Analog Electronic Circuits
LAB REPORT-2

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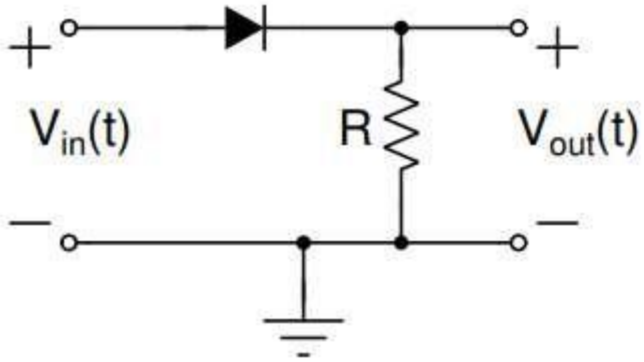
Diode characterization and applications:

1. Diode Characteristics:

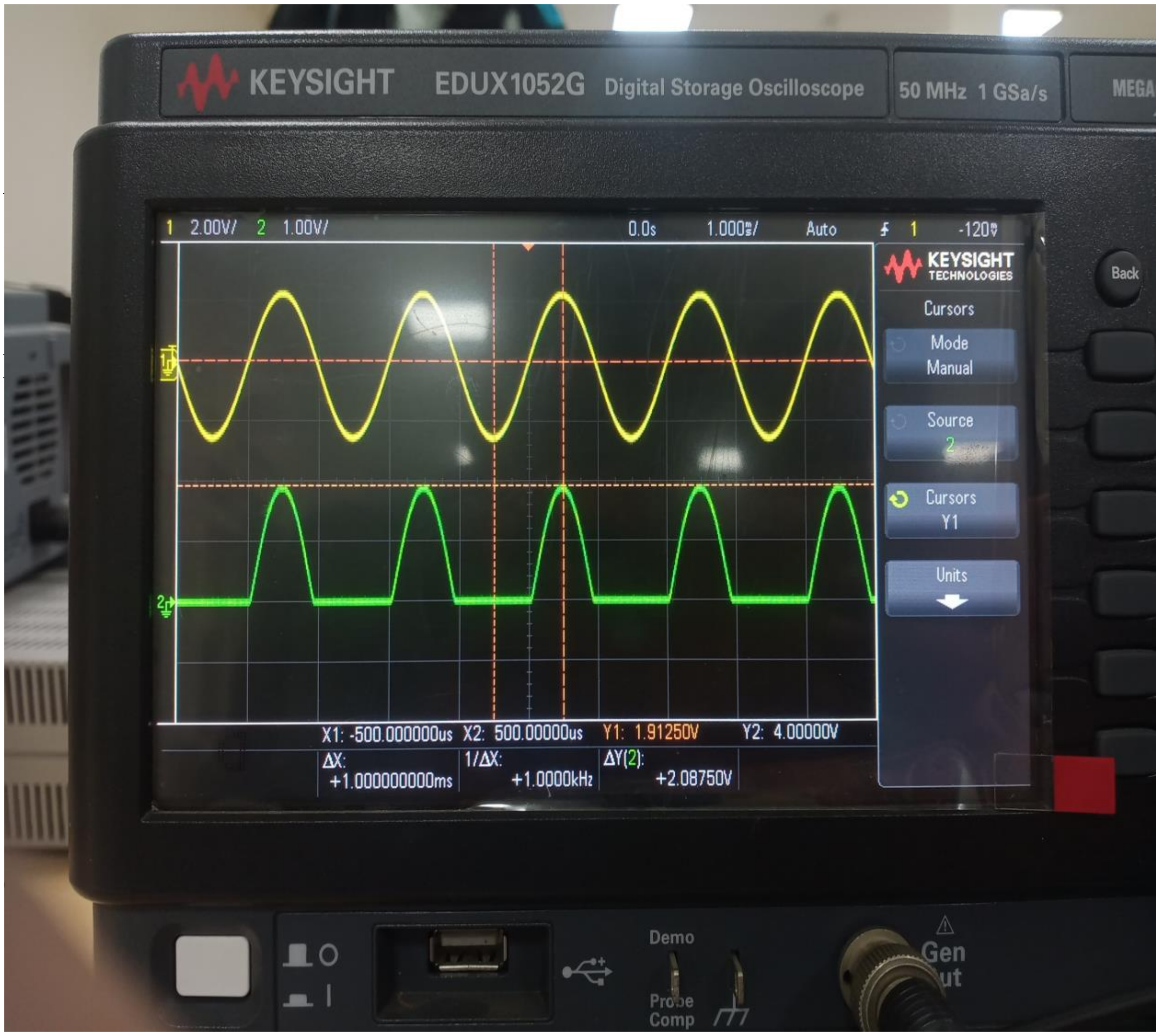
Firstly Connect the diode in forward bias as shown in Fig on the breadboard.



->Then apply a sinusoidal input (Vin), with amplitude 2 Vpp(peak-peak), using Wav-Gen and frequency=100Hz. ->Take resistance R=1000 ohm.

Case1: Connect the diode in the forward bias R=1k ohm. Initially,
Applying sinusoidal voltage as input using a Wave Gen Vin(amplitude)=1V
Vpp(peak-peak)=2V
A low frequency up to few 100’s of Hz.
This circuit is an example of a simple half-wave rectifier.

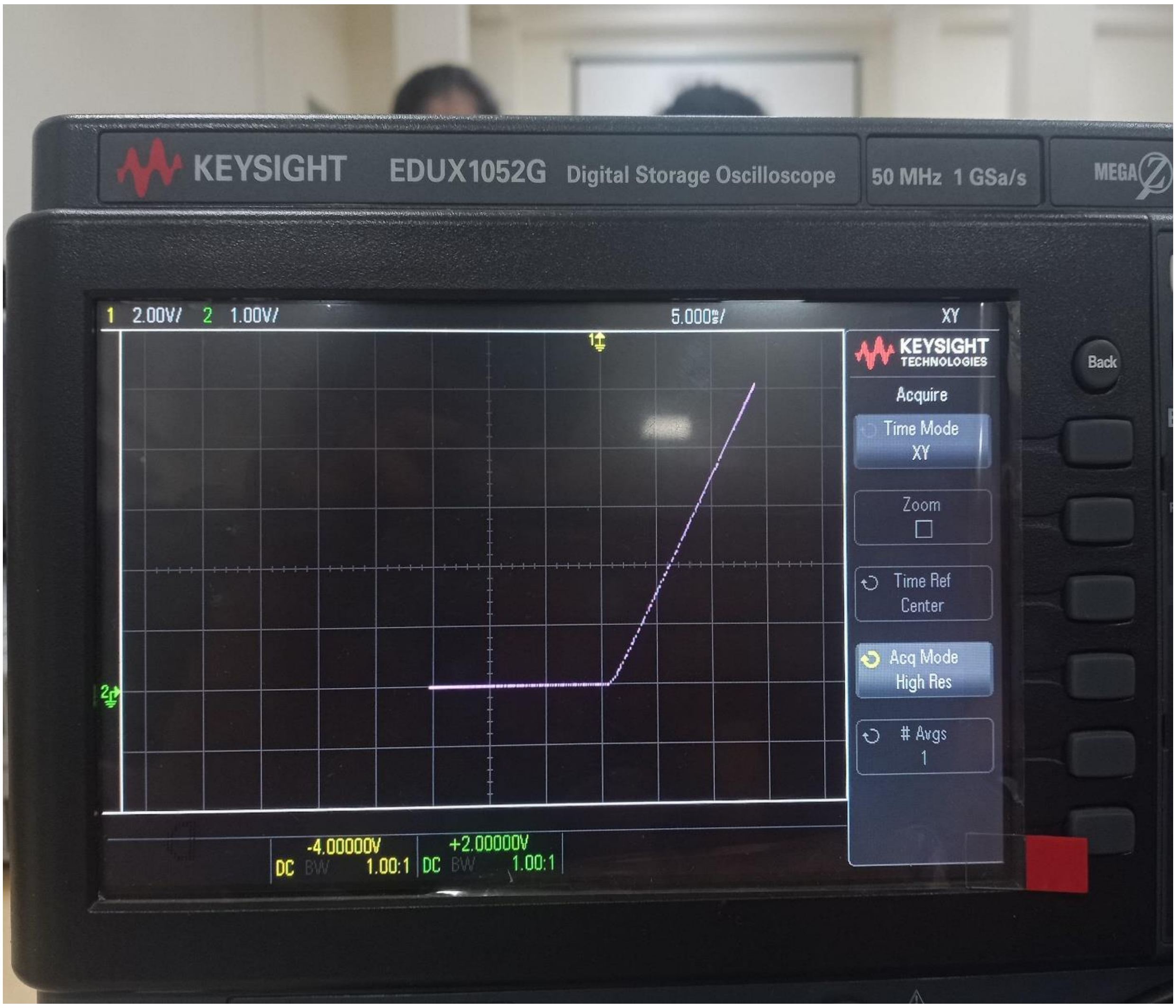
a) GRAPH of Vin vs V(out):



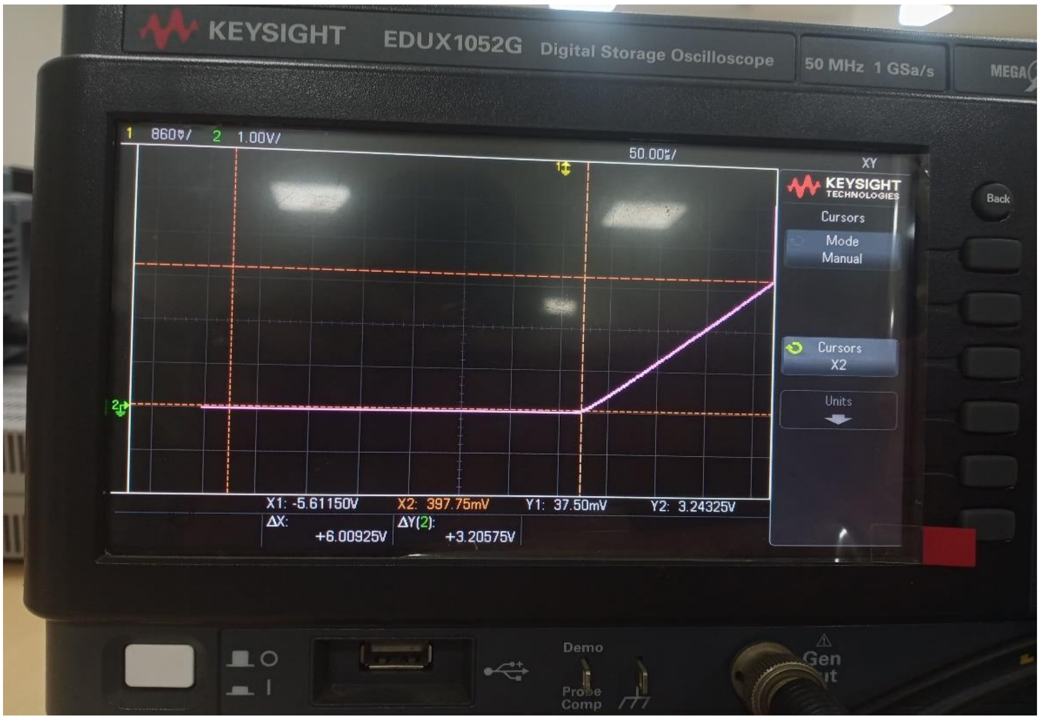
1. <u>Plot of Voltage transfer characteristics:</u> Acquire button->X-Y mode
2. To measure the V cut in accurately, the input and the output signal were pushed to zero by pressing the push to zero button. Now from the V(out) vs Vin graph,

The Vin from zero at which the Vout just starts to rise is the cut in voltage of the diode.

Using the Cursor X2, the voltage V cut in was practically meaured to be 397.75 mV.



c) To measure the V cut in accurately, the input and the output signal were pushed to zero by pressing the push to zero button.
Now from the V(out) vs Vin graph,
The Vin from zero at which the V(out) just starts to rise is the cut in voltage of the diode.
We use cursors to find the exact/appropriate value of cut-in Voltage.
As we can see in above plot x2[V cut-in] = 397.75mV.
As after when vin becomes greater than Cut-in voltage then only current increases suddenly.



d) Now finding internal resistances for the following cases:

Vin= sine wave

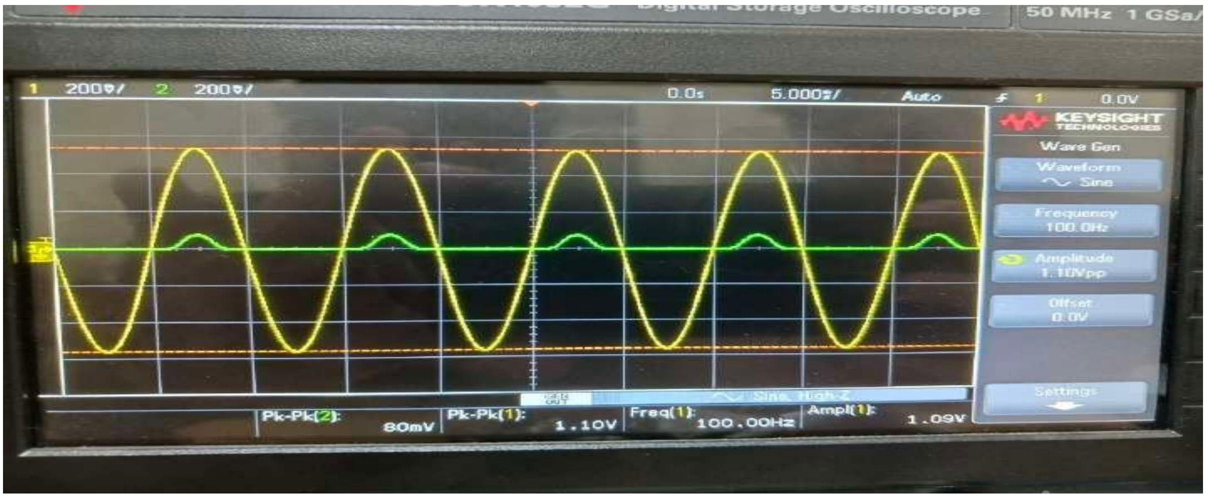
Amplitude:= 550mv

As Vin-V(out)=Vd

This implies Vin-V(out)=Vcutin+IR(on).

And I=V(out)/R.

Therefore R*(Vin-V(out)-V(cutin))/V(out)=R(on)



Case1:

Vin=0.55 V=550mV ==> Vpp=1.1V

Vout(pp)=80mV

Ron=R* (Vin -VD-Vout)/Vout. (derived).

=1000(550-397.75-80)/80= 900 ohm

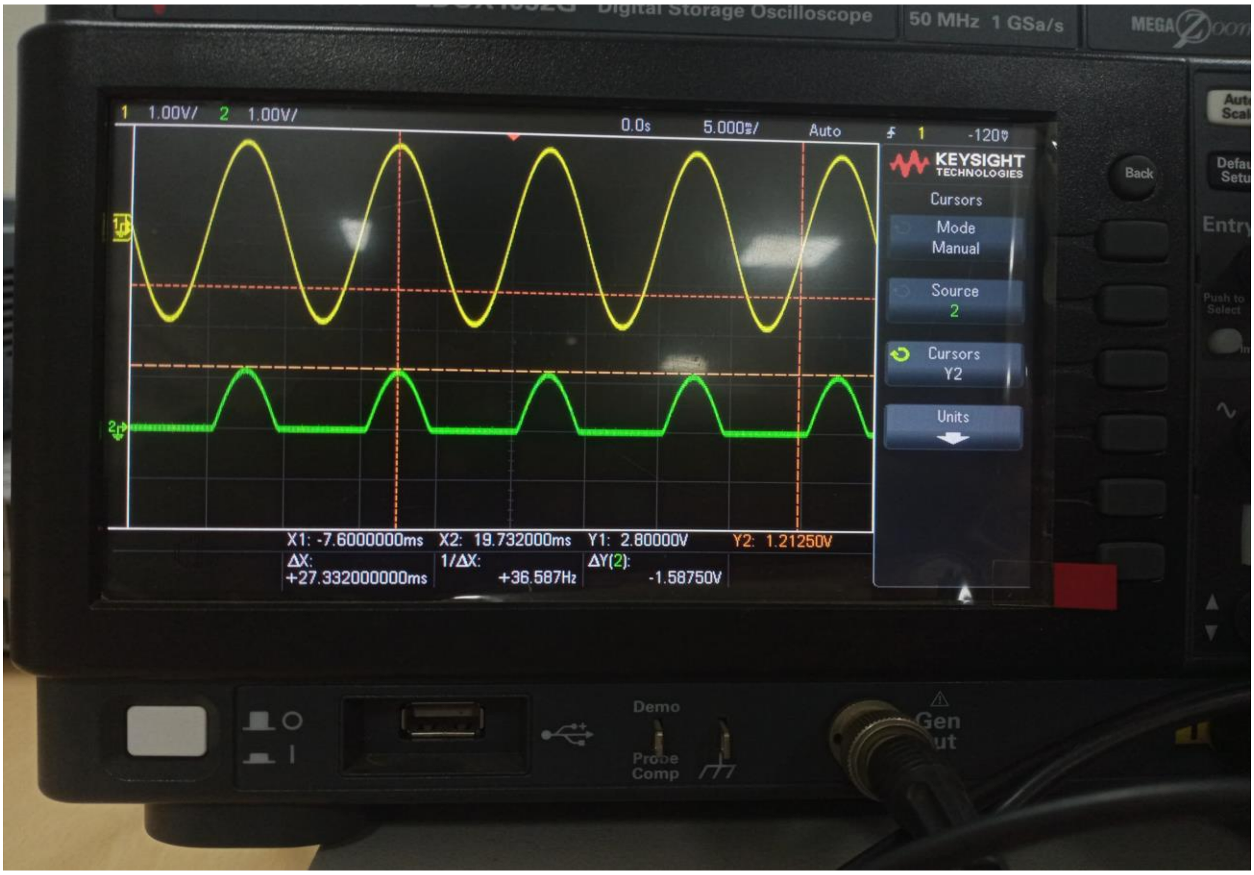
Case2:

Vin=1.8 ==> Vpp=3.6V

Vout(pp)=1.21

Ron=R* (Vin -VD-Vout)/Vout

Ron =1000(1.8-0.39575-1.21)/1.15=158.88 ohm



Case3:

Vin=2V ==> Vpp=4V

Vout(peak-peak)=1.4125V

Ron =R* (Vin -VD-Vout)/Vout

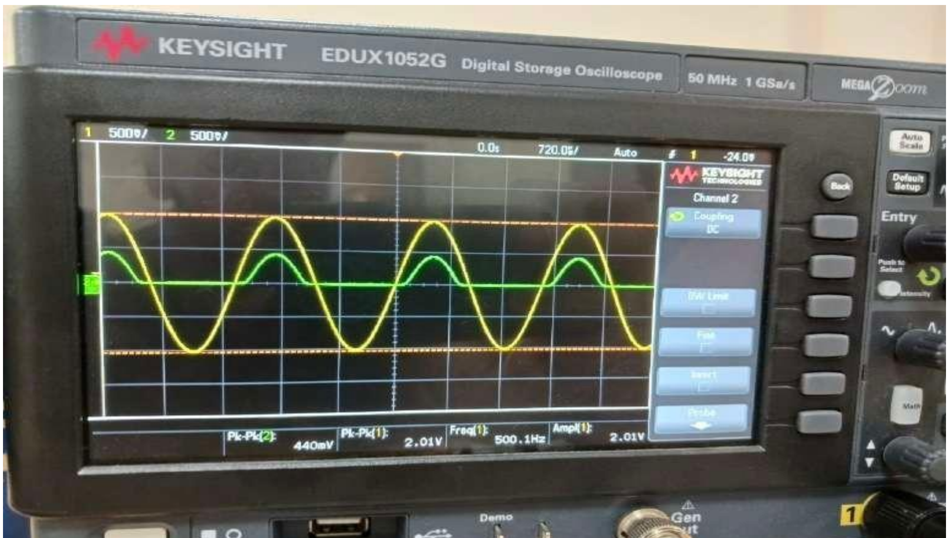
Ron =1000(2-0.33125-1.4125)/1.34= 132.79ohm

Vin (only Amp)	Vout (p-p)	Rd
2v	1.412v	132.79ohm
1.8v	1.21	158.88ohm
0.55v	80mv	900ohm

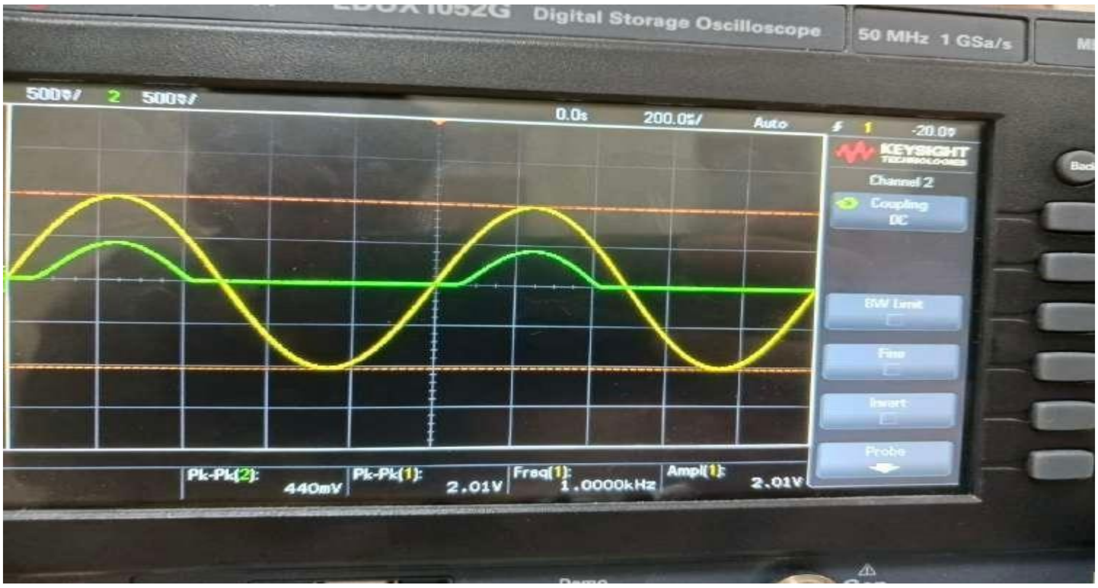
To find the internal resistance (R(on)) of the diode at different input voltages, we can use the formula: r(on) = (Vin - Vd) / Id when we decrease the input voltage, the current flowing through the diode also decreases. This causes an increase in the internal resistance of the diode, resulting in a higher overall resistance seen by the circuit. Therefore, the internal resistance of the diode increases as Vin decreases.

e) Observing transient response of the circuit by varying the frequency of the input:

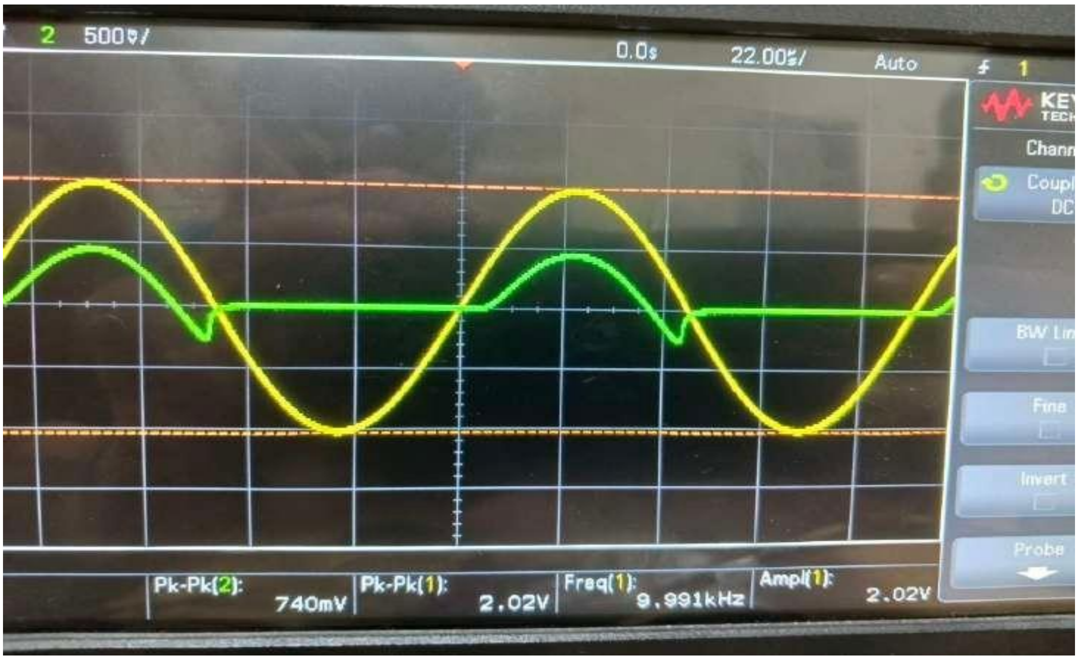
1)500Hz:



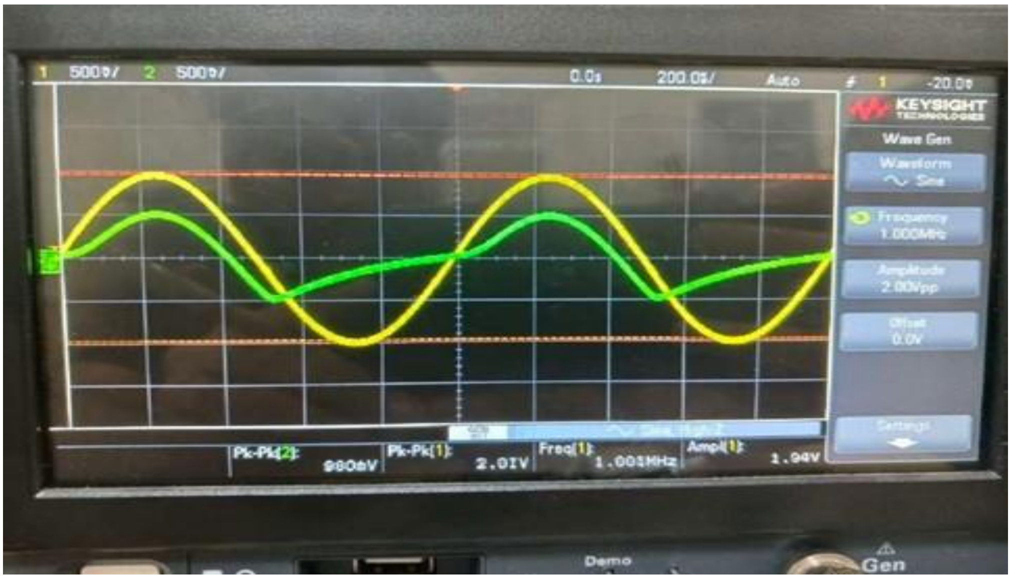
2)1000Hz:



3)10kHz:



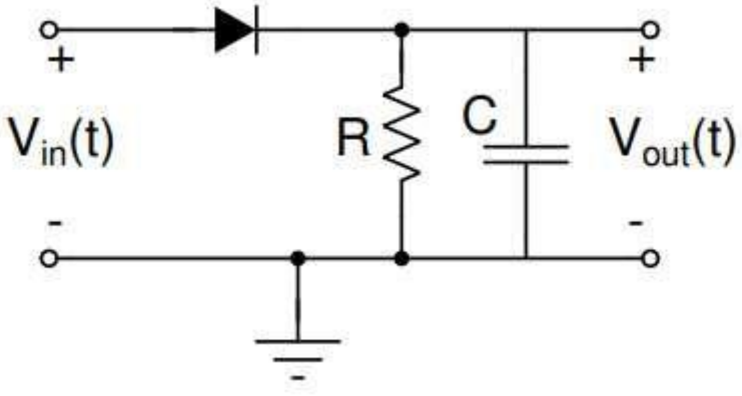
4) 1MHz:

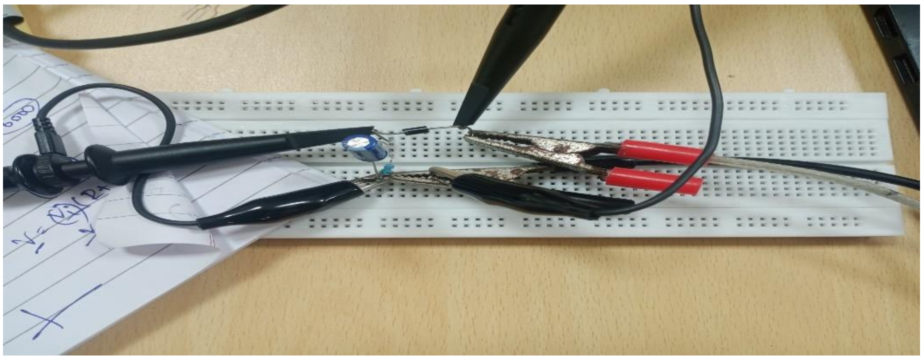


At higher frequencies, the diode may not be able to respond quickly enough to the changing input signal, and this can lead to distortion in the output waveform. This is because the internal capacitance of the diode prevents the diode from switching on and off instantaneously, and the diode can only discharge and conduct current for part of the cycle. As a result, the output waveform becomes distorted, and the peaks of the waveform become flattened. But this is not a problem for low frequency inputs and we get our desired output voltage.

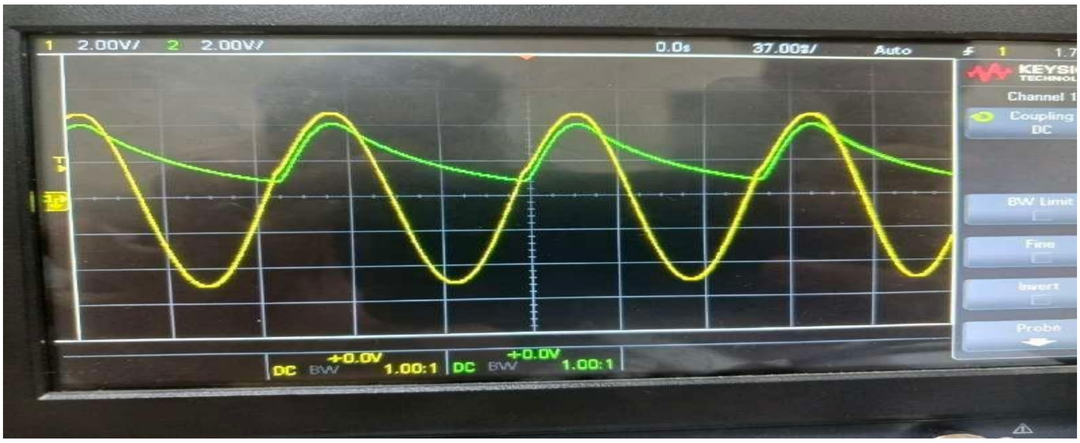
As the frequency of the input signal increases, the diode might take time To switch its position from on to off or vice.

f) Now connect a capacitor across the resistor as shown in Fig below:

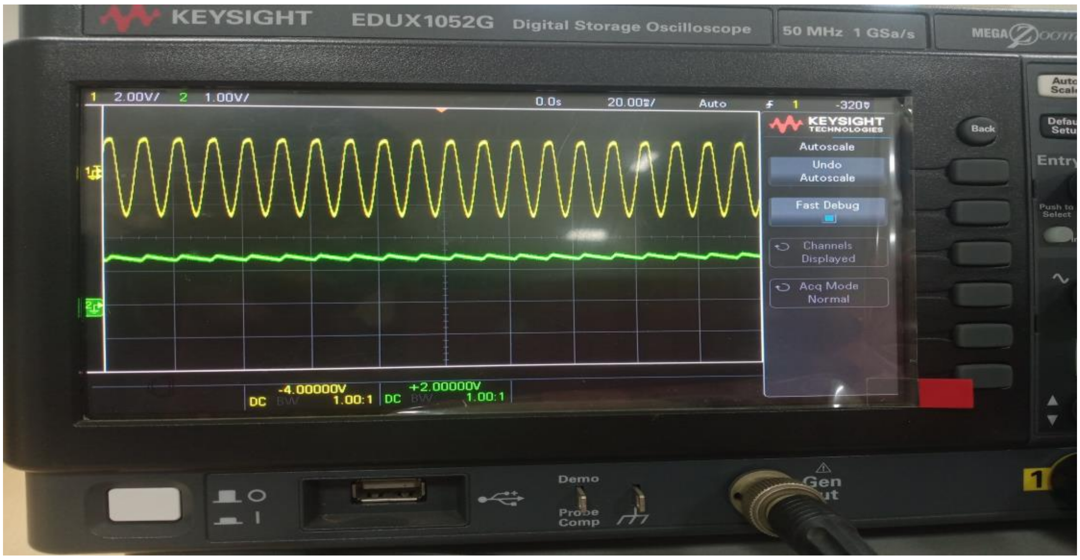


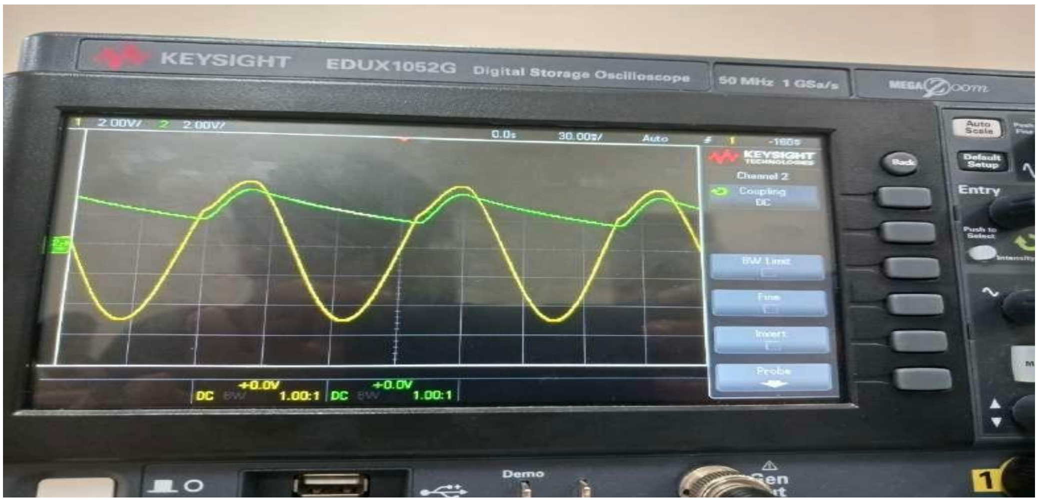


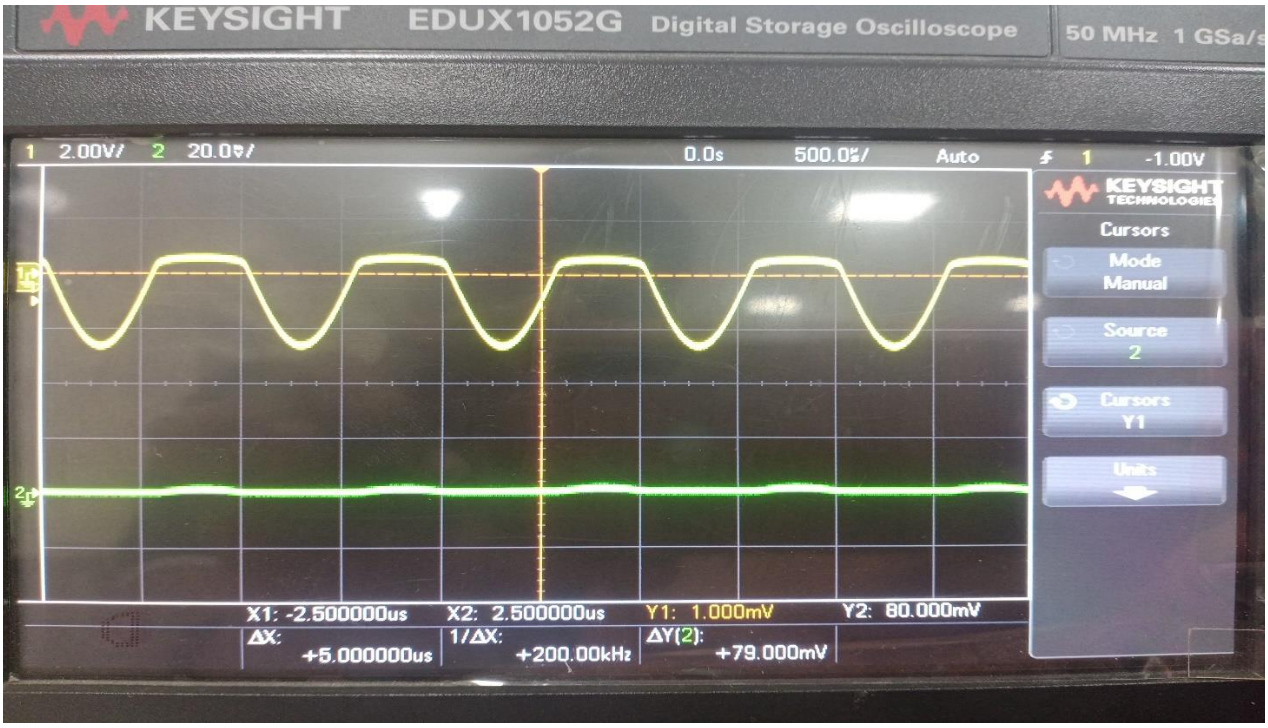
CASE 1: C=47 uF



CASE 2: C=100uF







Effect of capacitor on output voltage:

The above two graphs are for 47 μF and 100 μF. When the input increases upto its peak value in its half period V(out) also increases proportionally to Vin. Now when Vin is peak capacitor is fully charged so as soon as Vin comes below of its peak voltage diode will be in reverse bias now. So no current flow in circuit now, and the capacitor itself discharges until the diode comes in forward bias again.

Now if time constant is very greater than time period of input signal then only less charge is lost, i.e we can see almost a straight line while capacitor is discharging.

Therefore by using a capacitor and connecting as shown above we will get an output which is close to a constant voltage i.e DC output.

2. Clipper Circuits:

Connect the circuit as shown in the figure below:

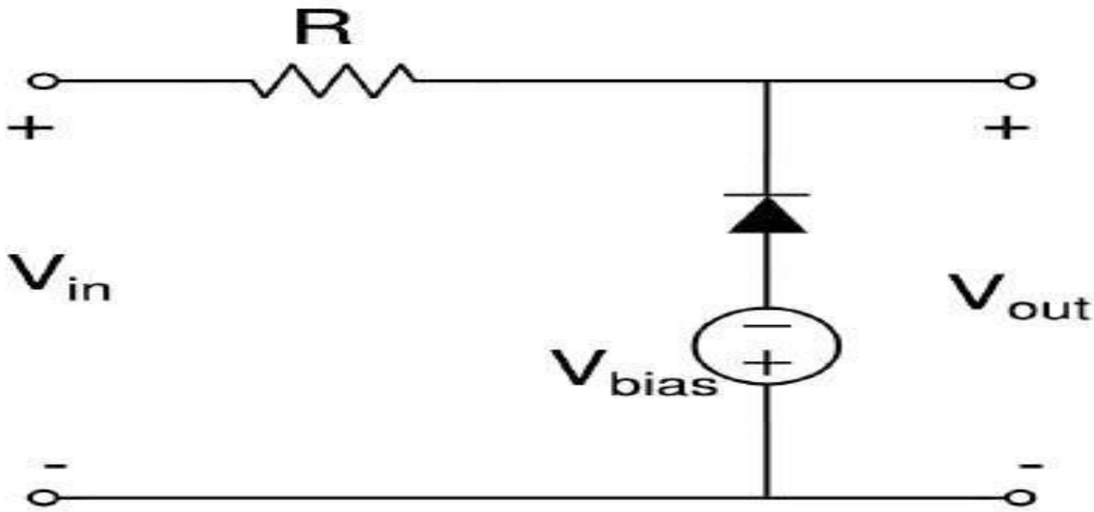
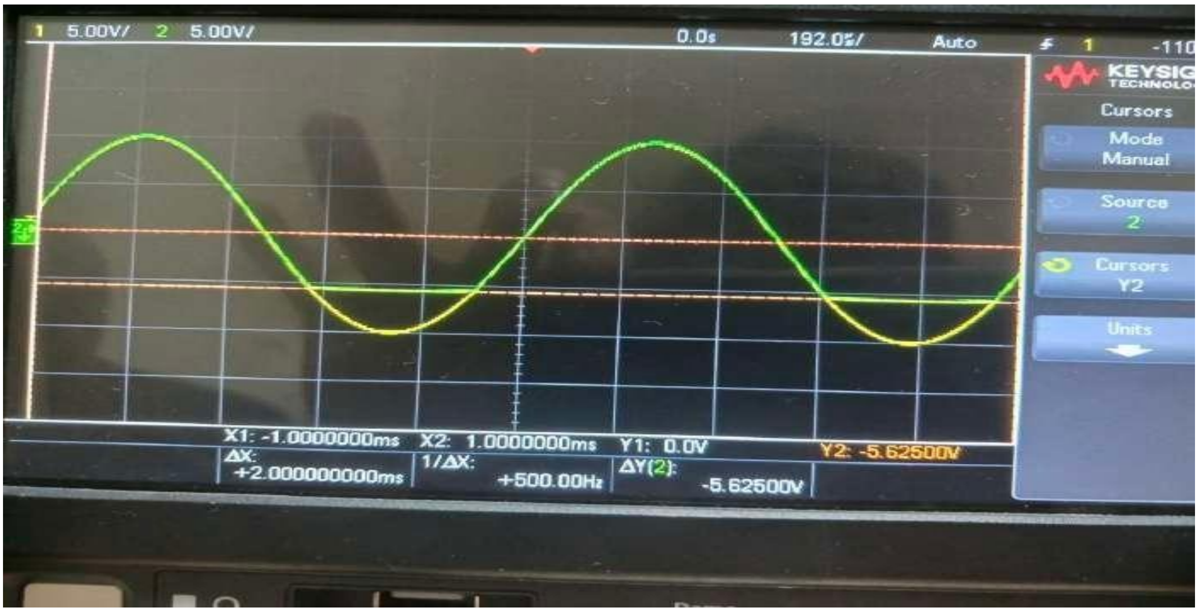


Figure 3: Negative Bias

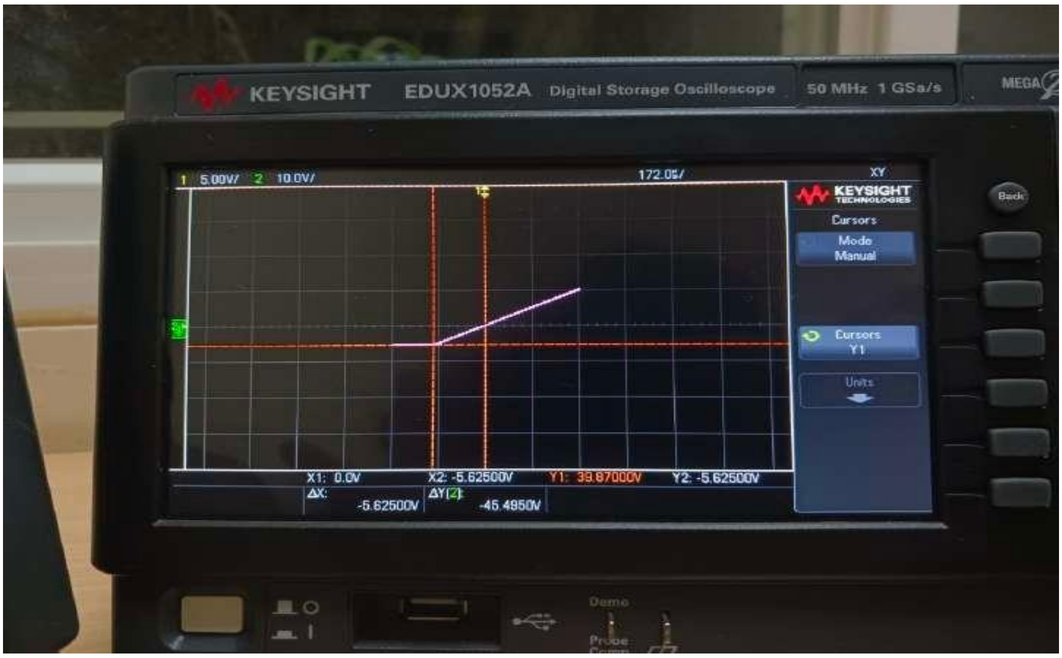
Use the DC power supply to give the bias voltage. Now Vary the bias voltage and observe its effects on the output.



A)VARING VBIAS TO NOTE THE OBSERVATIONS:

Here we are asked to observe the output of this clipper circuit by varying the V bias. voltage and analysing its effects on the output voltage.

when VBIAS increases, the diode has more chances of getting into working condition. In positive half cycle, the diode would always be in off state (provided that VBIAS is never negative) VBIAS = 0.33 Volt, 0 Volt, 0.49 Volt, -0.09 Volt in four different cases



Plot for input and output signal:

From the circuit, taking the base wire as the reference for ground (0V).

V(p side of diode)=-5V

Until Vin=-5-VD, the diode would be connected in reverse bias not allowing the current to flow in the circuit.

So V(out) would be equal to Vin.

For Vin>(-5-VD),the diode would be connected in forward bias so Vout= -5-VD.

V(out) was measured to be -5.625V. So VD=-5-Vout=-5+5.625=0.625V. So VD=625mV.

- Case2:

Vin(max amplitude)=10V Vpp=20V

Vbias=0V(no bias provided)

From the circuit, taking the base wire as the reference for ground (0V).

V(p side of diode)=0V

Until Vin=0-VD, the diode would be connected in reverse bias not allowing the current to flow in the circuit.So Vout would be equal to Vin.

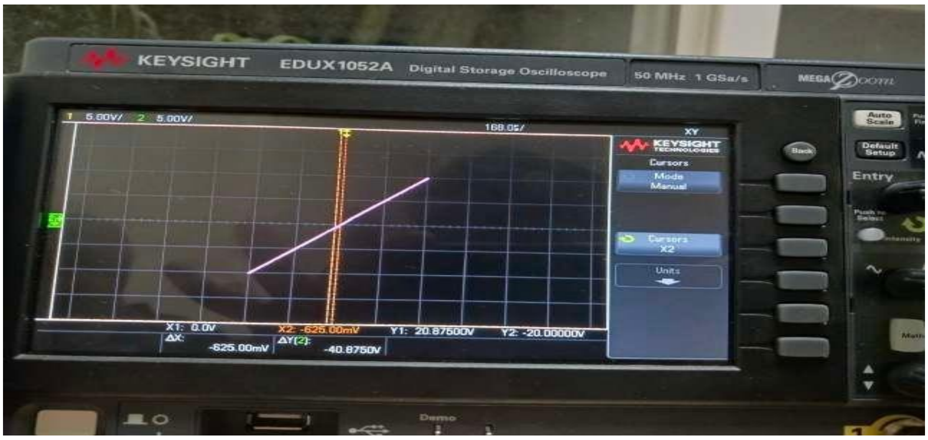
For Vin>(0-VD),the diode would be connected in forward bias so Vout= 0-VD.

Vout was measured to be -0.625V. So VD=0-Vout=0+0.625=0.625V. So VD=625mV.

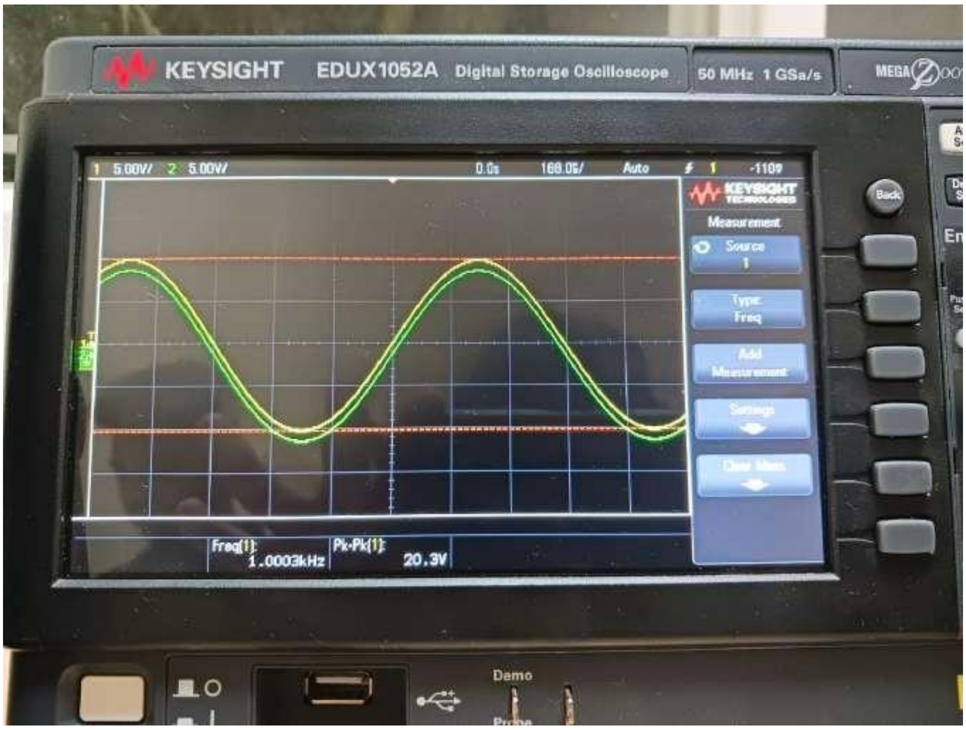
- Case3:

Vin(max amplitude)=10V Vpp=20V

Vbias=-15V

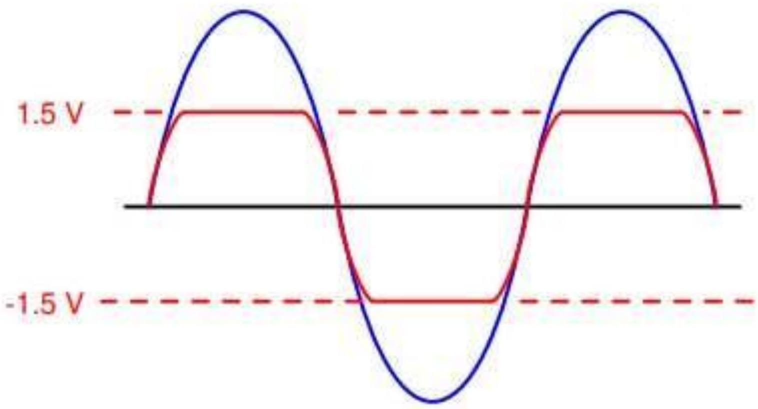


From the given input signal maximum peak voltage, we can infer that the diode would rectify the signal only when the Vin<-15-VD.
But the input Vpp=20V .so the max amplitude go the sine signal is 10V.since 15>10.the diode cannot rectify the input.So the output graphs follows the input graph with Vout =Vin (always satisfy).(always in revesed baise).



→Clipping both half cycles:

We have to design the circuit that exhibits the derived transfer characteristics by modifying the above used circuit to get output as below:



Now to do so we add another diode in opposite direction to previous diode with positive voltage bias in parallel to this circuit so that one combination clips positive voltages while the other combination clips negative voltages.

<u>Part C:</u>

From Part A and B we have inferred that the voltage across the diode VD=625mV.

Expected behaviour of the Vout.

For

- Vin<-(Vbias+VD), Vout=-(Vbias+VD)
- (Vbias+VD)<Vin<(Vbias+VD) , Vout=Vin
- Vin>(Vbias+VD), Vout=(Vbias+VD),

Given Vbias+VD=1.5V

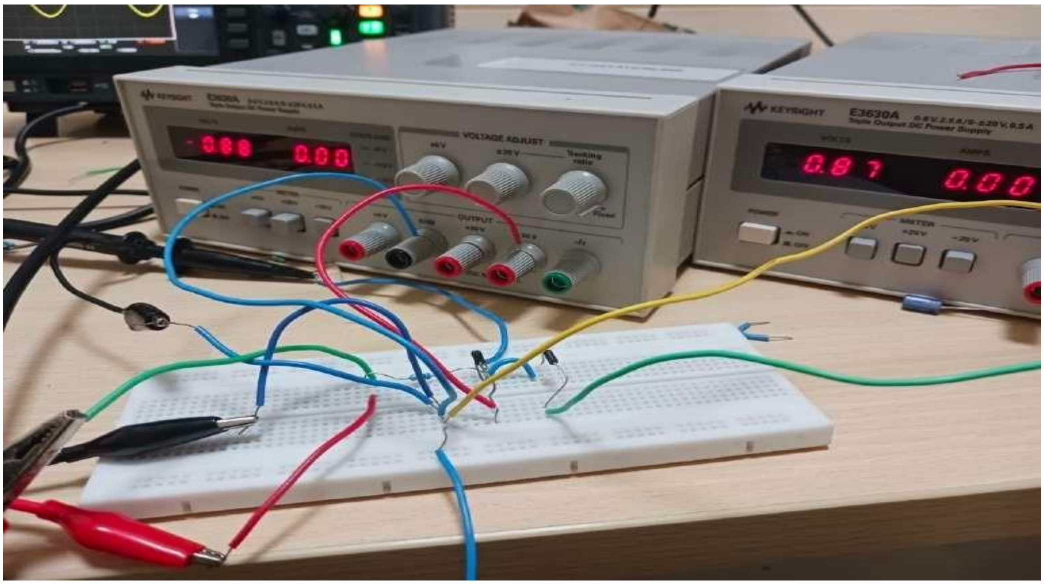
VD calculated=625mV=0.625V.

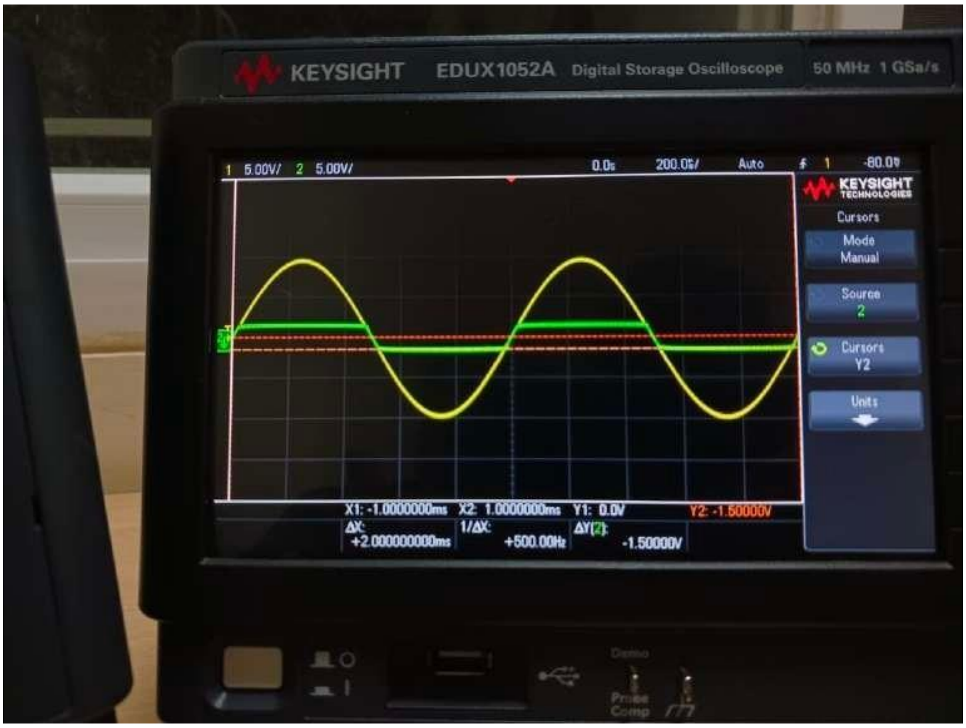
Vbias to be set for the desired output=1.5-0.625=0.875V


KEYSIGHT
EDUX1052G Digital Storage Oscilloscope
50 MHz 1 GSa/s
InfiniiVision
Run Stop
Single


KEYSIGHT
EDUX1052G Digital Storage Oscilloscope
50 MHz 1 GSa/s
InfiniiVision
Run Stop
Single
Channel 1
Coupling DC
BW Limit
Invert
Probe


KEYSIGHT
Cursors
Mode Manual

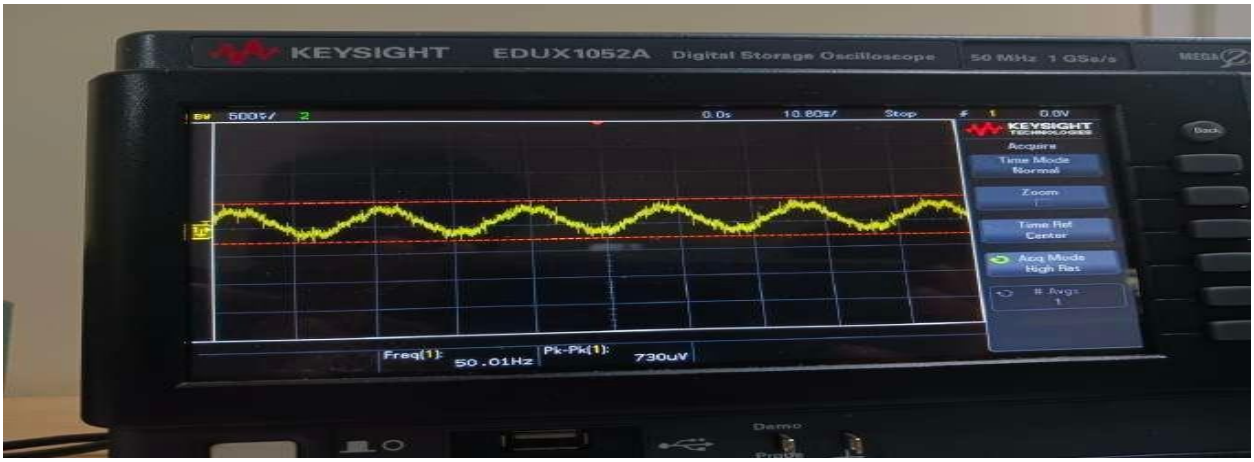

KEYSIGHT
E3630A
VOLTAGE ADJUST
OUTPUT


KEYSIGHT
EDUX1052A Digital Storage Oscilloscope
50 MHz 1 GSa/s
1 5.00V/ 2 5.00V/
0.0s 200.0?/ Auto
-80.0?
KEYSIGHT TECHNOLOGIES
Cursors
Mode
Manual
Source
2
Cursors
Y2
Units
X1: -1.0000000ms X2: 1.0000000ms Y1: 0.0V Y2: -1.50000V
ΔX:
+2.000000000ms
1/ΔX:
+500.00Hz
ΔY(2):
-1.50000V

3. Application of diode in Energy Harvesting:

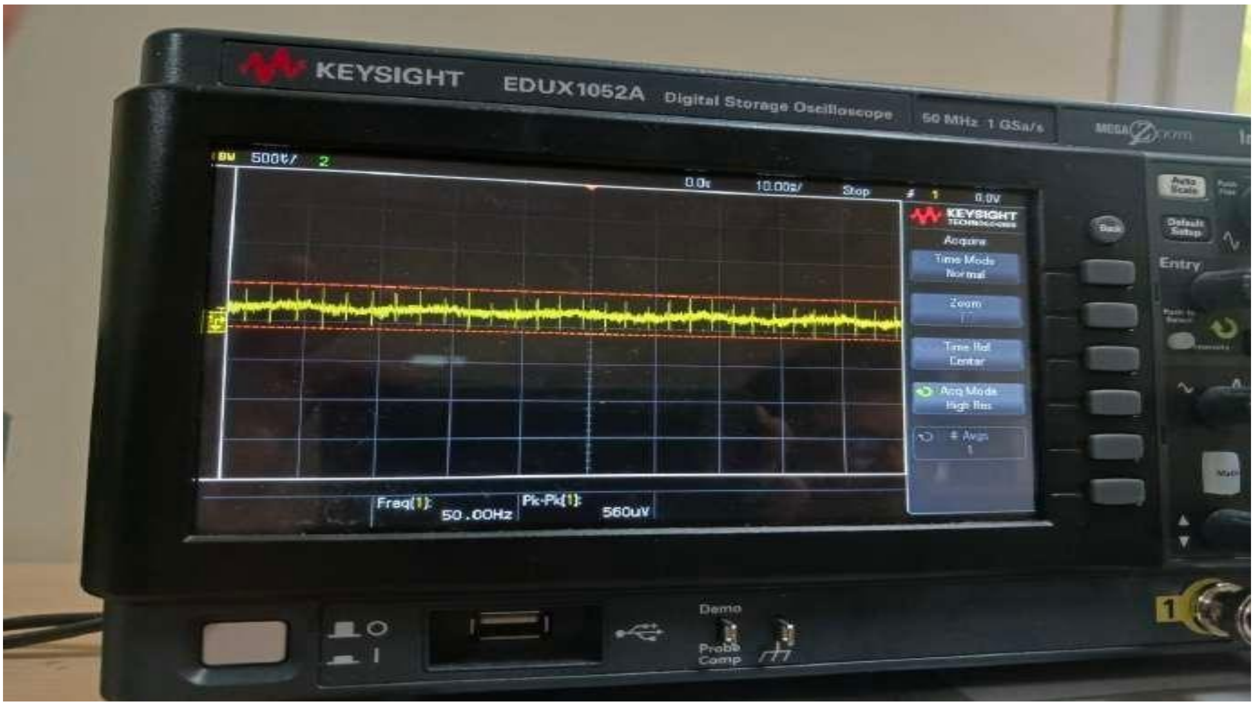
->Firstly Connect a probe to oscilloscope channel and leave it floating as it acts as an antenna for the 50 Hz signal.
->Then adjust time/amplitude scale and check for 50 Hz signal.

Probe when set free:



Probe is coiled :

Probe is stretched:



	Amplitude	Frequency
Probe set free	730uv	50.01Hz
Prob coiled	1.29mV	50.33Hz
Probe streched	560uV	50.00Hz

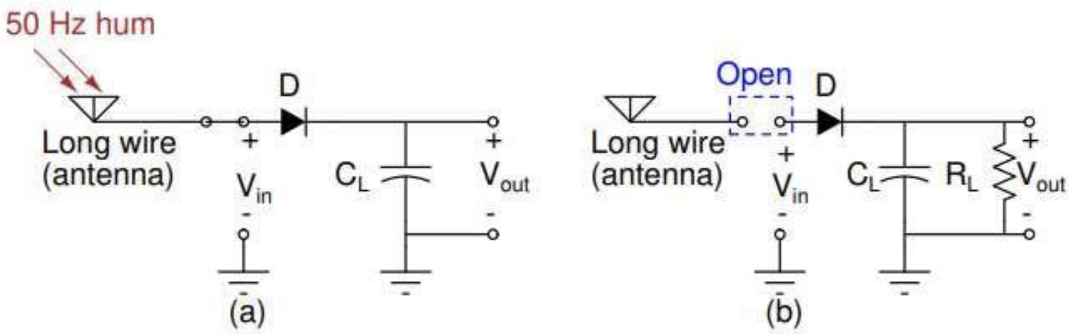
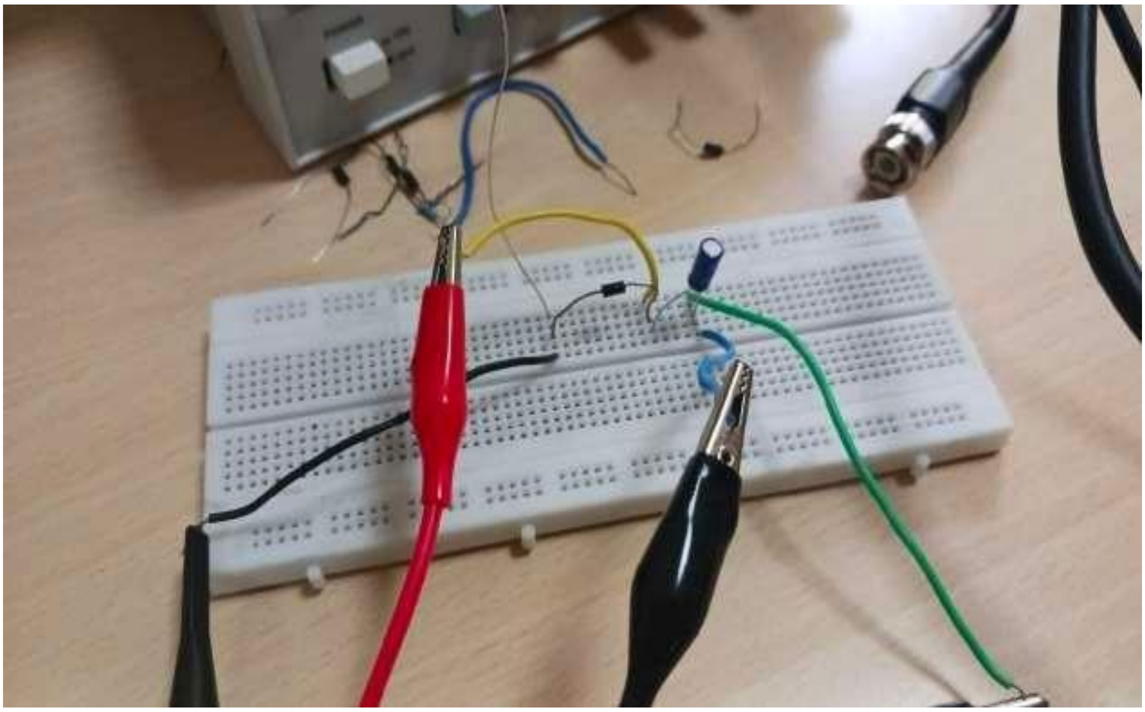


Figure 6



Connect a diode and a capacitor of capacitance CL = 100 μF.
Short both terminals of the capacitor to ground to discharge it.
Connect an oscillator probe at the output and observe that the voltage is zero.
Connect a large wire to the circuit and measure the amplitude of the 50 Hz signal using another channel of the oscilloscope.
Connect the large wire (antenna) to the input of the circuit as shown in Fig. 6(a).
Observe V(out), which should rise as energy is harvested from the environment.
When V(out) reaches 400 mV, disconnect the long wire (antenna) from the input as shown in Fig. 6(b).
The capacitor CL should hold this value for some time as energy is stored in it from the environment, but it will slowly start reducing due to leakage.
Once the voltage drops to 300 mV, connect a resistance RL = 1 kΩ to the circuit. Observe how V(out) changes now and what its final value is.

We can observe a gradual decay of the capacitor voltage while the current flows through the load. By doing so, we have effectively stored energy harvested from the environment and employed it as a source of power similar to that of a battery.