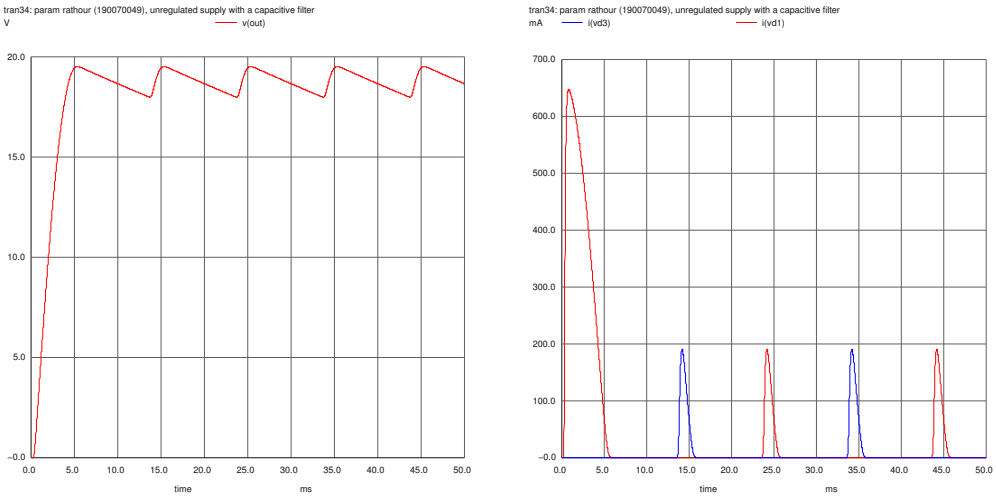
EE230 - Experiment 2

Param Rathour - 190070049
Autumn Semester 2021-22

1 Unregulated Supply with Capacitive Filter

1.1 Plots



(a) V_{out} (b) Currents through the diodes D_1 and D_3

Figure 1.1: $R_L = 1k$ and $C = 100\mu F$

1.2 Code

```
Param Rathour (190070049), Unregulated Supply with a Capacitive Filter
.include Diode_1N914.txt                                    ; Includes Diode Model
.param Vpeak = {15*sqrt(2)}                                 ; Peak Voltage

* Elements
Vin in mid sin(0 Vpeak 50 0 0)                              ; Input Voltage
Vd1 in d1 0                                                 ; Dummy Voltages
Vd3 mid d3 0

D1 d1 out 1N914                                             ; Diodes
D2 gnd in 1N914
D3 d3 out 1N914
D4 gnd mid 1N914

RL out gnd 1k                                               ; Resistor
C1 out gnd 100u                                             ; Capacitor

.tran 0.01m 50m                                             ; Transient Analysis

.control                                                    ; Control Functions
run

plot v(out)
plot i(Vd1) i(Vd3)
.endc
.end
```

1.3 Learnings

As Capacitance value is increased the ripple voltage decreases (output voltage becomes smoother).
But then the Diode current increases which can cause damage to Diode (if $> 1\text{m}A$).
The reason is because the Diode conducts current for a very short time. So, current increases to maintain the average.

2 DC Power Supply with Zener Diode Regulator

2.1 Values

Index	V_{in}	V_{out}	I_S	I_Z	I_L
0	$1.500000 \cdot 10^{+1}$	$1.020408 \cdot 10^{+1}$	$1.020408 \cdot 10^{-2}$	$3.710267 \cdot 10^{-11}$	$1.020408 \cdot 10^{-2}$
1	$1.550000 \cdot 10^{+1}$	$1.054422 \cdot 10^{+1}$	$1.054422 \cdot 10^{-2}$	$3.778295 \cdot 10^{-11}$	$1.054422 \cdot 10^{-2}$
2	$1.600000 \cdot 10^{+1}$	$1.088435 \cdot 10^{+1}$	$1.088435 \cdot 10^{-2}$	$3.849787 \cdot 10^{-11}$	$1.088435 \cdot 10^{-2}$
3	$1.650000 \cdot 10^{+1}$	$1.122449 \cdot 10^{+1}$	$1.122449 \cdot 10^{-2}$	$9.754691 \cdot 10^{-11}$	$1.122449 \cdot 10^{-2}$
4	$1.700000 \cdot 10^{+1}$	$1.156459 \cdot 10^{+1}$	$1.156469 \cdot 10^{-2}$	$9.838411 \cdot 10^{-8}$	$1.156459 \cdot 10^{-2}$
5	$1.750000 \cdot 10^{+1}$	$1.187787 \cdot 10^{+1}$	$1.196197 \cdot 10^{-2}$	$8.409802 \cdot 10^{-5}$	$1.187787 \cdot 10^{-2}$
6	$1.800000 \cdot 10^{+1}$	$1.200973 \cdot 10^{+1}$	$1.274526 \cdot 10^{-2}$	$7.355326 \cdot 10^{-4}$	$1.200973 \cdot 10^{-2}$
7	$1.850000 \cdot 10^{+1}$	$1.208601 \cdot 10^{+1}$	$1.364678 \cdot 10^{-2}$	$1.560762 \cdot 10^{-3}$	$1.208601 \cdot 10^{-2}$
8	$1.900000 \cdot 10^{+1}$	$1.214904 \cdot 10^{+1}$	$1.457651 \cdot 10^{-2}$	$2.427471 \cdot 10^{-3}$	$1.214904 \cdot 10^{-2}$
9	$1.950000 \cdot 10^{+1}$	$1.220753 \cdot 10^{+1}$	$1.551589 \cdot 10^{-2}$	$3.308364 \cdot 10^{-3}$	$1.220753 \cdot 10^{-2}$
10	$2.000000 \cdot 10^{+1}$	$1.226282 \cdot 10^{+1}$	$1.646208 \cdot 10^{-2}$	$4.199255 \cdot 10^{-3}$	$1.226282 \cdot 10^{-2}$
11	$2.050000 \cdot 10^{+1}$	$1.231638 \cdot 10^{+1}$	$1.741195 \cdot 10^{-2}$	$5.095567 \cdot 10^{-3}$	$1.231638 \cdot 10^{-2}$
12	$2.100000 \cdot 10^{+1}$	$1.236880 \cdot 10^{+1}$	$1.836426 \cdot 10^{-2}$	$5.995462 \cdot 10^{-3}$	$1.236880 \cdot 10^{-2}$
13	$2.150000 \cdot 10^{+1}$	$1.242034 \cdot 10^{+1}$	$1.931842 \cdot 10^{-2}$	$6.898083 \cdot 10^{-3}$	$1.242034 \cdot 10^{-2}$
14	$2.200000 \cdot 10^{+1}$	$1.247121 \cdot 10^{+1}$	$2.027401 \cdot 10^{-2}$	$7.802798 \cdot 10^{-3}$	$1.247121 \cdot 10^{-2}$
15	$2.250000 \cdot 10^{+1}$	$1.252156 \cdot 10^{+1}$	$2.123072 \cdot 10^{-2}$	$8.709161 \cdot 10^{-3}$	$1.252156 \cdot 10^{-2}$
16	$2.300000 \cdot 10^{+1}$	$1.257148 \cdot 10^{+1}$	$2.218833 \cdot 10^{-2}$	$9.616852 \cdot 10^{-3}$	$1.257148 \cdot 10^{-2}$
17	$2.350000 \cdot 10^{+1}$	$1.262105 \cdot 10^{+1}$	$2.314669 \cdot 10^{-2}$	$1.052564 \cdot 10^{-2}$	$1.262105 \cdot 10^{-2}$
18	$2.400000 \cdot 10^{+1}$	$1.267033 \cdot 10^{+1}$	$2.410567 \cdot 10^{-2}$	$1.143534 \cdot 10^{-2}$	$1.267033 \cdot 10^{-2}$
19	$2.450000 \cdot 10^{+1}$	$1.271937 \cdot 10^{+1}$	$2.506518 \cdot 10^{-2}$	$1.234582 \cdot 10^{-2}$	$1.271937 \cdot 10^{-2}$
20	$2.500000 \cdot 10^{+1}$	$1.276818 \cdot 10^{+1}$	$2.602514 \cdot 10^{-2}$	$1.325696 \cdot 10^{-2}$	$1.276818 \cdot 10^{-2}$

2.2 Code

```
Param Rathour (190070049), DC Power Supply with Zener Diode Regulator
.include Diode_1N914.txt                                                    ; Includes Diode Model

.subckt zener_12 1                                                          ; Zener Diode Subcircuit
 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

* Elements
Vin in gnd                                                                  ; Input Voltage
VS mids out                                                                 ; Dummy Voltages
VZ out midz 0
VL out midl 0

RS in mids 470
RL midl gnd 1k
XZ gnd midz zener_                                                          ; Zener Diode

.dc Vin 15 25 0.5                                                           ; DC Analysis

.control                                                                    ; Control Functions
run

print V(out) I(VS) I(VZ) I(VL)
.endc
.end
```

2.3 Learnings

For lesser values of V_{in} and R_L (< 600), the Zener Diode doesn't function properly, I_Z is of order -10
$\frac{V_{\text{in}} \cdot R_L}{R_L + R_S} \geq V_Z$ gives the theoretical values allowed. For a fixed , $V_{\text{in}} \geq 17.64V$ & for a fixed V_{in}, $R_L \geq 705\Omega$.

3 DC Power Supply with a BJT Series Regulator

3.1 Values

$V(b_i) \rightarrow$ base voltage of Q_i
For $V_{\text{in}} = 20V,\ R_L = 1k\Omega,\ R_1 = R_2 = 12.5k\Omega \quad \rightarrow \quad V_{\text{in}} = 20,\ V_{\text{out}} = 13.63194,\ V_{b_1} = 14.33892,\ V_{b_2} = 6.651469,\ V_z = 5.937728$
$R_1 + R_2 = 25k\Omega,\ V_{\text{out}} = 12 \quad \rightarrow \quad R_1 = 10.5k\Omega$ & $R_2 = 14.5k\Omega$ approximately

Index	V_{in}	V_{out}
0	15.00000	11.29941
1	15.50000	11.37754
2	16.00000	11.45185
3	16.50000	11.52574
4	17.00000	11.59862
5	17.50000	11.67064
6	18.00000	11.74197
7	18.50000	11.81275
8	19.00000	11.88308
9	19.50000	11.95304
10	20.00000	12.02270
11	20.50000	12.09211
12	21.00000	12.16132
13	21.50000	12.23038
14	22.00000	12.29932
15	22.50000	12.36816
16	23.00000	12.43693
17	23.50000	12.50565
18	24.00000	12.57435
19	24.50000	12.64304
20	25.00000	12.71174

3.2 Code

```
Param Rathour (190070049), DC Power Supply with a BJT Series Regulator
.include bc547.txt                                                    ; Includes BC547 Model
.include SL100.txt                                                    ; Includes SL100 Model
.subckt zener_5 1 2                                                   ; Zener Diode Subcircuit
 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

* Elements
Vin in gnd 20                                                         ; Input Voltage
Q1 in b1 out SL100
Q2 b1 b2 Vz bc547a
RC in b1 1k                                                           ; Resistors
R1 out b2 10.5k
R2 b2 gnd 14.5k
RL out gnd 1k
XZ gnd Vz zener_5                                                     ; Zener Diode

.dc Vin 15 25 0.5                                                     ; DC Analysis
.control                                                              ; Control Functions
run
print V(in) V(out)
.endc
.end1
```

3.3 Learnings

The BJT Series Regulator is better compared to Zener Regulator (the range of Voltages are much closer to $12V$ than in Zener).