EE236: Electronics Devices Lab
Lab No. 2

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1 PIN DIODE v/s PN DIODE

Aim

To find forward voltage, reverse saturation current and ideality factor of the given PIN diode (Infineon BAR 15-1) and compare with normal PN junction Diode (1N4007). To find reverse recovery time of the given PIN diode at various frequencies and compare with the reverse recovery time of normal PN junction Diode. To observe how the PIN diode works as an RF switch at different DC bias voltages.

Design

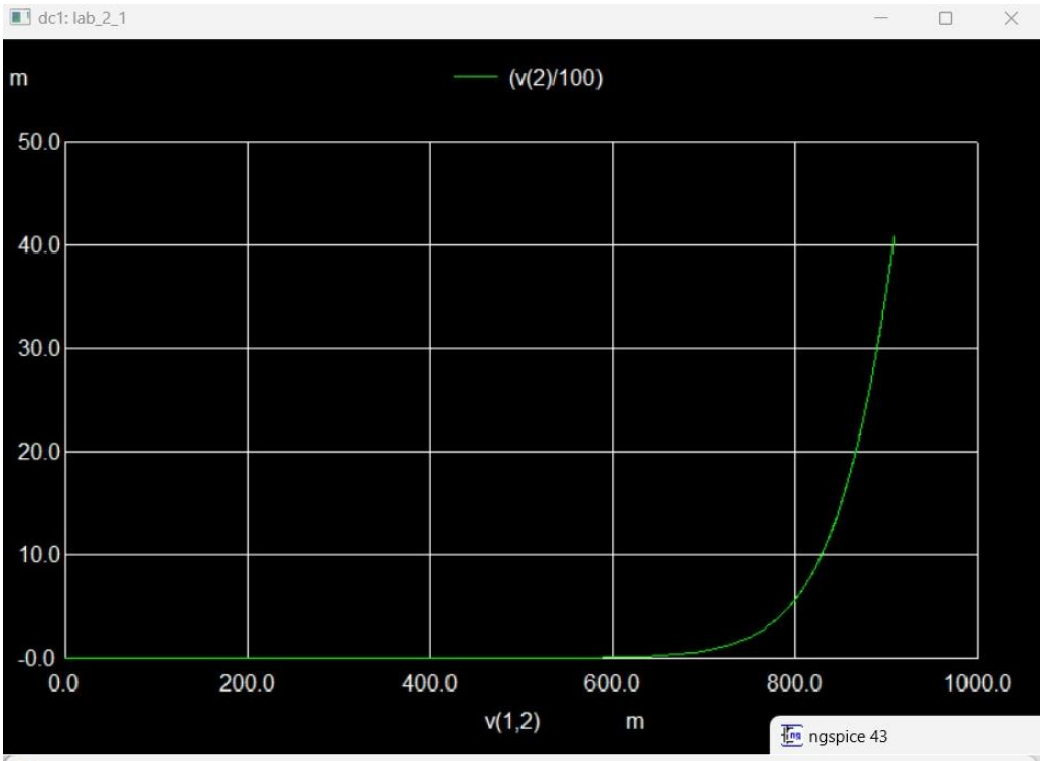
In the prelab report, we plotted the I-V characteristics of the RN142 PIN diode to measure the cut-in voltage and ideality factor. We then attempted to measure the reverse recovery time for the same diode. The next task involved understanding the operation of PIN diodes as RF switches by implementing the circuit provided in Figure 1 and comparing its performance with that of regular PN junction diodes. Write an NGSPICE netlist and simulate the RF switch circuit, then plot the output voltage, output current, and diode current for different DC bias voltages (-5V, 0V, 1V, 3V, 5V).Follwing is the code

```
+ N=1.7346
+ RS=.1581
+ IKF=.14089
+ CJO=385.59E-15
+ M=.11823
+ VJ=.78827
+ ISR=139.38E-12
+ NR=3
+ BV=60
+ TT=275.00E-9)
r1 2 0 100
d1 1 2 dmodel
vin 1 0 dc 0
*DC Analysis on source vin, to vary from 0 to +5V
.dc vin 0 10 0.01
.control
run
plot (v(2)/100) vs v(1,2)
.endc
.end
```

```
LAB_2_2
.model dmodel D (+ IS=127.76E-12
+ N=1.7346
+ RS=.1581
+ IKF=.14089
+ CJO=385.59E-15
+ M=.11823
+ VJ=.78827
+ ISR=139.38E-12
+ NR=3
+ BV=60
+ TT=275.00E-9)
r1 2 0 100
d1 1 2 dmodel
vin 1 0 PULSE (-1V +1V 0.02m 0.01m 0.01m 0.05m 0.1m)
.tran 0.02ms 0.2ms
.control
run
plot V(1)-V(2)
```

```
20 .endc
21 .end
```

Simulation results of PreLab



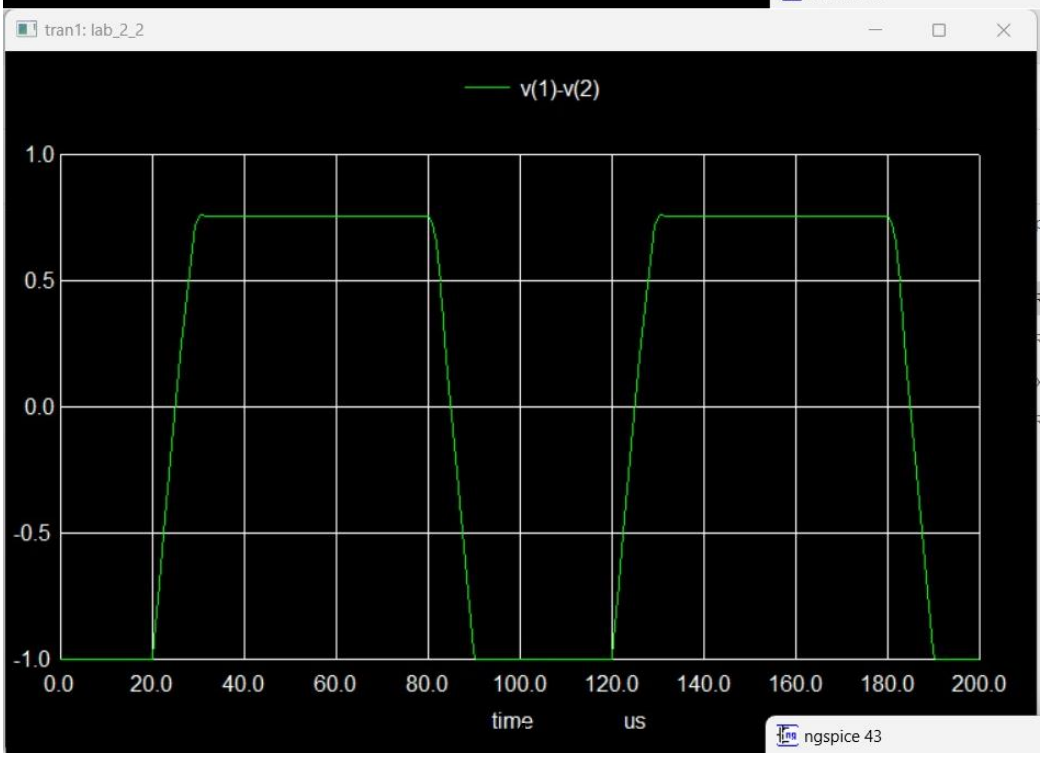
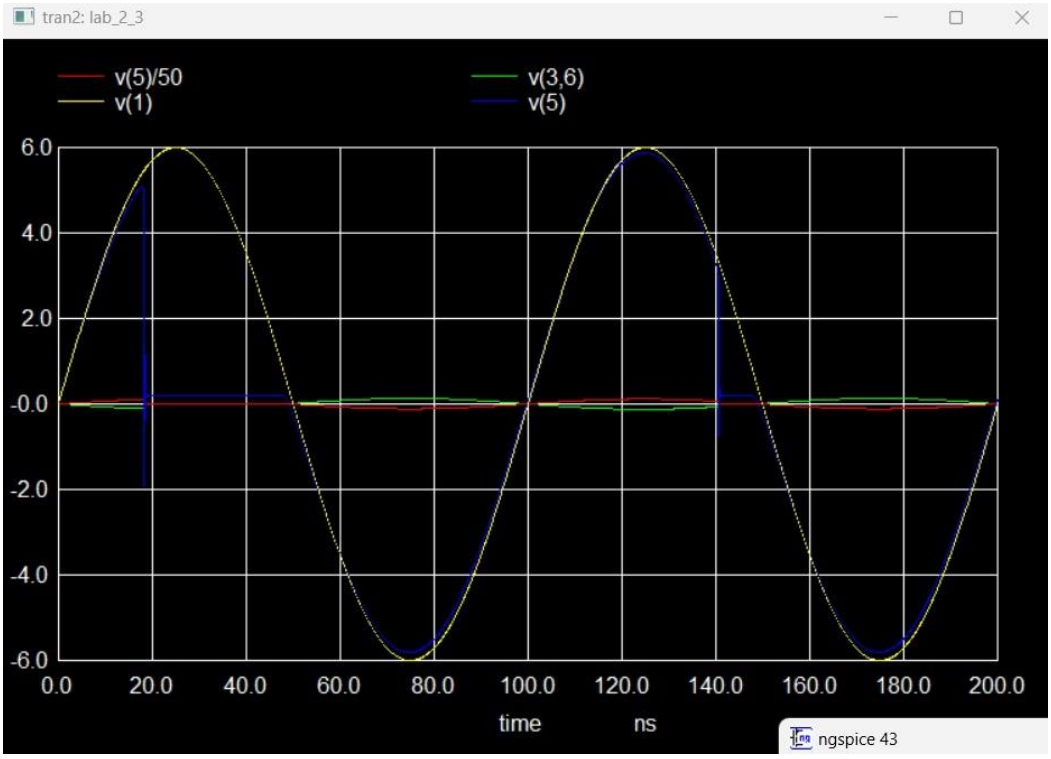


Figure 3 at bias 5volts



Values got:

Cut-in voltage = 800 mV

Ideality Factor (N) = 2.74

Recovery time = 5 microseconds

In-Lab

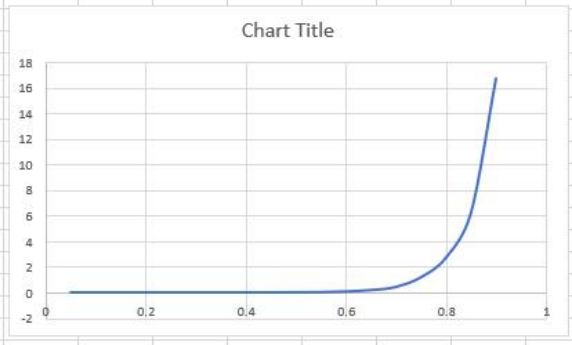
In the lab, we constructed the circuit using a potentiometer and transistors, then manually collected data to analyze the IV characteristics. The slope of the IV curve was determined using the LINEST function in Excel. We then calculated the ideality factor using the equation $\text{slope} = \frac{q}{nkT}$, where $\frac{kT}{q} = 0.026$, allowing us to determine the ideality factor.

Next, we compared the reverse recovery times of both diodes at four different frequencies, noting that there may be some error due to manual calculations. Finally, we built an RF switch and observed its operation at different bias voltages.

1.1 Simulation results of Lab

Vd	Id
0.05	0
0.1	0
0.15	0
0.2	0
0.25	0
0.3	0
0.35	0
0.4	0
0.45	0
0.5	0.01
0.55	0.02
0.6	0.07
0.65	0.18
0.7	0.42
0.75	1.18
0.8	2.71
0.85	6.22
0.9	16.72

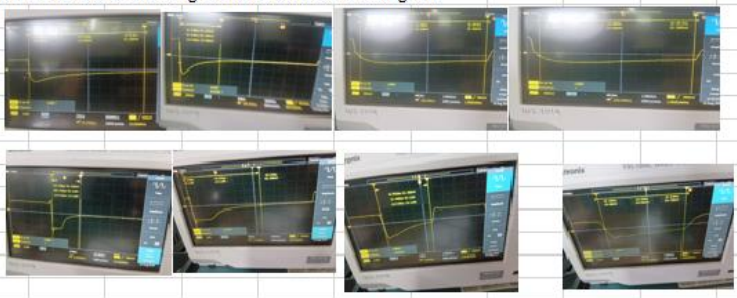
Vd	ln(Id)
0.5	-4.6052
0.55	-3.912
0.6	-2.6593
0.65	-1.7148
0.7	-0.8675
0.75	0.16551
0.8	0.99695
0.85	1.82777
0.9	2.81661



Slope	18.6997
Ideality fi	2.0568

For recovery time we have taken time from 10% after crossing 0 and 10% before crossing zero

Frequenc	RRT of PIN	RRT of PN
10kHz	2.03us	5.34us
100kHz	1.488us	3.01us
1MHz	0.464us	0.478us
3MHz	0.146us	0.155us

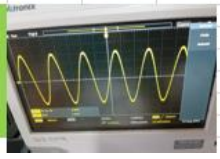


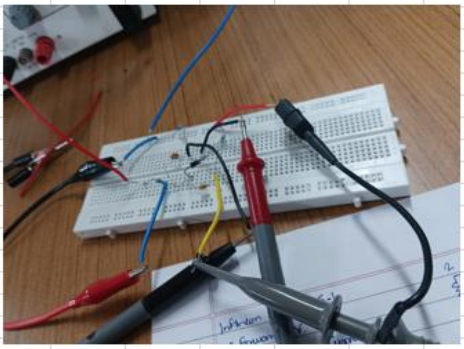
PIN

Vbias	Id	Vout
-5V	0.02mA	35mV
0V	1.07mA	600mV
1V	1.81mA	770mV
3V	3.04mA	961mV
5V	4.55mA	1.03V

PN

Vbias	Id	Vout
-5V	0.05mA	149mV
0V	0.5mA	993mV
1V	0.79mA	1.25V
3V	2.75mA	1.05V
5V	4.71mA	1.063V





1.2 Conclusion and Inference

In this experiment, the forward voltage, reverse saturation current, and ideality factor of the Infineon BAR 15-1 PIN diode were measured and compared with those of the standard 1N4007 PN junction diode. The results showed that the PIN diode has a lower forward voltage drop and higher reverse saturation current than the PN junction diode, making it more suitable for high-frequency applications.

The reverse recovery time was also measured for both diodes at different frequencies. It was observed that the PIN diode exhibited a significantly shorter reverse recovery time than the PN junction diode, especially at higher frequencies. This characteristic enhances the performance of the PIN diode in switching applications, particularly in RF circuits.

Additionally, the operation of the PIN diode as an RF switch was analyzed at various DC bias voltages. The experimental findings confirmed that the PIN diode can function effectively as an RF switch, with its performance strongly influenced by the applied bias voltage.

Finally, the experiment demonstrated that at a frequency of 3 MHz, the PIN diode has a greater capability to transmit a significant portion of the input signal to the output compared to the PN junction diode. This makes the PIN diode a better choice for high-frequency switching and signal processing applications.

Overall, the Infineon BAR 15-1 PIN diode outperforms the 1N4007 PN junction diode in high-frequency and RF switching applications, making it the preferred option in these scenarios.

1.3 Experiment completion status

Completed and checked bt the TA