EE236: Experiment 2

Sheel F. Shah, 19D070052

January 19, 2022

1 Overview of the experiment

1.1 Aim of the experiment

The aim of this experiment was to understand the I-V characteristics of a schottky and zener diode and study the operation of the regulator and doubler circuits.

1.2 Report Pattern

Instead of following the template, I have split the report into sections based on the questions/simulations. Each section is based on one question/simulation, and all associated details are in that section only

2 IV characteristics of schottky diode

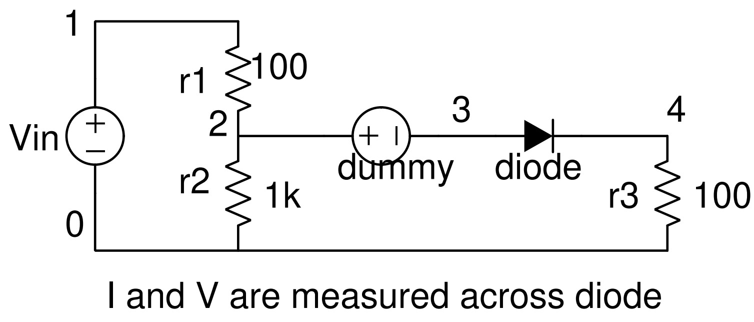

Figure 1: Circuit used

Netlist used:

```
19D070052 Sheel sxhottky iv

.include models/Diode_1N914.txt
.include models/schottky_BAT960.txt
.include models/schottky_BAT85.txt

v_dc 1 0
r_1_diode 1 12 100
r_2_diode 12 0 1k
** dummy voltage
v_d_diode 12 13 0
d_diode 13 14 1N914
r_3_diode 14 0 100

r_1_bat960 1 22 100
r_2_bat960 22 0 1k
** dummy voltage
v_d_bat960 22 23 0
x_bat960 23 24 BAT960
r_3_bat960 24 0 100

r_1_bat85 1 32 100
r_2_bat85 32 0 1k
```

```
** dummy voltage
v_d_bat85 32 33 0
x_bat85 33 34 BAT85
r_3_bat85 34 0 100

.dc v_dc 0 2 0.01

.control

run
plot i(v_d_diode) vs v(13)-v(14) i(v_d_bat960) vs v(23)-v(24) i(v_d_bat85) vs v(33
.endc

.end
```

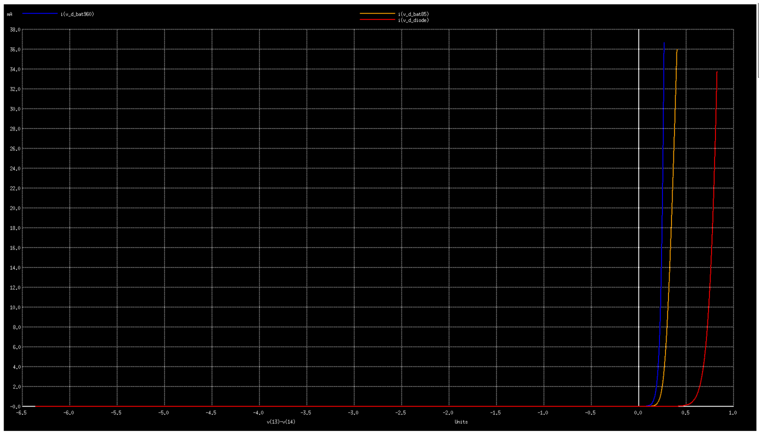

Figure 2: IV Characteristics
Cut-in voltages are 0.2, 0.25, 0.6 mV for bat960, bat85, 1n914

3 Rectifier with schottky diode

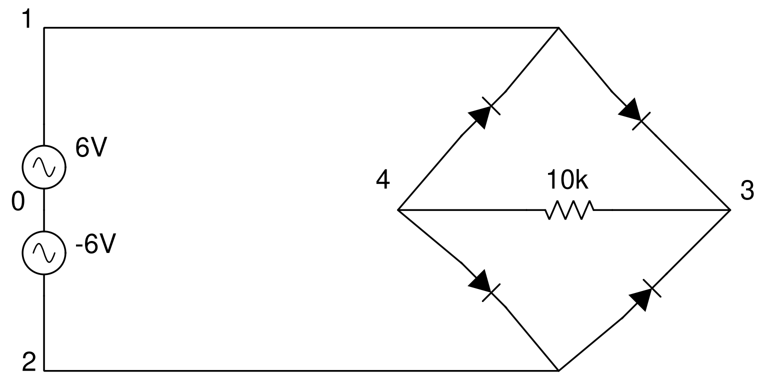

Figure 3: Circuit used

Netlist used:

```
19D070052 Sheel Shah Bridge Rectifier

.include models/schottky_BAT85.txt
v_in1 1 0 sin(0 6 50 0 0)
v_in2 2 0 sin(0 -6 50 0 0)
x1 1 3 BAT85
x2 2 3 BAT85
x3 4 2 BAT85
x4 4 1 BAT85

r_l 3 4 10k

.tran 0.1m 40m
.control
set color0 = rgb:f/f/f
set color1 = rgb:1/1/1

run

plot v(3) - v(4), v(1)-v(2)
```

```
.endc

.end
```

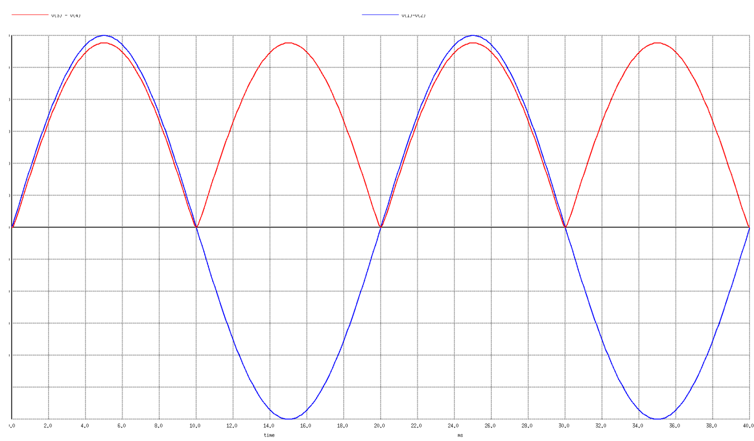

Figure 4: Rectifier output

We see that the output voltage is closer to 12V for schottky diodes as their forward voltage drop is lower

4 Reverse recovery of schottky diode

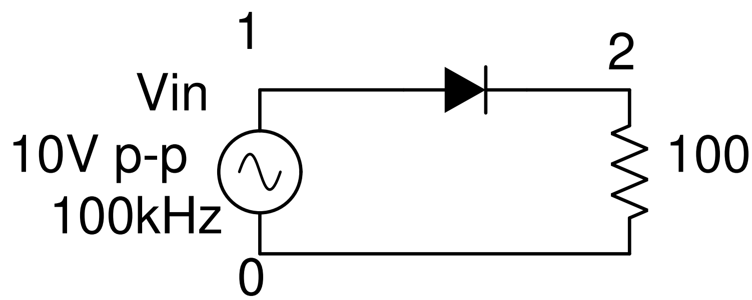

Figure 5: Circuit used

Netlist used:

```
19D070052 Sheel schottky reverse recovery

.include models/schottky_BAT85.txt
.include models/1N4007.txt

** 100k pulse
v_in 1 0 pulse(-5 5 0 0 0 5u 10u)
* d_diode 1 2 DI_1N4007
x_diode 1 2 BAT85
r3 2 0 100

.tran 0.1u 100u
.control

run
plot v(2) v(1)
.endc

.end
```

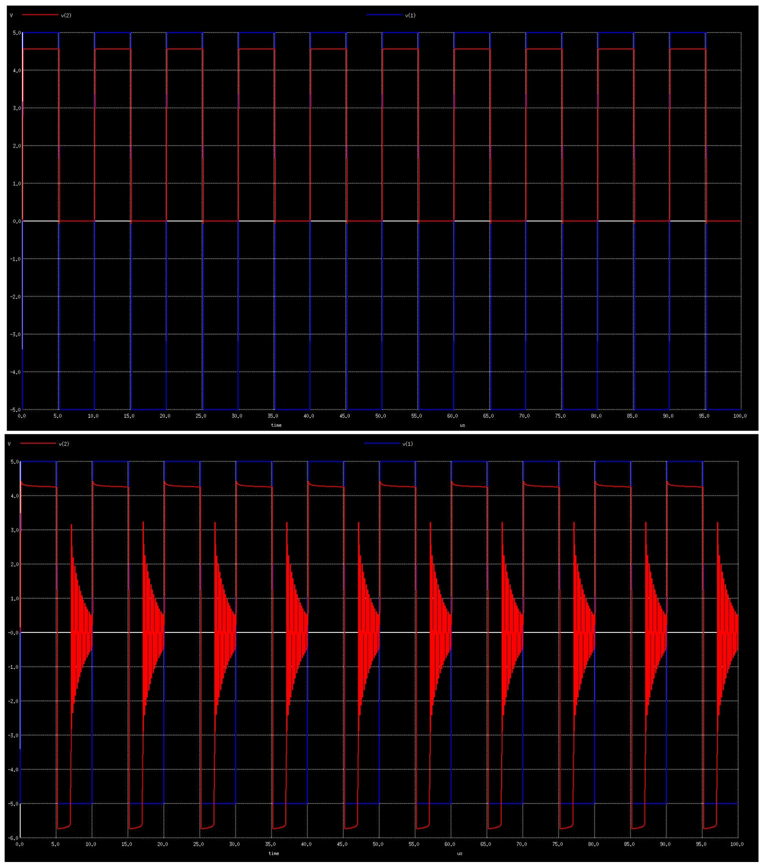

Figure 6: Rectifier output

We see that the reverse recovery time for the schottky diode (in ns) is significantly lower than pn diode. This feature can be used for design in high speed applications

5 IV characteristic of zener diode

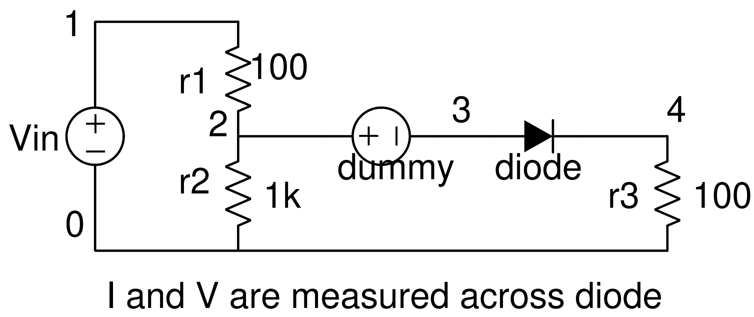

Figure 7: Circuit used

Netlist used:

```
19D070052 Sheel zener iv

.include models/zener.txt

v_dc 1 0
r_1_diode 1 12 100
r_2_diode 12 0 1k
** dummy voltage
v_d_diode 12 13 0
x_diode 13 14 DI_1N4734A
r_3_diode 14 0 100

.dc v_dc -8 8 0.01

.control

run
plot i(v_d_diode) vs v(13)-v(14)
.endc

.end
```

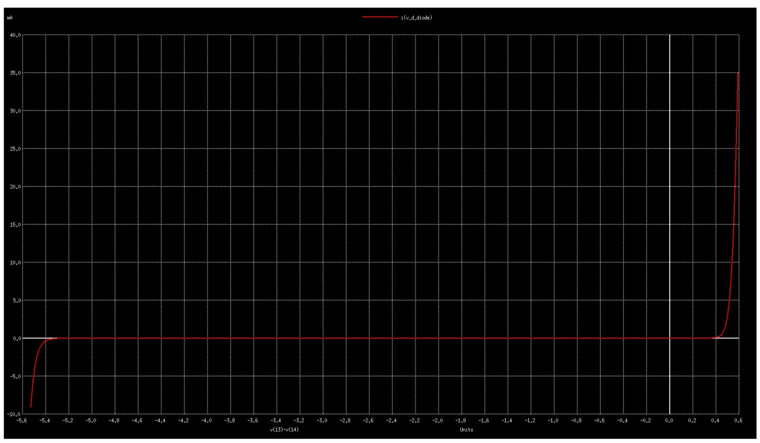

Figure 8: IV characteristic of zener diode

6 Voltage regulator using zener diode

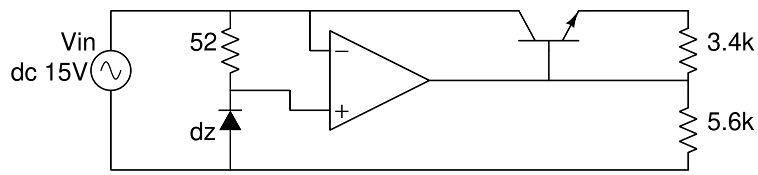

Figure 9: Circuit used

Netlist used:

```
19D070052 Sheel Voltage regulator using zener

.include models/zener.txt
.include models/ua741.txt
.include models/bc547.txt

** nodes: 1 v_s = vcc_opamp = collector_bjt
** 2 v_z = +_opamp
** 3 -_opamp = r2
** 4 out_opamp = base_bjt
** 5 emitter_bjt = r_load
v_s 1 0 sin(15 0.1 20 0 0)
r_s 1 2 52
x_zener 0 2 DI_1N4734A
x_opamp 2 3 1 0 4 ua741
q_bjt 1 4 5 bc547a
r1 5 3 3.4k
r2 3 0 5.6k
* r_load 5 0 0

.tran 0.1ms 1s

.control

run
plot v(5) v(1)
```

```
.endc

.end
```

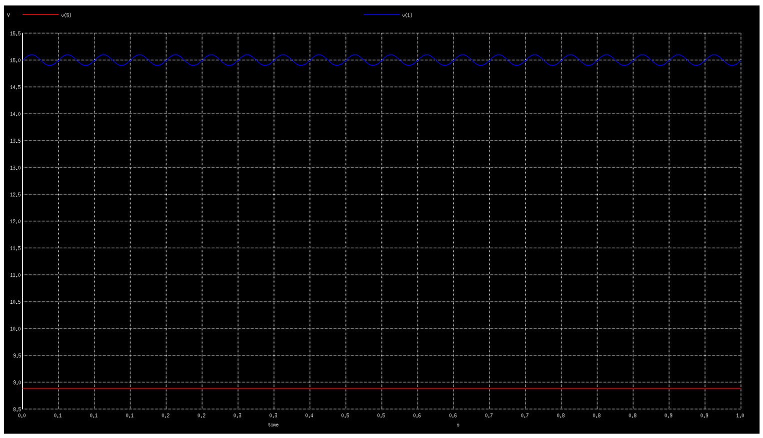

Figure 10: V_{out}(red) and V_{in}(blue)

Calculation of R_s:

$$I_s = P_z/V_z = 1/5.6$$

$$R_s = V_{R_s}/I_s = 1(5 - 5.6)/I_s$$

$$\therefore R_s = 52\Omega$$

The BJT used in the circuit is in emitter follower mode and hence is used as a buffer in this circuit

7 Design question 1

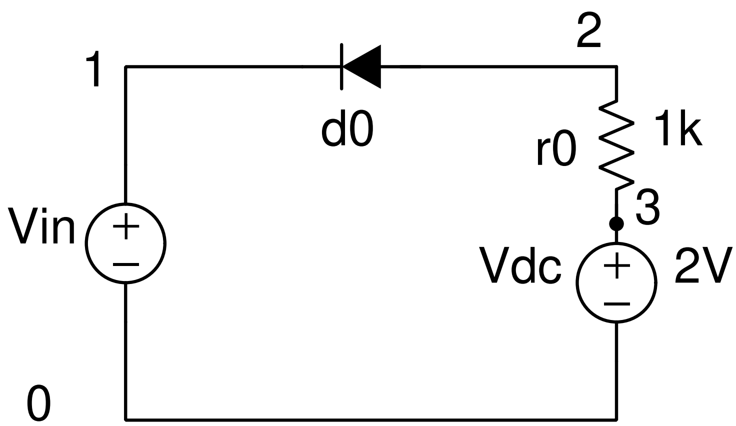

Figure 11: Circuit used (based on serial clipper)

Netlist used:

```
19D070052 Sheel Shah Design 1
** used shunt clipper with schottky instead of pn

v_in 1 0
d0 2 1
r0 2 3 1k
v_dc 3 0 2.3
.dc v_in -5 5 0.01
.control
run
plot v(2) vs v(1)
.endc
.end
```

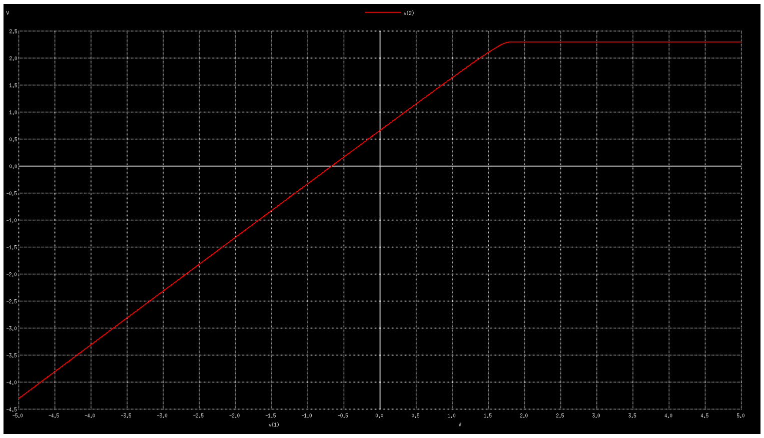

Figure 12: V_{out} vs V_{in}

8 Design question 2

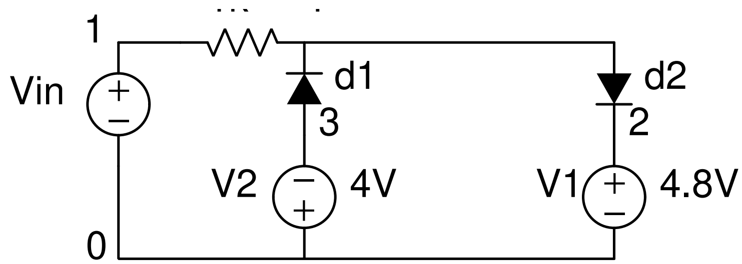

Figure 13: Circuit used (based on shunt clipper)

Netlist used:

```
19D070052 Sheel Shah Design 1
** used shunt clipper with schottky instead of pn

v_in 1 0
d0 2 1
r0 2 3 1k
v_dc 3 0 2.3
.dc v_in -5 5 0.01
.control
run
plot v(2) vs v(1)
.endc
.end
```

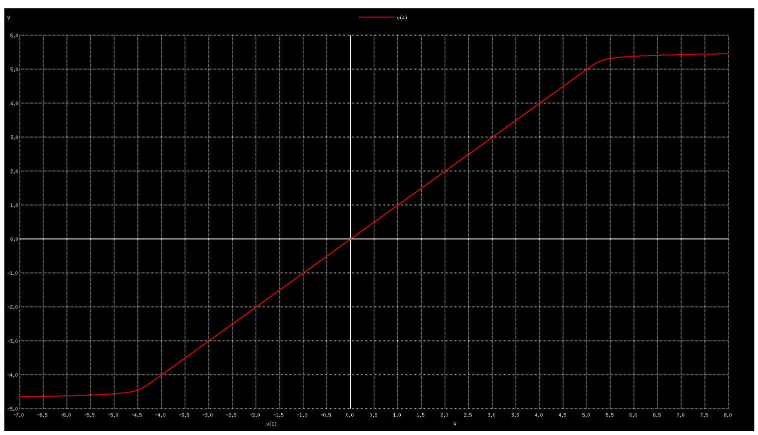

Figure 14: V_{out} vs V_{in}

9 Voltage doubler circuit

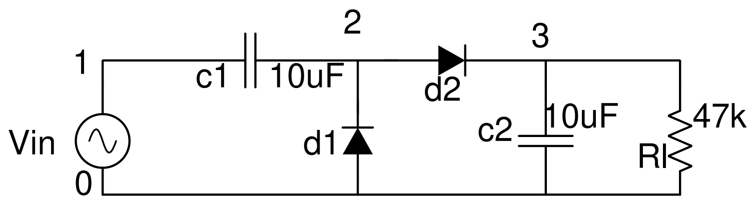

Figure 15: Circuit used (as given in sheet)

Netlist used:

```
19D070052 Sheel Voltage doubler


v_in 1 0 sin(0 10 1k 0 0)
c1 1 2 10u
d1 0 2
d2 2 3
c2 3 0 10u
r_l 3 0 47k

.tran 10u 20m
.control

run
plot v(3) v(1)
.endc

.end
```

C1 is charged to 10V, and C2 to 20V.
The circuit output is 20V(ignoring diode drops)
The output will fluctuate if 4.7k resistor is used instead of 47k. This is because time constant RC becomes lower, and hence the inertia is lost, causing the steady state output to fluctuate with input.

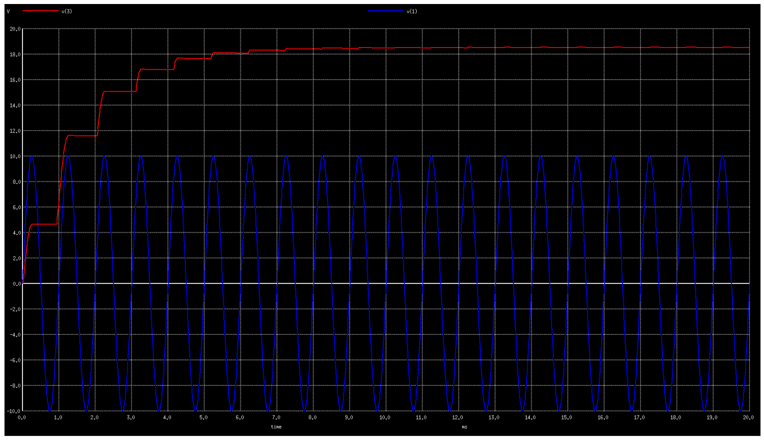

Figure 16: V_{out}(red) vs V_{in}(blue)

10 Experiment completion status

I was able to complete all parts of the experiment.