

**Faculty of Engineering and Technology**

**Electrical and Computer Systems Engineering**

ENEE3102

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***Course Name***

ELECTRONICS LAB (section 2)

***Experiment No. 1***

Diode Characteristics And Applications.

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**-** **Abstract:**

The purpose of this experiment is to learn more about diode , operation PN junction , VI characteristics ,application such as rectification ,clipping ,clamping and voltage multiplier .

In this lab we use basic equipment to do it like as , power supply , oscilloscope , DVM and some devices of diode and capacitor .

The main result was done of each part of experiment

* Diode is non liner device
* We can use diode as rectifier in DC power supply to get pulsating DC signal .
* Diode can use for clipping, clamping and voltage multiplier circuit.
* We can add capacitor to rectifier circuit to get smooth out the pulsating DC .

**- Objective:**

The purpose of this lab is to study the characteristics of the diode. Some of the

Characteristics that will be investigated are the I-V curve , the operation of PN junction and some applications like Rectification, clamping ,Clipping and voltage multiplier .

**- Theory:**

**Diode it is a semiconductor electronic device with a single pn junction as shown in fig (1) and it has the ability to conduct current in one direction while blocking current in the other direction.**

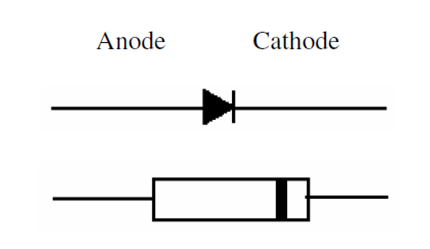
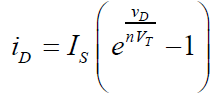
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Fig (1) : The symbol and actual package for a diode.

*The Diode non - linear Equation:*  The equation (1) below gives a reasonably good representation of the i*-v* characteristics of a nonlinear diode

……………………………… eq (1)

where :

iD : current through diode (ampere )

Is : reverse saturation current and it is approximate (10-12 ,10 -14 A )

VD : thermal voltage at room temperature equal 25.69 mv .

n: eta

for positive VD :-

iD ≈ Is e VD/nvT ……………………………….eq (2)

-for negative VD :

iD = - IS ……………………………eq (3)



Fig (2): Diode V-I characteristics curve

Diode large – signal applications:

1) Diode clipper circuit:

Used to eliminate portion of the input signal.-

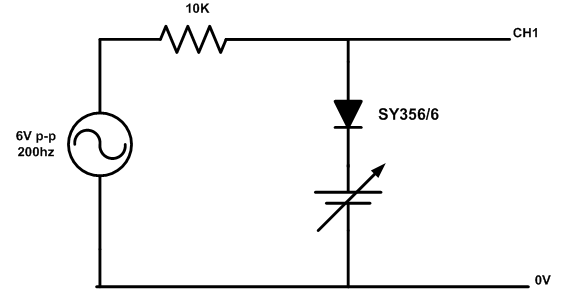
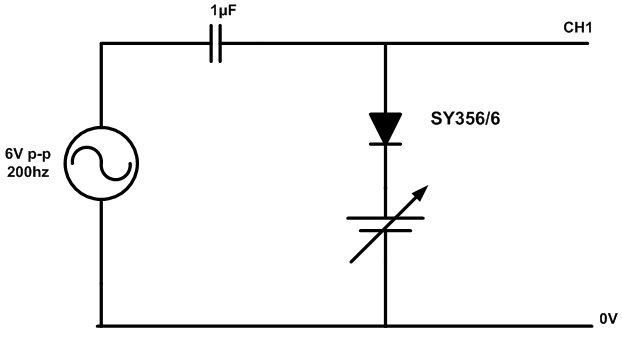


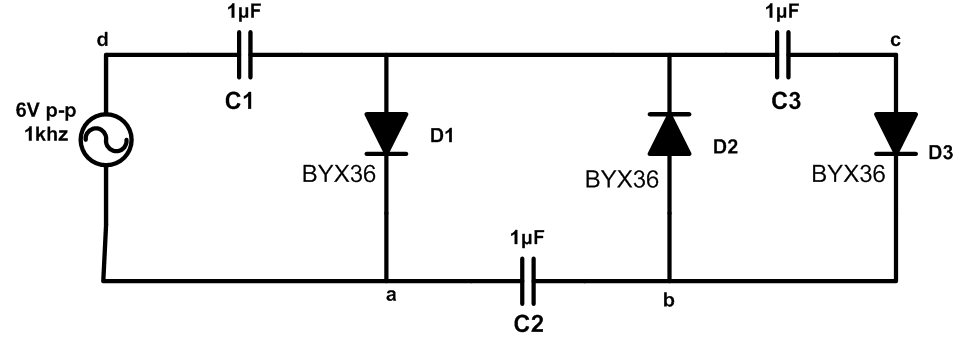
Fig (3) :Diode clipper circuit

2) Diode clamping circuit:



Fig(5) : Diode clamping circuit

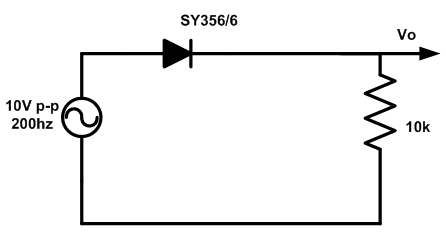
3) Diode voltage multiplier circuit:



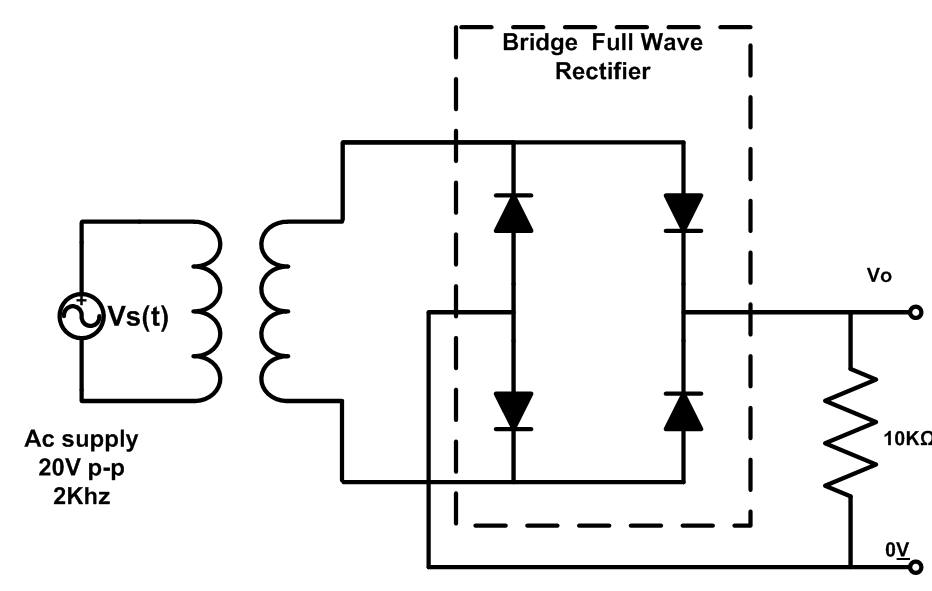
Fig(6): voltage Tripler circuit

4) Rectification (used to conver the ac voltage –zero average value – into either positive or negative pulsating dc )

a- Half – wave Rectifier

  
Fig( 7) : Half – wave Rectification

b- full-wave Rectifier

  
Fig (8) : Bridge full-wave Rectifier

5) used in Filter circuit :

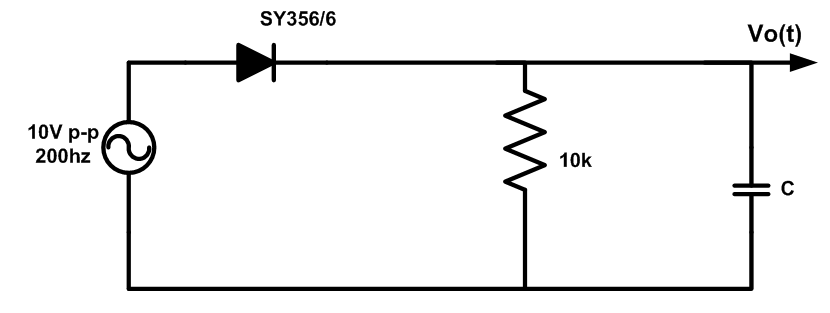


Fig (9) : Filter

**- Experimental / Procedure:**

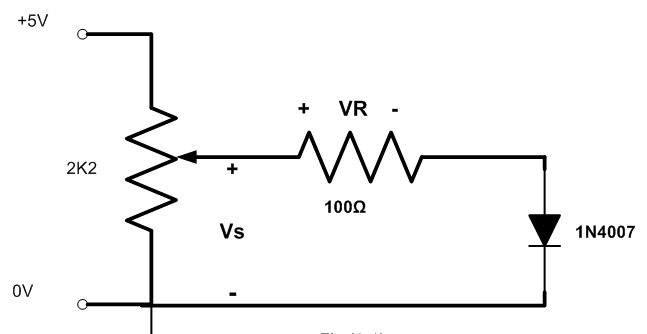
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Fig (10) : circuit to show diode behavior

1) Diode characteristics :

The circuit in fig (10) was connected, potentiometer was changed it’s value from zero to 1v in 0.1 v steps and 0.5 steps from 1 v to 3 v and for each setting measure the value of VR , Then VD , ID was calculated and enter them in table (1) .

2) Rectification

a- Half wave rectification

The circuit in fig (7) was connected, oscilloscope was switch and the sinusoidal was supplied . period time , peak voltage , and dc components of output were measured .

The capacitor was added to circuit in fig(7 ) , peak voltage, mean value were observed and then ripple factor was found . this steps was repeated for two capacitor .

b- full wave rectification

The circuit in fig (8) was constructed, oscilloscope was connected, output wave was drawn and dc and ac component were measured, and then capacitor was added . Output was observed .

3) clipping :

The circuit in fig (3) was connected , 3 different dc voltage was taken and observed the output .

4) clamping :

The circuit in fig (5) was connected, 3 different dc voltage was taken and observed the output .

5) voltage multiplier:

The circuit in fig (6) was connected , the voltage between different node was measured .

**- Calculations:**

I. DIODE CHARACTERISTICS.

To find voltage through diode apply KVL For circuit in fig (10) :-

Vs+ VR - VD =0 ……………… eq (4)

To find current through diode which is the same in resister apply ohm's law:-

ID = ………………. eq (5)

VR= 1.38v Take Vs = 2.000

We get VD = 3.38 v and ID =13.8 mv

* And so on for all values

II. RECTIFICATION.

1. *HALF - WAVE RECTIFICATION.*

Analysis the circuit shown in fig(7) using ideal diode model :

* When Vin > 0 , diode is on and replace by short circuit
* When Vin < 0 , diode is off and replace by open circuit

V0 ,avg = Vm / π = 5/π ≈ 1.59 v

IO,avg = Vm / R π ≈ 1.59\*10-4 A

PIV =-Vm ≈ -5 v

1. *FULL-WAVE RECTIFICATION*

Analysis the circuit shown in fig (7) using ideal diode model:

* when Vin >0

D1 and D3 are on

D2 and D4 are off

* when V in <0

D1 and D3 are off

D2 and D4 are on

For bridge full wave rectifier

V0 ,avg = 2 Vm / π = 5/π ≈ 6.366 v

PIV =-Vm= -10 v

*III. other applications:*

1. clipping:

Analysis the circuit shown in fig (3) using knee voltage model:

*When DC voltage equal 0*

* When Vin > Vk(=0.7 ) diode is on and replace by voltage source = 0.7 v
* When Vin < Vk(=0.7 ) diode is off and replace by open circuit

*When DC voltage equal 1.5 v*

* Assume that the diode is on and replace it by 0.7 v
* ID >0

ID =>0

V in – 2.2 >0

Vin >2.2 v diode is on

Vin < 2.2 v diode is off and VD= Vin

*When DC voltage equal 2.5 v*

* Assume that the diode is on and replace it by 0.7 v
* ID >0

ID =>0

V in – 3.2 >0

Vin >3.2 v diode is on

Vin < 3.2 v diode is off and VD= Vin

B. Clamping:

Analysis the circuit shown in fig (5):

*When DC voltage equal 0*

* At t = 0+

Vin (0+) =3

Vc(0+) = Vc(0-) =0

VD(0+)=3 v diode is on and replace by 0.7 v

VO(t) = 0.7 v

* T1> t > 0+

Vin  = 3 volt , diode is on and replace by 0.7 v

VO(t) =VD(t) = 0.7 v

* T1> t > T2

the diode is off and replace by open circuit

VO(t) = VD (t) = -VC -3 = -3-3 =-6 V

*When DC voltage equal 1V*

* At t = 0+

Vin (0+) =3

VDC = 1v

Vc(0+) = Vc(0-) =0

VD(t) = 2 v , diode is on

Vo(0+) = 2v

* T1> t > 0+

Vin  = 3 volt , diode is on and replace by 0.7 v

Vo(0+)= 2

* T1> t > T2

VD (t) = -1-3-3 =-7 V

the diode is off and replace by open circuit

*When DC voltage equal 4 V*

* At t = 0+

Vin (0+) =3

Vc(0+) = Vc(0+) =0

VD(0+)=3 v diode is on and replace by 0.7 v

VO(t) = 0.7 v

* T1> t > 0+

Vin  = 3 volt , diode is on and replace by 0.7 v

VO(t) =VD(t) = 0.7 v

* T1> t > T2

the diode is off and replace by open circuit

VO(t) = VD (t) = -VC -3 = -3-3 =-6 V

**FILTER:**

For circuit shown in fig(9)

Ripple factor for half wave rectifier =

When c= 2.2 µf r = 7.4%

C= 47 µf r= 0308%

Ripple factor for full wave rectifier =

When c= 2.2 µf r = 3.478%

C.VOLTAGE MULTIPLIER CIRCUITS

Vab = 2VP = 6 v

Vcd = 3 VP =9 v

Vc1 = VP = 3v Vc2 = 2 VP =6 v VC3 = 2 VP = 6 v

**- Results:**

I. DIODE CHARACTERISTICS.

Table(1) *: DIODE CHARACTERISTICS.*

|  |  |  |  |
| --- | --- | --- | --- |
| Vs (volt) | VR (volt) | VD (volt ) | ID( mA ) |
| 0 | 0 | 0 | 0.00 |
| 0.117 | 0 | 0.117 | 0.00 |
| 0.214 | 0 | 0.214 | 0.00 |
| 0.317 | 0 | 0.317 | 0.00 |
| 0.412 | 0 | 0.412 | 0.00 |
| 0.501 | 0.01 | 0.511 | 0.10 |
| 0.606 | 0.06 | 0.666 | 0.60 |
| 0.702 | 0.12 | 0.822 | 1.20 |
| 0.814 | 0.2 | 1.014 | 2.00 |
| 0.908 | 0.28 | 1.188 | 2.80 |
| 1.000 | 0.39 | 1.390 | 3.90 |
| 1.519 | 0.84 | 2.359 | 8.40 |
| 2.000 | 1.38 | 3.380 | 13.80 |
| 2.514 | 1.80 | 4.314 | 18.00 |
| 3.000 | 2.23 | 5.230 | 22.30 |

Graph (1) : Current and voltage through diode

*II. RECTIFICATION:*

1. *HALF - WAVE RECTIFICATION.*

Time T (the period) = 4.92 ms peak voltage Vpk = 4.80 v

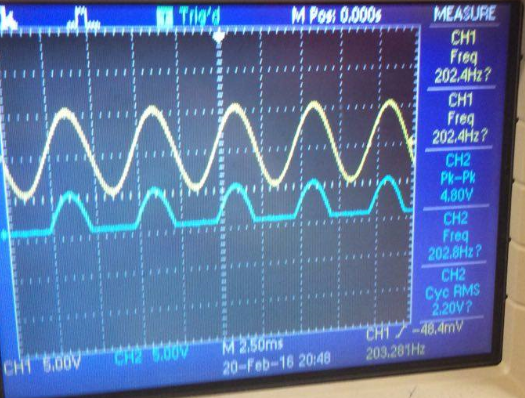
Vdc = 1.367 v Vac = 1.699 v

photo (1) : *HALF - WAVE RECTIFICATION*

C= 2.2 µf Vpk =820 mv V mean = 3.906 v

C= 47 µf Vpk =41.2 mv V mean = 4.063 v

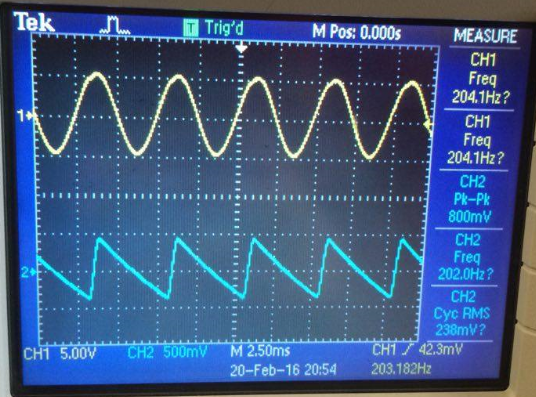
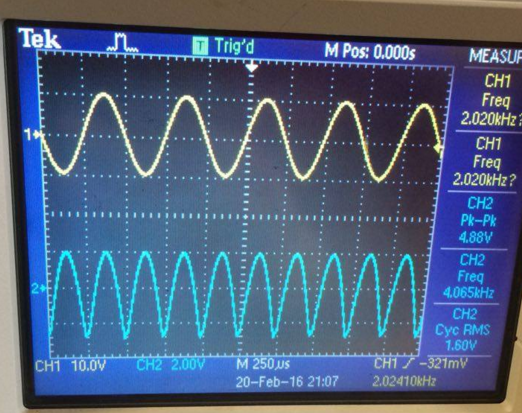


photo (2 ) : *ripple in filter circuit*

1. *FULL-WAVE RECTIFICATION.*

Vdc 2.293 v Vac = 1.599 v



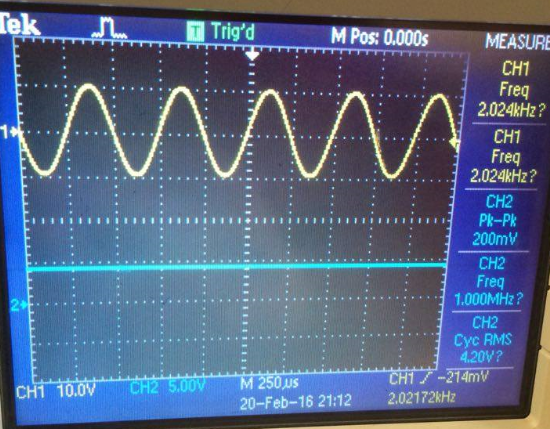
*FULL-WAVE RECTIFICATION* photo (3):

Photo (4): output waveform with filter (capacitor =2.2 µf)

*III. Other applications:*

*A. clipping:*

Vdc = 0 v Vpk = 3.20 v

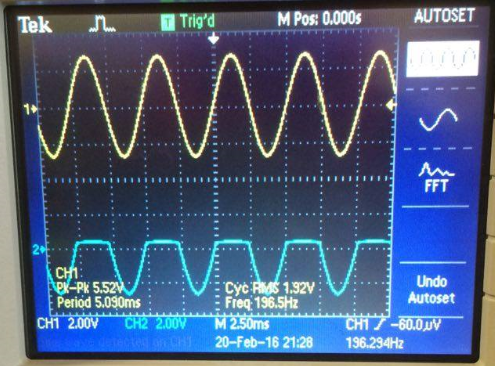


Photo (5): Clipping circuit with DC voltage source = 0v

Vdc = 1.5 v Vpk = 4.72 v

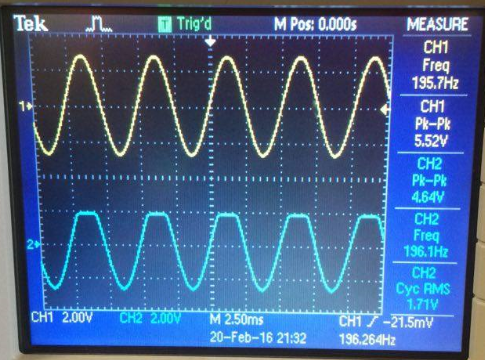


Photo (6): Clipping circuit with DC voltage source = 1.5 v

Vdc = 2.5 v Vpk =5.52 v



Photo (7): Clipping circuit with DC voltage source = 2.5 v

*B. Clamping:*

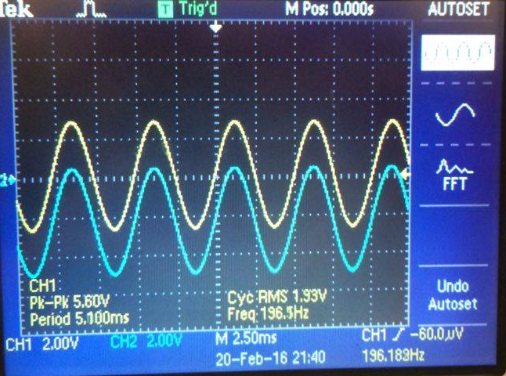


Photo (8): Clamping circuit with DC voltage source = 0

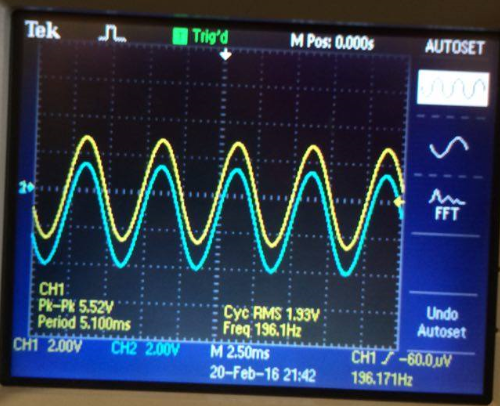


Photo (9): Clamping circuit with DC voltage source = 1 v

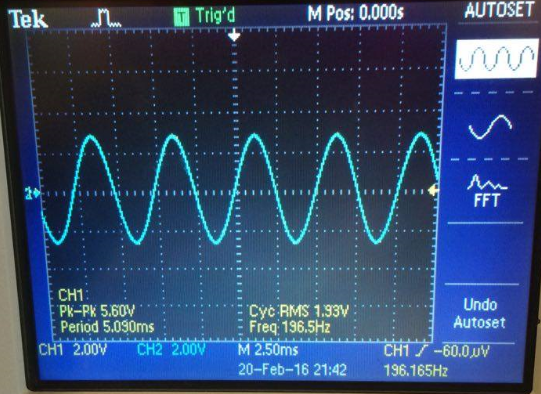


Photo (10): Clamping circuit with DC voltage source = 4 v

c .*VOLTAGE MULTIPLIER CIRCUITS*

Vab = 4.5 v

Vcd = 7.336 v

Vc1 =2.5 v Vc2 = 4.897 v VC3 = 4.9 v

**- Discussion of Results:**

From experimental and theoretical data we recognize that the diode is a non linear device that what equation (1) and graph (1) shown.

From graph (1) we note that the current through diode ID  begin to rise at approximate voltage 0.666 v and it rose very slightly above this level and this match with real behavior of silicon diode.

From photo (1), when we note the input wave we can show that it convert to pulsating DC this mean it convert from zero average voltage to positive or negative value and from calculation it is 1.59 v . also the VPK (4.8 v ) is nearly to the peak voltage of the supply and it is must not be exactly because we have diode we are dealing with is not ideal so it has a voltage across its terminals that is subtracted from the peak voltage of the source from the peak voltage of the source and this differ will be around the knee voltage. We can get negative pulsating if we connect the cathode of diode with the positive polarity of source (just let diode in other opposite direction of fig (7)) .

From photo (4) , When we add a capacitor to the rectifier in fig (7) the pulsating dc gets smooth by removing its ac ripple contents and passing its dc component ( average value) .

And from calculation we show that when we use bigger capacitor is bitter than the smaller because the ripple factor become small and the mean value become greater.

In Bridge full wave fig (8) the periodic time is half the periodic time of input and the average value twice the half wave rectifier as shown in photo (3) .

When the capacitor add to the bridge full wave circuit the output wave get DC signal photo (4) this mean the ripple factor is too small and from calculation is smaller than in half wave rectifier , the ripple factor depend on frequency that is if we increase the frequency the ripple factor will decrease .

For Clipping circuit and its photo (6, 7, 8), when compare the input and output wave we show it used to eliminate portion of the input signal. And At the value of the dc voltage source plus the knee voltage of the diode will chopped off and it not change if ac is change to 10p-p

The clipped level=dc voltage + Vknee of the capacitor.

For clamping circuit fig (5) ,photo (8,9,10) represent the different vertical shift as dc change , and it isn't still clamped to the same level

The clamping level = Vdc+ Vknee(Diode)-Vp(source)

Final application is voltage multiplier circuits fig (6 ) , comparing theoretical and experimental data we note that the output voltage between a ,b twice the input voltage and the voltage between c ,d is three times the input voltage .

In all part of experiment the result is acceptable when we compare it with calculated data . there is some small error maybe it come from the approximation for the number , wrong reading in DVM , oscilloscope .

**- Conclusion:**

The aim of lab was done, we learn how deal with diode in different circuit and recognize its behavior and some application that use in our daily life in form of telephone , radios, television , audio equipment’s, home appliances, computers, and equipment for industrial control and automation .

**- Appendix:**

**- References:**

Electronics lab manual