EE236: Experiment No. 3
PIN Diode I-V Characteristics usage as RF Switch

Narne Avinash , 200070047

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1 Overview of the experiment

1.1 Aim of the experiment

The aim of the experiment are:
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.

1.2 Methods

- Setup the circuit on bredaboard and the used oscilloscope to measure V_d and I_d

- Applied different frequency waveforms to measure RRT

- Compared V_d and I_d as V_{bias} changes

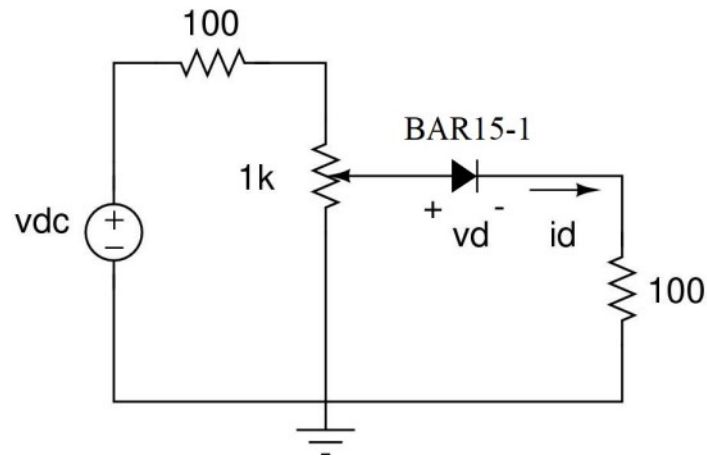# 2 Design

2.1 I-V Characteristics of PIN Diode

Figure 1: Circuit to measure I/V characteristics of a PIN Diode

Applied different potential V_d from 0-1V and measured I_d to plot the I-V characteristics
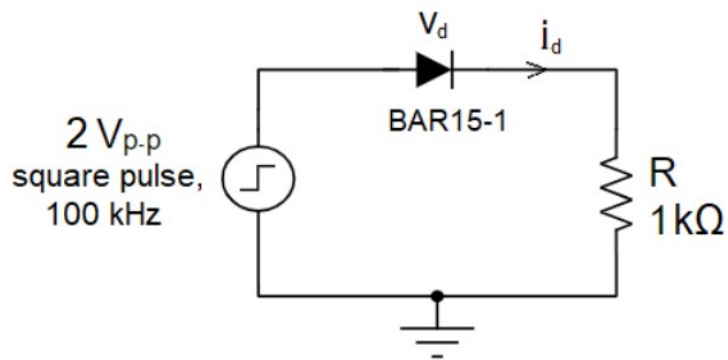
2.2 RRT PIN Diode

Figure 2: Circuit to measure reverse recovery time
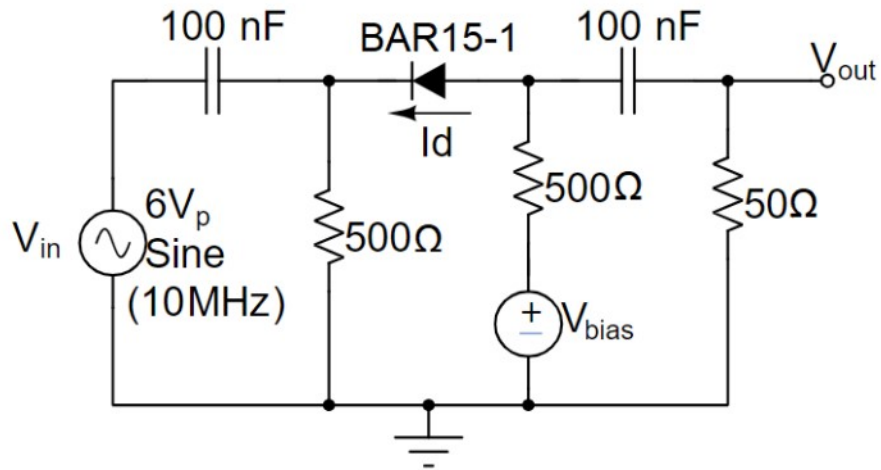
2.3 RF switch with PIN Diode

Figure 3: Circuit to characterize PIN diode as RF switch

V_{bias} is set to -5V, 0V, 1V, 3V, 5V and for each value of V_d I_d is measured and compared against PN diode

3 Simulation results

3.1 Code snippet

3.1.1 PIN Diode I-V Characteristics(PreLab)

```
.include rn142.txt
v1 1 0 dc
v2 1 2
r1 2 3 100
d1 3 0 DRN142S
.dc v1 0 1 .05
.control
run
plot i(v2) vs v(3)
.endc
```

3.1.2 RRT of RN142 Diode(PreLab)

```
.include rn142.txt
v1 1 0 pulse(-1, 1, 1us,1us, 1us, .05ms, .1ms)
v2 1 2
r1 2 3 100
d1 3 0 DRN142S
.tran .1us 1ms
.control
run
plot v(1), (2+100*i(v2))
.endc
```

3.1.3 RN142 diode as RF Switch(PreLab)

```
.include rn142.txt
v1 1 0 sin(0 3 10Meg 10ns)
c1 1 2 100n
r1 2 0 500
v2 2 6 dc 0
d1 3 6 DRN142S
r2 3 4 500
vb 4 0 dc -5
c2 3 5 100n
r3 5 0 50
.tran .00001u .5u
.control
run
set color2 = green
set color3 = blue
plot v(5) 10*i(v2)
.endc
.end
```

3.1.4 Dynamic Resistance of RF Switch (PostLab)

.include rn142.txt
v1 2 1 dc 1
v2 1 0 sine(0, .25, 1Meg, 1us)
d1 3 0 DRN142S
r1 2 3 1k
.tran 10ns 15us
.control
run
plot v(3) 100*i(v1)
meas tran vptp pp v(3) from=10u to=30u
meas tran iptp pp i(v1) from=10u to=30u
.endc
.end

3.2 Simulation results
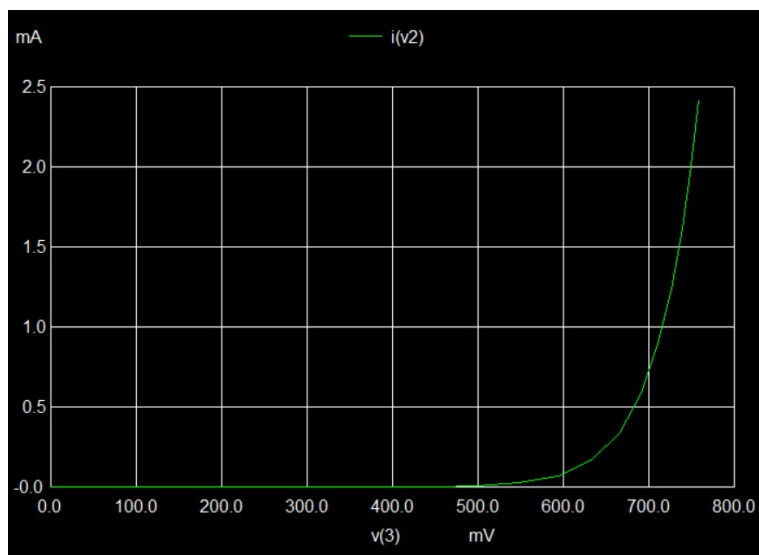
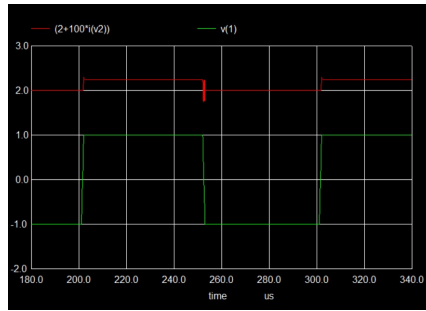### 3.2.1 PIN Diode I-V Characteristics(PreLab)
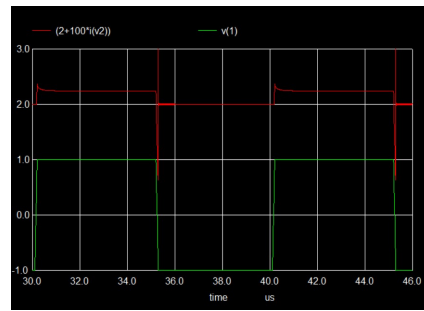

Figure 4: I-V Characteristics of RN142

At 1mA current voltage acroos diode is .715V. So, Cut-in Voltage = .715V
Using the given equation to find ideality factor. Using the $\ln(I_d)$ plot
Slope = 22.07
$\eta = 1.769$

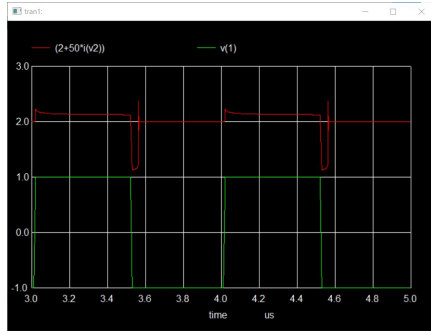$$ln(\frac{I_D}{I_0}) + \frac{E_g}{kT} = \frac{qV}{\eta kT}$$
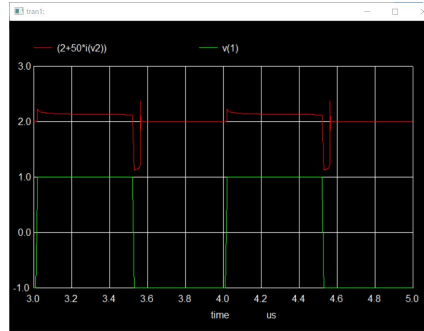
3.2.2 RRT of RN142 Diode(PreLab)

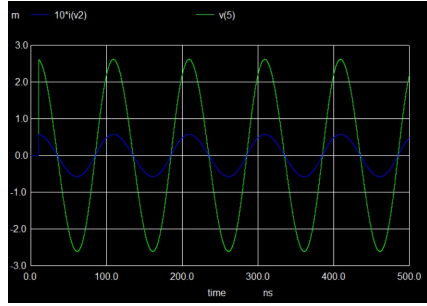(a) Frequency: 10Khz

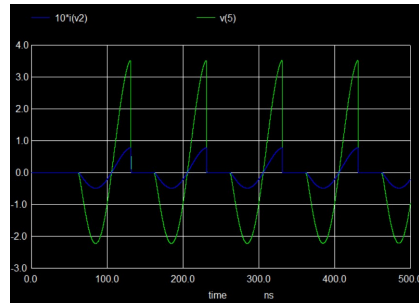(b) Frequency: 100Khz

(c) Frequency: 1Mhz

(d) Frequency: 10Mhz

Figure 5: RN142 Diode RRT Plots

RRT at freq :10KHz = .27 μs
RRT at freq :100KHz = .084 μs
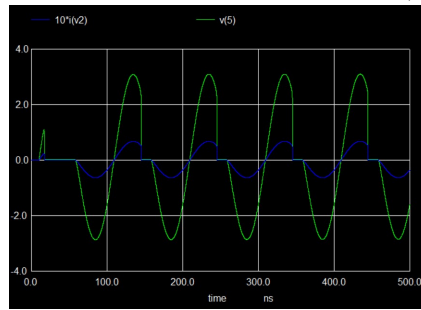RRT at freq :1MHz = 40 ns
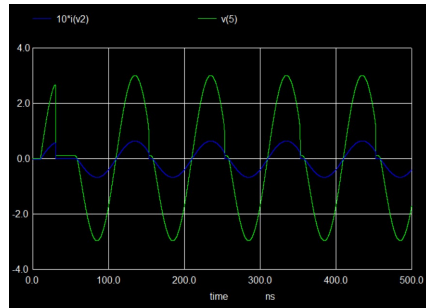RRT at freq :10mHz = 10ns

3.2.3 RN142 diode as RF Switch(PreLab)

(a) $V_{bias=-5V}$
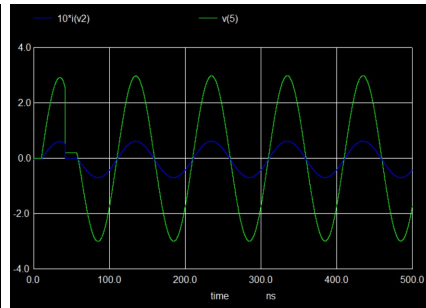
(b) $V_{bias=0V}$

(c) $V_{bias=1V}$

(d) $V_{bias=3V}$

(e) $V_{bias=5V}$

Figure 6: RN142 Diode Plots
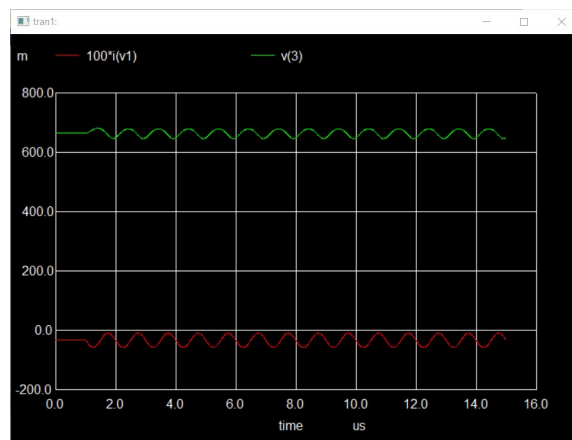
3.2.4 Dynamic Resistance of RF Switch (PostLab)

Figure 7: RN142 V_d and I_d plot

RF resistance at 1MHz = 67.58Ω
RF resistance at 10MHz = 102.2Ω

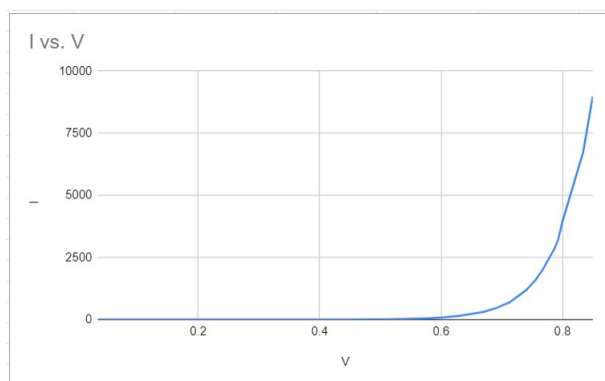# 4 Experimental results

4.1 I-V Characteristics of PIN Diode

Figure 8: PIN Diode I-V Characteristics

V	I (uA)
0.035	0
0.167	0
0.31	0.1
0.354	0.6
0.38	1
0.414	2.2
0.45	4.5
0.485	8.8
0.506	13.8
0.523	19.1
0.556	35.2
0.577	52.1
0.584	59.8
0.6	82.1
0.629	144
0.67	311
0.68	381
0.693	483
0.701	570
0.713	695
0.741	1202
0.749	1416
0.755	1576
0.767	1989
0.787	2860
0.793	3220
0.8	3950
0.834	6730
0.85	8980

Table 1: PIN Diode I-V Readings

4.2   RRT of PIN Diode

Freq	PIN (BAR15)	PN
10k	38us	2.4us
100K	5us	1.6us
1M	420ns	220ns
10M	46ns	

Table 2: RRT values of PIN and PN Diodes

4.3   PIN Diode as RF Switch

Vbias	PIN		PN	
	Id (mA)	Vout(V)	Id (mA)	Vout(V)
-5	0	0.7	0	1.05
0	0.075	1.8	0.027	10
1	0.55	5	0.0467	14.2
3	2.27	14.5	2.39	14.4
5	4.16	14.6	4.32	14.5

Table 3: V_{Out} and I_d for different V_{bias}

5   Experiment completion status

Experiment completed in the lab slot

6   Questions for reflection

Which diode has the potential of passing major portion of the input signal to the output at 10 MHz?

Ans: The PIN Diode has the potential to pass input to output at 10MHz