EE230: Experiment No.02
Zener and BJT Regulator

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1 Overview of the experiment

1.1 Aim of the experiment

Aim of this experiment is :
1.Understanding the limits of performance of a Zener regulator
2. Understanding a BJT based series voltage regulator to appreciate the basic blocks of an IC voltage regulator.

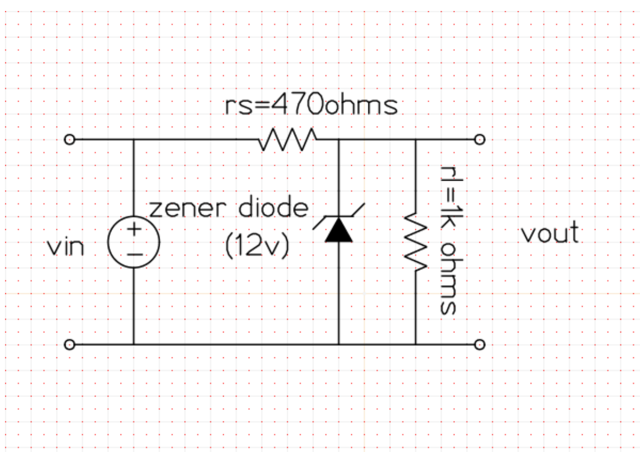
1.2 Methods

I used ngspice software to write code and performed DC analysis for different parameters for zener regulator circuit like changing Load resistance value to 1,10,100,500,1000 ohms and for BJT regulator circuit Load resistance value at 1k ohms and then printed out hardcopy of vout vs vin and currents across different nodes of the circuit , and then extracted output files from each .cir ngspice file in .txt format and then used matplotlib to visualise this data from text file .

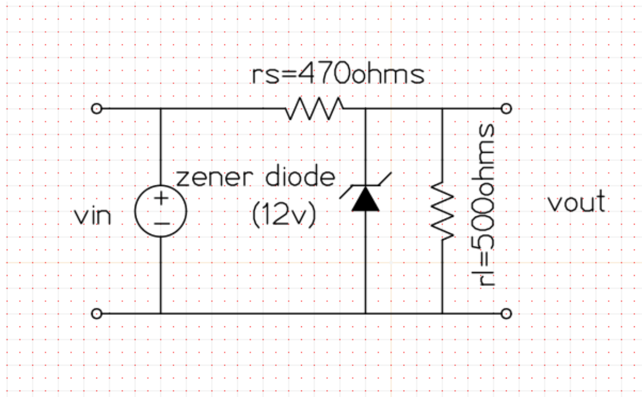
2 Design

2.1 Zener regulator

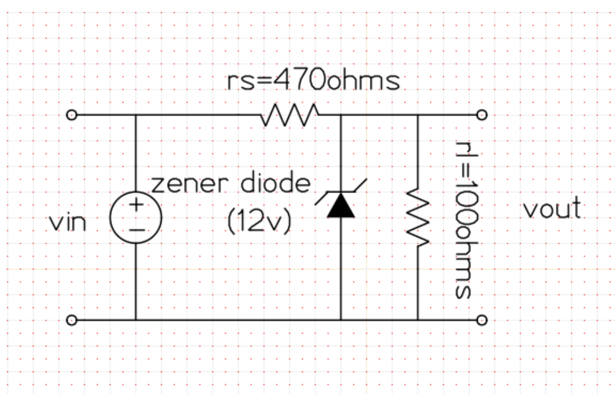
Case 1: Load resistance (R_l)= 1k ohms.
connect a constant 20 volts source with resistances and zener diode as shown below and measure vout at load resistance (R_l).
for $v_{in} = 20v$:
$v_{out} = 1.226269 * 10^{01} V$
$i_{vs} = 1.646236 * 10^{-02} A$
$i_{vze} = 4.199669 * 10^{-03} A$
$i_{vl} = 1.226269 * 10^{-02} A$
Now connect a varying volatage source with resistances and zener diode as shown below and measure vout at load resistance (R_l). **Case 2: Load**



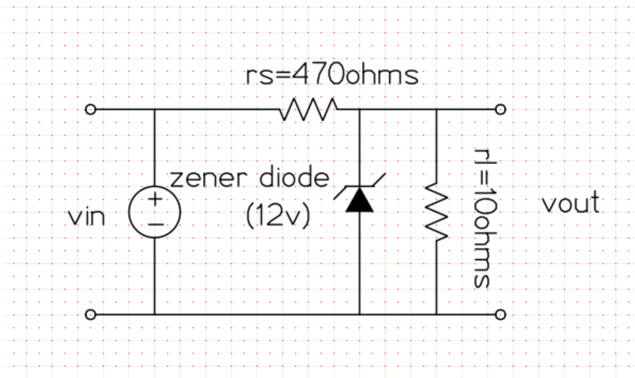
resistance (R_l)= 500 ohms.
connect a varying volatage source with resistances and zener diode as shown below and measure vout at load resistance (R_l).



Case 2: Load resistance (R_l)= 100 ohms.
connect a varying volatage source with resistances and zener diode as shown below and measure vout at load resistance (R_l).

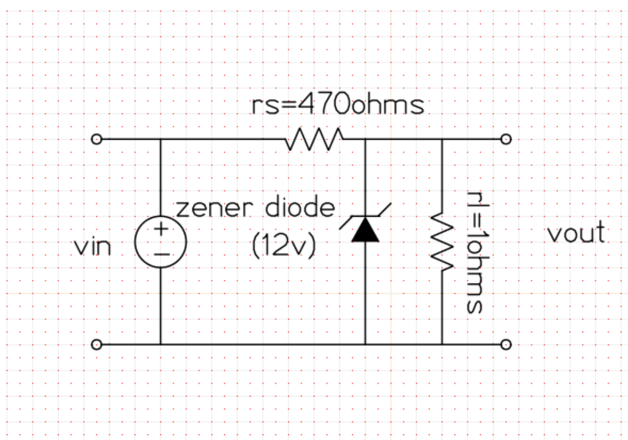


Case 2: Load resistance (R_l)= 10 ohms.
connect a varying volatage source with resistances and zener diode as shown below and measure vout at load resistance (R_l).

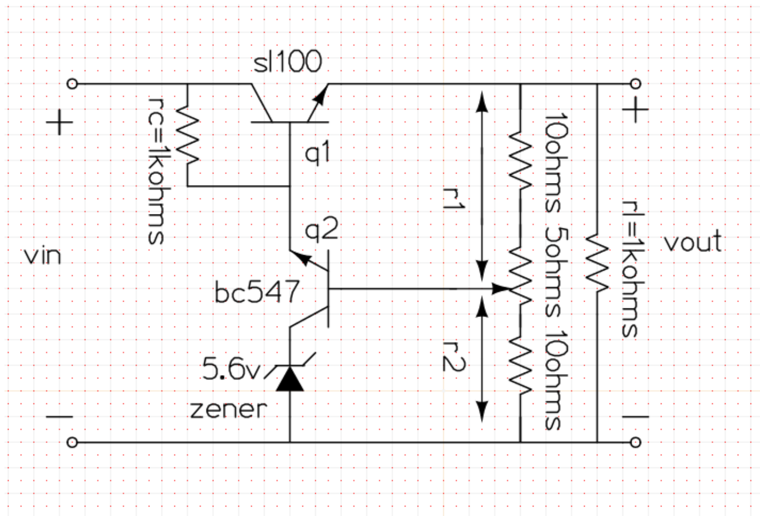


Case 2: Load resistance (R_l)= 1 ohms.

connect a varying volatage source with resistances and zener diode as shown below and measure vout at load resistance (R_l).



2.2 BJT Regulator



Case 1: V_{in} is 20v , R_1 and R_2 =12.5v
Connect the circuit as shown above , we get $v_{out} = 13.78716v$ which is close to theoritical value.

Case 2:V_{in} is 20v ,$R_1 = 10.21kohms$ and $R_2 = 14.79kohms$
Connect the circuit as shown above , we get $v_{out} = 12v$.

Case 3:V_{in} is varried from 15 v to 25 v and DC analysis is performed in steps of 0.5 v

3 Simulation results

3.1 Code snippet

3.1.1 Zener regulator

Case 1: Load resistance (R_l)= 1k ohms and $v_{in} = 20v$

```
zener regulator
.subckt ZENER_12 1 2
d1 1 2 df
dz 3 1 dr
vz 2 3 10.8
.model df D ( IS=27.5p RS=0.620 N=1.10 CJO=78.3p VJ=1.00 M=0.330
TT=50.1n)
.model dr D ( IS=5.49f RS=50 N=1.77 )
.ends
r1 1 2 470
vs 2 3 0
x1 4 3 ZENER_12
vze 4 0 0
r2 3 5 1k
vl 5 0 0
vin 1 0 20
.op
.control
run
print v(2)
print v(1)
print i(vs)
print i(vze)
print i(vl)
.endc
.end
```

For other cases only load resistance value r(2) is changed in code for zener regulator and operating point analysis is performed.

Case 2: Load resistance (R_l)= 1k ohms nd v_{in} varies from 15 to 20v.

```
zener regulator
.subckt ZENER_12 1 2
d1 1 2 df
dz 3 1 dr
vz 2 3 10.8
.model df D ( IS=27.5p RS=0.620 N=1.10 CJO=78.3p VJ=1.00 M=0.330
TT=50.1n)
.model dr D ( IS=5.49f RS=50 N=1.77 )
.ends
r1 1 2 470
vs 2 3 0
x1 4 3 ZENER_12
vze 4 0 0
r2 3 5 1k
vl 5 0 0
vin 1 0
.dc vin 15 25 0.5
.control
run
print i(vl)
plot v(1) v(3)
plot i(vs) i(vze) i(vl)
.endc
.end
```

3.1.2 BJT regulator

Case 1: V_{in} is 20v , R_1 and R_2 =12.5v

```
BJT regulator
.subckt ZENER_12 1 2
d1 1 2 df
dz 3 1 dr
vz 2 3 4.4
.model df D ( IS=27.5p RS=0.620 N=1.10 CJO=78.3p VJ=1.00 M=0.330
TT=50.1n)
.model dr D ( IS=5.49f RS=50 N=1.77 )
.ends
.include low_power_bjt.txt
.include sl500_bjt.txt
Q1 1 2 3 SL100
vin 1 0 20
rc 1 2 1k
r1 3 5 12.5k
r2 5 0 12.5k
rl 3 0 1k
Q2 2 5 4 bc547a
x1 0 4 ZENER_12
.op
.control
run
print v(1) v(2)-v(3) v(2)-v(5) v(1)-v(3) v(1)-v(2) v(2)-v(5) v(5)-v(4) v(3)-
v(5) v(5)-v(0) v(3)
.endc
.end
```

Case 2:V_{in} **is 20v ,**$R_1 = 10.21 kohms$ **and** $R_2 = 14.79 kohms$

```
BJT regulator
.subckt ZENER_12 1 2
d1 1 2 df
dz 3 1 dr
vz 2 3 4.4
.model df D ( IS=27.5p RS=0.620 N=1.10 CJO=78.3p VJ=1.00 M=0.330
TT=50.1n)
.model dr D ( IS=5.49f RS=50 N=1.77 )
.ends
.include low_power_bjt.txt
.include sl500_bjt.txt
Q1 1 2 3 SL100
vin 1 0 20
rc 1 2 1k
r1 3 5 10.21k
r2 5 0 14.79k
rl 3 0 1k
Q2 2 5 4 bc547a
x1 0 4 ZENER_12
.op
.control
run
print v(1) v(2)-v(3) v(2)-v(5) v(1)-v(3) v(1)-v(2) v(2)-v(5) v(5)-v(4) v(3)-
v(5) v(5)-v(0) v(3)
.endc
.end
```

Case 3:V_{in} **is varried from 15 v to 25 v and DC analysis is performed in steps of 0.5 v and** $R_1 = 10.21kohms$ **and** $R_2 = 14.79kohms$

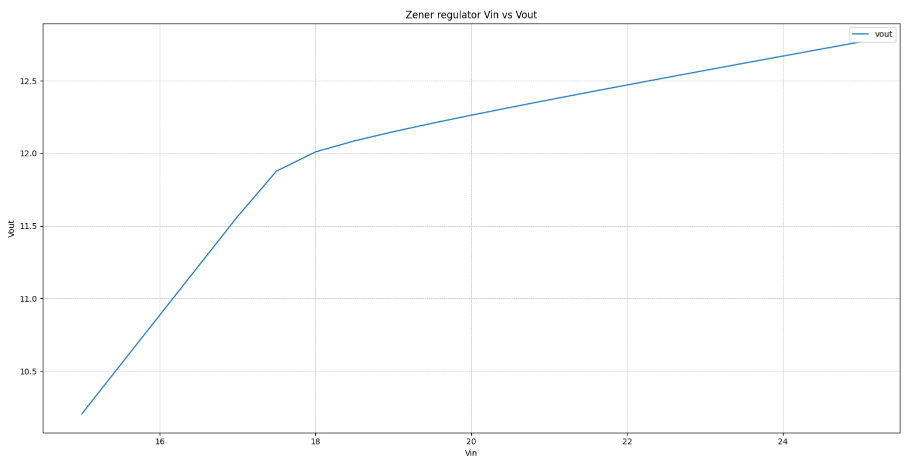
```
BJT regulator
.subckt ZENER_12 1 2
d1 1 2 df
dz 3 1 dr
vz 2 3 4.4
.model df D ( IS=27.5p RS=0.620 N=1.10 CJO=78.3p VJ=1.00 M=0.330
TT=50.1n)
.model dr D ( IS=5.49f RS=50 N=1.77 )
.ends
.include low_power_bjt.txt
.include sl500_bjt.txt
Q1 1 2 3 SL100
vin 1 0
rc 1 2 1k
r1 3 5 10.21k
r2 5 0 14.79k
rl 3 0 1k
Q2 2 5 4 bc547a
x1 0 4 ZENER_12
.dc vin 15 25 0.5
.control
run
print v(3)
plot v(1) v(3)
.endc
.end
```

3.2 Simulation results

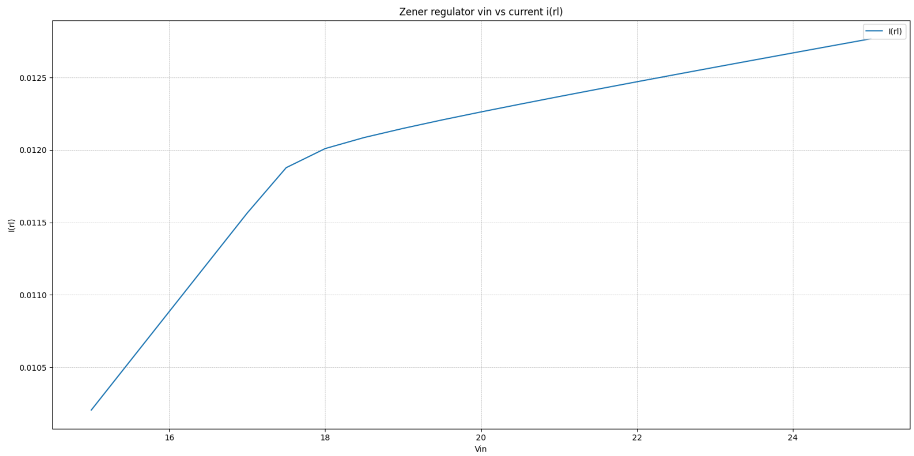
3.2.1 zener regulator

Case 1: Load resistance (R_l)= 1k ohms and v_{in} varies from 15 to 20v.

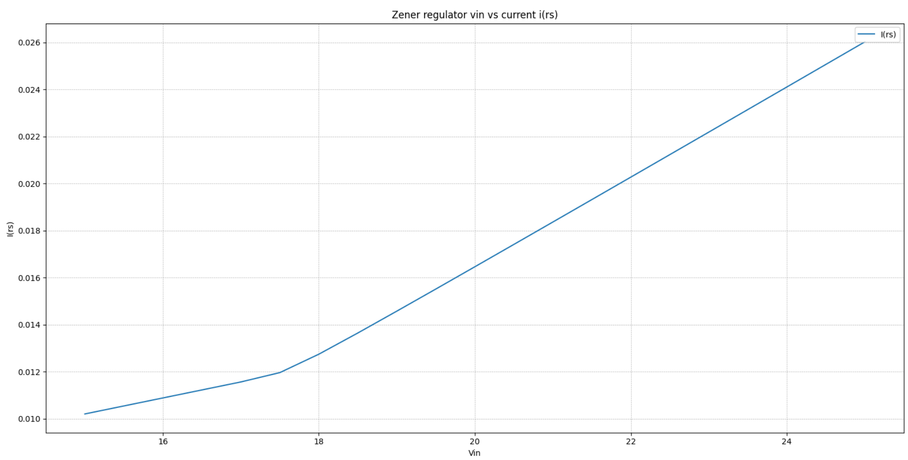
X-axis is V_{in} axis in volts and Y- axis is V_{out} axis . plot shows linear curve till some point and bends a little.



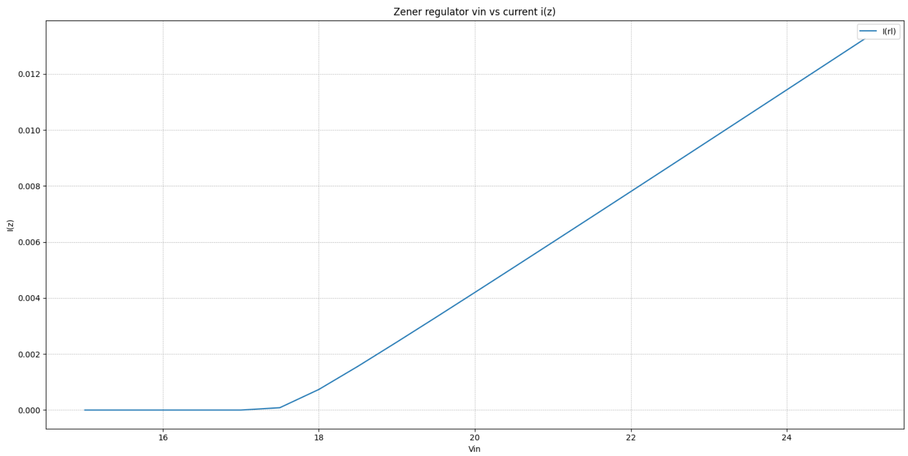
X-axis is V_{in} axis in volts and Y- axis is I_{rl} axis . plot shows linear curve till some point and bends a little.



X-axis is V_{in} axis in volts and Y- axis is I_{rs} axis . plot shows linear curve till some point and rises up a little.

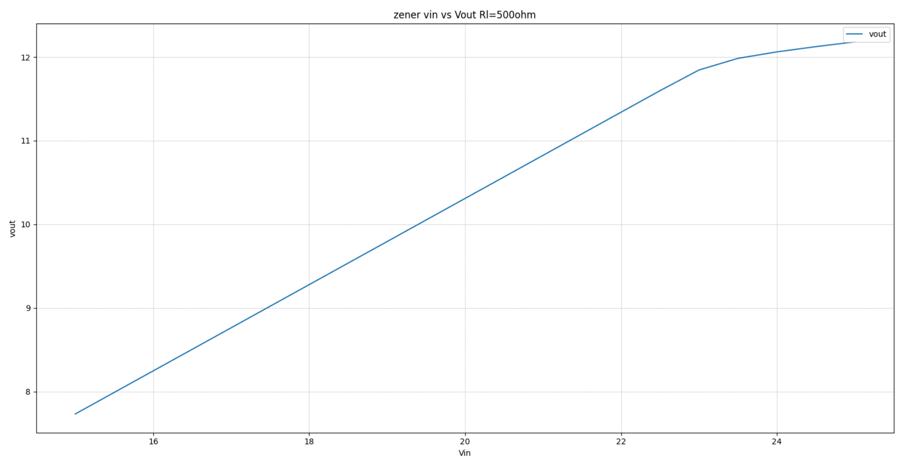


X-axis is V_{in} axis in volts and Y- axis is I_z axis . plot shows linear curve till some point and rises up a little.



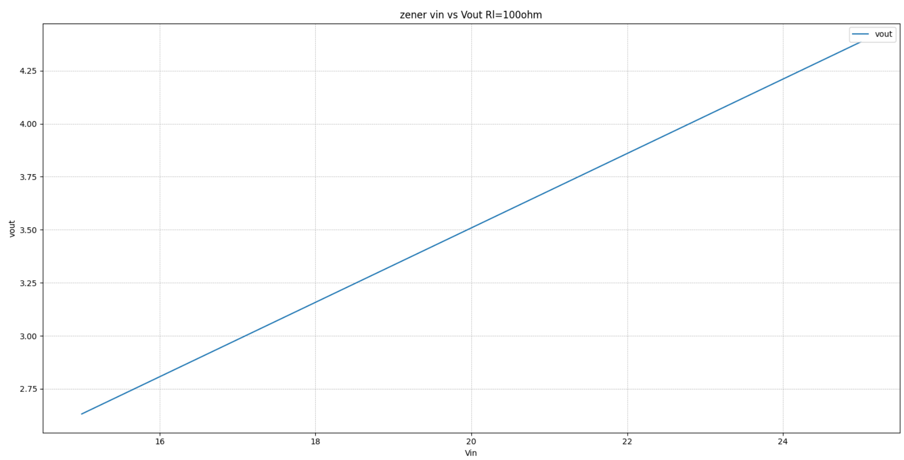
Case 2: Load resistance (R_l)= 500 ohms and v_{in} varies from 15 to 20v.

X-axis is V_{in} axis in volts and Y- axis is V_{out} axis . plot shows linear curve till some point and bends a little.



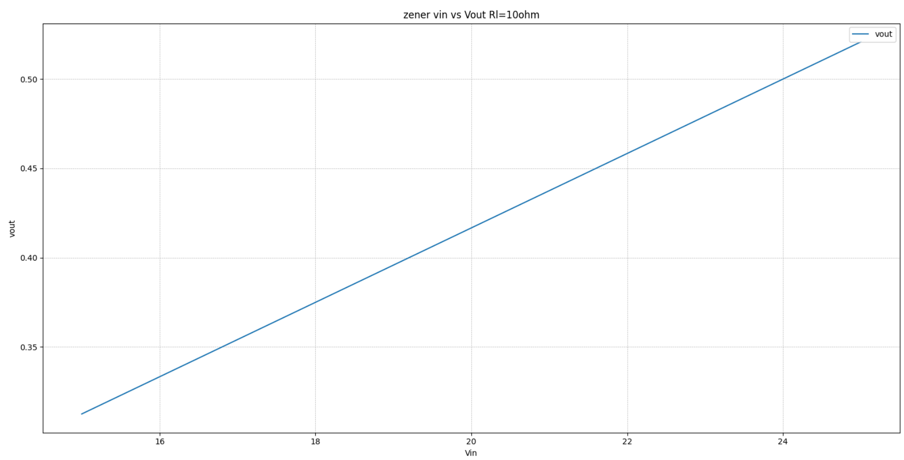
Case 3: Load resistance (R_l)= 100 ohms and v_{in} varies from 15 to 20v.

X-axis is V_{in} axis in volts and Y- axis is V_{out} axis . plot shows linear curve.



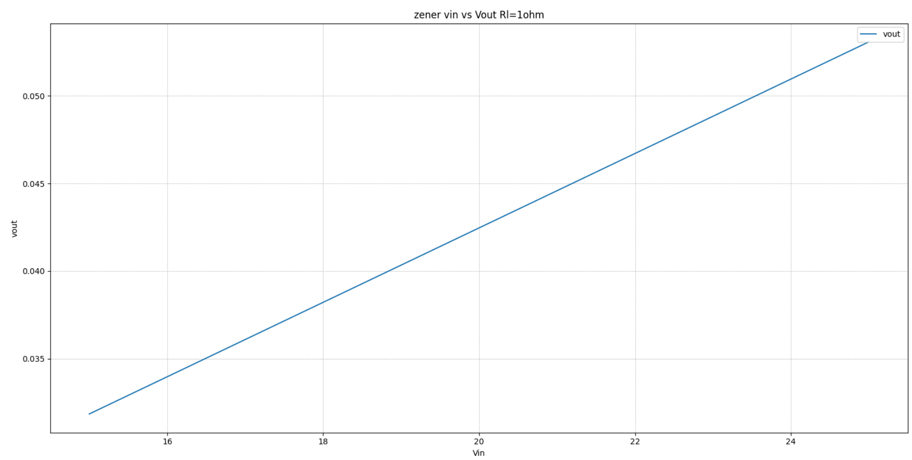
Case 4: Load resistance (R_l)= 10 ohms and v_{in} varies from 15 to 20v.

X-axis is V_{in} axis in volts and Y- axis is V_{out} axis . plot shows linear curve.



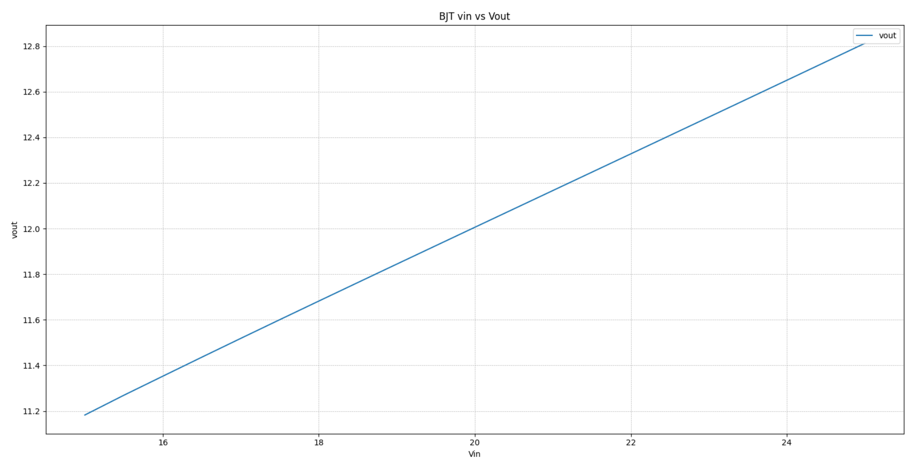
Case 5: Load resistance (R_l)= 1 ohms and v_{in} varies from 15 to 20v.

X-axis is V_{in} axis in volts and Y- axis is V_{out} axis . plot shows linear curve.



3.2.2 BJT regulator

Case 1:V_{in} **is varried from 15 v to 25 v and DC analysis is performed in steps of 0.5 v and** $R_1 = 10.21 kohms$ **and** $R_2 = 14.79 kohms$
X-axis is V_{in} axis in volts and Y- axis is V_{out} axis . plot shows linear curve .



4 Experimental results

Table 1: zener regulator voltage and current values for $v_{in} = 20v$.

Sr. No.	Rl=1k ohms	Rl=500 ohms	Rl=100 ohms	Rl=10 ohms	Rl=1 ohms
Vout	12.26269V	10.30928V	3.508772V	0.4166667V	0.04246285V
Ivs	0.01646236A	0.02061856A	0.03508772A	0.04166667A	0.04246285A
Ivl	0.01226269A	0.02.061856A	0.03508772A	0.04166667A	0.04246285A

5 Experiment completion status

I have completed all sections in Lab only.