LAB REPORT-3
EC29201

BATCH-5

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Part 1:VI characteristics of a diode

AIM: At the end of the experiment a student must be able to

1.Explain the structure of a P-N junction diode.

2.Explain the function of a P-N junction diode.

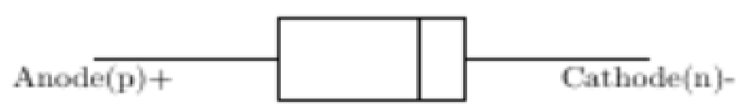
3.Explain forward and reverse biased characteristics of a Silicon diode.

4.Explain forward and reverse biased characteristics of a Germanium diode.

P-N Junction Diode

A diode is a semi-conductor device that allows current to flow in only one direction, restricting current flow in other direction. It is made by a junction of p-type(doped with group 13 element) and n-type(doped with group 15 element).The lead connected to P side of diode is called anode and that connected to the N side is called cathode.

Structure of a P-N junction diode



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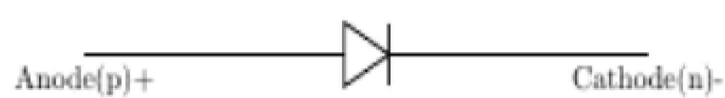
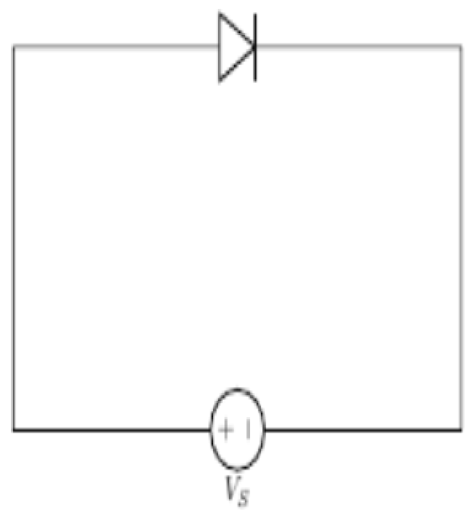


Working of P-N junction diode in forward and reverse bias.

- Forward Biased P-N Junction diode

The P-N junction diode is said to be in forward bias if the P-side of the diode is connected to the positive terminal of the battery and the N-side is connected to the negative terminal of the battery or rather simply, when P-side end is at higher potential than N-side .During forward bias, holes from the P-side get attracted to the N-side and electrons from the N-side get attracted to the P-side. This leads to generation of a current called diffusion current. In this setup, the width of the depletion region reduces with increase in the voltage. As voltage is further increased the electric field of the depletion layer becomes weak enough to not be able to prevent charge carrier transfer from P to N-side and vice versa. The amount of minority diffusion in the near neutral zones(away from depletion region)determine the amount of current that may flow through the diode The voltage at which the electric field of depletion layer becomes equal to the externally applied voltage is called cut-in voltage(or knee point).

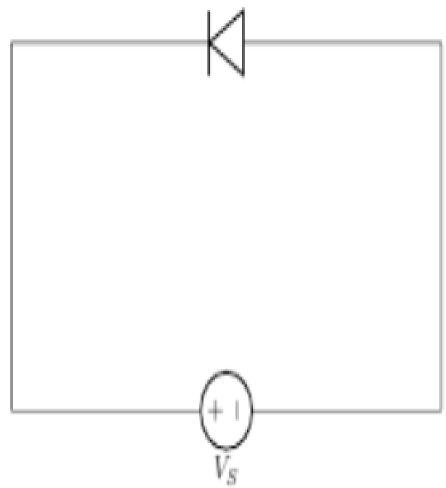
P-N Junction diode in forward bias



- Reverse Biased P-N junction diode

In this configuration, the positive terminal of the battery is connected to the P-side and the negative terminal is connected to the N-side of the diode. Thus, very little current flows unless diode breakdown. As the externally applied electric field is from N-side to P-side, the electrons are pulled away from the junctions. This increases the electric field of the depletion layer and widens the depletion zone thereby increasing the voltage barrier and effectively acts as a very high resistance load(or insulator).If the reverse bias voltage crosses a certain limit called breakdown voltage, a huge amount of current starts flowing from the N-side to the P-side which may burn the diode. Such a breakdown can be either zener or avalanche breakdown .Both these processes are non-destructive and reversible, as long as the amount of current flowing does not reach levels that cause semi-conductor material to overheat and cause thermal damage.

P-N Junction diode in reverse bias



Equations and formula to be used

$I_f = I_s(\exp(V_f/nV_T)-1)$

I_s is reverse saturation current or leakage current,
I_f is current through the diode(forward current),

V_f is potential difference across the diode terminals(forward voltage)

V_T is Thermal voltage given by equation $V_T=KT/q$

n is empirical constant between 0 and 2 which is affected by diode manufacture, levels of doping and purity level of material.

$K=1.38*10^{(-23)}$ J/K (Boltzmann's constant)

$q=1.6*10^{(-19)}$

T=273 + t(in degree C)

V_T=25.7mV at room temperature(298 K)

VI characteristics of Si and Ge diode

- Si diode
- Cut-in voltage=0.6V
- $1.3<n<1.6$
- Breakdown voltage is between 20 to 30V
- Ge diode
- Cut-in voltage=0.3V
- $n\sim1$
- Breakdown voltage is approx 30 V

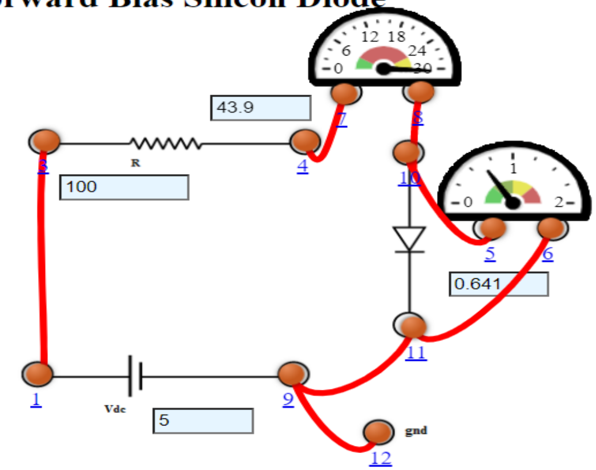
Simulations(Si diode-Forward and Reverse Bias)

INSTRUCTION

EXPERIMENTAL TABLE

No.	Voltage(Volt)	Current(mAmp)
1	0	0
2	0.593	1.99
3	0.601	4.99
4	0.609	8.97
5	0.614	12.0
6	0.618	15.0
7	0.622	18.9
8	0.625	21.9
9	0.627	23.9
10	0.630	26.9
11	0.632	29.9
12	0.634	32.9
13	0.636	35.9
14	0.638	38.9
15	0.639	41.9
16	0.641	43.9

Forward Bias Silicon Diode



CONTROLS

Select Diode: 1N4007 V_F 0.6

DC volt : Volt

Resistance : ohms

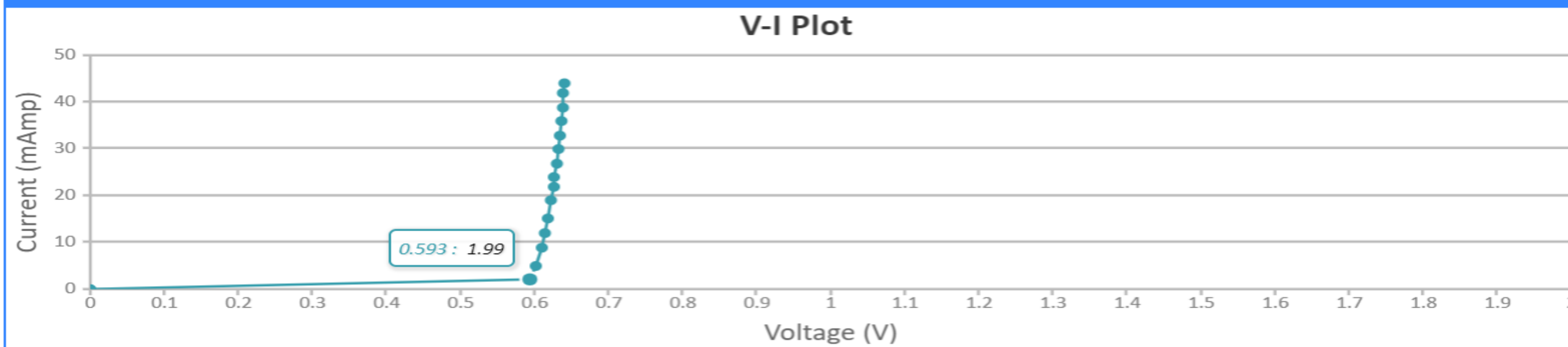
Add to Table | Plot | Clear

Check connection | Delete all connection

Print It

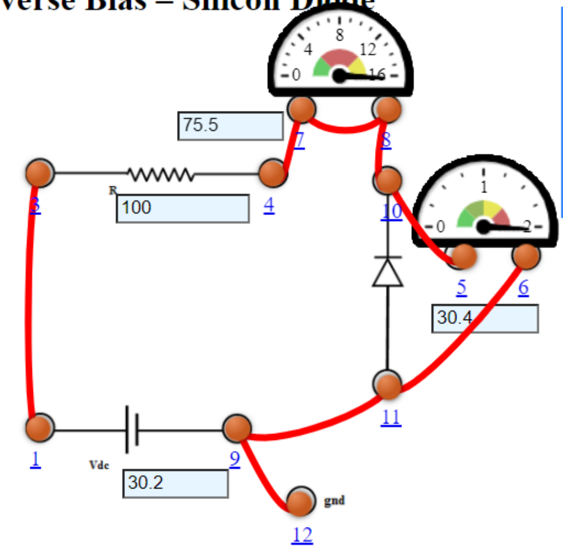
Check for Reverse Bias

GRAPH PLOT



INSTRUCTION

Reverse Bias – Silicon Diode



CONTROLS

Select Diode: 1N4004 V_R 30

DC volt : Volt

Resistance : ohms

Add to Table | Plot | Clear

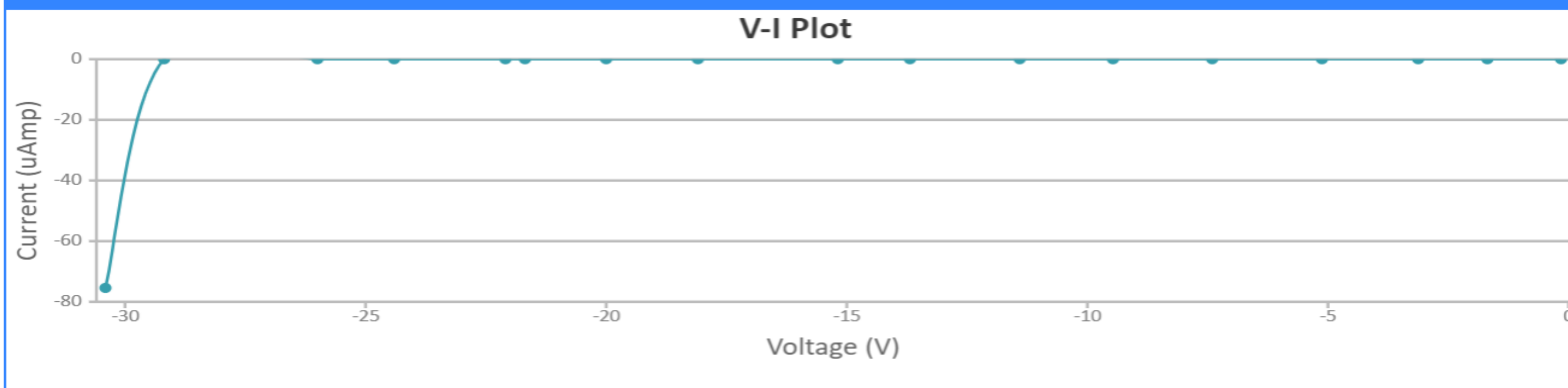
Check connection | Delete all connection

Print It

EXPERIMENTAL TABLE

Serial No.	Reverse Voltage(Volt)	Reverse Current(µAmp)
1	0.170	0.100
2	1.70	0.100
3	3.14	0.100
4	5.14	0.100
5	7.42	0.100
6	9.46	0.100
7	11.4	0.100
8	13.7	0.100
9	15.2	0.100
10	18.1	0.100
11	20.0	0.100
12	21.7	0.100
13	22.1	0.100
14	24.4	0.100
15	26.0	0.100

GRAPH PLOT



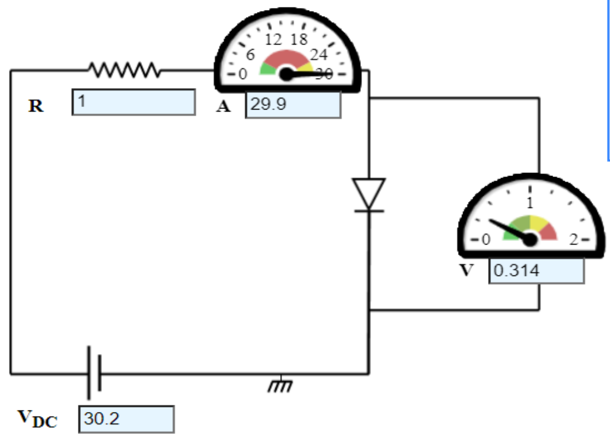
Simulations(Ge diode-Forward and Reverse Bias)

INSTRUCTION

EXPERIMENTAL TABLE

Serial No.	Forward Voltage(Volt)	Forward Current(mAmp)
1	0	0
2	0.277	1.45
3	0.286	3.20
4	0.291	5.10
5	0.296	7.45
6	0.299	9.20
7	0.301	11.4
8	0.304	13.9
9	0.306	16.2
10	0.307	18.3
11	0.309	20.2
12	0.310	22.1
13	0.311	24.3
14	0.312	26.8
15	0.313	29.1

Forward Bias – Germanium Diode



CONTROLS

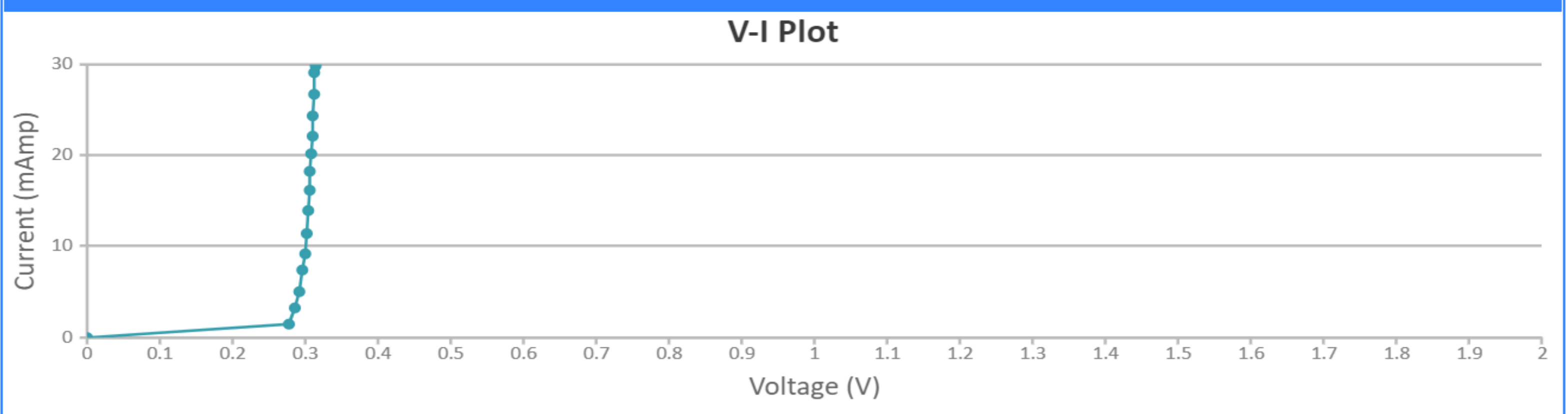
DC volt : Volt

Resistance : Kohms

Add to Table | Plot | Clear

Print It

GRAPH PLOT

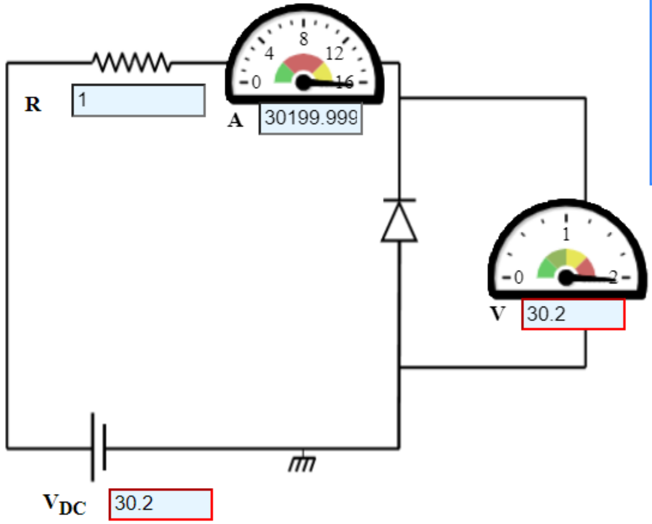


Reverse Bias – Germanium Diode

INSTRUCTION

EXPERIMENTAL TABLE

Serial No.	Reverse Voltage(Volt)	Reverse Current(μAmp)
1	0.200	0
2	1.60	0
3	3.20	0
4	4.95	0
5	6.55	0
6	8.75	0
7	10.3	0
8	11.8	0
9	13.6	0
10	15.3	0
11	17.1	0
12	19.0	0
13	22.5	0
14	24.3	0



CONTROLS

DC volt : Volt

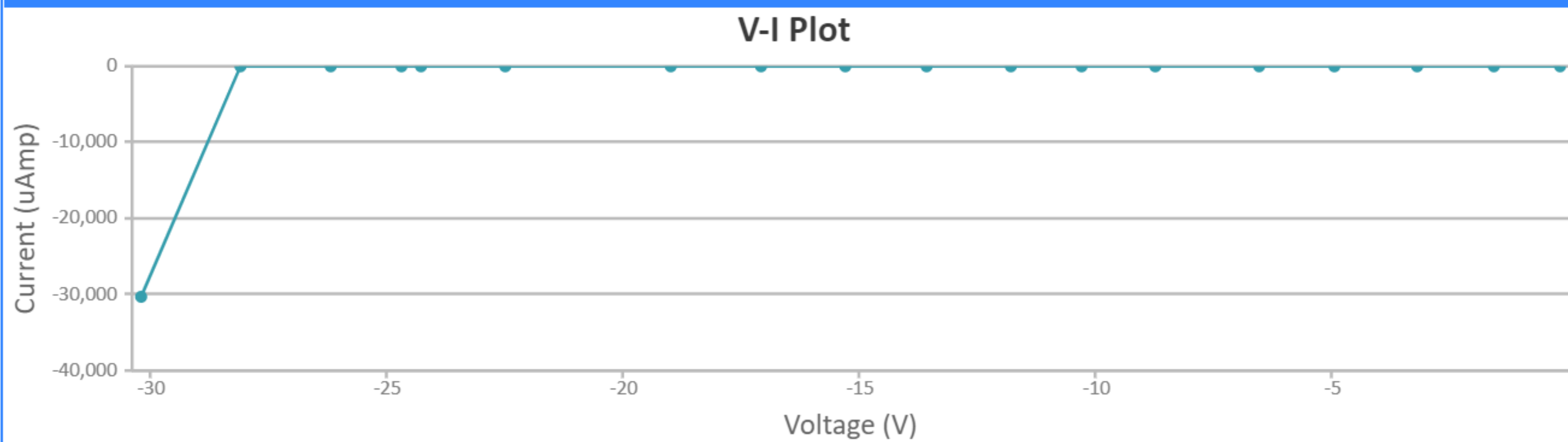
Resistance : Kohms

Add to Table | Plot | Clear

Vary DC voltage

Print It

GRAPH PLOT



Discussion

- The V-labs experiment page for reverse bias configuration of Germanium diode gives a straight line graph until the diode reaches breakdown voltage, however if the scale is changed to micro amperes on y-axis the graph would be a curve.(nearly straight line parallel to y-axis)
- The voltmeter and ammeter are considered ideal which is not the case in practical scenario and might distort the reading.
- We need to check the diode specifications and not allow current to cross rated value after crossing breakdown voltage barrier.

Summary

At the end of this experiment, we learned

- The V-I characteristics of a diode and the working of a diode in forward and reverse bias(various concepts such as leakage current, diffusion current, cut-in voltage and breakdown voltage)
- The simulation in forward and reverse bias of Ge and Si diode and subsequent plotting of graph gave us an idea of cut-in voltage and breakdown voltage and nature of graph.
- The equation used to compute forward and reverse bias current through a diode and the use of empirical constant.

PART 2:Half Wave Rectifier

- Aim: At the end of the module the student would be able to

1.Explain Rectification

2.Explain Half Wave Rectification

3.Explain Half Wave Rectification: For Positive Half Cycle

4.Explain Half Wave Rectification: For Negative Half Cycle

Rectification

A rectifier is a device that converts AC to DC, a process known as rectification.

There are 2 types of rectifiers,

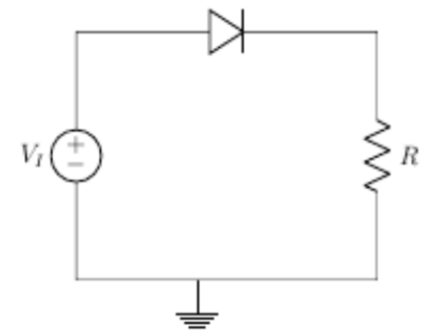
1.Half wave rectifier

2.Full wave rectifier

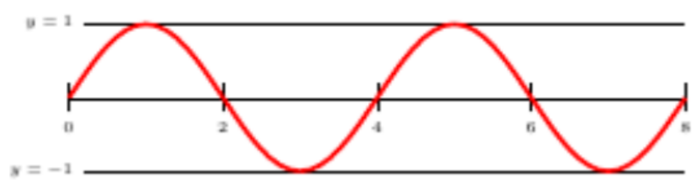
Terminologies

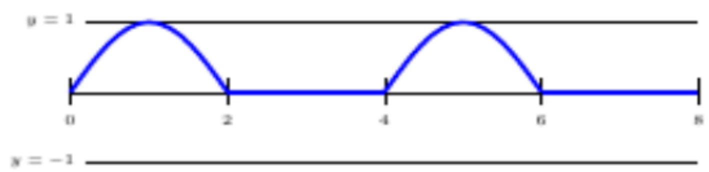
- **Rectification Efficiency**: Rectification Efficiency is the ratio of DC power output to the AC power input of the rectifier. It is usually denoted by η and expressed in percentage.
- **Ripple factor**: The ripple factor is the ratio between the RMS value of the AC voltage (on the input side) and the DC voltage (on the output side) of the rectifier.
- **Peak Inverse Voltage (PIV):**Peak Inverse Voltage (PIV) or Peak Reverse Voltage (PRV) refer to the maximum voltage a diode can withstand in the reverse-biased direction before breakdown. Also may be called Reverse Breakdown Voltage.

Half Wave Rectifier(Circuit)



Input and Output waveforms(considering diode is ideal)





Working of Half Wave Rectifier Circuit

On the positive half cycle(the P-side is at higher potential) the diode is forward biased and on the negative half cycle, the diode is reverse biased. Therefore, it allows flow of current in only the positive half cycle and therefore output voltage no longer changes polarity. In short, the AC source has been converted into a pulsating DC source. The half wave rectifier circuit is formed by a single diode in series with a resistor, with the resistor acting as a load.

Vpeak=Vrms*root(2);

Vdc(average output voltage)=(Vpeak/∏)

Equations used in calculations of various quantities

Let us analyze the circuit,

For positive half cycle,

$V_i=V_b+I*r_d+I*R$ (considering piecewise linear model of diode)

or $I=(V_i-V_b)/(r_d+R)$, $V_o=I*R$

If $r_d<<R$, (neglecting diode resistance).

$V_o=V_i-V_b$

If $V_i<=V_b$, diode is OFF and $V_o=0$;

else if $V_i>V_b$, diode is ON and $V_o=V_i-V_b$,

For negative half cycle,

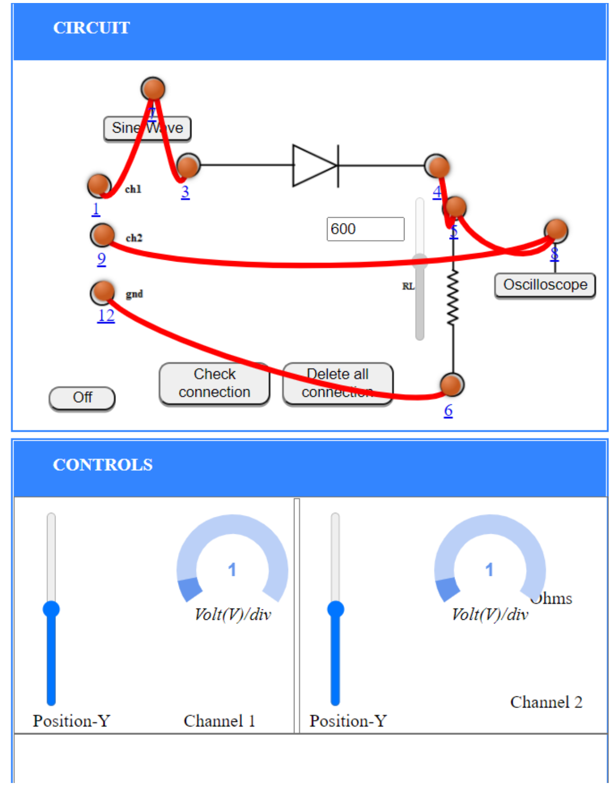
The diode acts as open circuit and hence $V_o=0$ as $I=0$.

Vo is output voltage ,

Vi is input voltage, V_b is barrier potential , I is total current, R is load resistance, rd is diode resistance

For ideal diode,
Vb=0,
Vo=Vi (for positive half cycle) and Vo=0 (for negative half cycle)
Average output voltage,
Vo=Vm(sinwt) for 0<=wt<=pie
Vo=0   pie<=wt<=2*pie
Vav=(Vm/pie)
RMS load voltage
Vrms=Irms*R=Vm/2
Average load current
Iav=Vav/R=Vm/(pie*R)
Form Factor
FF=Vrms/Vav=pie/2=1.57 rms>=av
Ripple Factor=sqrt(F.F^(2)-1)=1.21
Efficiency=Pout/Pin=(Idc/Irms)^(2)=40.56%
Peak Inverse Voltage=the maximum value of reverse voltage which occurs at the peak of the input cycle when the diode is reverse-biased.
PIV>=Vm

Simulations(calculations and observations)



CALCULATION

$V_{rms} = \frac{V_m}{2}$, V_m is the peak voltage

$V_{dc} = \frac{V_m}{\pi}$

Ripple Factor=$\frac{V_{ac}}{V_{dc}}$ Since, $V_{ac} = \sqrt{(V_{rms}^2 - V_{dc}^2)}$

Peak Current: 0.4999999982115235 mA

Vrms=0.55V
Vdc=0.35V
Ripple factor=1.21

Discussion

- Upon increasing frequency of input waveform, the output wave form shows some non zero positive voltage in the negative half cycle which seems to be an error in the V-labs simulation.
- In reality the diode is not ideal and therefore the output waveform is non zero only when input waveform crosses barrier potential.(so the graph of input and output waveform do not overlap in positive half cycle)
- We can use a series resistance to regulate current flow through load below rated value.

Summary

After this experiment, we were able to learn,

1.The use of a diode in a half wave rectifier circuit.

2.The calculation of quantities like ripple factor, average dc voltage, form factor, efficiency, peak inverse voltage and their significance.

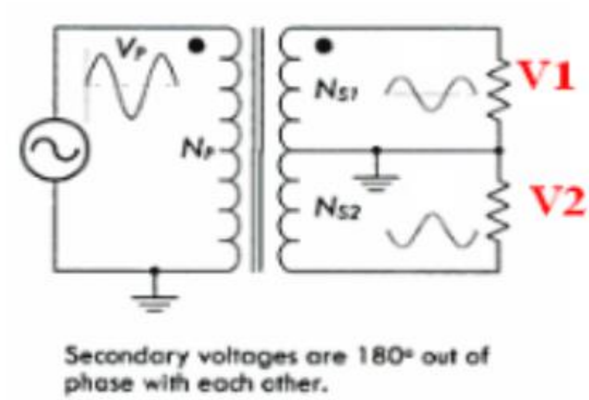
3.We also learnt the utility of a load resistance in the half wave resistor circuit to limit amount of current flow.

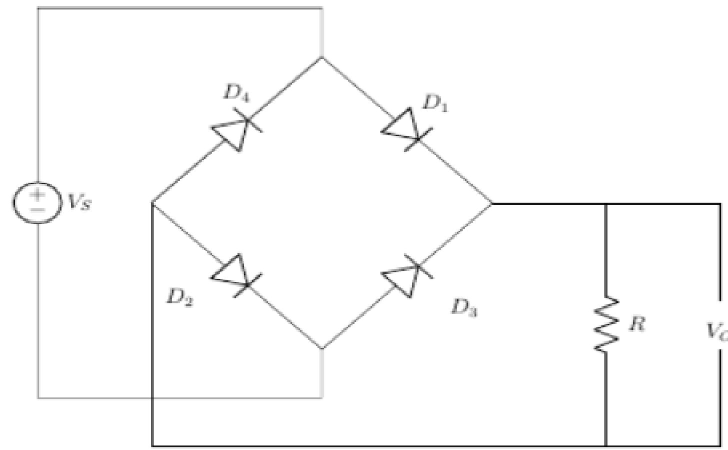
PART 3:Full Wave Rectifier

AIM: At the end of the experiment the student would be able to

- Explain Rectification
- Explain Center Tapped Full Wave Rectification
- Explain Bridge Full Wave Rectification

Full wave Rectifier(Circuit-center tapped and Bridge rectifier) and typical Output waveform





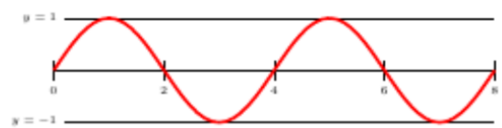


Figure:7

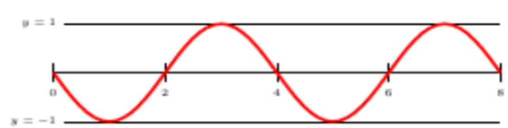
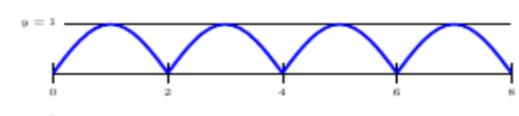


Figure:8



Working of a Full Wave Rectifier circuit

A full wave rectifier circuit allows unidirectional current flow through the entire sinusoidal cycle(as opposed to only half the cycle in the half wave rectifier).The whole input waveform is converted to a constant polarity waveform at the output.

- Centre tapped.

This configuration of the circuit gives us 2 sinusoids so that exactly one of the waveforms is positive at one time. It uses 2 diodes as opposed to a single diode, such that one diode is always in conduction in each cycle. Only one diode is forward biased at any point of time and therefore there is unidirectional current flow.

- Bridge Configuration

This configuration requires 4 diodes to be connected in a ‘bridged’ configuration to produce the desired output but does not require a special center tapped transformer thereby it is less costlier than the center tapped configuration.

Equations used in calculation of various quantities

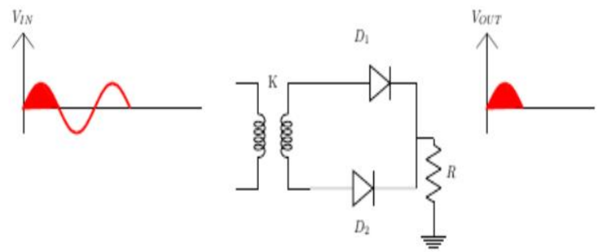
Centre tapped, positive half cycle

D1 is forward biased and D2 is reverse biased

Vi-Vo=0

Vi=Vo (for ideal diode)

Vo=Vi-Vb(for actual diode)



negative half cycle,

D1 is reverse biased and D2 is forward biased

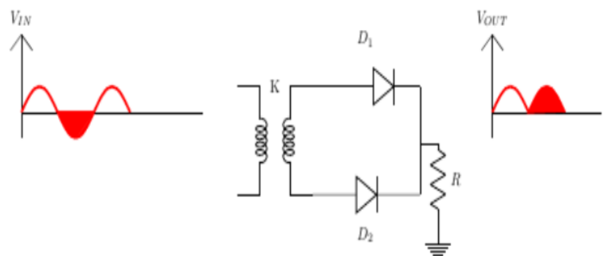
Vi-Vo=0

Vo=Vi

The polarity of output

waveform is same

as in the positive half cycle



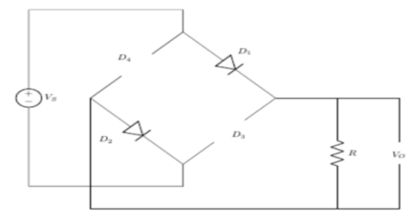
Bridge rectifier, positive half cycle

D1 and D2 is forward biased,D3 and D4 is reverse biased.

Vi-Vo=0

Vo=Vi (ideal diode)

Vo=Vi-2*Vb (practical diode)



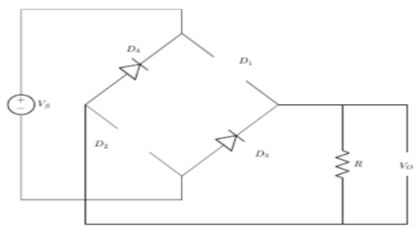
negative half cycle

D3 and D4 are forward biased and D1 and D2 are reverse biased.

Vi-Vo=0

Vi=Vo

The direction of current flow through the load is same as before.



Average DC voltage(average output voltage)

$V_{av}=(2*V_m/pie)$

Average Load current

$I_{av}=V_{av}/R=(2*V_m/pie*R)$

Rms load current

$I_{rms}=I_m/root(2)$

Rms load voltage

$V_{rms}=V_m/root(2)$

Form factor=V_{rms}/V_{av}=1.11

Ripple factor=sqrt(FF^2-1)=0.481

Efficiency=Ratio of dc power at load to ac input power.

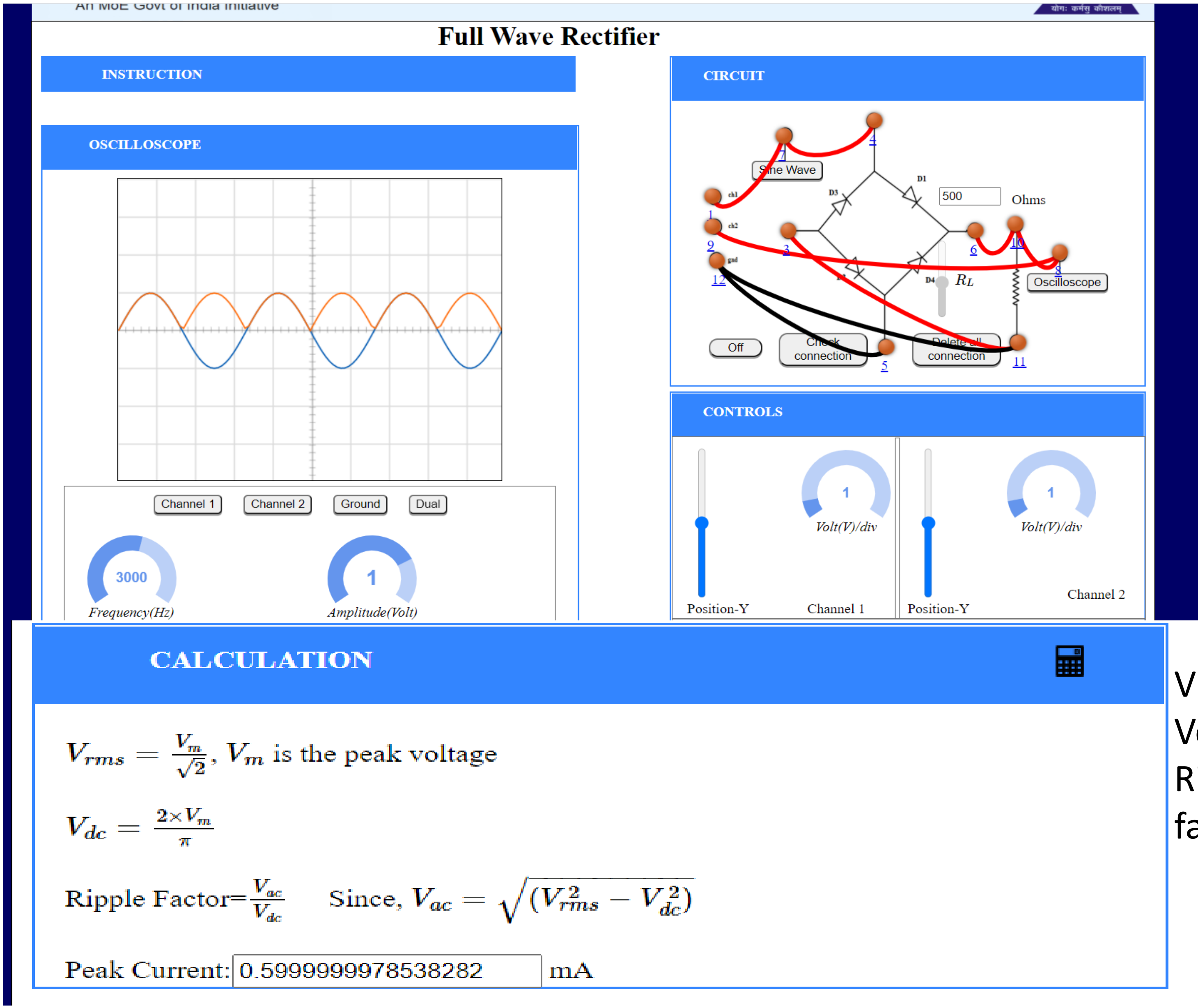
n=((I_{dc}/I_{rms})^2)*100=81.13%

Peak Inverse Voltage (defined earlier)

For Bridge Rectifier,
D1 and D2 is Forward Biased
D3 and D4 is Reverse Biased
$V_m-V_o=0$
$\Rightarrow V_o=V_m$
$-V_o+PIV=0$
$\Rightarrow PIV=V_m$
$PIV\geq V_m$

For Centre Tapped Rectifier,
D2 is Forward Biased,
PIV at D1, $V_m-V_o=0$
$\Rightarrow V_o=V_m$
$V_o-PIV+V_m=0$
$\Rightarrow PIV=2V_m$
$PIV\geq 2V_m$

Simulation of working of a bridge rectifier(with calculations)



Vrms=0.707 V
Vdc=0.637V
Ripple factor=0.48

Discussion

- All calculation were done assuming diode is ideal, however in reality diode is best approximated by a voltage source and a fixed resistance called diode resistance.
- The PIV of diode in bridge rectifier is much less than that of center tapped configuration, this makes it easier to get the required specification of diode for a bridge configuration.
- The center tapped configuration is costlier due to requirement of transformer of turning double the turns in primary side of transformer.
- The peak output voltage is reduced by one time cut in voltage in center tapped whereas it is 2 times cut in voltage in bridge, however the cut in voltage is too small to show a noticeable change in peak output voltage.(If input voltage is greater than 50V)

Summary

After this experiment we learnt,

1.The methods to utilize diodes to make a full wave rectified circuit and discussed pros and cons of each such configuration.

2.The values of efficiency, ripple factor, rms load current, form factor and compared them with that of a half wave rectifier circuit.

3.The conditions to be kept in mind for designing the required diodes for such circuits.

PART IV: Capacitive Rectification

AIM: At the end of the experiment the student would be able to

- Learn Filtering of Rectified signal
- Ripple Voltage and Ripple Factor
- Learn Capacitive filtering

Filtering of rectified signal

The target is to convert the time varying DC output of rectifier to a constant DC supply.Thus,we want to filter the pulsating output signal, This can be done by splitting the output waveform to AC and DC components. Filter is a device that allows passing the dc component of the load and blocks the ac component of rectifier output. Therefore, the output waveform will be a steady voltage

Filtering devices and process

The filter circuit can be constructed by combination of components like capacitors, resistors and inductors. Inductor is used for its property that it allows the signal to pass through it and blocks ac signal whereas capacitor allows ac signal to pass through it and blocks dc signal.Thereby,if we use a capacitor across the output of a rectifier, the AC component will easily pass through it leaving behind DC component of output waveform.

Choosing an apt capacitor

The capacitor works by filling in the gaps between two peaks of the output waveform. Thus higher the time constant or value of capacitance, smaller is the ripple voltage as it discharge slowly and by that time reaches the peak of the output waveform of the next cycle. However, a too high capacitance capacitor will cost more and create higher peak currents in secondary transformer and in the supply feeding it.

Calculation of Ripple voltage and Ripple factor

Half wave rectifier+filtering

Vac,rms=Vm/2

With capacitor,(Vmax is max of output waveform and Vmin is min of output waveform)

Vmax=Vm

Vmin=Vm(1-T/RC)

(As it goes from peak to peak so time interval is nearly T and since RC>>T,this approximation holds good)

Vr-(p-p)=Vm/fRC

Vdc=Vm-Vr-(p-p)=Vm(1-1/fRC)

By approximating the output waveform to a sawtooth waveform,we obtain Vrrms and thereby ripple factor is 1/(2*root(3)*fRC)

Full wave rectifier+filtering

Vac,rms=Vm/root(2)

Vmax=Vm

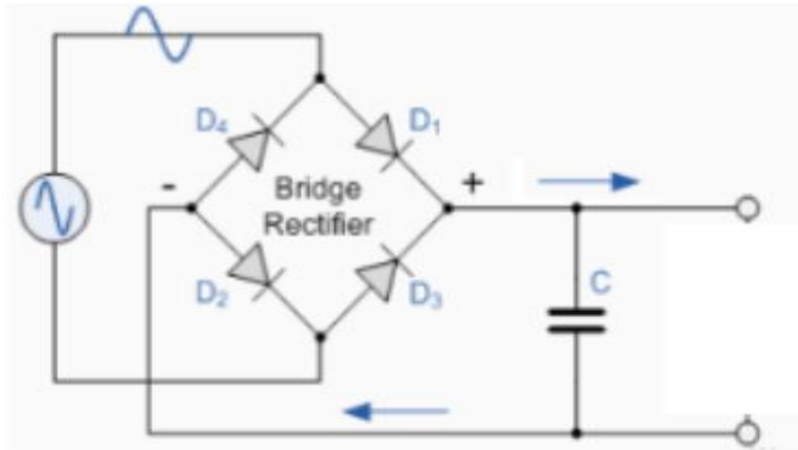
Vmin=Vm(1-T/2*RC)

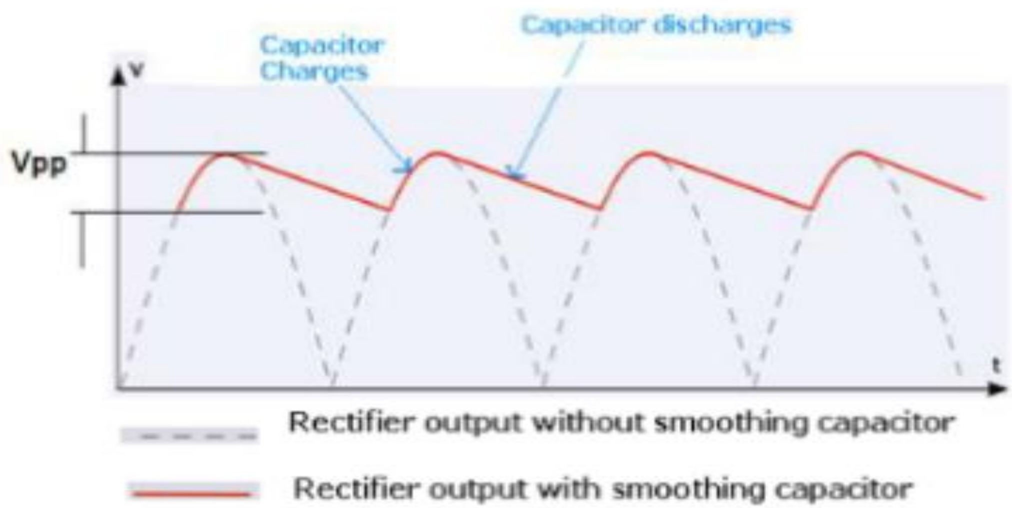
(As it goes from peak to peak so time interval is nearly T/2 and since RC>>T,this approximation holds good)

Vdc=Vmax-Vr-(p-p)=Vm(1-1/2RC)

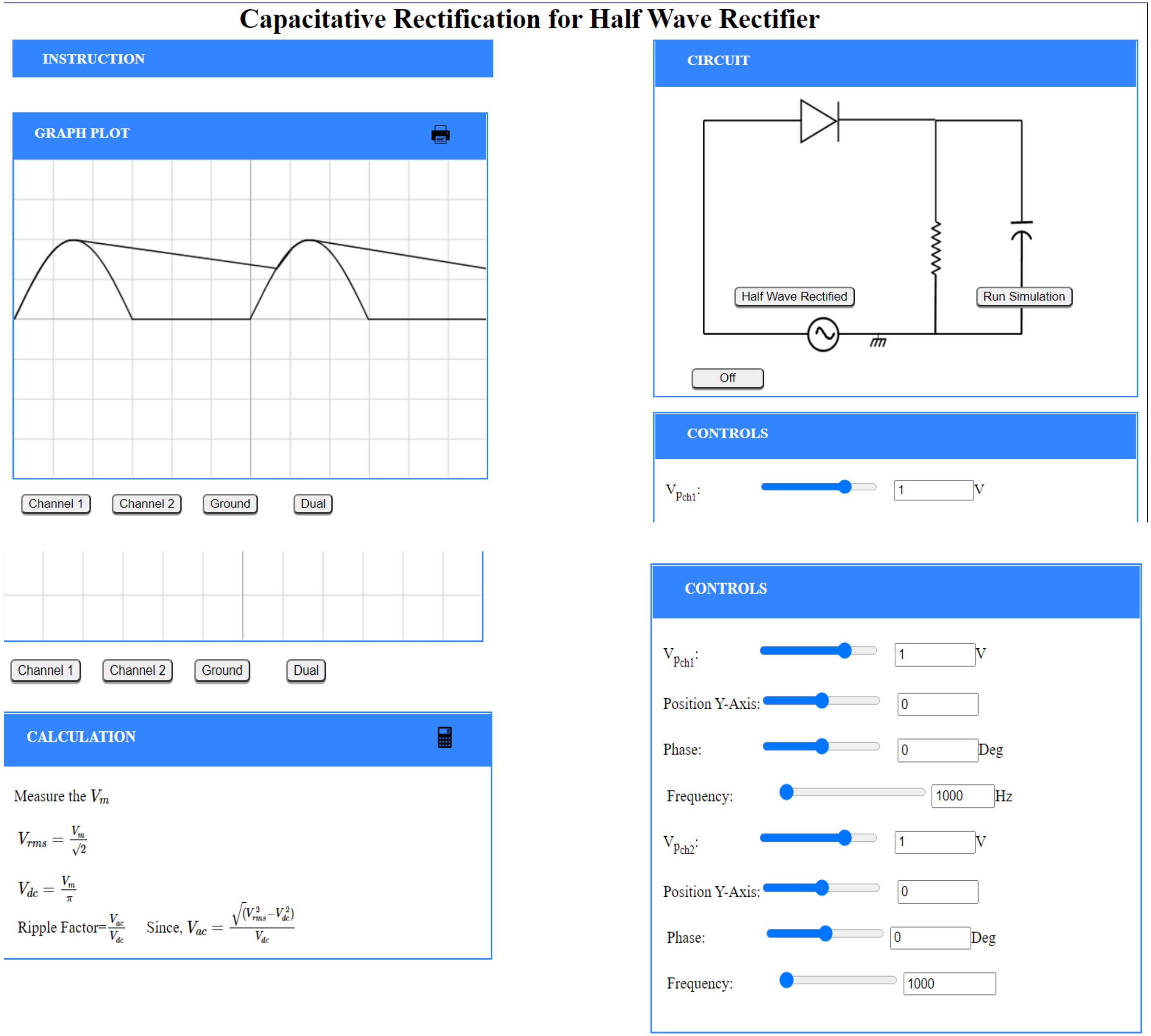
By approximating the output waveform to a sawtooth waveform,we obtain Vrrms and thereby ripple factor is 1/(4*root(3)*fRC)

Full wave rectifier+filtering circuit and output waveform



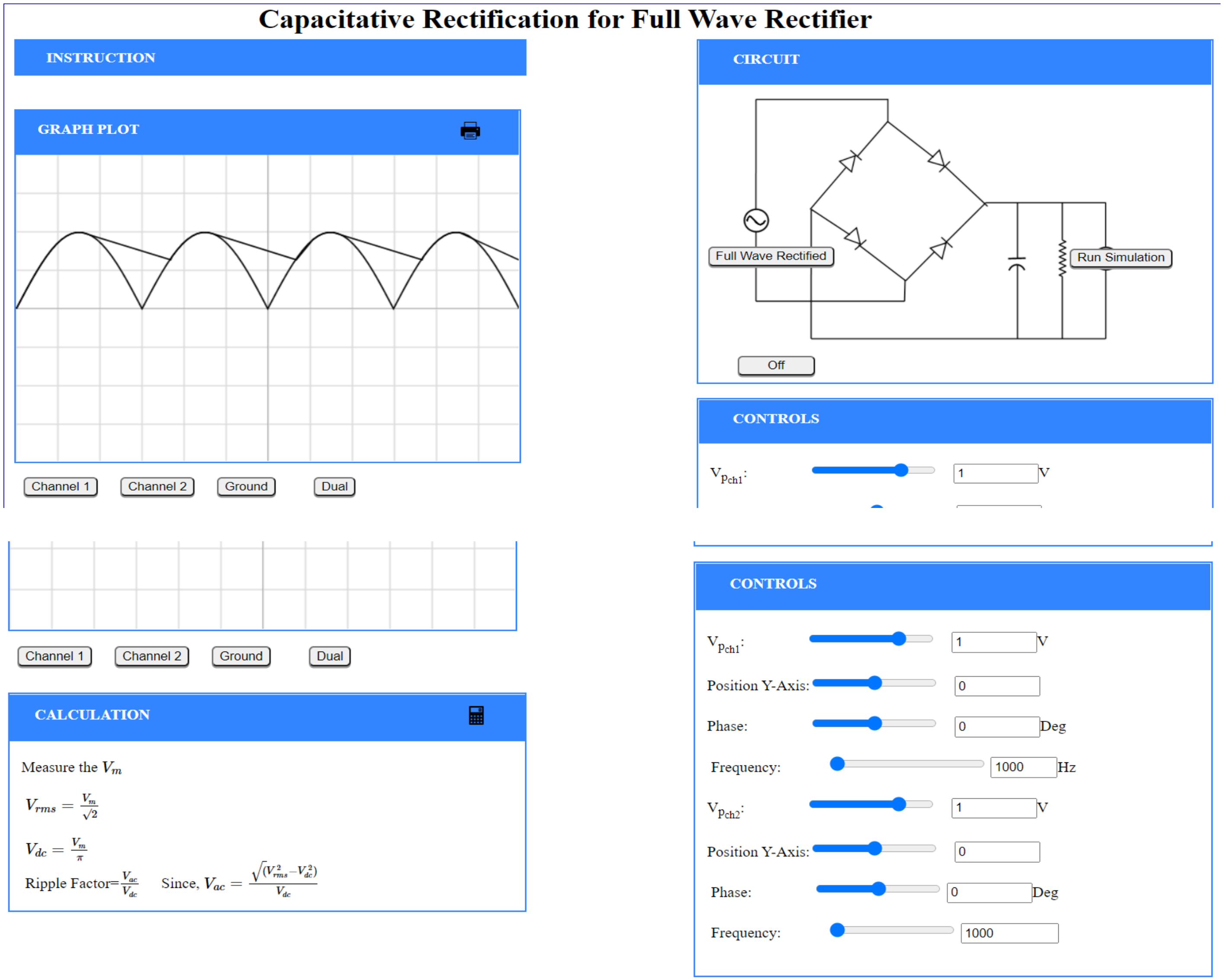


Simulation(Half wave rectifier+filtering)



Ripple factor:
1/(2root*3)fRC
=0.06

Simulation(Full wave rectifier+filtering)



Ripple factor:
0.03
=1/(4root(3)F
RC)

Discussion

- The calculation for Vrms and Vdc is given wrongly for filtering with half wave and full wave rectifier in the V labs experiment
- The approximation that time interval between the charging and discharging of capacitor is time interval between two peaks. However, in reality that is not the case.
- The value of RC should be much larger than time period of the input waveform. For that capacitance should be very however, a too high capacitance capacitor will cost more and create higher peak currents in secondary transformer and in the supply feeding it.
- Due to less time duration between two peaks, the full wave rectifier output is more filtered than half wave rectifier output
- The capacitor allows ac signal to pass through it whereas inductor allows dc signal to pass through it easily.

Summary

After this experiment, we learnt

- The various filtering techniques and different combination of device for producing different filtering output
- The calculation and formula to calculate the ripple factor and the value of capacitance required.
- The comparison of filtering with half wave rectifier and full wave rectifier.

PART V:Zener Diode

AIM: At the end of the experiment, the student will be able to

1.Explain the function of a Zener diode

2.Explain Zener Diode as Voltage Regulator

Zener characteristics

It is a special diode which is used to work in breakdown condition. It permits current flow in the forward direction as usual, but will also allow it to flow in the reverse direction when the voltage is crosses a limit called breakdown voltage or ‘zener’ voltage. Zener diodes are designed so that their breakdown voltage is low.

Zener diode as a Voltage regulator

It provides a stable DC voltage independent of the load current, temperature and AC line voltage variations. It works in reverse bias. As the reverse bias voltage crosses breakdown voltage output remains constant thereafter as it varies the current flowing through it to adjust the voltage across it.

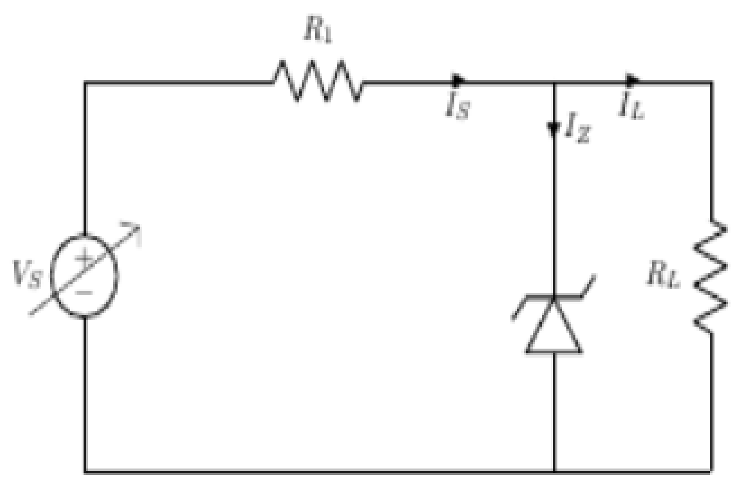
There are 2 types of Regulations mainly

1.Line regulation

2.Load regulation

Circuit diagram

- Based upon this diagram, all equations are written in next page.



Line regulation and Load regulation(Theory with equations governing their working mechanisms)

Line regulation

In this configuration, the input voltage is varied keeping the load resistance fixed.

VI: Input voltage, Vo:output voltage,Rs:series resistance, Rl:load resistance,Vl:voltage across load,Vs:voltage across series resistor

Vl=Vz=(Vi,min*Rl)/(Rl+Rs)

Vi,min=Vz*(Rl+Rs)/(Rl)

Now for upper limit,we consider max current through zener diode,

Vz/Rl=Il,

Is=Il+Iz,so we get Vi,max=Iz,max*Rs+Vz+Vz*Rs/Rl

Load regulation

In this configuration,the input voltage is fixed and load resistance is varied.

Rl,min,as if Rl<Rl,min ,Vth<Vz

So if Vth=Vz,

Rl,min=Vi*Rs/(Vi-Vz)

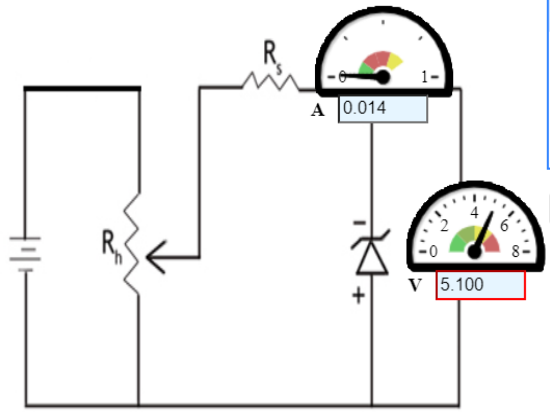
Simulations(Zener characteristics)

INSTRUCTION

EXPERIMENTAL TABLE

Serial No.	Zener Voltage(Volt)	Current(mAmp)
1	0.120	0.000
2	0.719	0.000
3	1.841	0.000
4	2.360	0.001
5	2.865	0.001
6	3.853	0.002
7	5.100	0.002

Zener characteristics



CONTROLS

Select Diode: IN4733A 5.1

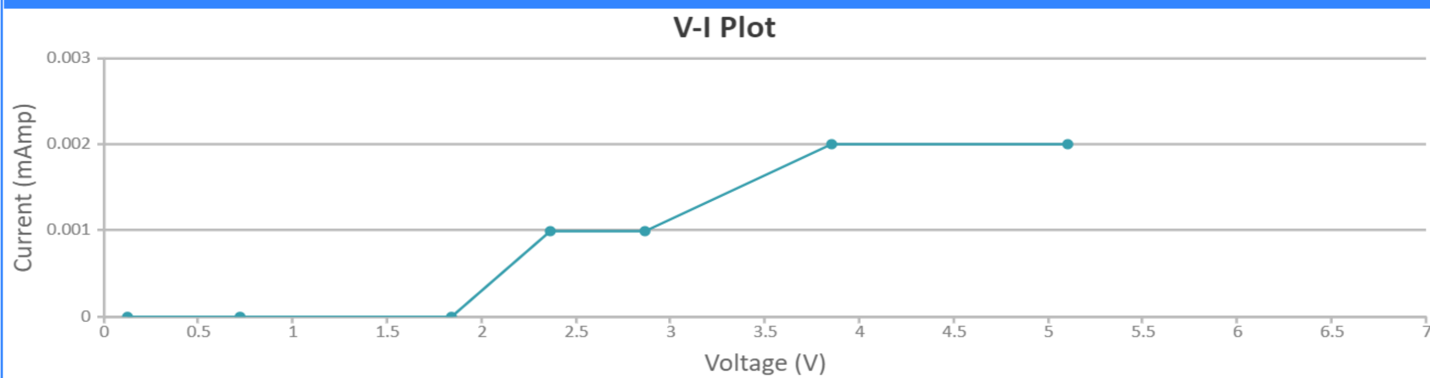
R_h : ohms 66

Add to Table | Plot | Clear

Vary DC voltage

Print It

GRAPH PLOT



Simulations(Line Regulation)

INSTRUCTION

EXPERIMENTAL TABLE

Zener Voltage(V_Z): 5.1 V

Series Resistance(R_S): 1 KΩ

Load Resistance (R_L): 2.1 KΩ

Serial No.	Unregulated supply voltage(V_S) V	Load Current(I_L) mAmp	Zener Current(I_Z) mAmp	Regulated Output Voltage(V_O) V	% Voltage Regulation
1	0	2.43	0	0	NaN
2	2	2.43	0	2	100
3	4	2.43	0	4	100
4	5.8	2.43	-1.729	5.10	100
5	7.6	2.43	0.071	5.10	71.4
6	9.4	2.43	1.871	5.10	55.6

Print It

Take another sets of Output Volatge
for another Zener value

CONTROLS

DC volt : Volt

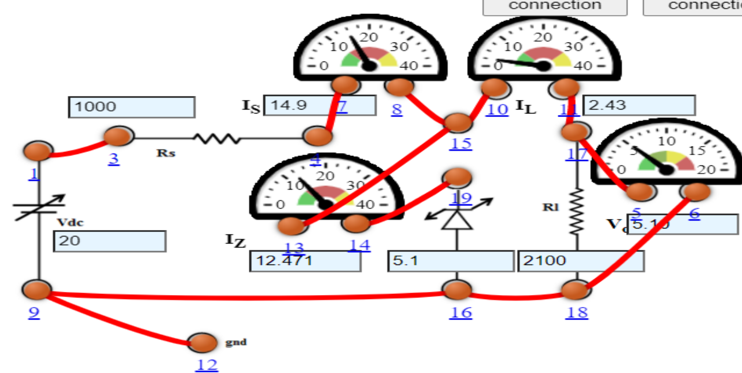
Zener Diode(V_Z) : Volt

Resistance(R_S) : Ohms

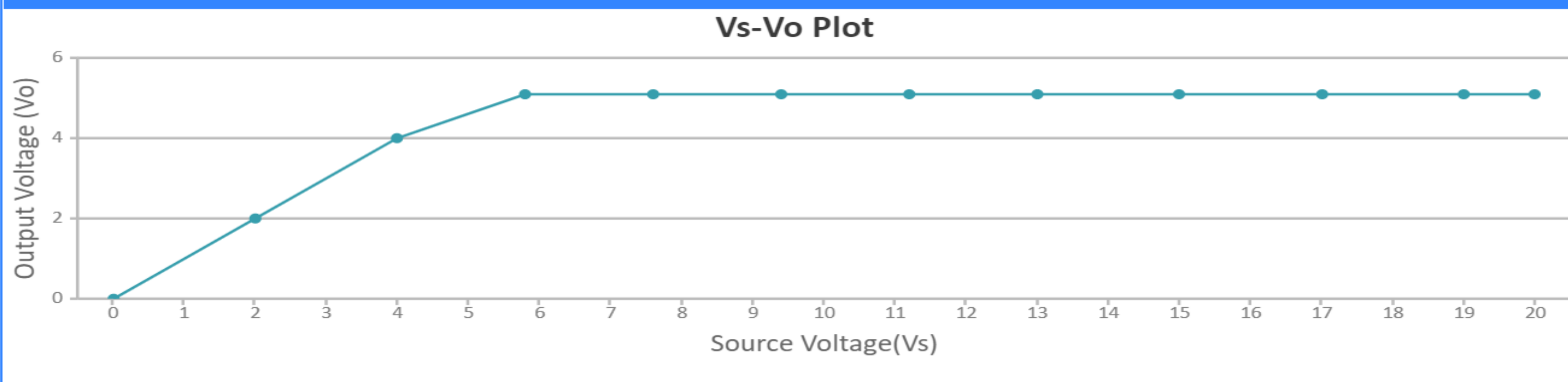
Resistance(R_L) : Ohms

Add to Table | Plot | Clear

Check connection | Delete all connection



GRAPH PLOT



Simulation(Load regulation)

Zener Diode - LOAD Regulator

INSTRUCTION

EXPERIMENTAL TABLE

DC Voltage (V_{DC}): 6 V Zener Voltage(V_Z): 5.1 V

Series Resistance(R_S): 0.1 KΩ

Serial No.	Load Resistance(R_L) Ohm	Load Current(I_L) mAmp	Zener Current(I_Z) mAmp	Regulated Output Voltage(V_O) V	% Voltage Regulation
1	150	34.0	0	6	40.0
2	211	24.2	0	6	32.2
3	285	17.9	0	6	26.0
4	383	13.3	0	6	20.7
5	456	11.2	0	6	18.0

Print It

Take another sets of Output Volatge for another Zener value

CONTROLS

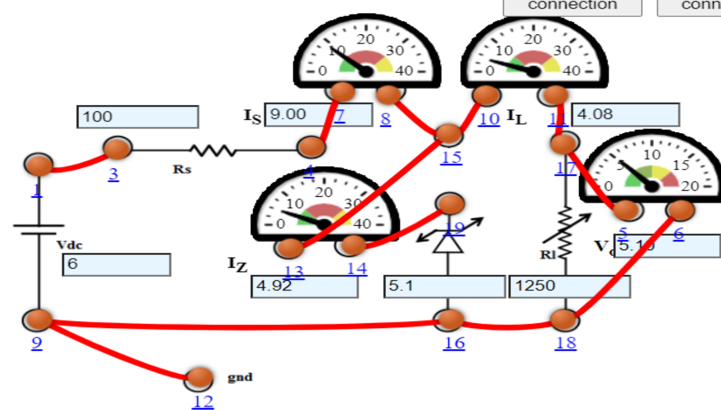
DC volt : Volt

Zener Diode(V_Z) : Volt

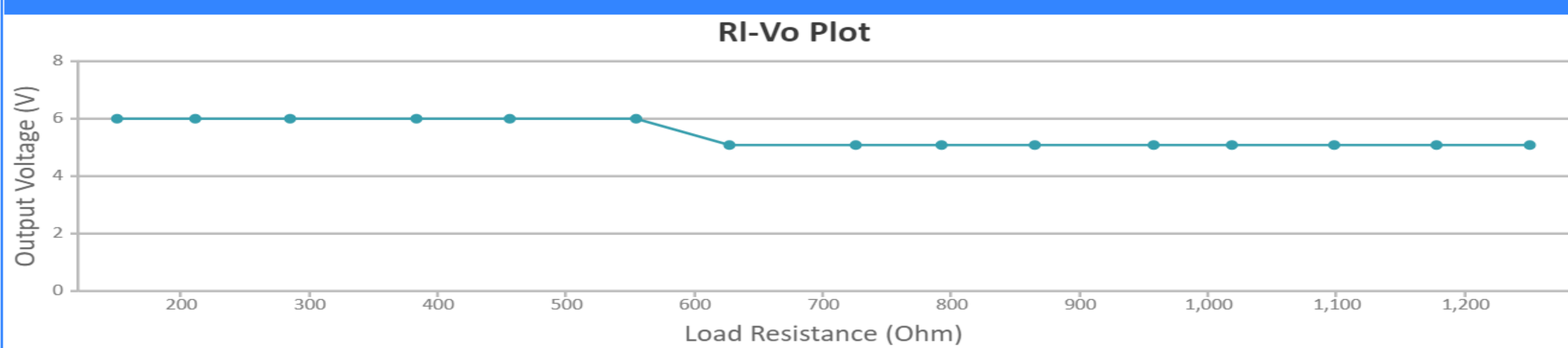
Resistance(R_S) : Ohms

Resistance(R_L) : Ohms

Add to Table | Plot | Clear | Check connection | Delete all connection



GRAPH PLOT



Discussion

1.The graph in the vlab page comes out to be stepped and that is a glitch in vlab due to its nature of sampling of points.

2.From the observation table of load regulation, we see as load resistance increases, percentage voltage regulation decreases

3.The breakdown voltage is 5.1V across zener diode. It is small enough to work in breakdown at very low reverse bias voltage. Hence it is more suitable as a voltage regulator than normal diodes.

4. When the line voltage decreases,

Vs decreases →Is decreases →Iz decreases →Voltage across diode remains same and IL remains unchanged

When the line voltage increases

Vs increases →Is increases →Iz increases →Voltage across diode remains same and IL remains unchanged

Summary

After this experiment we learnt,

1.The utility of zener diode as a voltage regulator.

2.The required minimum and maximum values of load resistance and input voltage for a given circuit for zener diode to be ON

3.The calculations necessary to design a zener diode of correct specifications and also the series resistance so that it can regulate voltage.

References

- All picture cut-out , simulated data and circuit diagram have been taken from the V-lab's experiments.
- Theory and equations have been compiled by myself after reading it from various sources.