EE236: Experiment No. 2
Diodes Transients C-V Characteristics of Schottky Diode

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1 Overview of the experiment

1.1 Aim of the experiment

The aim of the experiment is:
To measure and analyze reverse recovery time for (1N4007) and Schottky diode(1N5822)
To measure C-V characteristics of a Schottky diode and extract its built-in potential and doping density

1.2 Methods

1.2.1 Reverse Recovery Time

First, we setup the circuit on a breadboard and then using the oscilloscope we measured the time for various frequency.

1.2.2 C-V Characteristics of Schottky Diode

After setting up the circuit given on breadboard, we changed V_{dc} and measured V_{dut} and V_{out}.
Using these value we calculated C_{dut} and plot $\frac{1}{C_{dut}^2}$ vs V_{dc}

2 Design

2.1 Reverse Recovery Time

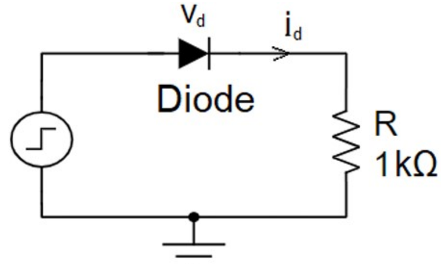


Figure 1: Circuit of Reverse Recovery Time Calculation

2.2 C-V characteristic of Schottky Diode

For this we calculated C_{DUT} using V_{DUT} and V_{OUT}. After that we plotted $\frac{1}{C_{dut}^2}$ vs V_{dc}. The slope and $Y_{intercept}$ gives the value of V_{bi} and N_d

$$\frac{1}{C^2} = \frac{2(V_{bi} - V_i)}{q\epsilon_s\epsilon_o S^2 N_d}$$

$$\frac{V_{OUT}}{V_{DUT}} = \frac{C_{DUT}}{C_{fb}} \frac{1}{\sqrt{1 + \frac{1}{(\omega R_{fb} C_{fb})^2}}}$$

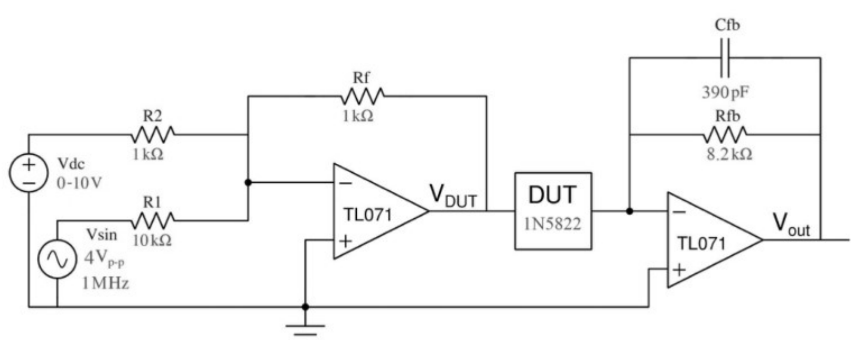


Figure 2: Circuit to determine C-V characteristics

$$Slope = \frac{-2}{q\epsilon_s\epsilon_o S^2 N_d}$$

Using the slope in the above equation we can get N_d, and to calculate S for the above equation we can use relation of I_{rev}

$$I_{Rev} = SA^*T^2e^{\frac{-V_{bi}}{V_T}}$$

A^* is the Richardson's constant, which is equal to $110A/K^2cm^2$
The built-in potential (Vbi) will be equal to the magnitude of x-intercept
I_{rev} (reverse current) for the Schottky diode is 4 μA

3 Simulation results

3.1 Code snippet

3.1.1 PreLab

1N4007 Diode

```
.include 1N4007.txt
vp 1 0 PULSE(-1 1 2NS 2NS 2NS .0005MS .001MS)
d1 1 2 1N4007
r1 3 0 100
v2 2 3 0
.tran .001u .005m
.control
run
plot v(1, 2) 5+100*i(v2)
.endc
```

Schottky Diode

```
.include BAT85.txt
vp 1 0 PULSE(-1 1 2NS 2NS 2NS .0005MS .001MS)
x1 1 2 BAT85
r1 3 0 100
v2 2 3
.tran .001u .005m
```

```
.control
run
plot v(1, 2) 2.5+100*i(v2)
.endc
```

3.1.2 PostLab

1N4007 Diode

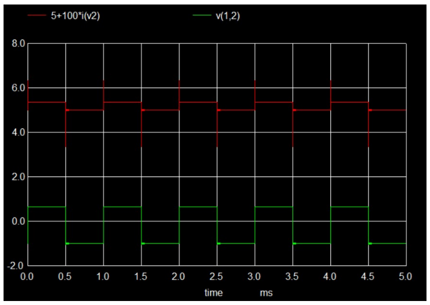
```
.include 1N4007.txt
v1 1 0 SINE(0 5 50)
d1 1 3 1N4007
d2 2 1 1N4007
d3 2 0 1N4007
d4 0 3 1N4007
r1 2 3 100
.tran 1u 100m
.control
run
plot v(3,2) v(1)
plot v(3,2) vs v(1)
.endc
```

Schottky Diode

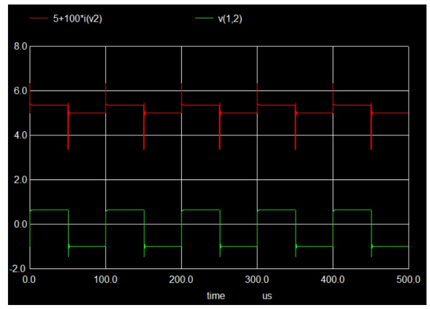
```
.include BAT85.txt
v1 1 0 SINE(0 5 50)
x1 1 3 BAT85
x2 2 1 BAT85
x3 2 0 BAT85
x4 0 3 BAT85
r1 2 3 1k
.tran .1u 60m
.control
run
plot v(3,2) v(1)
plot v(3,2) vs v(1)
.endc
```

3.2 Simulation results

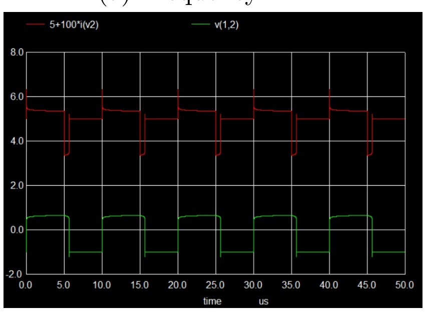
3.2.1 PreLab



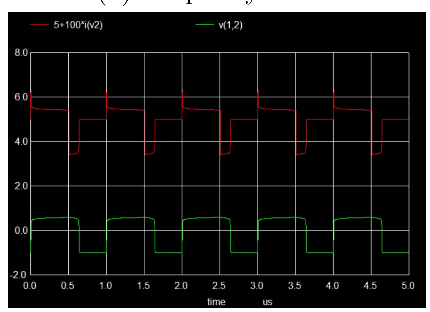
(a) Frequency: 1Khz



(b) Frequency: 10Khz



(c) Frequency: 100Khz

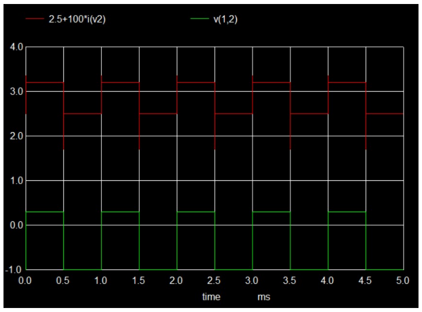


(d) Frequency: 1Mhz

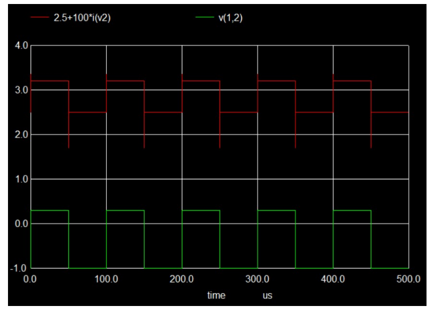
Figure 3: 1N4007 Diode Plots

Frequency	1N4009	BAT 85
1kHz	1.12us	4ns
10Khz	.85us	3.4ns
100khz	.64us	3.3ns
1MHz	.139us	3.1ns

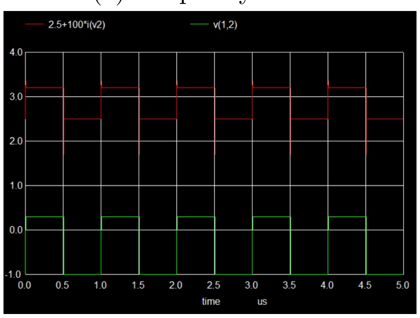
Table 1: Reverse Recovery Time



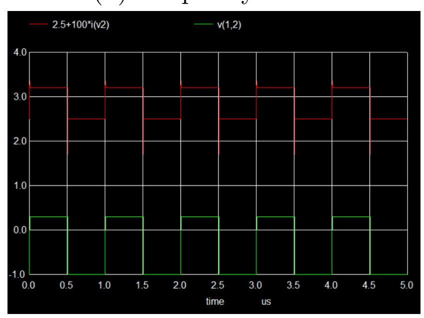
(a) Frequency: 1Khz



(b) Frequency: 10Khz



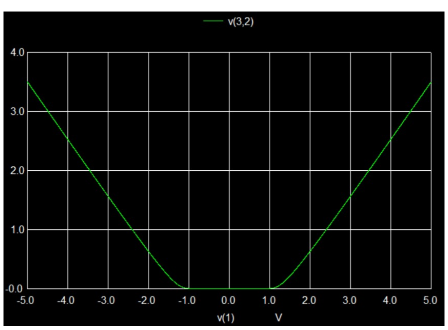
(c) Frequency: 100Khz



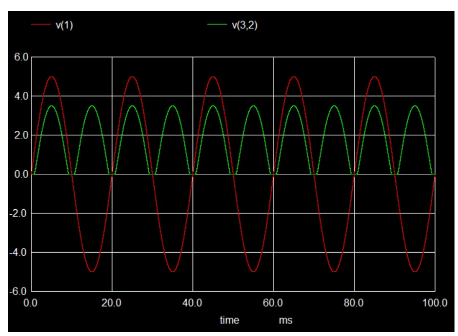
(d) Frequency: 1Mhz

Figure 4: Schottky Diode Plots

3.2.2 PostLab

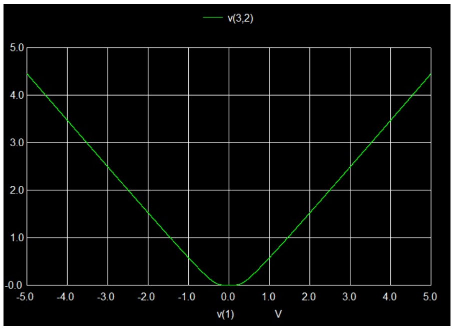


(a) Tranfer Characeristics

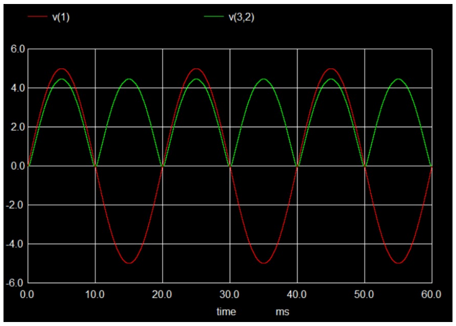


(b) Output

Figure 5: 1N4007 Diode



(a) Tranfer Characeristics



(b) Output

Figure 6: Schottky Diode

4 Experimental results

4.1 Reverse Recovery Time

Freq	1N4007	BAT 85
10Khz	2.4us	.28us
100khz	1.6us	.23us
1M	220ns	38ns

Table 2: RRT readings

4.2 C-V characteristic of Schottky Diode

$V_{dc}(V)$	$V_{DUT}(V)$	$V_{OUT}(V)$	C(F)	$1/C^2$
0.9	0.76	0.74	4.06e-10	6.06e+18
1.5	0.96	0.576	2.50e-10	1.60e+19
2.3	1.04	0.472	1.89e-10	2.79e+19
3	1.04	0.424	1.70e-10	3.45e+19
4.2	1.06	0.368	1.45e-10	4.76e+19
5	0.96	0.336	1.46e-10	4.69e+19
6.8	0.96	0.28	1.22e-10	6.75e+19
7.7	1.04	0.272	1.09e-10	8.40e+19
8.7	1.04	0.248	9.95e-11	1.01e+20
10	1.04	0.24	9.63e-11	1.08e+20

Table 3: C-V Readings

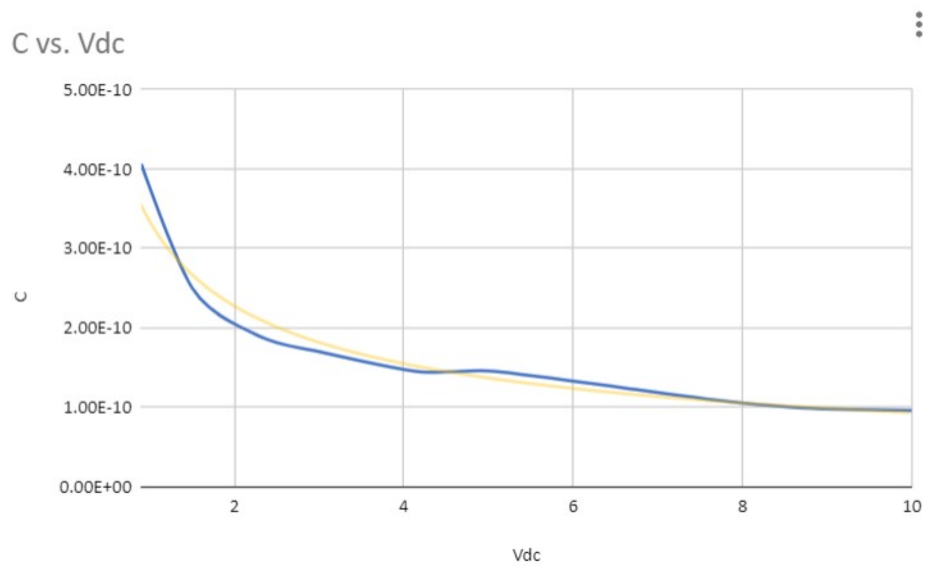


Figure 7: C vs V plot with trendline

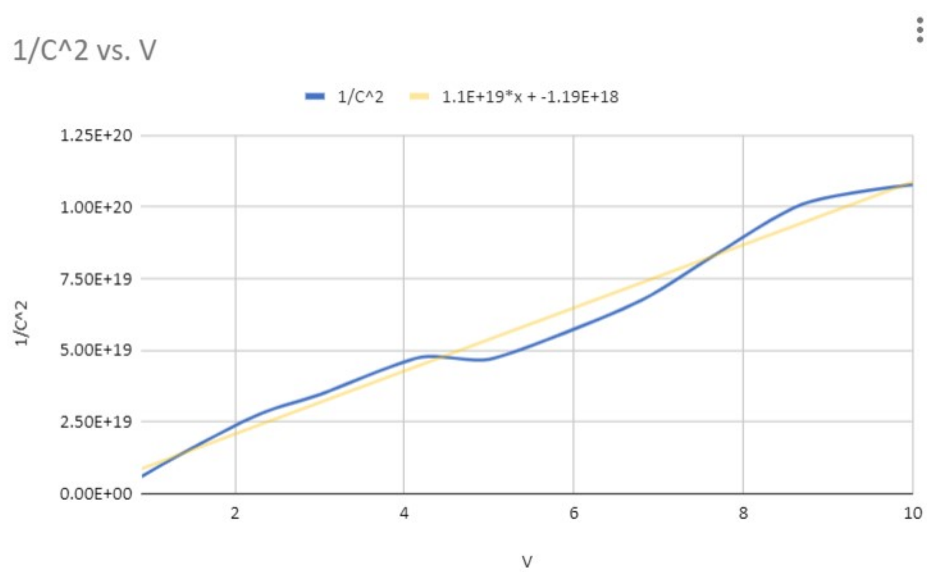


Figure 8: $\frac{1}{C^2} vs V_{dc}$ plot with trendline

Slope $= 1.9 \times 10^{19}$

X-intercept = V_{bi} = .108

Using $I_{Rev} = SA^{*}T^{2}e^{\frac{-V_{bi}}{V_T}}$
S = $2.69 \times 10^{-11} cm^2$

$$Slope = \frac{-2}{q\epsilon_s\epsilon_o S^2 N_d}$$

Using the slope in the above equation we can get N_d, and to calculate S for the above equation we can use relation of I_{rev}

$$I_{Rev} = SA^{*}T^{2}e^{\frac{-V_{bi}}{V_T}}$$

$N_d = 1.22 \times 10^{14} cm^{-3}$

5 Experiment completion status

Experiment completed in the lab slot.

6 Questions for reflection

Which of the 2 diodes is a better rectifier and why?
Ans: Schottky diode is better for full bridge rectifier as it has low cuttin voltage which prevent clipping of voltage also Schottky diodes has a faster recovery as compared to 1N4007 which help in faster switching