

EE 236 Electronic Devices Lab

Lab - 02

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14th August, 2024

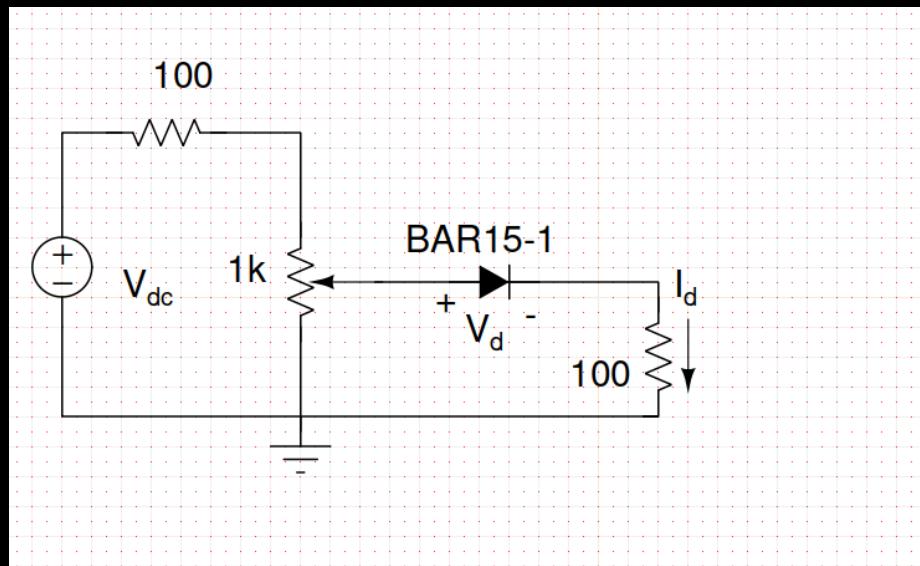
PIN Diode IV Characteristics, Transient Analysis & Application

1 Experiment - 1: I/V characteristics

1.1 Aim of the experiment

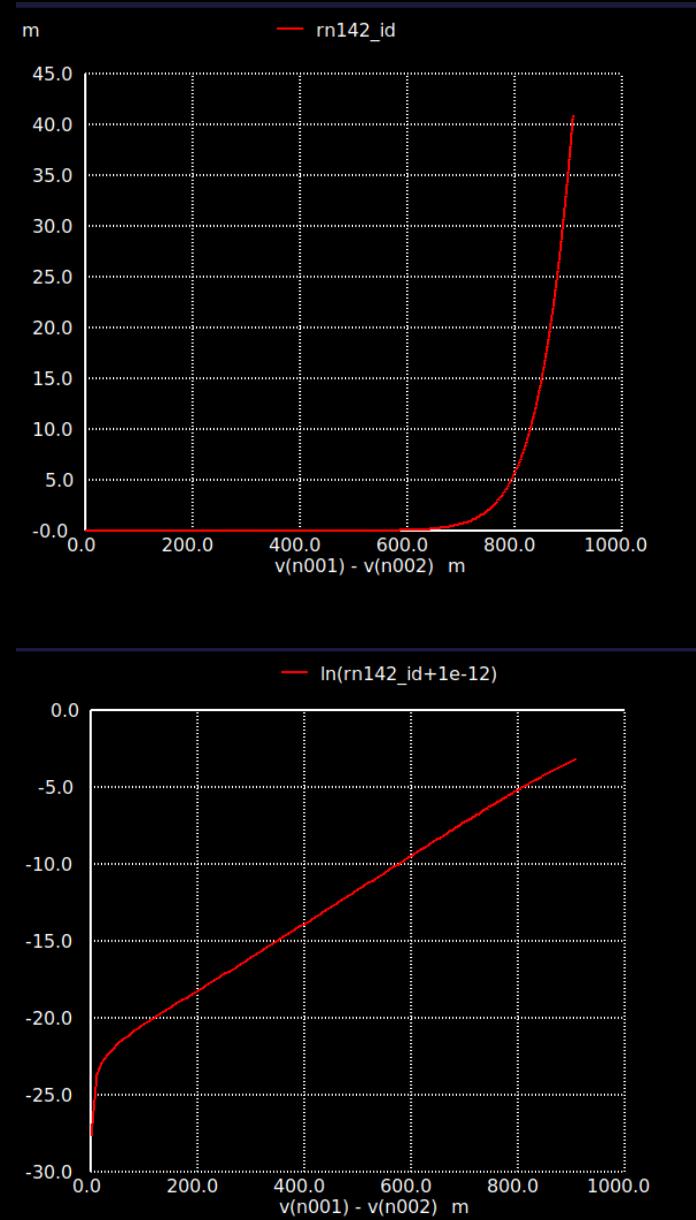
Find the forward voltage, reverse saturation current and ideality factor of *Infineon BAR 15-1* (PIN diode) and compare with *1N4007* (normal pn junction).

1.2 Design



The circuit consists of power source, resistor, 1k pot and BAR15-1 diode. The 1k pot is used to vary the voltage from 0V to 1V.

1.3 Simulation Results (Ngspice)



Parameter	Value
Cut-in Voltage (at 1mA)	0.00645161 V
Ideality Factor	1.734

1.4 Simulation Code (Ngspice)

```
.include "../Handouts/rn142_1.txt"

vs N001 0 dc 0
d1 N001 N002 DRN142S
r1 N002 0 100

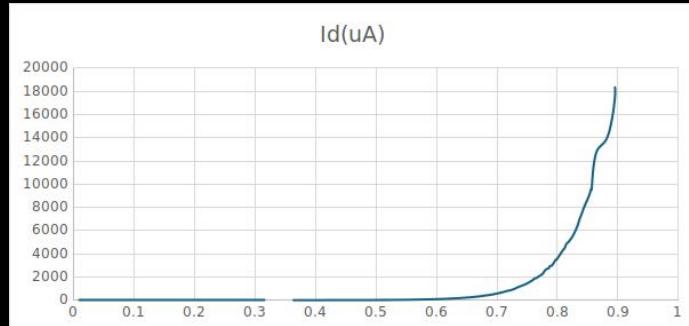
.dc vs 0 5 0.01
.control
run
let RN142_Id = v(N002) / @r1[ r ]

plot RN142_Id vs v(N001) - v(N002)
plot ln(RN142_Id + 1e-12) vs v(N001) - v(N002)
.endc
.end
```

1.5 Experimental Results

Vd(V)	Id(μA)								
0.01	0	0.604	91.9	0.663	283	0.72	828	0.796	3400
0.312	0.01	0.606	96	0.664	298	0.726	915	0.798	3500
0.388	1.5	0.607	97.3	0.666	300	0.73	995	0.8	3600
0.49	10	0.611	106	0.668	313	0.735	1122	0.809	4300
0.497	12.6	0.613	110.7	0.67	321	0.74	1220	0.812	4500
0.505	14	0.616	116	0.673	345	0.745	1333	0.815	4860
0.526	20.8	0.617	118	0.678	379	0.749	1419	0.818	5000
0.537	25.5	0.619	123.5	0.679	383	0.753	1540	0.821	5200
0.541	27.7	0.622	130	0.68	404	0.755	1600	0.826	5600
0.548	30.8	0.625	138	0.684	420	0.756	1639	0.833	6400
0.56	40.3	0.628	141	0.688	452	0.758	1685	0.836	6900
0.568	46.3	0.629	148	0.69	466	0.762	1848	0.84	7450
0.57	48.2	0.635	166	0.692	488	0.765	1910	0.844	8000
0.578	56.3	0.639	179.2	0.695	516	0.771	2108	0.851	8850
0.583	61.4	0.642	190.7	0.697	540	0.776	2300	0.854	9300
0.586	65.6	0.644	198	0.7	572	0.78	2600	0.856	9600
0.59	70.1	0.647	206	0.704	611	0.785	2740	0.857	9900
0.595	77.8	0.648	213	0.705	634	0.786	2800	0.864	12700
0.597	79.7	0.659	260	0.712	720	0.788	2950	0.882	14000
0.598	81.8	0.662	278	0.716	783	0.791	3000	0.894	17000
								0.895	18337

Table 1: V_d vs $I_d(\mu A)$ for diode at different voltages and currents



Parameter	Value
Slope	27.9239330966879
η	1.37736823564086
Intercept	-27.1562114790413
I_s (Saturation Current, A)	$1.60770812003159 \times 10^{-12}$
V_γ (V)	0.312

1.6 Conclusion and Inference

1.7 Experiment Completion Status

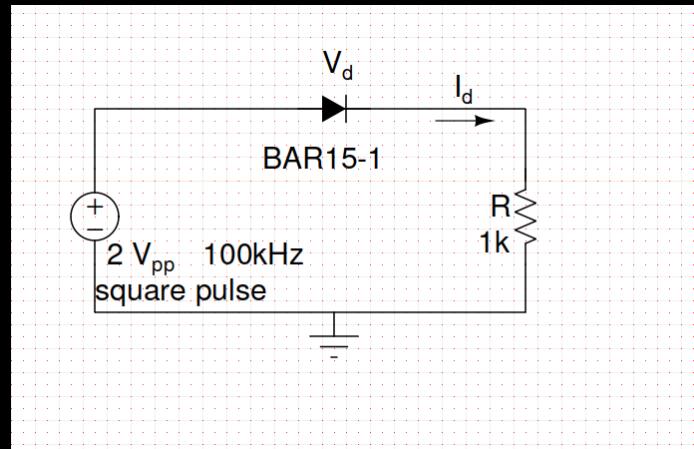
The experiment including both hardware and simulation implementation was completed and submitted during the lab hours and before the deadline respectively.

2 Experiment - 2: Recovery Time

2.1 Aim of The Experiment

Find and compare the reverse recovery time of given PIN diode at various frequencies and that of normal PN junction Diode.

2.2 Design



2.3 Simulation Results (Ngspice)

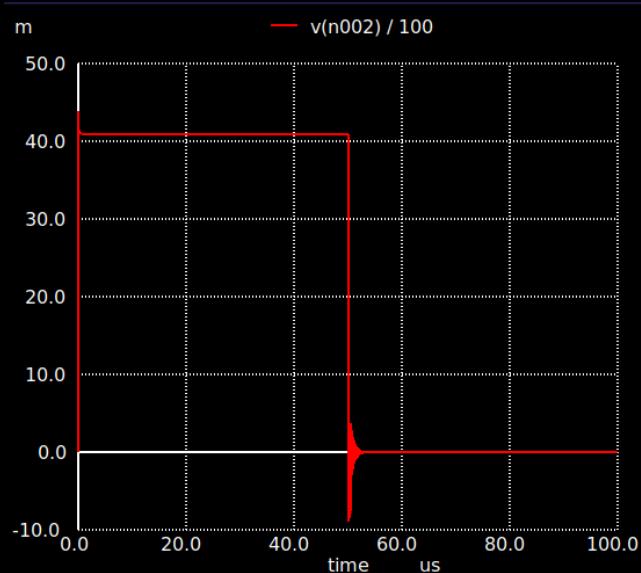


Figure 1: Plot of diode current at 10kHz

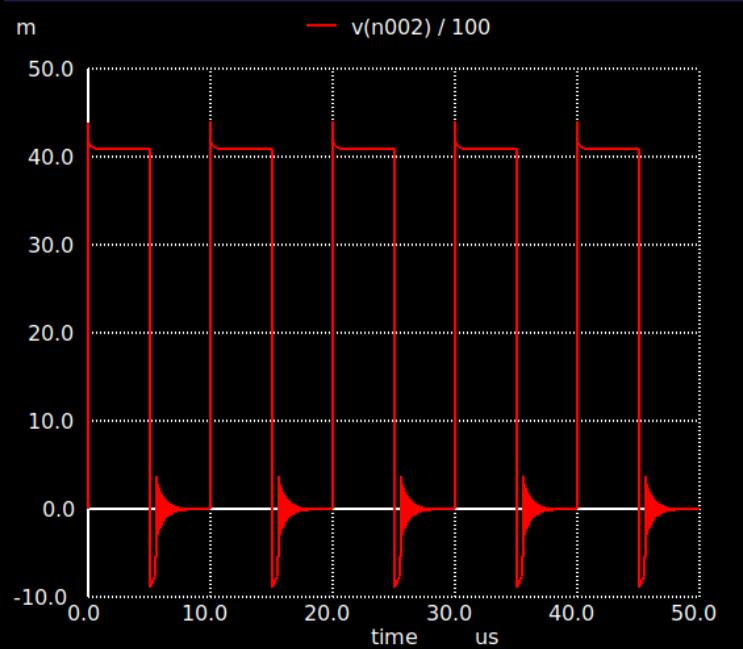


Figure 2: Plot of diode current at 100kHz

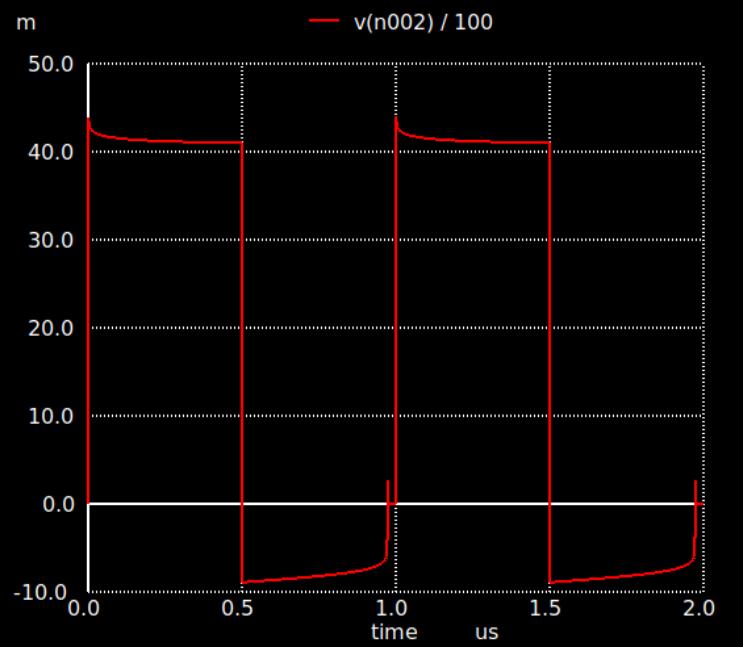


Figure 3: Plot of diode current at 1MHz

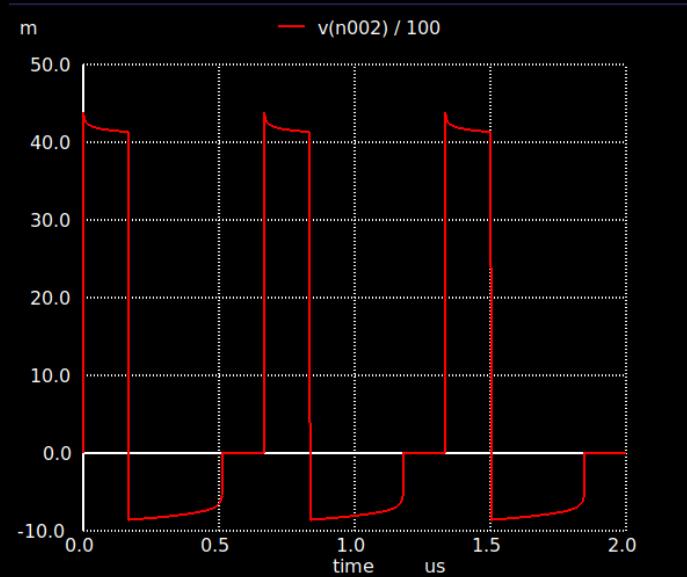


Figure 4: Plot of diode current at 3MHz

2.4 Simulation Code (Ngspice)

```
.include "../Handouts/rn142_1.txt"

vs N001 0 pulse(0 5 0 1ns 1ns <time_period/2> <time_period>)
d1 N001 N002 DRN142S
r1 N002 0 100

.tran 1n 2u

.control
run
meas tran t_1 when v(N002)=0.00 cross=1
meas tran t_2 when v(N002)=0.00 cross=2
meas tran t_3 when v(N002)=0.00 cross=3

let trr = t_3 - t_2
print trr

plot v(N002) / 100 vs time
.endc
.end
```

2.5 Experimental Results

Frequency	RRT of PIN	RRT of PN	RRT (Simulation)
100 kHz	3.99 μ s	5 μ s	534.983 ns
10 kHz	47.1 μ s	50 μ s	534.980 ns
1 MHz	429 ns	435 ns	470.849 ns
3 MHz	171 ns	172 ns	343.713 ns

Table 2: RRT of PIN and PN Diodes at Different Frequencies

2.5.1 BAR15-1 diode



Figure 5: Plot of BAR15-1 diode current at 10kHz



Figure 6: Plot of BAR15-1 diode current at 100kHz



Figure 7: Plot of BAR15-1 diode current at 1MHz

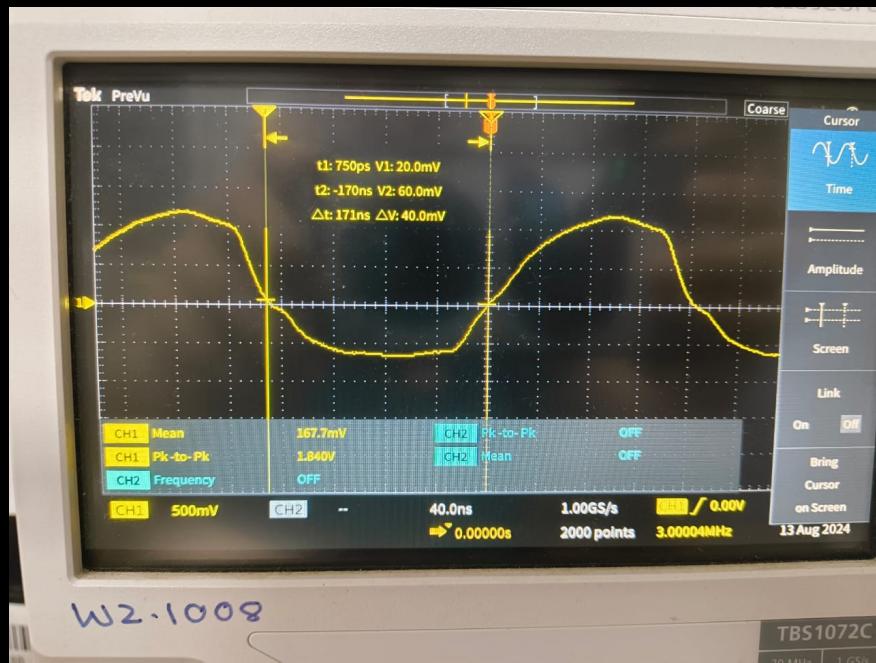


Figure 8: Plot of BAR15-1 diode current at 3MHz

2.5.2 IN4007 diode

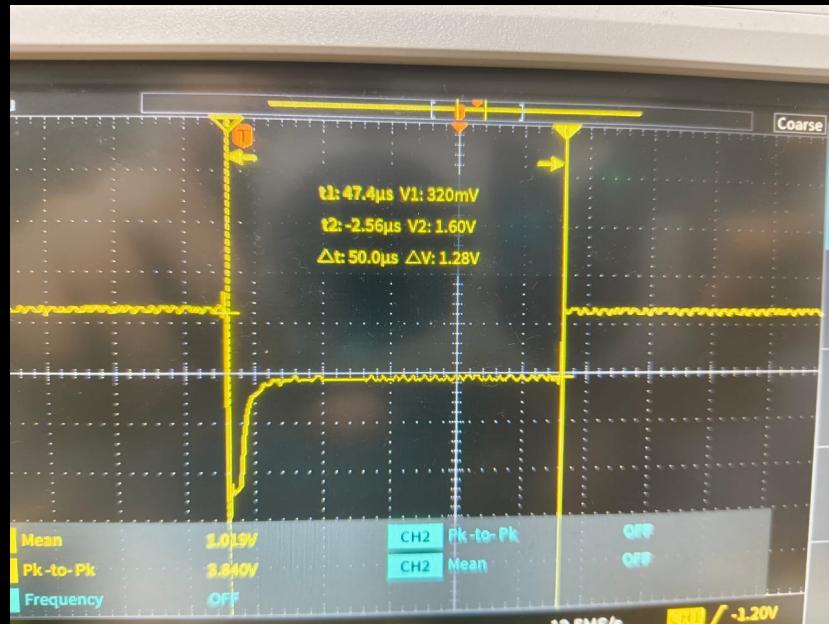


Figure 9: Plot of IN4007 diode current at 10kHz

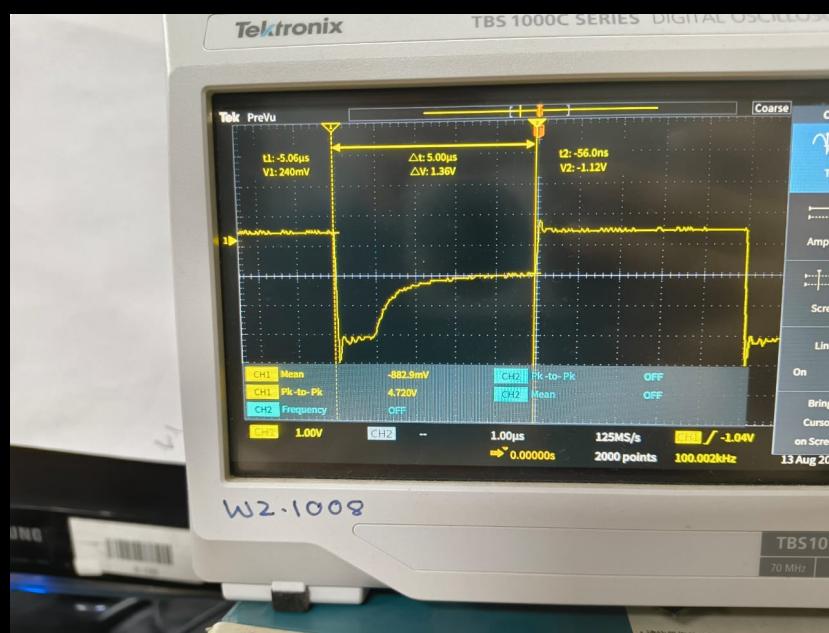


Figure 10: Plot of IN4007 diode current at 100kHz



Figure 11: Plot of IN4007 diode current at 1MHz

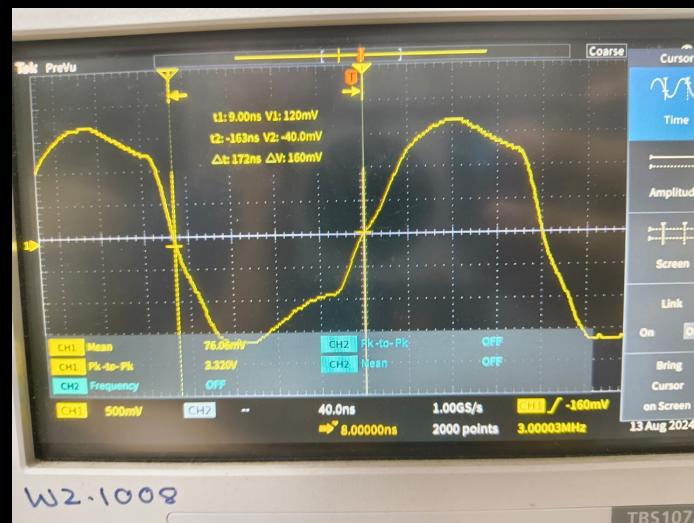


Figure 12: Plot of IN4007 diode current at 3MHz

2.6 Experiment Completion Status

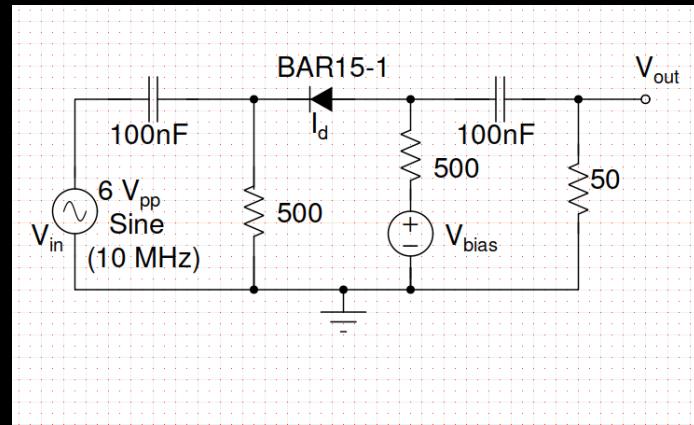
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3 Experiment - 3: RF Switch

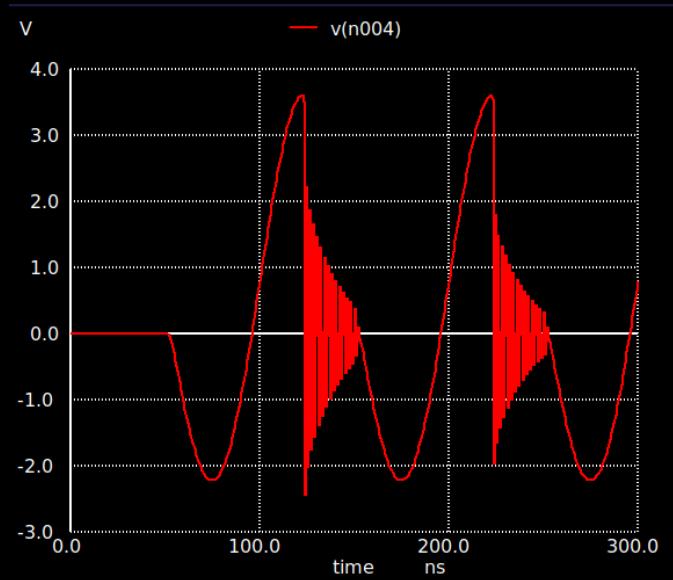
3.1 Aim of the experiment

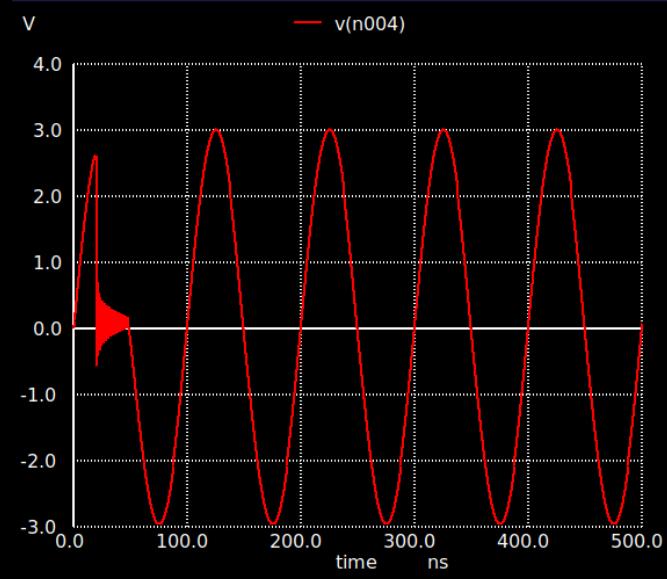
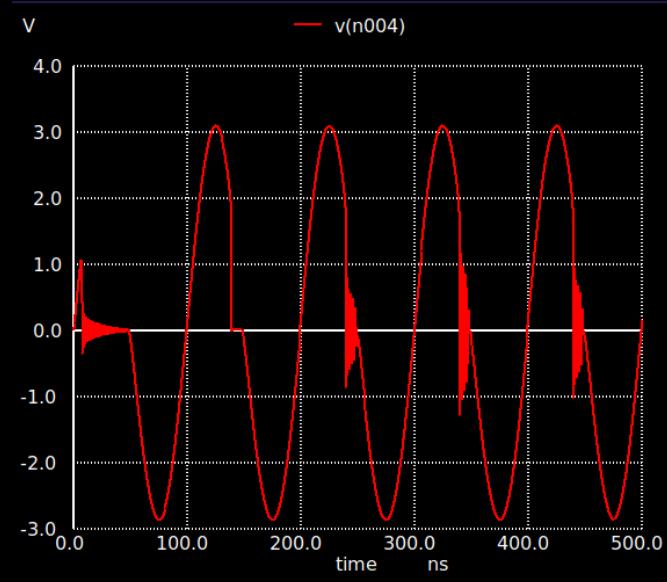
Observe how the PIN diode works as an RF switch at different DC bias

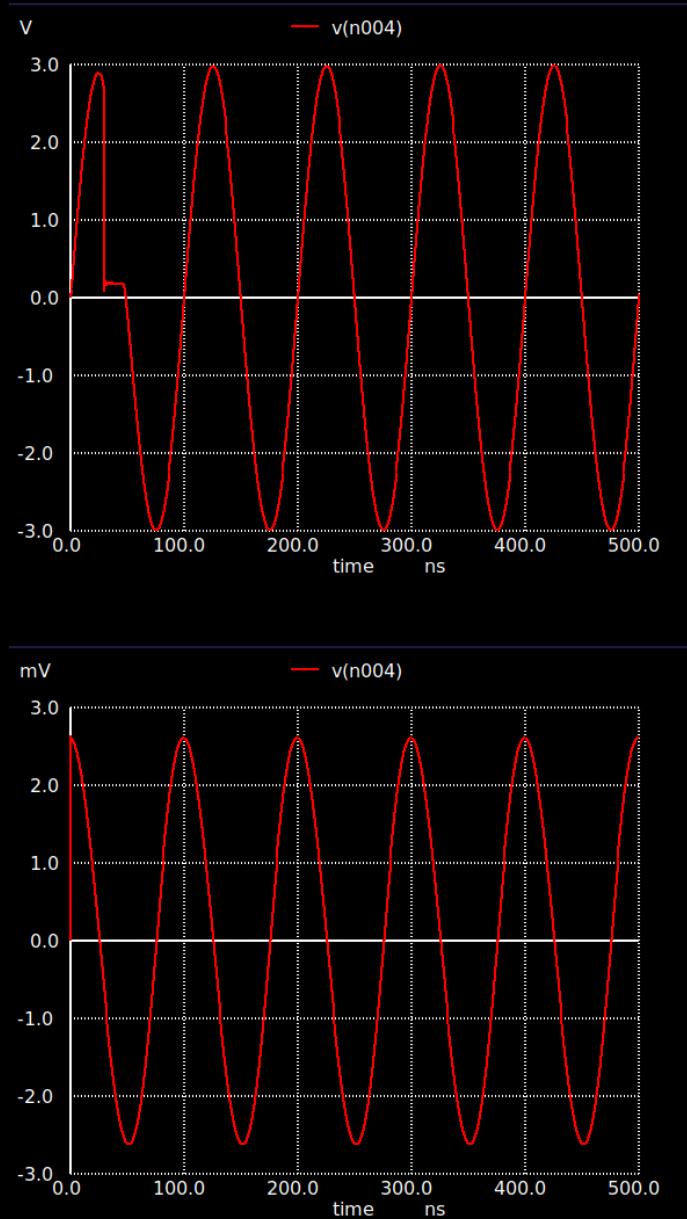
3.2 Design



3.3 Simulation Results (Ngspice)







3.4 Simulation Code (Ngspice)

```

vin N001 0 sin(0 3 10MEG 0 0)
c1 N002 N001 100n
r1 N002 0 500
d1 N003 N002 DRN142S
r2 N003 N005 500
c2 N004 N003 100n

```

```

r3 N004 0 50
Vbias N005 0 dc 1

.tran 1n 0.5u

.control
run

plot v(N004)

.endc
.end

```

3.5 Experimental Results

V_{bias}	I_d (mA)	V_{out}
0 V	1.36 mA	1.6
1 V	1.76 mA	
3 V	2.64 mA	
5 V	4.41 mA	
-5 V	0.21 mA	5.73

Table 3: RF Switch Characteristics: V_{bias} , I_d , and V_{out}

3.6 Experiment Completion Status

The experiment was completed during the lab hours but the actual hardware implementation didn't give satisfactory V_{out} result, despite changing several devices, equipments and even seeking help from TAs and RAs.