EE 236: Experiment 2
Diodes Transients C-V Characteristics of Schottky Diode

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1 Overview

1.1 Aim

The main objective of this experiment is to measure and compare the reverse recovery times of a P-N and Schottky diode. To measure C-V characteristics of a Schottky diode and extract its built-in potential and doping density.

2 Prelab Simulations

The spice models of PN diode and BAT85 were imported into the NGSPICE netlist and the following graphs were current variations plotted for input square waves of 1kHz, 10kHz, 100kHz frequencies via transient analysis.

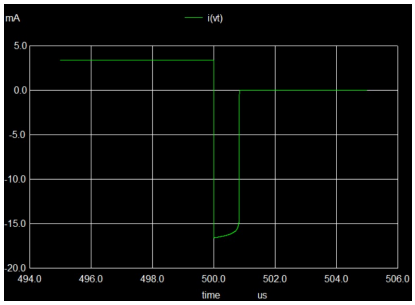
2.1 NGSPICE Code

```
*Schottky Diode
*Rohan Rajesh Kalbag 20D170033
.include 1N4007.txt
.include BAT85.txt

*square wave sources
*v1k 1 0 pulse(-1 1 0 1ns 1ns 0.5ms 1ms 0)
*v10k 1 0 pulse(-1 1 0 1ns 1ns 0.05ms 0.1ms 0)
v100k 1 0 pulse(-1 1 0 1ns 1ns 0.005ms 0.01ms 0)

*uncomment for pn diode
d1 1 4 1N4007
vt 4 5 0 dc
ra 5 0 100
```

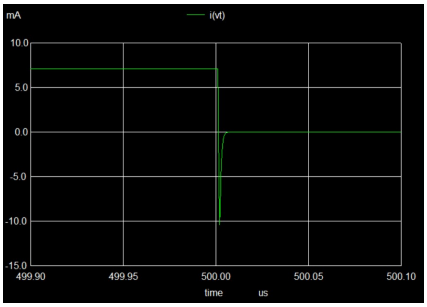
```
*uncomment for schottky diode
* x1 1 4 BAT85
* vt 4 5 0 dc
* ra 5 0 100

.tran 1ns 576us 574us
.control

run
plot i(vt)
.endc
.end
```

2.2 Results

The following plots, values of the reverse recovery time were obtained

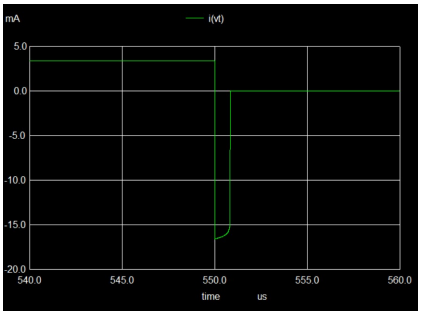


(a) PN Junction

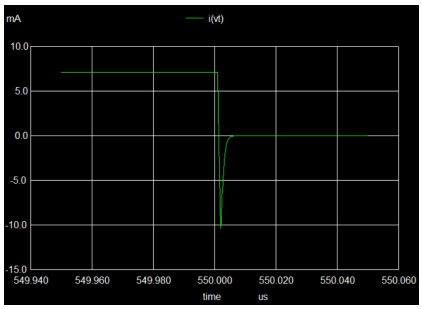


(b) Schottky

Figure 1: For 1kHz Square Wave Input

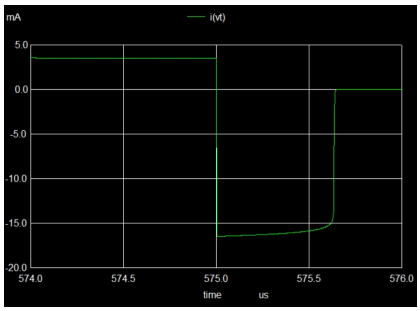


(a) PN Junction

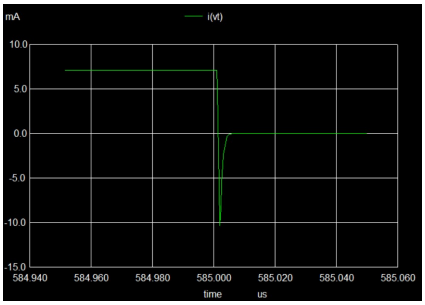


(b) Schottky

Figure 2: For 10kHz Square Wave Input



(a) PN Junction



(b) Schottky

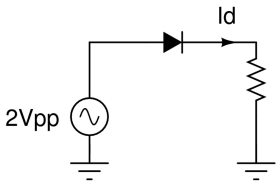
Figure 3: For 100kHz Square Wave Input

Frequency	PN Junction	Schottky
10kHz	4 us	350 ns
100kHz	1.5 us	400 ns
1MHz	400 ns	200 ns
10MHz	50 ns	150 ns

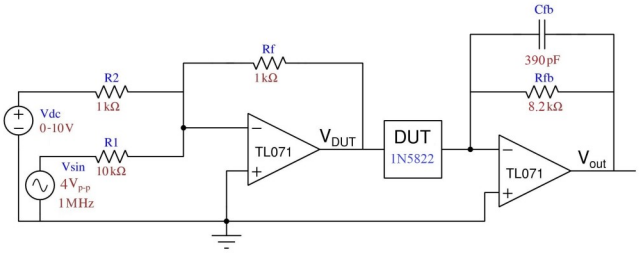
Observed Values of Reverse Recovery Time

3 Design

3.1 Circuit Diagrams



Circuit To Obtain Reverse Recovery Time



Circuit To Measure C-V Characteristics of Schottky Diode

4 Observations

4.1 Reverse Recovery Time

These were the values that were obtained after measuring of the RRT for PN diode and Schottky by following the instructions in the handout

Frequency	**PN Junction**	**Schottky**
1kHz	850 ns	5 ns
10kHz	840 ns	5 ns
100kHz	650 ns	5 ns

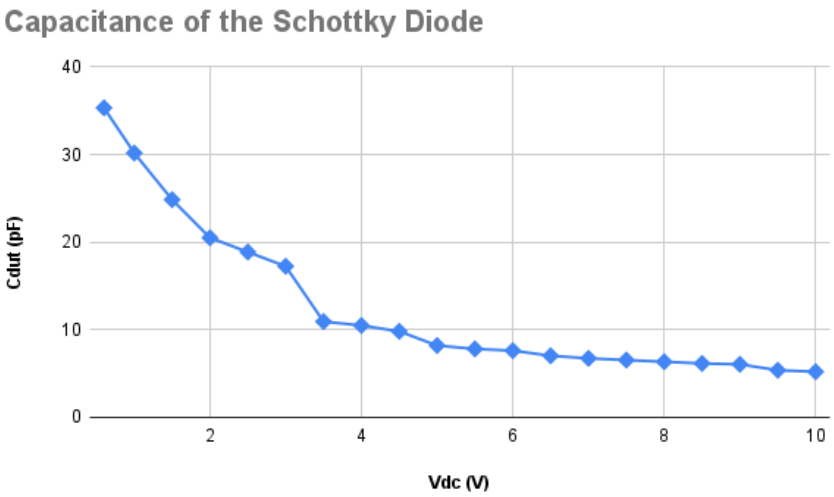
Experimentally Obtained Values of Reverse Recovery Time

4.2 C-V characteristics for Schottky Diode

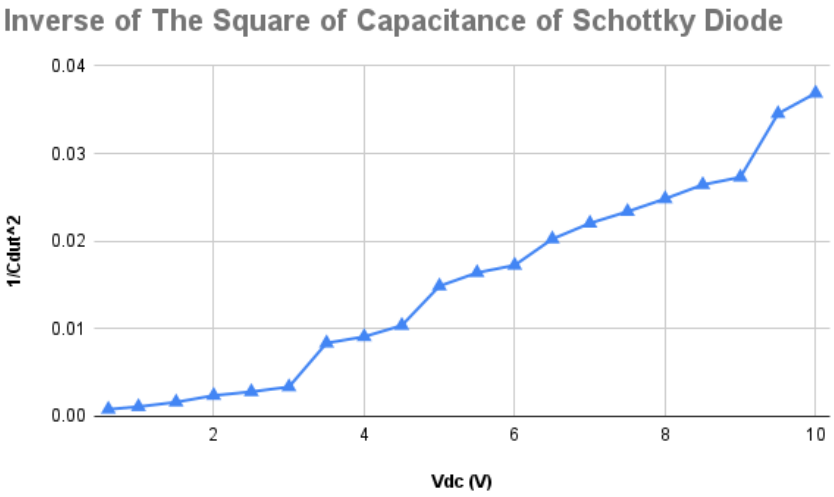
The value of V_{DC} was varied in small steps and the value of V_{out}, V_{dut} was measured for it corresponding to the steps. The scaling factor relating the value of capacitance with voltage was evaluated as 390.48

V_{dc} (V)	V_{out} (p-p) mV	V_{dut} (p-p) mV	Ratio of V_{out} and V_{dut}	C_{dut} (pF)
0.6	76	840	0.09047619048	35.32942861
1	68	880	0.07727272727	30.1736986
1.5	56	880	0.06363636364	24.84892826
2	50.4	960	0.0525	20.50036581
2.5	46.4	960	0.04833333333	18.87335265
3	42.4	960	0.04416666667	17.24633949
3.5	39.2	1400	0.028	10.93352843
4	37.6	1400	0.02685714286	10.48726197
4.5	35.2	1400	0.02514285714	9.817862267
5	33.6	1600	0.021	8.200146325
5.5	32	1600	0.02	7.809663167
6	31.2	1600	0.0195	7.614421587
6.5	28.8	1600	0.018	7.02869685
7	27.6	1600	0.01725	6.735834481
7.5	26.8	1600	0.01675	6.540592902
8	26	1600	0.01625	6.345351323
8.5	25.2	1600	0.01575	6.150109744
9	24.8	1600	0.0155	6.052488954
9.5	24.8	1800	0.01377777778	5.379990181
10	24	1800	0.01333333333	5.206442111

The following plots were obtained from the above data



Variation of Capacitance with Voltage



Inverse of The Square of Capacitance of Schottky Diode

The value of slope was $m = 3.85 \times 10^{-3} \frac{1}{(pF)^2 V}$ and x-intercept was 0.41 V
Area of Schottky Diode (S) $= 1.937 \times 10^{-6}\ cm^{-2}$
We thus obtain the value of doping density N_d as $-8.357 \cdot 10^{23}\ m^{-3}$

5 Post Lab Simulation

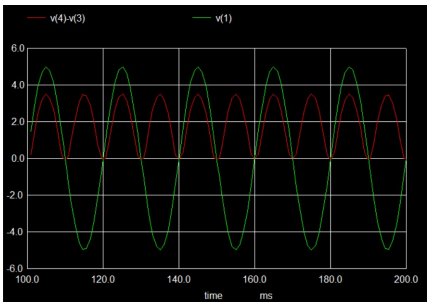
5.1 NGSPICE Code

```
*Rectifiers
*Rohan Rajesh Kalbag 20D170033
.include 1N4007.txt
.include BAT85.txt

*sources
v1 1 0 sin(0 5 50 0 0 0)

*uncomment for pn diode
* d1 1 4 1N4007
* d2 3 1 1N4007
* d3 3 0 1N4007
* d4 0 4 1N4007
* ra 4 3 100

*uncomment for schottky diode
x1 1 4 BAT85
x2 3 1 BAT85
x3 3 0 BAT85
x4 0 4 BAT85
ra 4 3 100


.tran 1ms 200ms 100ms
.control

run
plot v(1) {v(4) - v(3)}
.endc
.end
```

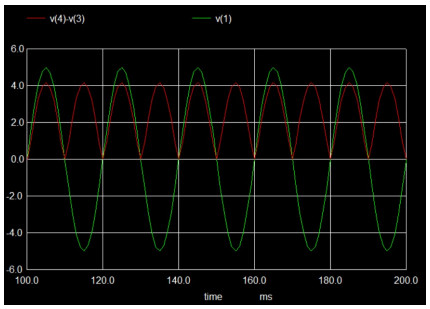
5.2 Results of Simulation

The following plots were obtained for the two diode based bridge rectifiers

- Using PN Junction Diode 1N4007
- Using BAT85 Schottky Diode



Rectified Waveform for 1N4007



Rectified Waveform for BAT85

5.3 Simulation Inference

We notice that the output waveform for the BAT85 Schottky diode has much lesser drop as compared to the input (because smaller value of V_{bi}) as compared to the PN junction diode. Also Schottky diode has smaller reverse response time as compared to the PN diode hence when the Voltage changes sign, the former produces a more input-like rectified output waveform. Hence we can conclude that the Schottky Diode does a much better job as a Rectifier as compared to the PN Junction Diode.

6 Experiment Completion Status

The experiment was completed in the lab hours and the values and plots obtained for the various diodes, the simulation outputs were shown to the TA and were verified. The `.xlsx` containing all the readings and plots after verification from the TA were uploaded on Moodle during the lab hours