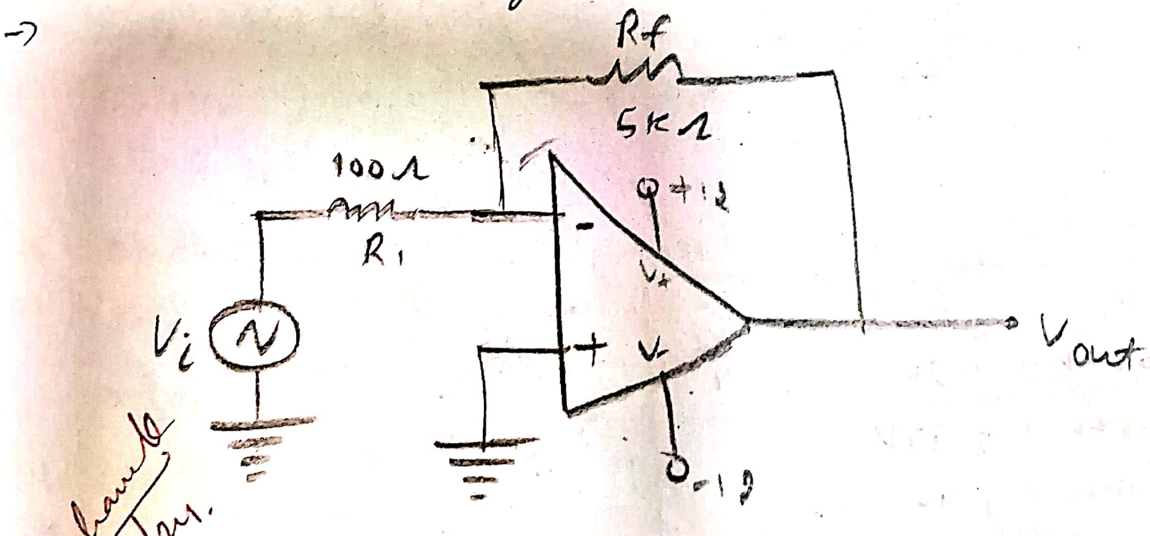
(a) For a source with high internal impedance which config. (inverting or non-inverting) will be suitable for designing a good amplifier?

→ Non-inverting Operational Amplifier Voltage follower.

→ As the input impedance is extremely high, the unity gain buffer (voltage follower) can be used to provide a large power gain as the extra power comes from the Op-amps supply rails and through the op-amps output to the load and not directly from the input.

(b) Design an Amplifier System to obtain a gain of '-50' for a source with high internal resistance. You may use combinations of inverting and non-inverting configurations?

→



5/3/21.

$$A = \frac{-R_f}{R_1} = -\frac{5000}{100} = -50$$

Conclusion :→

In this experiment we have learnt the inverting and non-inverting OP-Amp circuits.

Experiment → 6 (POST LAB) → 23010211 Mayank

Objective:- Designing a voltage follower, Integrator, Diffrentiator for and precision Rectifier for a small AC signal.

Material Required:-

1- Bread board
2- Equipment: multi output DC power supply, function generator, oscilloscope.
3- Components:
- Op-Amp: two - LM741 (2 nos).
- Diode: Two - 1N4007 (2 nos).
- Resistance: Ten - 1 kΩ (3 nos), 10 kΩ (3 nos), 1 MΩ (1 no), 100 kΩ (3 nos)
- Capacitor: Two - 0.1 μF, 10 μF.

I => **General Guidelines / Prequations:-**

1) The op-amp gerndly works on split power supply (eg: ±12V) both positive and negative power supplies must be present whenever op-amp is powered. The range of power supply is from ±5V to ±15V. Do not forget to connect the common terminal of the power supply to the ground on the breadboard.

2.) Connecting only one side of power supply or interchanging positive and negative power supplies damages the op-amp.

3.) For connecting power supply →
(a) Disconnect the power supply to op-amps.
(b) Switch on the power supply.
(c) Set the output voltage as required (e.g. ±12V)
(d) Switch odd the power supply.
(e) Connect to power supply to op-amps.
(f) Switch on the power supply.

4.) For any IC, never exceed the input voltage beyond the power supply limits.

5.) Key ground terminals of the oscilloscope probes and function generator output, and power supply common connected together througout the experiment.

6.) Make sure that the power lines in the breadboard given on the top and bottom for the power supply must be used and from their you connect to the other parts of the circuit.

7.) Swith off the supply to all the equipments before you make any chages in the ckt.

II => **Operation Amplifier Applications:-**

High I/P impedence, low O/P impedence, high open loop gain, high unity gain bandwidth.

II.I → Voltage follower :- (B=1)

This connection forces the op-amp to adjust its o/p voltage simply equal to the i/p voltage (Vo follows Vi) so the ckt is normal op-amp voltage follower.

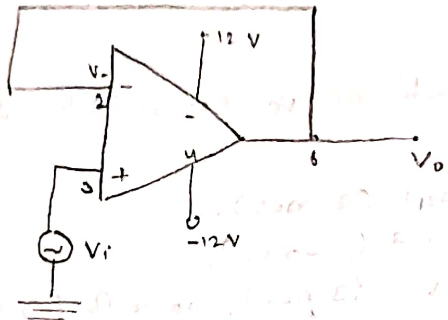


Fig 1 → Voltage follower Amplifier

Voltage follower :-

It is used to transfer a voltage from a first ckt having a high o/p impedence level, to a second ckt with a low i/p impedence level.

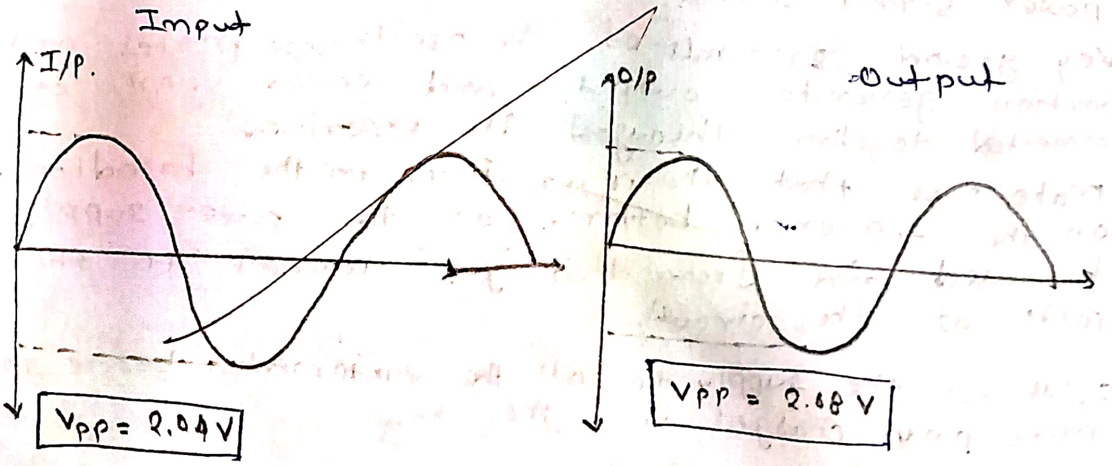
Current follower :-

It is used to transfer current from a first ckt, having a low o/p impedence level, to a second ckt with a high i/p impedence level, The voltage follower with a high prevents the second ckt from loading the first ckt unacceptably and interfering with its desired operation.

observation :-

1. measure the power supply ± 12V from the bread board power lines with respect to ground using multimeter.
2. Connect the ckt as shown in Fig.1. make sure the power supply (±12V) ground is connected to ckt to ckt ground.
3. Apply 2 Vp-p, 1KHz sine wave at Vi from the function generator and see the o/p in the oscilloscope.
4. Before you connecting i/p voltage to the ckt measure the function generator o/p voltage using the oscilloscope.
5. observe Vo and Vi and determine voltage gain = $\frac{V_o}{V_i}$

Wave form :-



$\boxed{V_{pp} = 2.04V}$ $\boxed{V_{pp} = 2.08\ V}$

∵ max = 1 V ; min = 1.08 V

Gain = $A = \frac{V_o}{V_i}$ ⇒ $V_o = 2.08$, $V_i = 2.04$ so $A = \frac{2.08}{2.04} = 1.0194$

II.II ⇒ Integrator :-

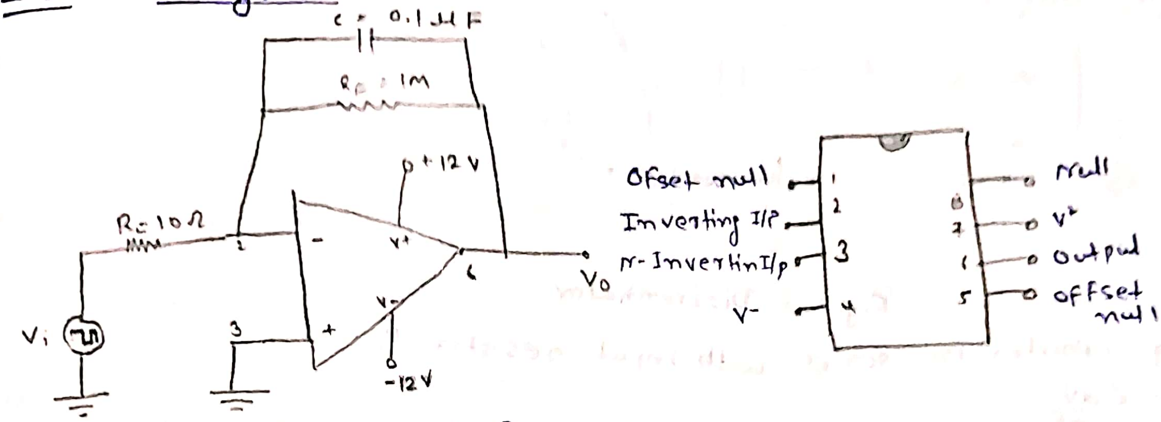


Fig. 2: Integrator

→ By adding capacitor in parellal with feed such Resistor R_F in a inverting amplifier. the op-amp can be used as perform integration. An ideal or fault less integrator ($R_F = \infty$) perform the compe tation.

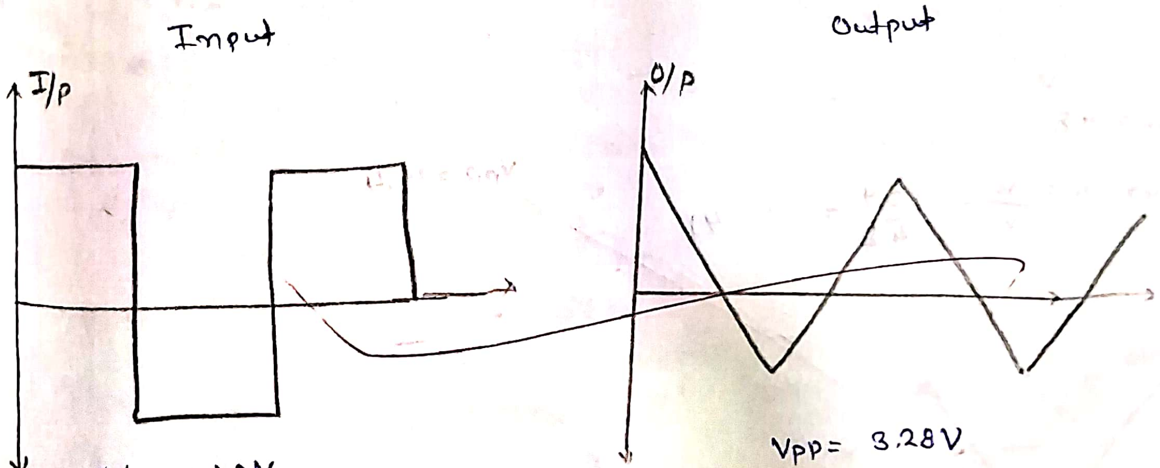
$V_o = -\frac{1}{R_1 C} \int V_i \, dt$. Thus a squre ($R_F < \infty$)

$\tau = R_F C$

⇒ observation:→

1) Assemble the ckt as shown in fig. 2 make sure that power supply (±12V), ground is connected to ckt to ckt ground.
2.) Apply 10 Vp-p a squre wave with period of 1 ms at V_i from the function generator and see the o/p in the oscilloscope.
3.) Before you connecting i/p voltage to the ckt measure the function generator o/p voltage using the oscilloscope (measure V_i and time period)
4.) Observe V_o and V_i, and determine voltage V_o and connect on the o/p voltage (draw the i/p / o/p wave form together)

⇒ Wave Form :-



$V_{pp} = 10V$ $V_{pp} = 3.28V$

∴ Max = 4.24 V & min = 920mV

⇒ Gain = $A = \frac{V_o}{V_1}$ So $A = \frac{3.28}{10} = 0.328$

II. III Diffrentiator →

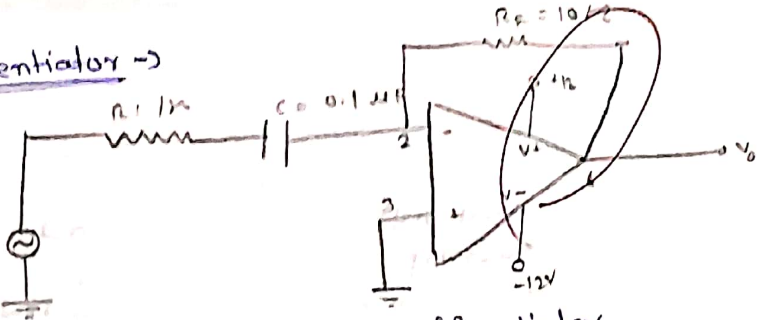


Fig. 3 → Diffrentiator

By adding capacitor in series with input resistor R.

→ $V_o = -R_2 C \frac{dv_i}{dt}$

→ Triangular wave input would cause a square wave o/p.

→ However in a real ckt will ($R_1 > 0$) have some memory of the system state (like a lossy integrator) with exponential decay of time constant of $\tau = R_1 C$.

observations →

1.) Assemble the ckt as shown in Fig. 3 make sure the power supply (±12V) ground is connected to ckt to ckt ground.

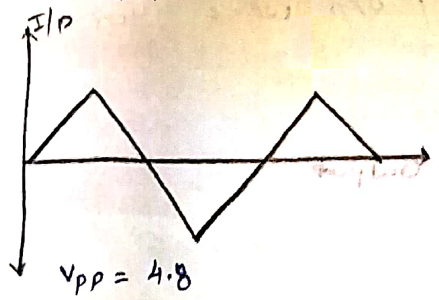
2) Apply 5 Vp-p, triangular wave with period of 1ms or sine wave with 1 KHz at V_i from the function generator and see the output in the oscilloscope.

3.) Before you connecting input voltage to the ckt measure the function generator o/p voltage using the oscilloscope (measure V_i and time period)

4) Observe V_o and V_i, determine V_o and comment on the o/p voltage (draw the i/p / o/p wave form together)

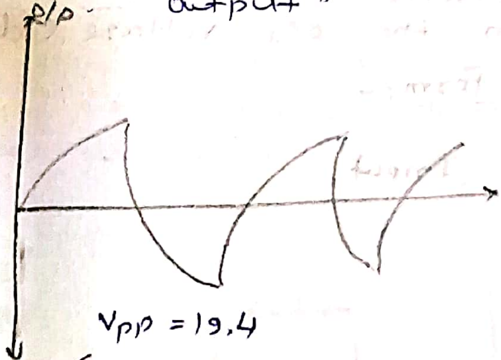
WAVE Forms :-

Input



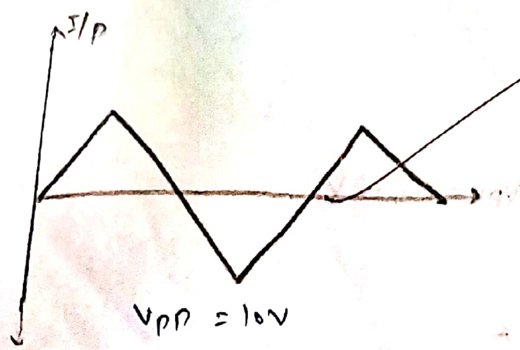
Vpp = 4.8

output

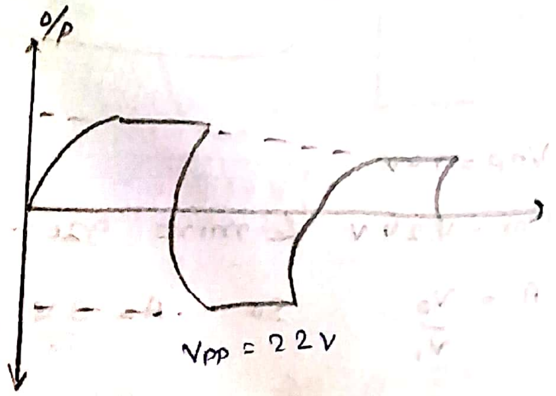


Vpp = 19.4

Gain = A = $\frac{V_o}{V_i} = \frac{19.4}{4.8} = 4.041$



Vpp = 10V

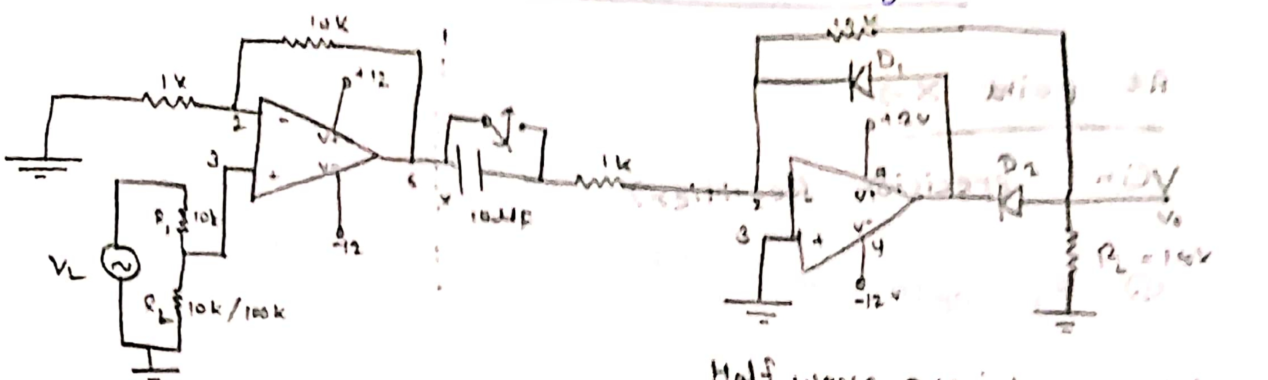


Vpp = 22V

Gain = A = $\frac{V_o}{V_i} = \frac{22}{10} = 2.2$

Scanned with OKEN Scanner

II. IV Precision Rectifier for a small AC signal →



Non inverting Amplifier

Half wave precision rectifier with gain

Fig. 4. Precision Rectifier for small AC Signal

The circuit shown in fig 4 is of precision rectifier for a small signal as it consists of two stages.

- Stage -1: Non inverting Amplifier.
- Stage -2: Half wave precision rectifier with gate.

Pre experimental reading:–

Draw O/P waveforms with magnitude at points 'x' (stage 1 o/p) and 'y' (stage 2 o/p)

- with R_2 = 10kΩ and
- without R_2 open (i.e. disconnected)

Observations :→

1.) Assemble the ckt shown in Fig. 4 with R_1=100kΩ and R_2=1kΩ. Make sure the power supply ground is connected to the circuit ground.

2.) Apply 100mVp-p, 1kHz sine wave at V_i from the function generator. and see the output in the oscilloscope.

3) Observe Vo at 'y' for:

(a) R_2=1kΩ (i) with capacitor 'c' and (ii) without capacitor 'c' (i.e. replace with a short circuit)

b) R_2= 10kΩ (i) with capacitor 'c' and (ii) without capacitor 'c' (i.e replace with a short circuit)

c) R_2=100kΩ (i) with capacitor 'c' and (ii) without capacitor 'c' (i.e replace with a short circuit)

d) R_2 open (disconnected) (i) with capacitor 'c' and (ii) without capacitor 'c' (i.e replace with a Shortcircuit.

4.) Draw the appropriate waveforms for Vo at 'y' and define the values (Theortical and practical).

At point x →

(in precision Rectifier)

① R_2 = open

$$A = \frac{1.16}{0.106}$$

$$A = 11.32$$

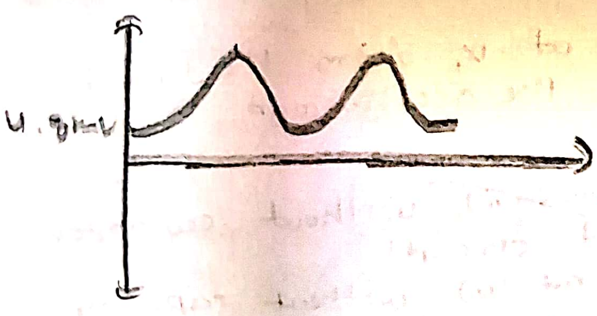
② $R_2 = 10k\Omega$

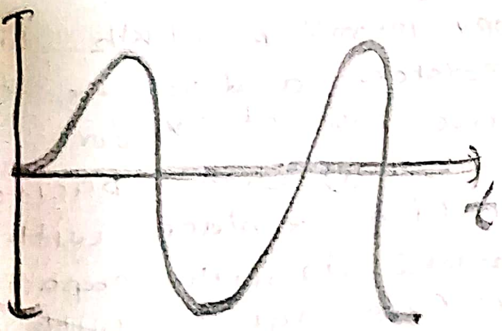
$$A = \frac{104}{106}$$

$$A = 0.98$$

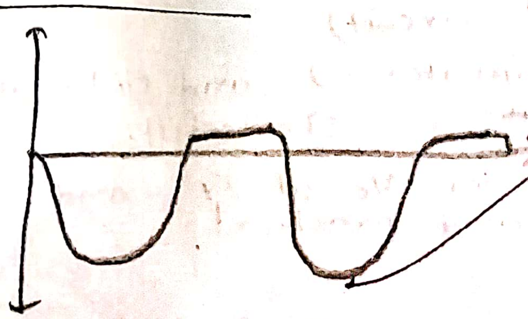
R_2 = open

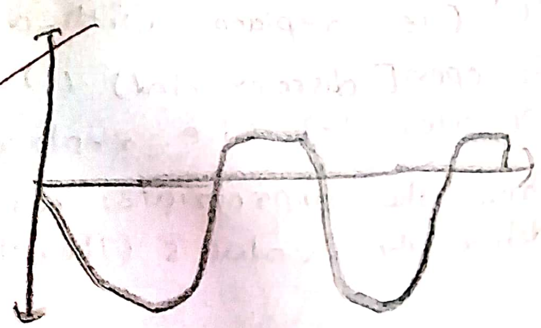
$R_2 = 10k\Omega$





at point y →





$R_1 = 10k\Omega$

R_2 = open

Precision Rectifier→

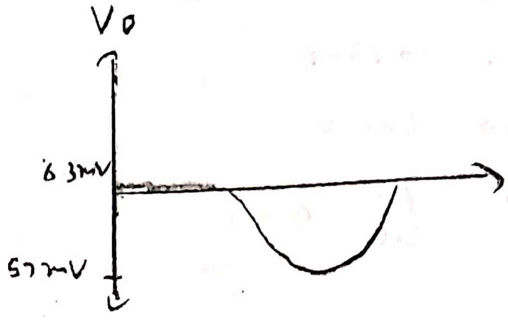
with capacitor→

① $R_2 = 1K\Omega$

$V_i = 106\,mV$

$V_o = 63.2\,mV$

$$A_{CL} = \frac{63.2}{106} = 0.59$$

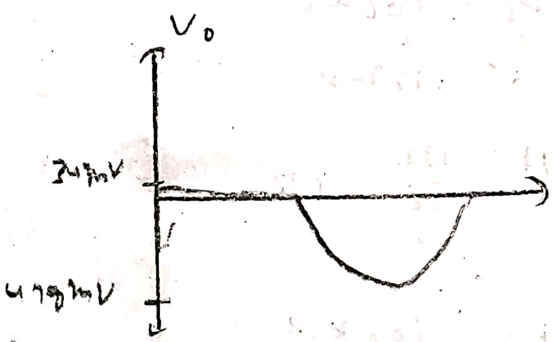


② $R_2 = 10K\Omega$

$V_i = 106\,mV$

$V_o = 512\,mV$

$$A_{CL} = \frac{512}{106} = 4.830$$

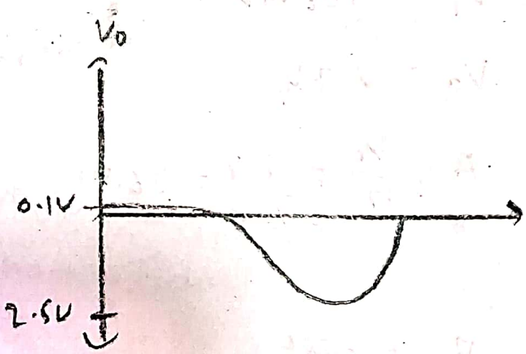


③ $R_2 = 100K\Omega$

$V_i = 106\,mV$

$V_o = 2.6\,V$

$$A_{CL} = \frac{2.6}{0.106} = 24.52$$

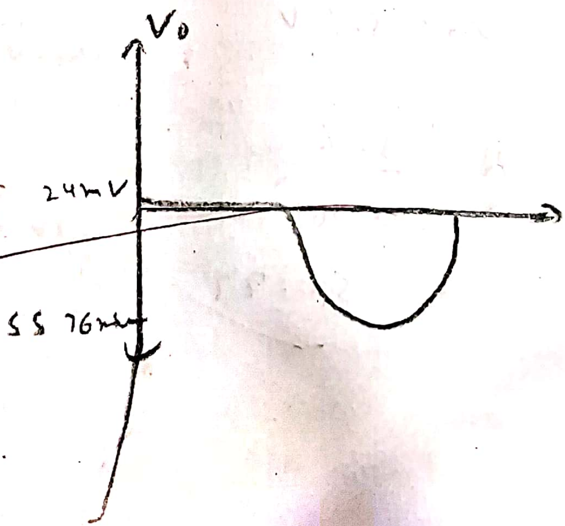


④ R_2 = open

$V_i = 106\,mV$

$V_o = 5.6\,V$

$$A_{CL} = \frac{5.6}{0.106} = 52.83$$



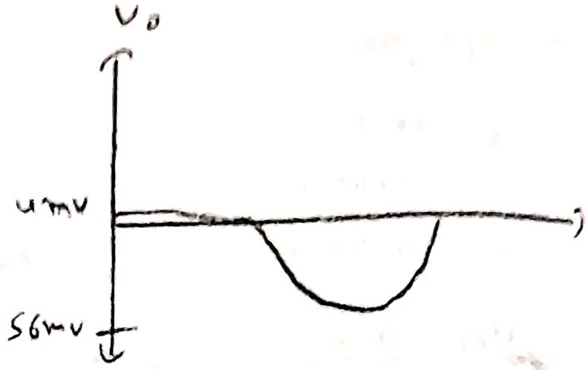
without capacitor :

1. $R_2 = 1k\Omega$

   $V_i = 106mV$

   $V_o = 60mV$

   $A = \frac{60}{106} = 0.59$

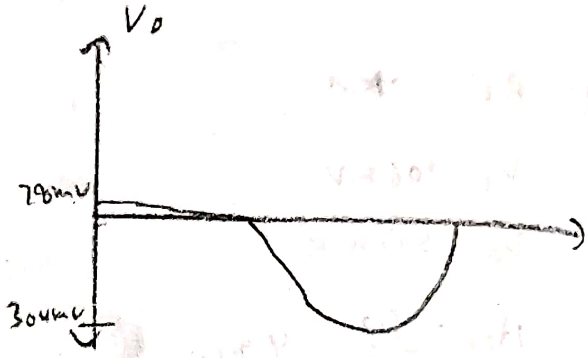


2. $R_2 = 10k\Omega$

   $V_i = 106mV$

   $V_o = 332mV$

   $A = \frac{332}{106} = 3.13$

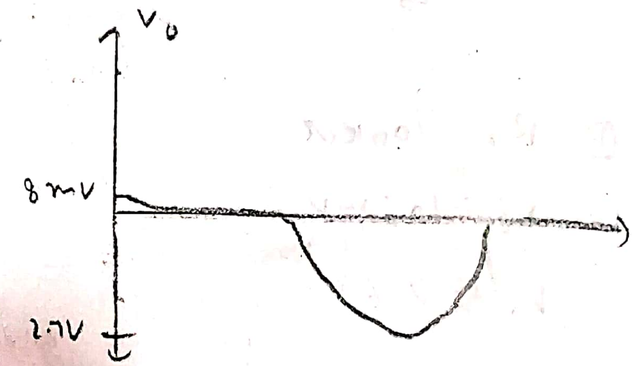


3. $R_2 = 100k\Omega$

   $V_i = 108mV$

   $V_o = 2.8V$

   $A = \frac{V_o}{V_i} = \frac{2.8}{0.106} = 26.41$



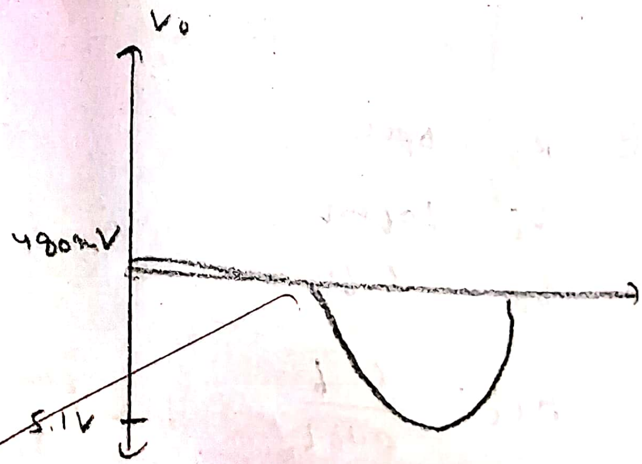
4. $R_2 =$ open

   $V_i = 106mV$

   $V_o = 5.6V$

   $A = \frac{5.6}{0.106}$

   $= 52.83$



Questions:-

→(i) what is effect of B=1 on op-amp characterstics ?

Solⁿ:- when B=1 is an op-amp it means that the feedback n/w has unity gain, indicating that the o/p voltage is equal to the input voltage i.e a voltage follower.

→ii) How did you measure the internal input impedence of 741 op-amp justify?

Solⁿ:- Impedence is represented by $Z = \frac{\Delta V}{\Delta I}$ The variation in the Input bias current is measured against the variation in the input common-mode voltage range.

→iii) How did you measure the internal output impedence of 7410 op-amp justify?

Solⁿ:- Impedence is represented by the ratio of the current variation ΔI the voltage variation ΔV, $Z = \frac{\Delta V}{\Delta I}$

In a voltage follower configuration. The variation in the output voltage B measured by changing the o/p source and sink currents. In same o/p circuit configuration. the impedence may be different b/w the source and sink sides. Therefore, the variation in output voltage should be checked during both o/p current sourcing and sinking.

→ iv) What is the role of feedback resistor R_f.

Solⁿ (i) Gain control

(ii) Stability

iii) Input impedence

iv) Output impedence.

→ (v) If the polarities of ~~all the diodes~~ are changed, what will be ~~the~~ waveform at point x & y.

Solⁿ:- At point x the waveform will remain similar to the opposite waveform of a non inverting amplifier but at point y the o/p will be opposite i.e in -ve half cycle there will be o/p and not in +ve half cycle.

* Conclusion:-

we learnt about working of voltage follower, integrator, diffrentiator & precision rectifier and we also studied the output waveforms with different values of Resistance.

Kashank 19/3/24

Post 1978

Sarwar

Experiment 7: First Order Filters

Objective:-

Designing a Active low pass Filter, Active High pass Filter and Active Band Pass Filter.

Materials Required

1. Breadboard
2. Equipment: Multi-Output DC power supply, Function Generator, Oscilloscope.
3. Components:
   - Op-Amp: Two - LM741 (2 nos).
   - Resistor: Four - 470Ω (1 no), 1kΩ (2 nos), 10kΩ (1 no).
   - Capacitor: Two - 0.1 μF, 10 μF.

I General Guidelines:-

1. The op-amp generally works on split power supply (e.g. ±12V). Both positive and negative power supplies must be present whenever op-amp is powered. The range of power supply is from ±5V to ±15V. Do not forget to connect the common terminal of the power supply to the ground on the breadboard.

2. Connecting only one side of power supply or interchanging positive and negative power supply damages the op-amp.

3. For connecting power supply, you have to follow the procedure as given below.
   a) Disconnect the power supply to op-amps.
   b) Switch on the power supply.
   c) Set the output voltage as required (e.g. ±12V)
   d) Switch off the power supply
   e) Connect the power supply to op-amps.
   f) Switch on the power supply.

4. For any IC, never exceed the input voltage beyond the power supply limits.

5. Keep ground terminals of the oscilloscope probes and function generator output, and power supply common connected together throughout the experiment.

6. Make sure that power lines in the breadboard given on the top and bottom for the power supply must be used and from there you connect to the other parts of the circuit.

7. Switch off the supply to all the equipments before you make any changes in the circuit.

II Active RC Filters

A filter is a circuit that has designed to pass a specified band of frequencies while attenuating all signals outside the band.

Active filters employ transistors or ~~amp~~ op-amps in addition to resistors, capacitors and inductors. Active filters offer several advantages over passive filters. The high input and low output resistance of the op-amp, the active filter does not cause loading of the source or load.

A low pass filter has a pass band from 0 Hz to a high cut off frequency f_H. This cut off frequency is defined as the frequency where the voltage gain is reduced to 0.707, that is at f_H the gain is down by 3dB; after that $(f > f_H)$ it decreases as f increases. The frequencies between 0Hz and f_H are called pass band frequencies whereas the frequencies beyond f_H are the so-called stop band frequencies. A common use of a low pass filter is to remove noise or other unwanted high frequency components in a signal for which you are only interested in the dc or low frequency components.

Correspondingly, a high pass filter has a stop band for $0 < f < f_L$, where f_L is the low cut off frequency. A common use for a high pass filter is to remove the dc component of a signal for which you are only interested in the ac components.

A band pass filter has a pass band between two cut off frequencies f_H and f_L ($f_H > f_L$), and two stop bands $0 < f < f_L$ and $f > f_H$. The bandwidth of a bandpass filter is equal to $f_H - f_L$.

II.I Active low pass filter

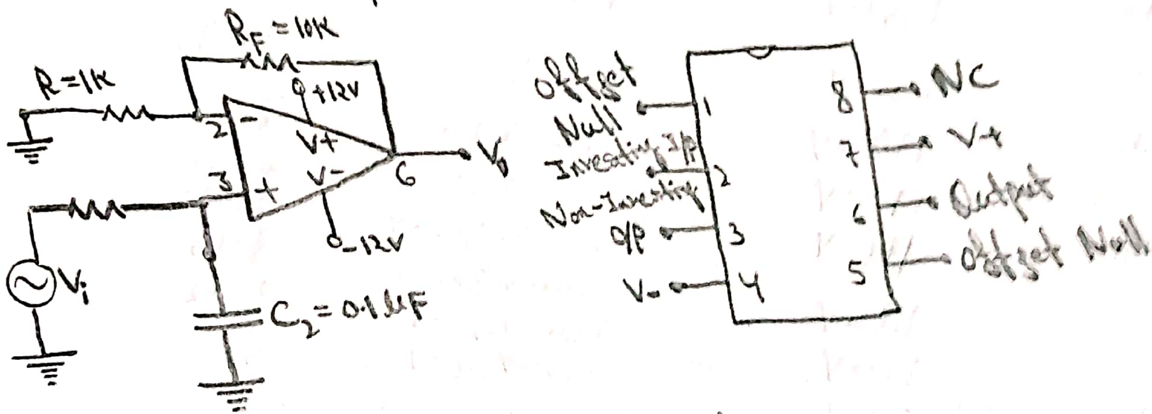


Fig. 1: Active low pass filter

Observations:-

1. Measure the power supply ±12V from the breadboard power lines with respect to ground using multimeter.

2. Fig. 1 shows a high pass filter. Connect the circuit and make sure the power supply (±12 V) ground is connected to the circuit ground.

3. Apply a sinusoidal signal of 150 mVp as a input to the circuit from a function generator, and vary the input signal frequency (f) from 10Hz to 30KHz. Observe the output voltage corresponding to the input voltage at different frequencies like 10Hz, 100Hz, 1kH, 5kHz, 10kHz, 15kHz, 17kHz, 18kHz, 19kHz, 20kHz, 21kHz, 22kHz, 23kHz, 25kHz, 30kHz.

4. Observe the input voltage V_i and output voltage V_o together on the oscilloscope.

5. Draw the frequency response curve (Gain in dB vs f).

6. Calculate the higher cut off frequency f_H and compare with the theoretical value.

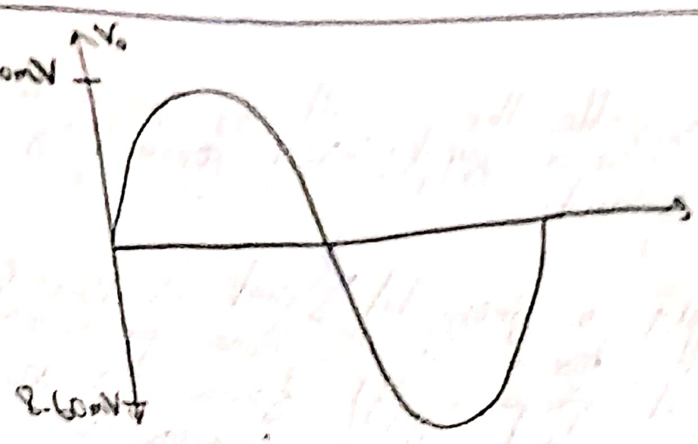
Note:

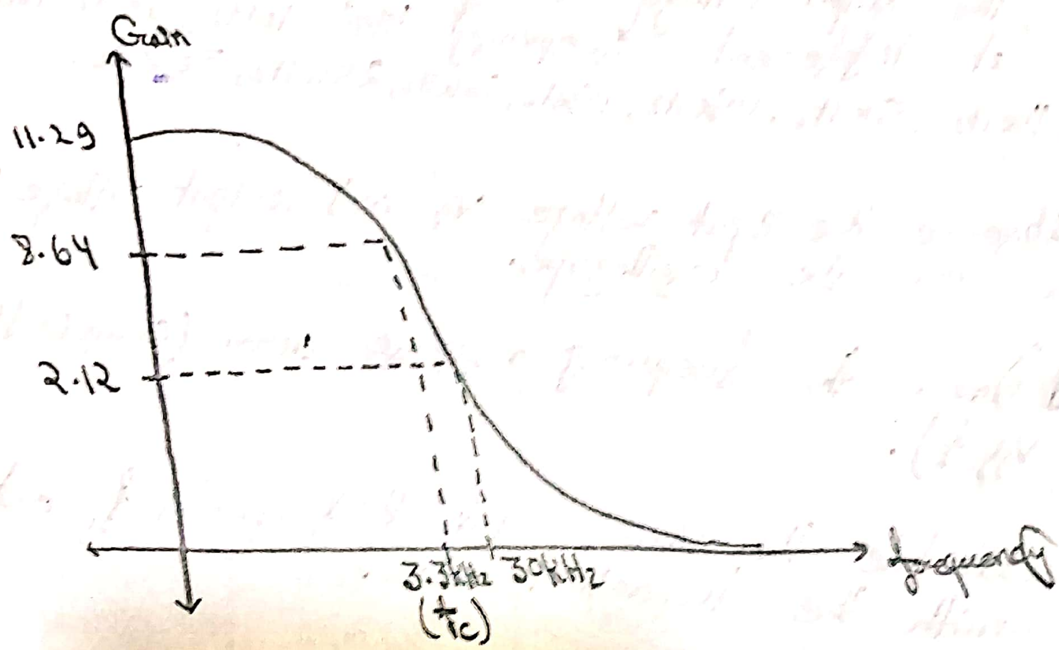
a) What is the output voltage for the input voltage of 300mV.

b) Gain in dB $A_V = 20 \log \frac{V_o}{V_i}$

Frequency	V_i	V_o	Gain $= \frac{V_o}{V_i}$
10Hz	154mV	1.74V	11.29
100Hz	156mV	1.76 V	11.28
1000Hz	150mV	1.64V	10.93
3.3kHz	112mV	~~820mV~~ 1.02V	8.64
3.5kHz	118mV	~~500mV~~ 1V	8.47
3.7kHz	118mV	~~320mV~~ 960mV	8.13
5kHz	112mV	~~300mV~~ 820mV	2.32
10kHz	100mV	~~280mV~~ 500mV	5
15kHz	94mV	~~270mV~~ 320mV	3.4
17kHz	94mV	300mV	3.19
18kHz	94mV	280mV	2.97
19kHz	94mV	280mV	2.97
20kHz	94mV	260mV	2.76
21kHz	94mV	240mV	2.55
22kHz	94mV	240mV	2.55
23kHz	94mV	240mV	2.55
25kHz	94mV	220mV	2.34
30kHz	94mV	200mV	2.12
2kHz	134mV	1.32V	9.85
3kHz	122mV	1.08V	8.85
4kHz	112mV	920mV	8.21

$F = 100Hz$
$V_p = 154mV$
$V_o = 1.76V$





II.II Active High Pass Filter

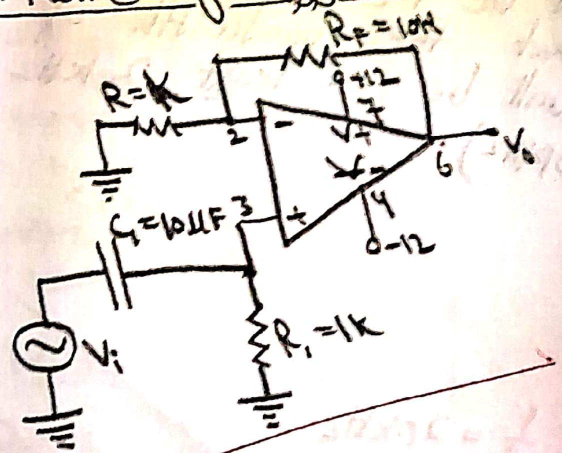


Fig. 2: Active High Pass Filter

Observation :-

1. Assemble the circuit as shown in Fig-2. Make sure the power supply ($\pm 12V$) ground is connected to circuit to circuit ground.

2. Apply a sinusoidal signal of 150 mVp as a input to the circuit from a function generator, and vary the input signal frequency (f) from 10Hz to 30KHz. Observe the output voltage corresponding to the input voltage at different frequency like 10Hz, 50Hz, 100Hz, 500Hz, 1kHz, 5kHz, 10kHz, 15kHz, 20kHz, 25kHz, 30kHz.

3. Observe the input voltage V_i and output voltage V_o together on the oscilloscope.

4. Draw the frequency response curve (Gain in dB vs f).

5. Calculate the lower cutoff frequency f_L and compare with the theoretical value.

Note :

a) What could be the maximum closed loop gain so that the bandwidth of the op-amp will be at least 20kHz (GB = 1.5MHz).

Sol :-

$$A_{CL} = \frac{f_{GB}}{f_c - f_{GB}}$$

Given, $f_{GB} = 1.5MHz$ and $f_c = 20kHz$

Let's plug the values into the formula :

$$A_{CL} = \frac{1.5MHz}{20kHz - 1.5MHz} = \frac{1.5 \times 10^6}{-1.48 \times 10^6}$$

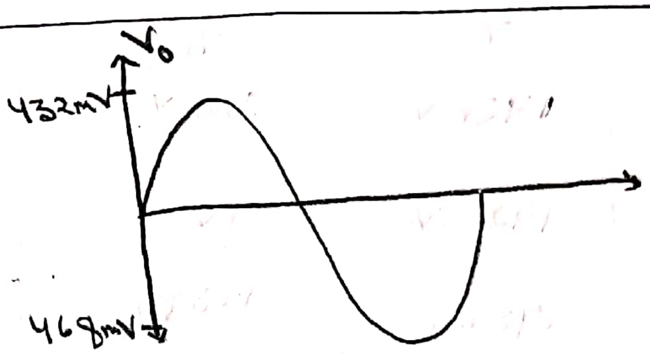
$$\Rightarrow A_{CL} = -1.01$$

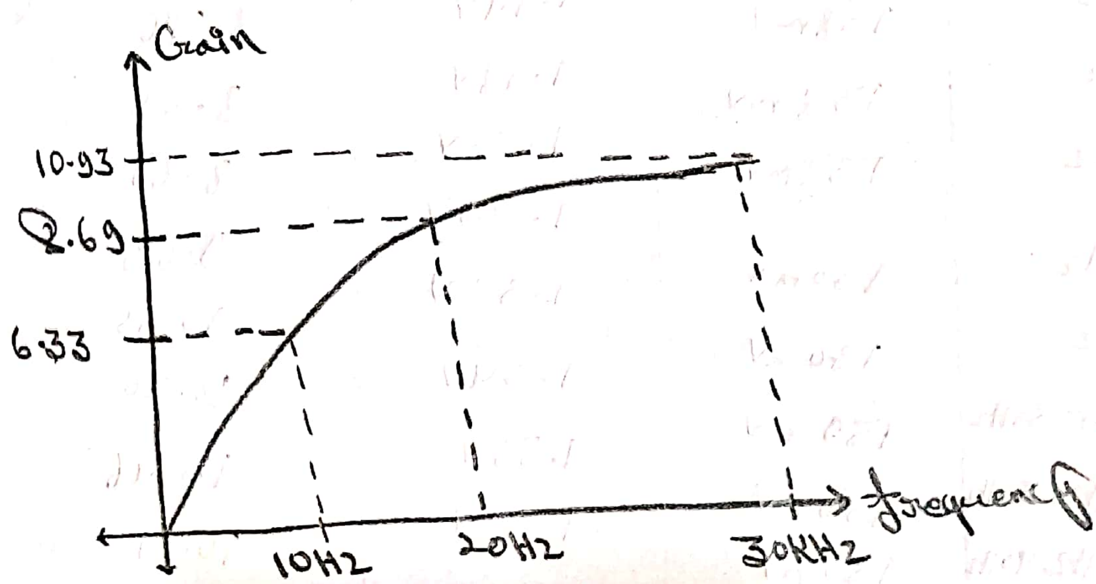
Frequency	V_i	V_o	Gain = $\frac{V_o}{V_i}$
10Hz	142mV	900mV	6.33
12Hz	142mV	1V	7.04
14Hz	142mV	1.09V	7.60
16Hz	138mV	1.14V	8.26
18Hz	138mV	1.18V	8.33
20Hz	138mV	1.20V	8.69
25Hz	130mV	1.26V	9.69
30Hz	130mV	1.32V	10.15
~~100Hz~~ 30Hz	130mV	1.34V	10.20
~~1kHz~~ 35Hz	130mV	1.36V	10.46
~~5kHz~~ 40Hz	130mV	1.38V	10.61
~~10kHz~~ 45Hz	130mV	1.38V	10.61
~~15kHz~~ 50Hz	128mV	1.40V	10.93
~~20kHz~~ 100Hz	128mV	1.44V	11.25
~~25kHz~~ 1kHz	128mV	1.46V	11.40
~~30kHz~~ 5kHz	128mV	1.46V	11.58
10kHz	126mV	1.48V	11.51
15kHz	126mV	1.4V	11.11
20kHz	126mV	1.38V	10.95
25kHz	126mV	1.38V	10.95
30kHz	126mV		

$F = 10Hz$

$V_p = 142mV$

$V_o = 800mV$





II. III Active Band Pass Filter

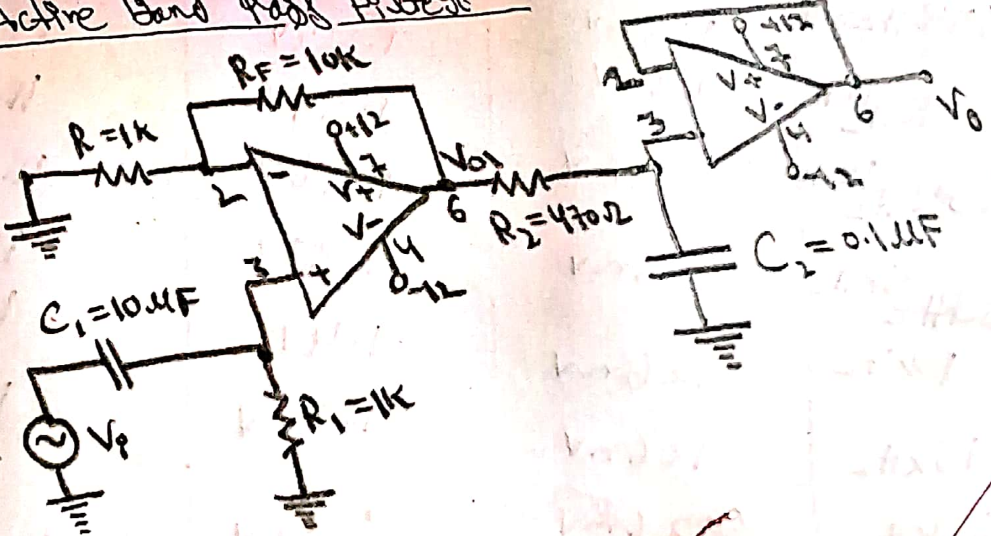


Fig. 3: Active Band Pass filter

Observation :->

1. Assemble the circuit as shown in fig. 2. Make sure the power supply ($\pm 12V$) ground is connected to circuit to circuit ground.

2. Apply a sinusoidal signal of 150mV$_p$ as a input to the circuit from a function generator, and vary the input signal frequency (f) from 10Hz to 30kHz. Observe the output voltage corresponding to the input voltage at different frequencies like 10Hz, 50Hz, 100Hz, 500Hz, 1kHz, 5kHz, 10kHz, 15kHz, 17kHz, 18kHz, 19kHz, 20kHz, 21kHz, 22kHz, 23kHz, 25kHz, 30kHz.

3. Observe the input voltage V_i and output voltage V_o together on the oscilloscope.

4. Draw the frequency response curve (Gain in dB vs f).

5. Calculate the pass band frequency range $f_L \leq f \leq f_H$ and compare with the theoretical value.

Important Note :->

Pre observation reading - Determine the appropriate theoretical values and draw the expected waveforms.

$$f_L = \frac{1}{2\pi \times 10^{-3}} \qquad f_H = 3.388 \text{kHz}$$

$$\Rightarrow f_L = 15.92 \text{ Hz}$$

~~for the~~ So the band frequency range,

$$15.92\text{Hz} \leq f \leq 3.388\text{kHz}$$

Active low pass filter

a) What is the o/p voltage for DC i/p voltage of 300mV

Sol:→ $f_c = \frac{1}{2\pi RC} = \frac{1}{6.28\times10^{-7}\times470} = 3.388\ kHz$

$$V_o = \left(1+\frac{10}{1}\right)\left(\frac{1}{\sqrt{1+\frac{10^{-1}}{3.388\times10^{3}}}}\right)$$

$\Rightarrow V_o = 1.1V$

b) Gain in dB.

Sol:→ $A_v = 20\log\frac{V_o}{V_i}$

$\Rightarrow A_v = 20.827$

Active High pass filter

a) What could be the maximum closed loop gain so that the bandwidth of the op-amp will be at least 20kHz (GB = 1.5 MHz).

Sol:→

$f_c = \frac{1}{2\pi RC} = 15.92Hz$

$$V_o = \frac{\frac{f}{f_c}}{\sqrt{1+\left(\frac{f}{f_c}\right)^2}}\times150\times10^{-3}\times11 = \frac{\frac{150}{15.92}}{\sqrt{1+\left(\frac{150}{15.92}\right)^2}}\times0.15\times11$$

$\Rightarrow V_o = 1.57V > V_i$

$A_v = 20\log\frac{V_o}{V_i}$

$= 20\log\frac{1.57}{0.15}$

$\Rightarrow A_v = 20.40$

Conclusion :-

Active RC filters offer advantages such as adjustable gain, improved selectivity and reduced sensitivity to component variations. Active RC filters required additional power supplies and careful consideration of op-amp specifications. Despite these challenges, active RC filters are invaluable tools in modern electronic design, offering flexibility and precision in signal processing applications.

26/3/24.

Experiment - 8 (Post - Lab) → (Abhishek)

Oscillators

Objective →

Designing of a phase shift Oscillator, wien bridge Oscillator and Relaxation Oscillator.

Materials Required →

1. Bread board
2. Equipment : Multi output DC power supply, Function Generator, Oscilloscope.
3. Components :
   - Op-Amp : One - LM741 (1 no).
   - Resistor : Eleven - 820Ω (2 nos), 1kΩ (3 nos), 2kΩ (1no), 2.2kΩ (1 no), 3.3 kΩ (1 no), 4.7kΩ (1 no), 5.6kΩ (1 no), 100kΩ (1 no).
   - Potentiometer : Two - 0 to 10kΩ (1 no), 0 to 100kΩ (1no)
   - Capacitor : Six - 0.1μF (3 nos), 0.002 μF (2 nos), 0.047 μF (1no)

I General Guidelines / Precautions :

1. The op-amp generally works on split power supply (e.g. ±12V). Both positive and negative power supplies must be present whenever op-amp is powered. The range of power supply is from ±5V to ±15V. Do not forget to connect the common terminal of the power supply to the ground on the bread board.
2. Connecting only one side of power supply or interchanging positive and negative power supplies damages the op-amp.

3- For connecting power supply, you have to follow the procedure as given below.

(a) Disconnect the power supply to op-amps.

(b) Switch on the power supply.

(c) Set the output voltage as required (e.g. ±12V).

(d) Switch off the power supply.

(e) Connect the power supply to op-amps.

(f) Switch on the power supply.

4- For any IC, never exceed the input voltage beyond the power supply limits.

5- Keep ground terminals of the oscilloscope probes and function generator output, and power supply common connected together throughout the experiment.

6- Make sure that the power lines in the breadboard given on the top and bottom for the power supply must be used and from their you connect to the other parts of the circuit.

7- Switch off the supply to all the equipments, before you make any changes in the circuit.

II Oscillators

Oscillator is an electric circuit which converts dc signal into ac signal. Oscillator is basically a positive feedback amplifier with unity loop gain. If the feedback signal is not positive and gain is less than unity, oscillations dumped out. If the gain is higher than unity then oscillation saturates. Use positive feedback through frequency-selective feedback network to ensure oscillation at ω_0. Oscillators can be categorized according to the types of feedback network used:

- RC oscillators: Phase shift and wien bridge oscillator.
- LC oscillators: Colpitt and Hartley oscillators.

II.I Phase Shift Oscillator

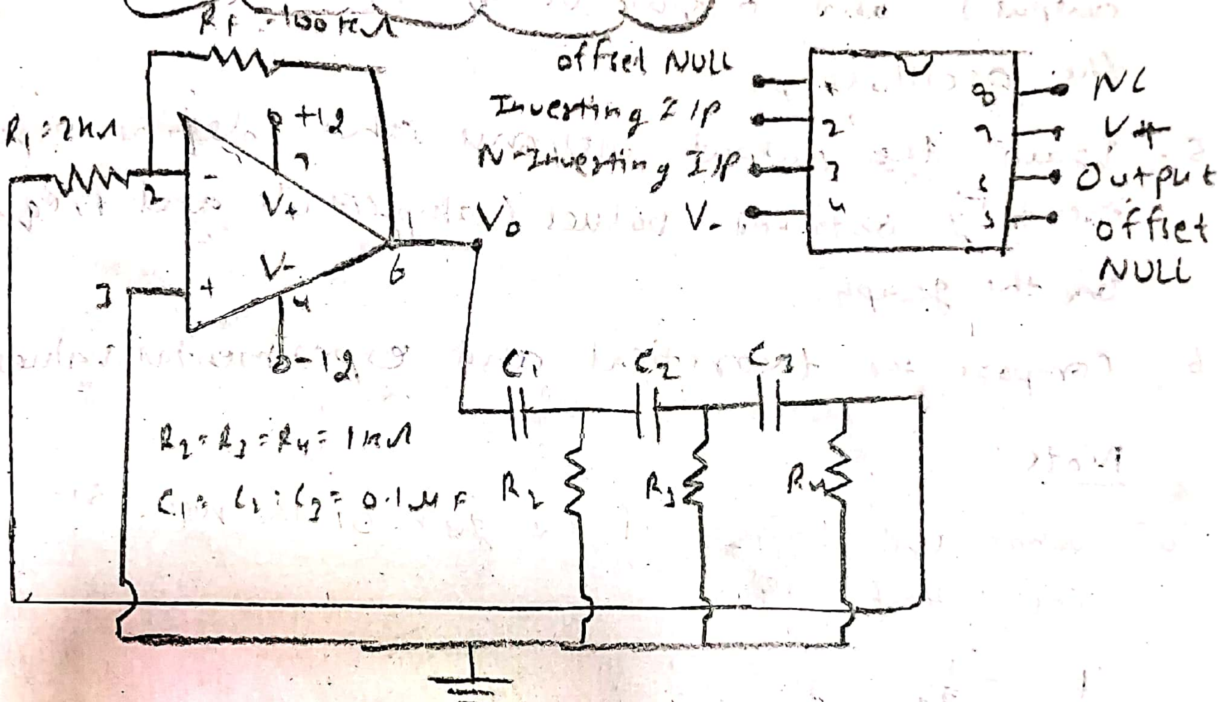


Fig. 1 : Phase Shift Oscillator

Observations

1- Measure the power supply ±12V from the bread board power lines with respect to ground using multimeter.

2- Fig. 1 shows a phase shift oscillator. Connect the circuit and make sure the power supply (±12V) ground is connected to circuit to circuit ground.

3. Initially, set the reference sinusoidal voltage from the function generator according to the theoretical calculations. The output voltage of the phase shift oscillator and the reference from the function generator need to be connected to the oscilloscope.

4. Observe the input voltage V_i (function generator output) and output voltage V_o together on the oscilloscope.

5. Draw the output response and define experimentally obtained values (amplitude and frequency) on the graph.

6. Compare the theoretical and experimental values.

Note:

(a) What will happen if the gain of the network is less than $-1/29$.

$\beta = -\frac{1}{29}$

feed back Gain $|(\beta)| = \frac{1}{29}$

for oscillator $|A\beta| \geq 1$ $\qquad |A| \geq 29$

$\frac{V_o}{V_{in}} = -\frac{R_c}{R_0} = A$

$\frac{V_o}{V_{in}} = \beta$

$\beta = -\frac{5}{w^2R^2C^2}$

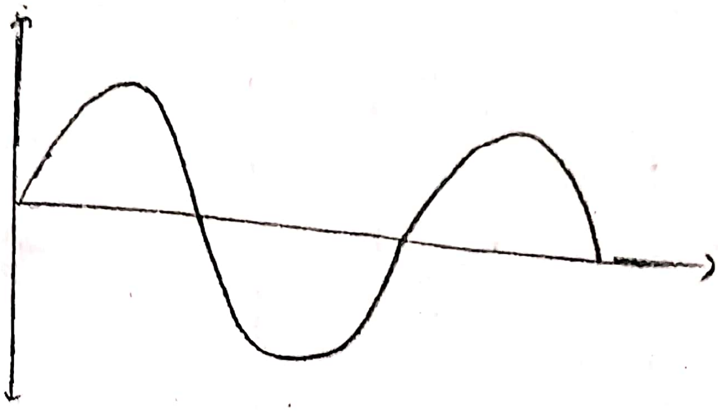
$f = \frac{1}{2\pi RC\sqrt{6}}$, $w = \frac{1}{RC\sqrt{6}}$

$f = \frac{1}{2\times3.14\times10^3\times0.1\times10^{-6}\sqrt{6}}$

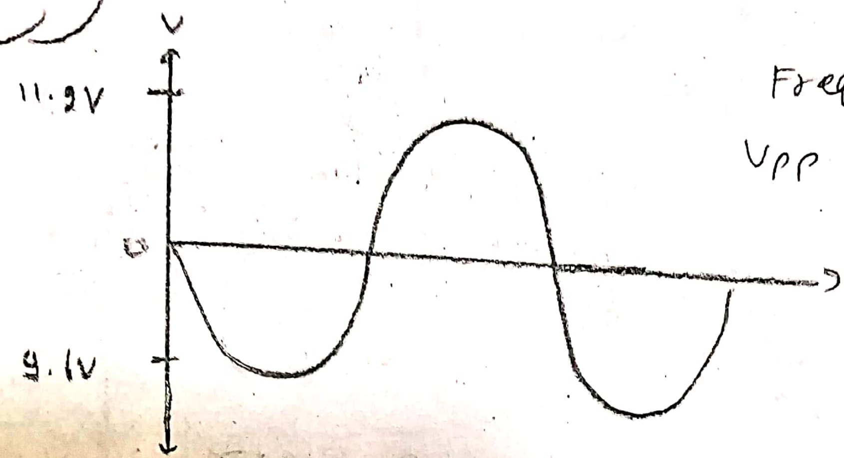
$f = 0.65\ kHz$

Total phase shift $= 0^\circ$ or 360°

Input →



Output →



Freq. = 1.02 KHz

Vpp = 20.8V

RC Phase & Angle

$X_c = \frac{1}{2\pi f c}$, $R = R_1$

$Z = \sqrt{(R)^2 + (X_c)^2}$

$\phi = \tan^{-1} \frac{X_c}{R}$

$f_n = \frac{1}{2\pi RC \sqrt{2N}}$

$f_n = \frac{1}{2\pi \times 2 \times 0.1 \times 10^{-6} \sqrt{2\times 3}}$

$= \frac{10^6 \times 10^{-3}}{4\pi \times 0.1 \times \sqrt{6}}$

$= 324 \text{ Hz}$

II. II Wien Bridge Oscillator :-

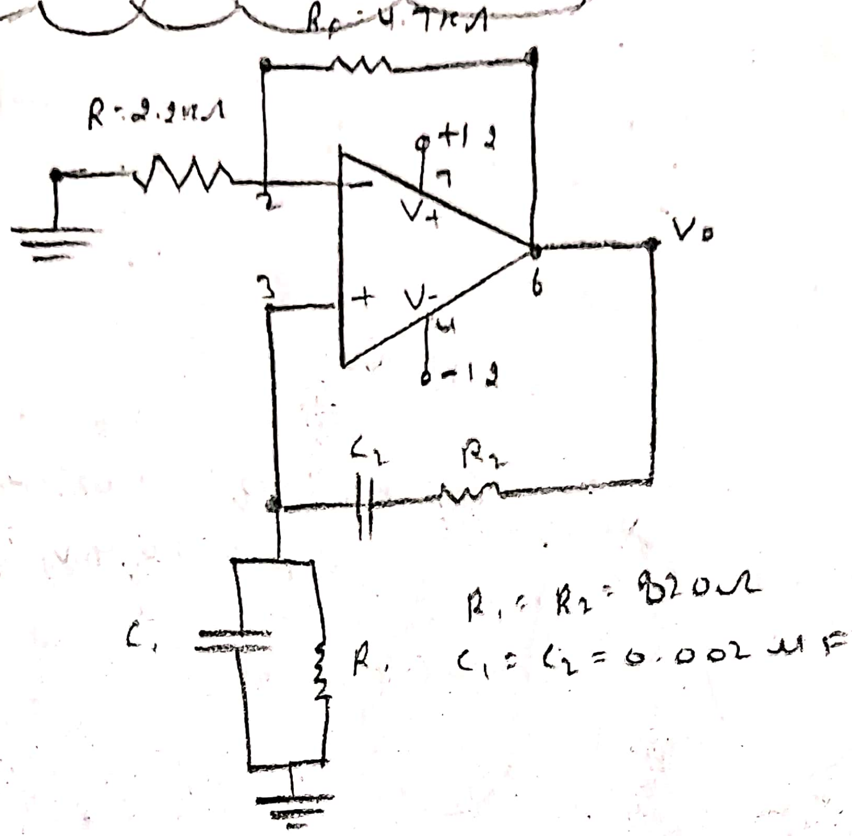


Fig. 2: Wien's Bridge Oscillator

Observations :-

1. Assemble the circuit as shown in Fig. 2. Make sure the power supply ($\pm 12V$) ground is connected to circuit - to - circuit ground.

2. Initially, set the reference sinusoidal voltage from the function generator according to the theoretical calculations. The output voltage of the phase shift oscillator and the reference from the function generator need to be connected to the oscilloscope.

3. Observe the input voltage V_i (function generator output) and output voltage V_o together on the oscilloscope.

4. Draw the output response obtained values (amplitude and define experimentally and frequency) on the graph.

5. Compare the theoretical and experimental values.

Note :

(a) What is the advantage of wien bridge oscillator compared to phase shift oscillator.

→ However, they differ in their circuit topology, operating principle, and frequency stability. In phase shift oscillators, we use 3 capacitors to ensure oscillation. However, we only use 2 capacitors for wien-bridge and the circuit oscillates fine.

Wien's bridge Oscillator

feedback Gain $|\beta| = \frac{1}{3}$ for oscillator $\rightarrow |A\beta| \geq 1 \Rightarrow A \geq 3$

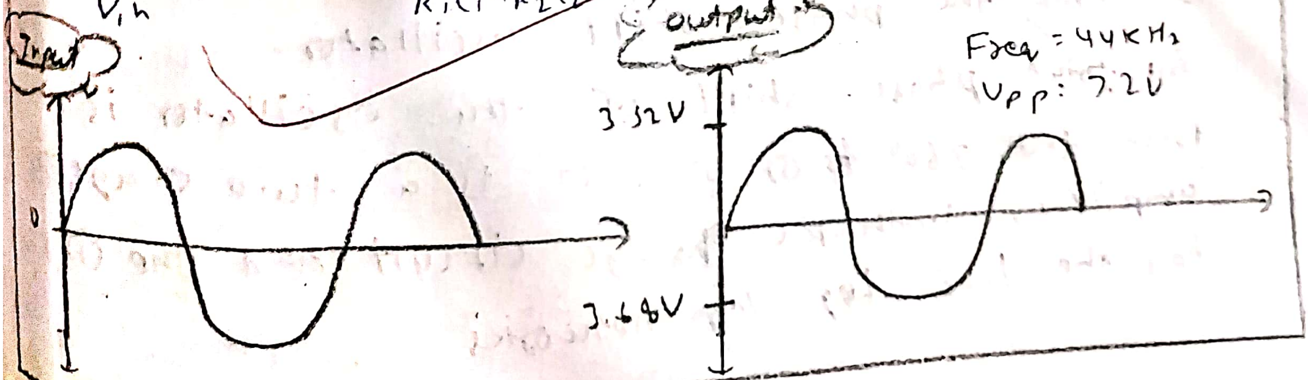
$$\omega = \frac{1}{\sqrt{R_1 R_2 C_1 C_2}}, \quad f_r = \frac{1}{2\pi\sqrt{R_1 C_1 R_2 C_2}} \quad \frac{R_1 = R_2}{C_1 = C_2}, \quad f_r = \frac{1}{2\pi RC}$$

$$f_r = \frac{1}{2 \times 3.14 \times 810 \times 820 \times 0.002 \times 10^{-6}} = 97.09 \text{ kHz}$$

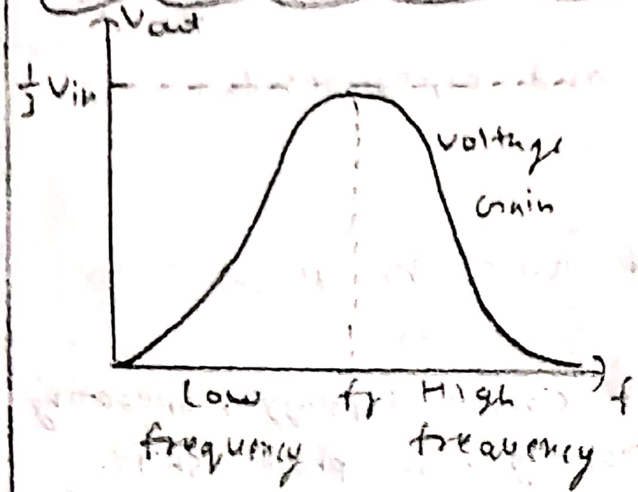
at resonate :→ $\frac{R_f}{R_1} = \frac{R_2}{R_1} + \frac{C_2}{C_1} = 2$

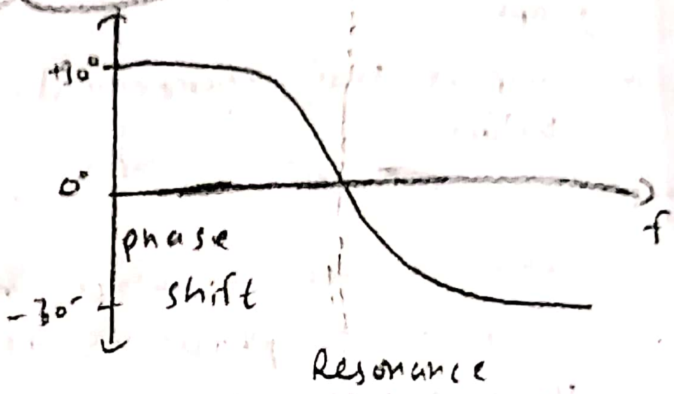
$$\frac{V_o}{V_{in}} = 1 + \frac{R_f}{R_1} = A \qquad \text{Total Phase shift} = 0°$$

$$\frac{V_o}{V_{in}} = \beta = \frac{R_1 C_1}{R_1 C_1 + R_2 C_2}$$



Oscillator Output Gain and phase shift :-





Wien bridge Oscillator Frequency :-

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

f_r = Resonant freq. in Hz
R = Resistance in Ω
C = Capacitance in F

Series circuit

$$X_C = \frac{1}{2\pi f C}$$

$$Z_S = \sqrt{R^2 + X_C^2}$$

Parallel circuit :-

$$\frac{1}{Z} = \frac{1}{R} + \frac{1}{X_C}$$

$$Z_{out} = \frac{Z_P}{Z_P + Z_S}$$

CONCLUSION

Hence the maximum O/P frequency of the wien bridge oscillator is 1MHz and this frequency is from the phase shift oscillator.
The total phase shift of the oscillator is from the 360° ~~to~~ or 0° : It is a two stage amplifier with RC bridge circuit and the circuit has the lead ~~leg~~ lag networks.

Post lab Experiment 9 (230102011)
Mayank

Objective :-

Designing of a Astable multivibrator.

Materials required:-

1. Breadboard
2. Equipment : Multi-output DC power supply, oscilloscope.
3. Components :-
   - 555 timer : LM555 (1 no)
   - Capacitor : 0.1 μF (1 no) & 0.001 μF (1 no.)
   - Resistor : 18 kΩ (1 no.) & 33 kΩ (1 no.)

I. General Guidelines / Prequations :-

i) The op-amp generally works on split power supply (eg. ±12v) Both positive and negative power supplies must be present whenever op-amp is powered. The range of power supply is from ±5v to ±15v. Don't forget to connect the common terminal of the power supply to the ground on the breadboard.

ii) Connecting only one side of power supply or interchanging positive and negative power supplies damges the op-amp.

iii) For connecting power supply, you have to follow the procedure as given below.

a) Disconnect the power supply to op-amps.
b) Switch on the power supply.
c) Set the output voltage as required (eg. ±12v).
d) Switch off the power supply.
e) Connect the power supply to op-amps.
f) Switch on the power supply.

iv) For any IC, never exceed the input voltage beyond the limits.

v) For only IC, never exceed the input voltge beyond keep ground terminals of the oscilloscope probes and function generator output throughout the experiment.

vi) Make sure that the power lies in the breadboard given on the top and bottom for the power supply must be used and from their you connect to other parts of ckt.

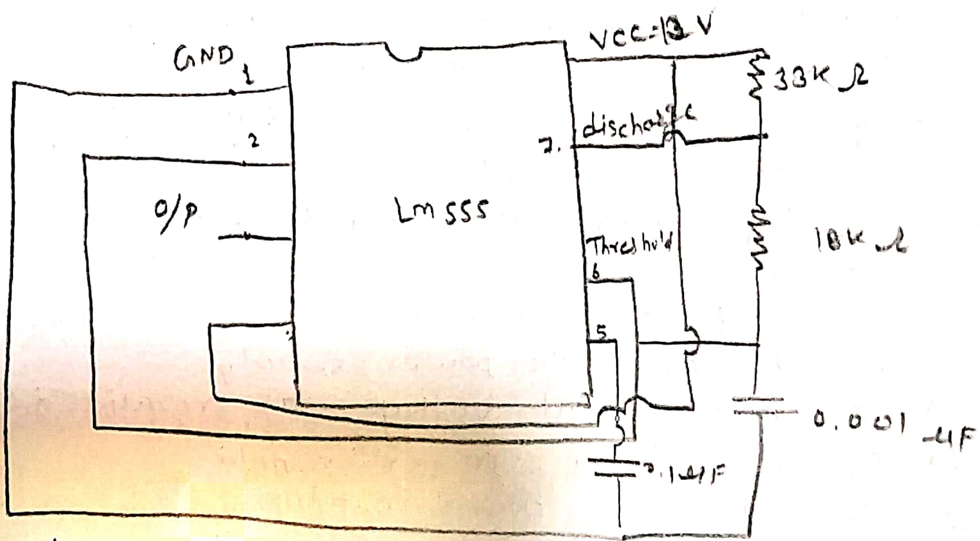
vii) Switch off the supply to all the equipments before you make any changes in the ckt.

II. Astable Multi Vibrator:-

The 555 timer is a highly stable device for generating accurate time delay ranging from micro seconds to hours where as counter timer can have a maximum timing range of days. These functions are needed in many analog digital or mixed-signal applications.

With the addition of an external capacitor and two external resistors, the 555 timer can be configured to produce a periodic pulsating wave form at the output, without any external trigger pulses the key difference between the monostable and the astable operation is that the trigger input is connected together with the threshold input so that the times triggers itself during operation.

Circuit:-



Observations:-

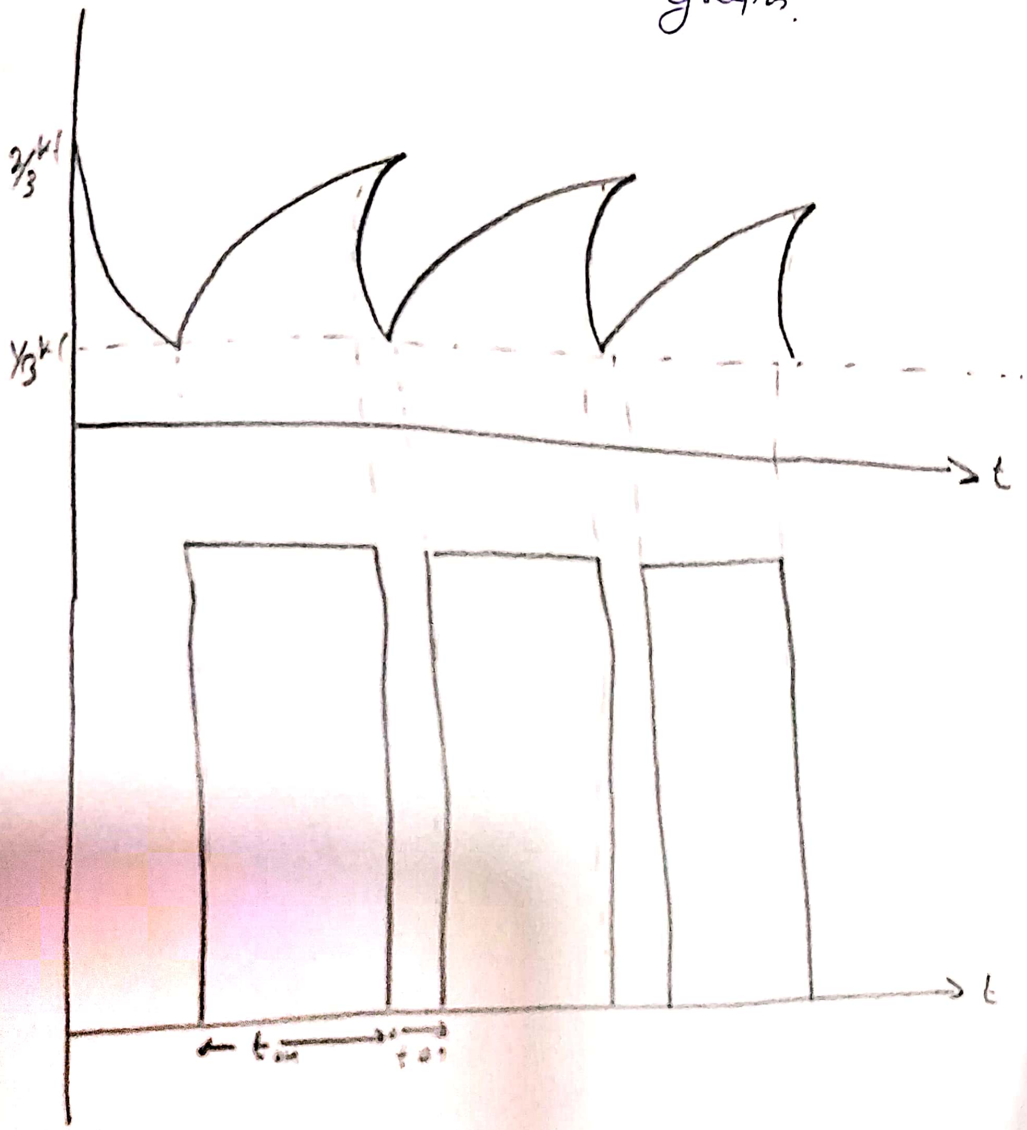
1. Assemble the circuit and it is a basic configuration for astable operation.

2. The capacitor 'c' is pereodically charged and discharged between the trigger level $V_L = V_{cc}/3$ and threshold level $V_H = 2V_{cc}/3$

3. Astable circuit produce pereodic output rules with frequency $f_p = 20kH_2 (\pm 2)$

4. Observe the O/P waveform and define the total time period (T_p), on time (T_H) or charging time, off time (TH) or charging time, off time (T_L) discharging time and duty cycle CD.

5. Draw the o/p response $V_o(t)$ as well as the capacitor voltage $V_c(t)$ and define experimentally obtained values on the graph.



Readings :-

~~Duty Cycle~~ = 99.1%

Time period = 41.8 μs

f = 23.9 kHz

V_{pp} = 10 V

1. Compose the theortical and experimental values.

Note:-

(a) What will be value R_A to get 75% duty cycle

$$\Rightarrow 3/4 = \frac{0.693(R_1+R_2)C}{0.693(R_1+2R_2)C}$$

$$3/4 = \frac{R_1+R_2}{R_1+2R_C}$$

$$3R_1+6R_2 = 4R_1+4R_2$$

$$2R_2 = R_1$$

so $R_A = 2R_B$

$$T_{ON} = 0.693(R_1+R_2)C$$
$$= 3.534 \times 10^{-5} \text{ sec}$$

$$T_{off} = 0.693 \times R_2 \times C$$
$$= 1.247 \times 10^{-5} \text{ sec}$$

$$T_{total} = 0.693(R_1+2R_2)C$$
$$= 4781 \times 10^{-5} \text{ sec}$$

$$f = 1/T = 20913.06 \text{ Hz}$$
$$= 20.913 \text{ kHz}$$

Conclusion:-

In this experiment we designed and implemented the Astable multi window vibrator and checked it Vpp, Vmax, frequency and reading to simplify everything.