EE230 Analog Lab

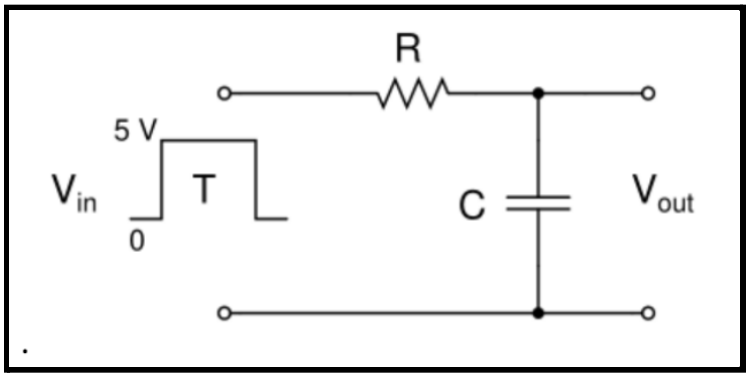
Experiment - 1

Familiarization with NGSPICE Circuit Simulator and Lab Equipment

Report by Prasann Viswanathan - 190070047

1. RC Integrator

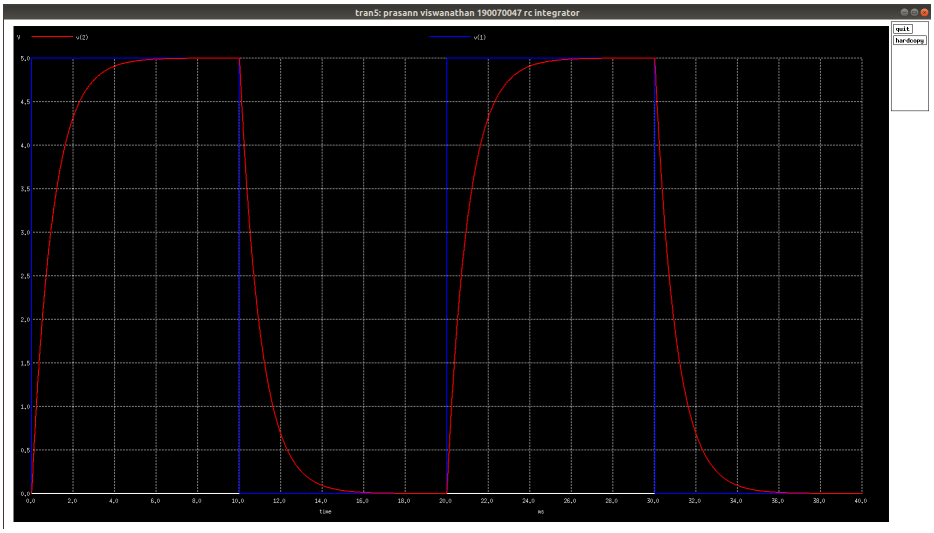
a. Circuit Diagram:

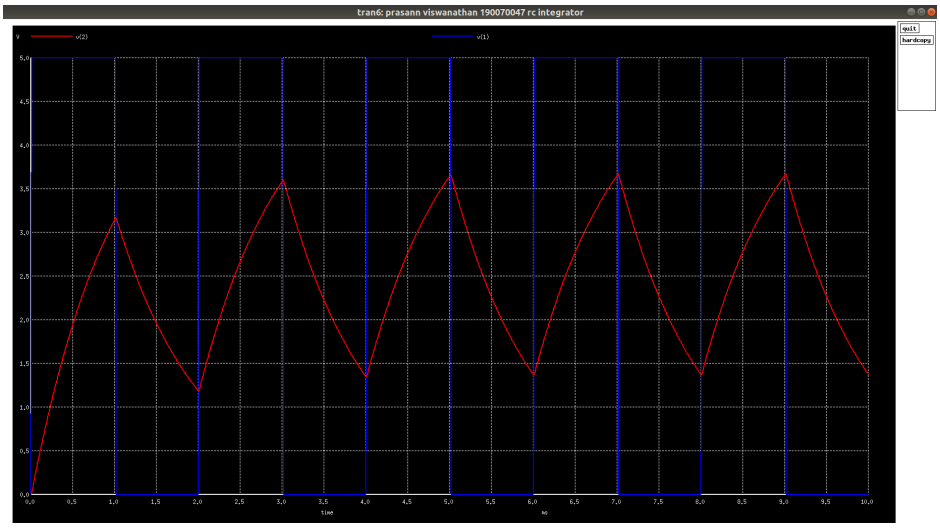


b. ngspice code:

```
Prasann Viswanathan 190070047 RC Integrator

r1 1 2 10k
c1 2 0 0.1u
*v_in 1 0 pulse(0 5 0.1u 0 0 10m 20m)
v_in 1 0 pulse(0 5 0.1u 0 0 1m 2m)

*analysis command
*.tran 10u 40m
.tran 10u 10m
.control
run

*display commands
plot v(2) v(1)
.endc
.end
```

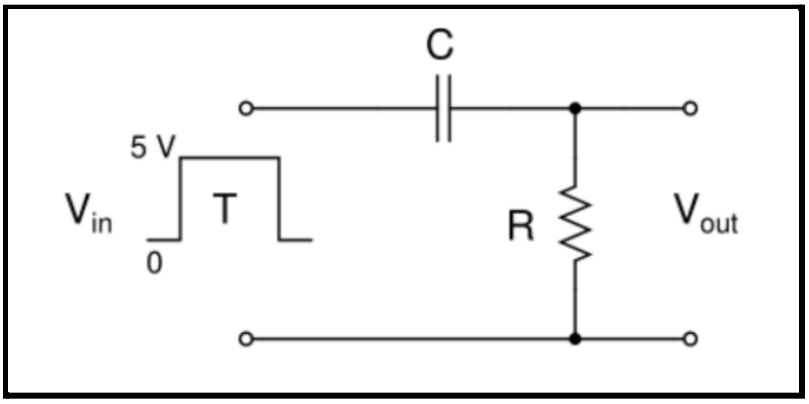
c. Results:


tran5: prasann viswanathan 190070047 rc integrator
v(2)
v(1)
quit
hardcopy
Time
ms


tran6: prasann viswanathan 190070047 rc integrator
v(2)
v(1)
quit
hardcopy
Time
ms

2. RC Differentiator

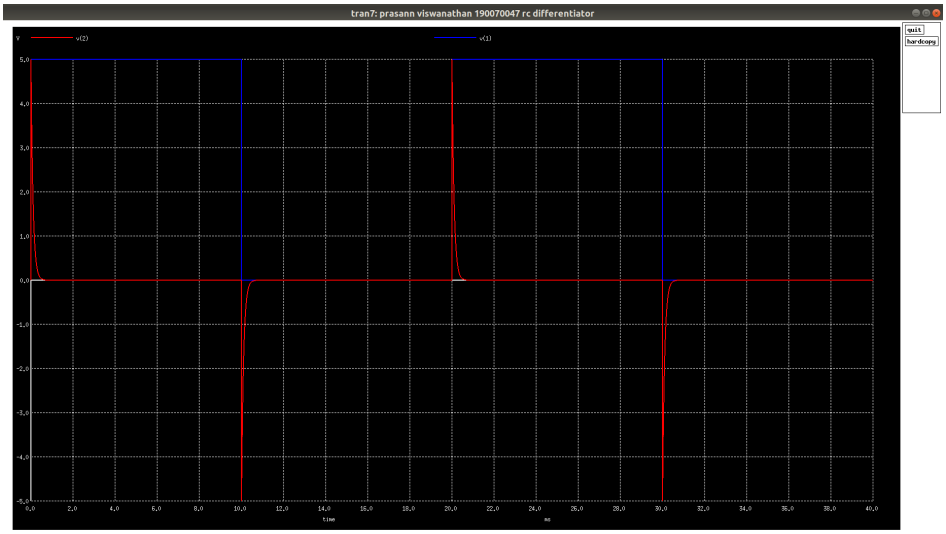
a. Circuit Diagram:

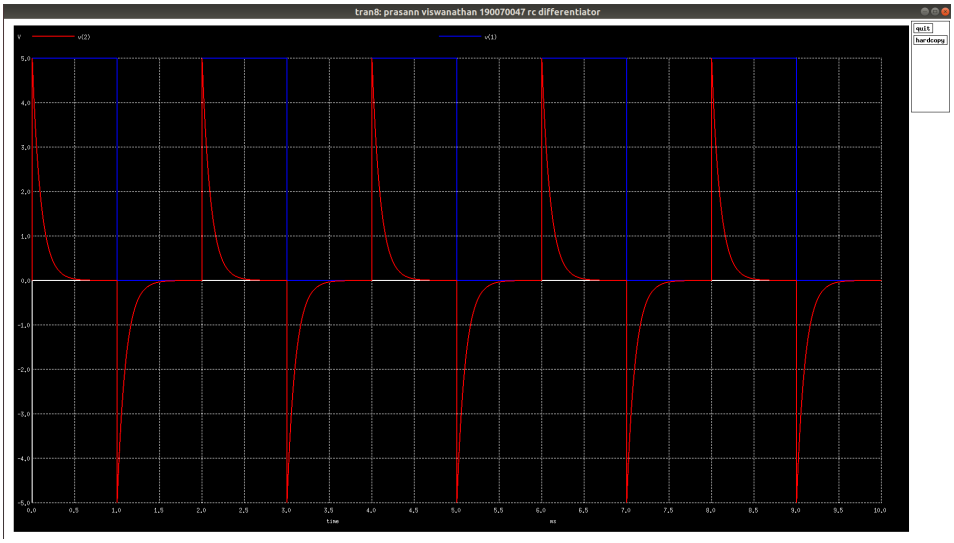


b. ngspice code:

```
Prasann Viswanathan 190070047 RC Differentiator

r1 2 0 1k
c1 1 2 0.1u
*v_in 1 0 pulse(0 5 1u 0 0 10m 20m)
v_in 1 0 pulse(0 5 1u 0 0 1m 2m)

*analysis commands
*.tran 0.1u 40m
.tran 0.1u 10m
.control
run

*display commands
plot v(2) v(1)
.endc
.end
```

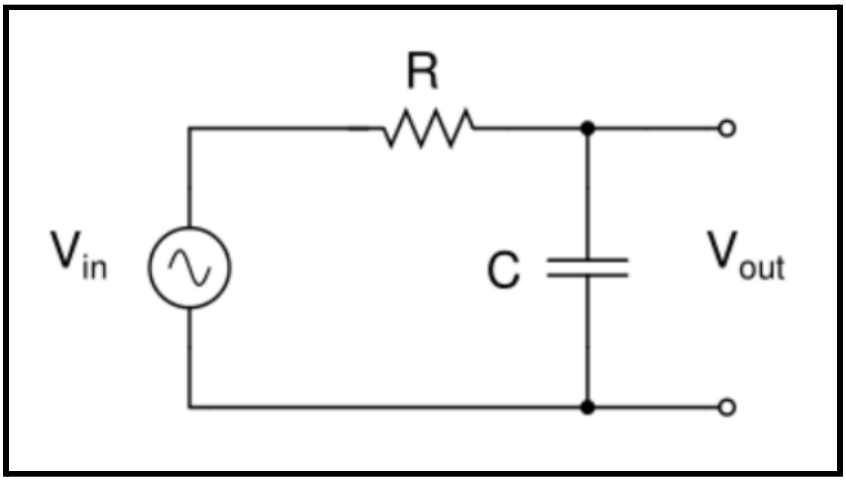
c. Results:


tran7: prasann viswanathan 190070047 rc differentiator
v(2)
v(1)
quit
hardcopy
time


tran8: prasann viswanathan 190070047 rc differentiator
v(2)
v(1)
quit
hardcopy
time

3. RC Low-pass Filter

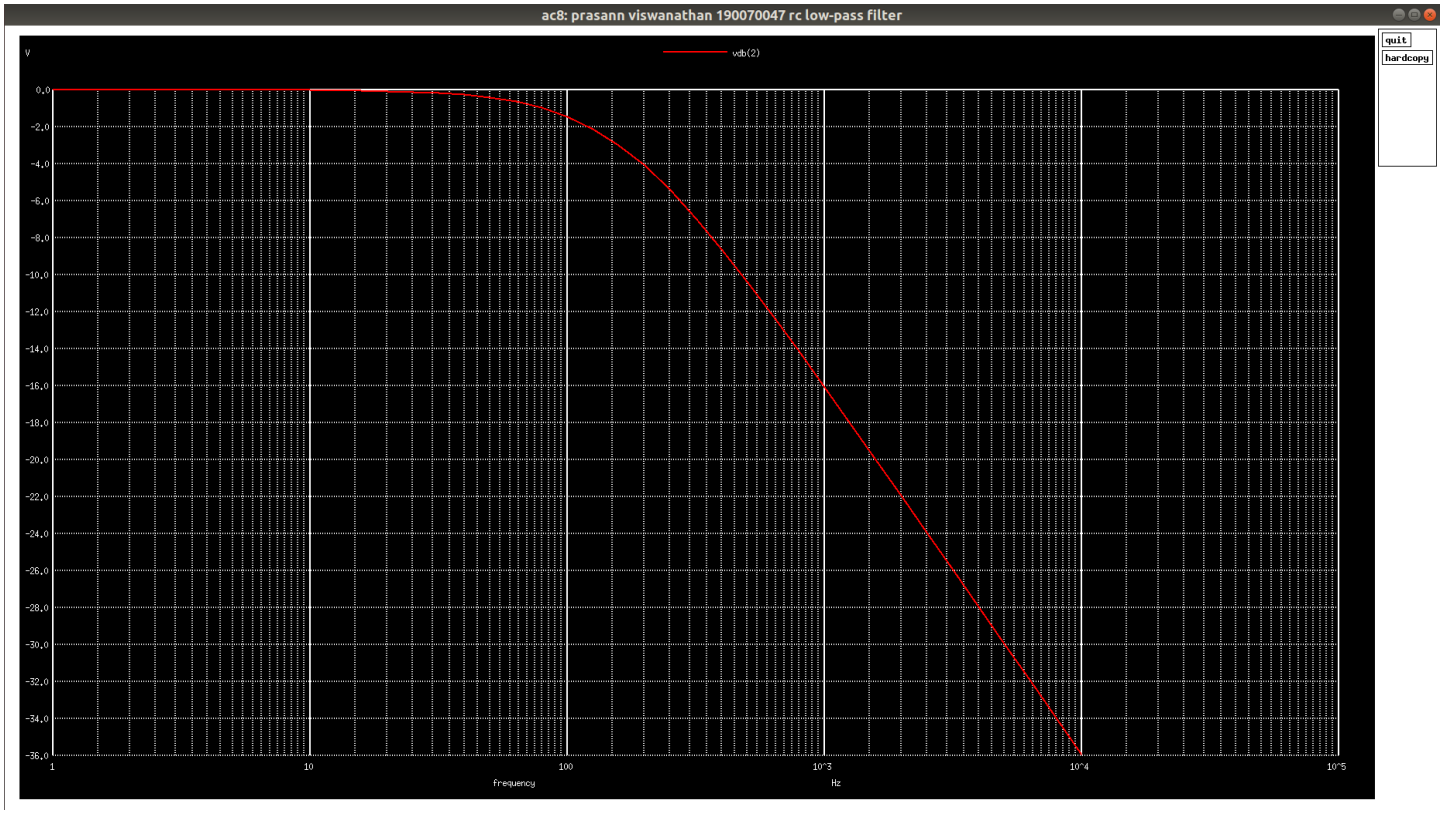
a. Circuit Diagram:



b. ngspice code:

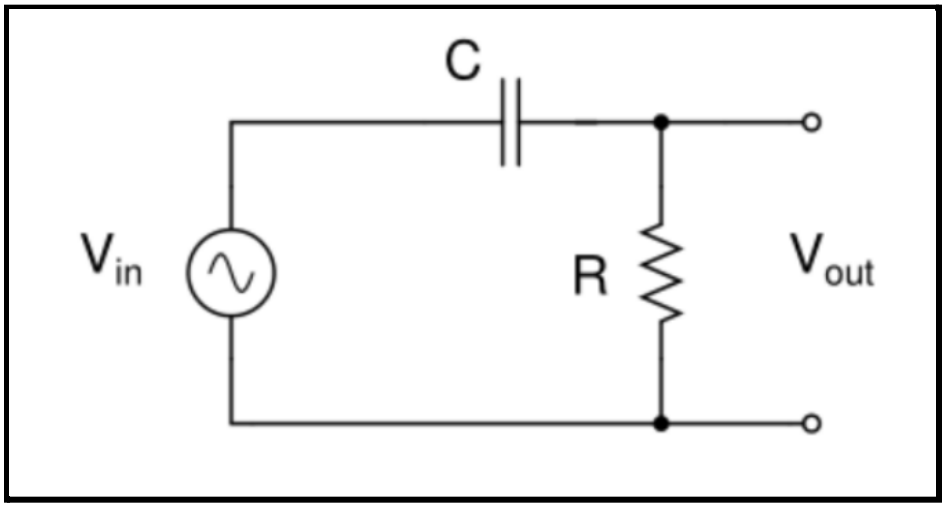
```
Prasann Viswanathan 190070047 RC Low-pass Filter

r1 1 2 10k
c1 2 0 0.1u
v_in 1 0 dc 0 ac 1

*analysis command
.ac dec 10 1 10k
.control
run

*display commands
plot vdb(2)
.endc
.end
```

c. Results:


ac8: prasann viswanathan 190070047 rc low-pass filter
quit
hardcopy
V
vdb(2)
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
-12.0
-14.0
-16.0
-18.0
-20.0
-22.0
-24.0
-26.0
-28.0
-30.0
-32.0
-34.0
-36.0
1
10
100
10^3
10^4
10^5
frequency
Hz

4. RC High-pass Filter

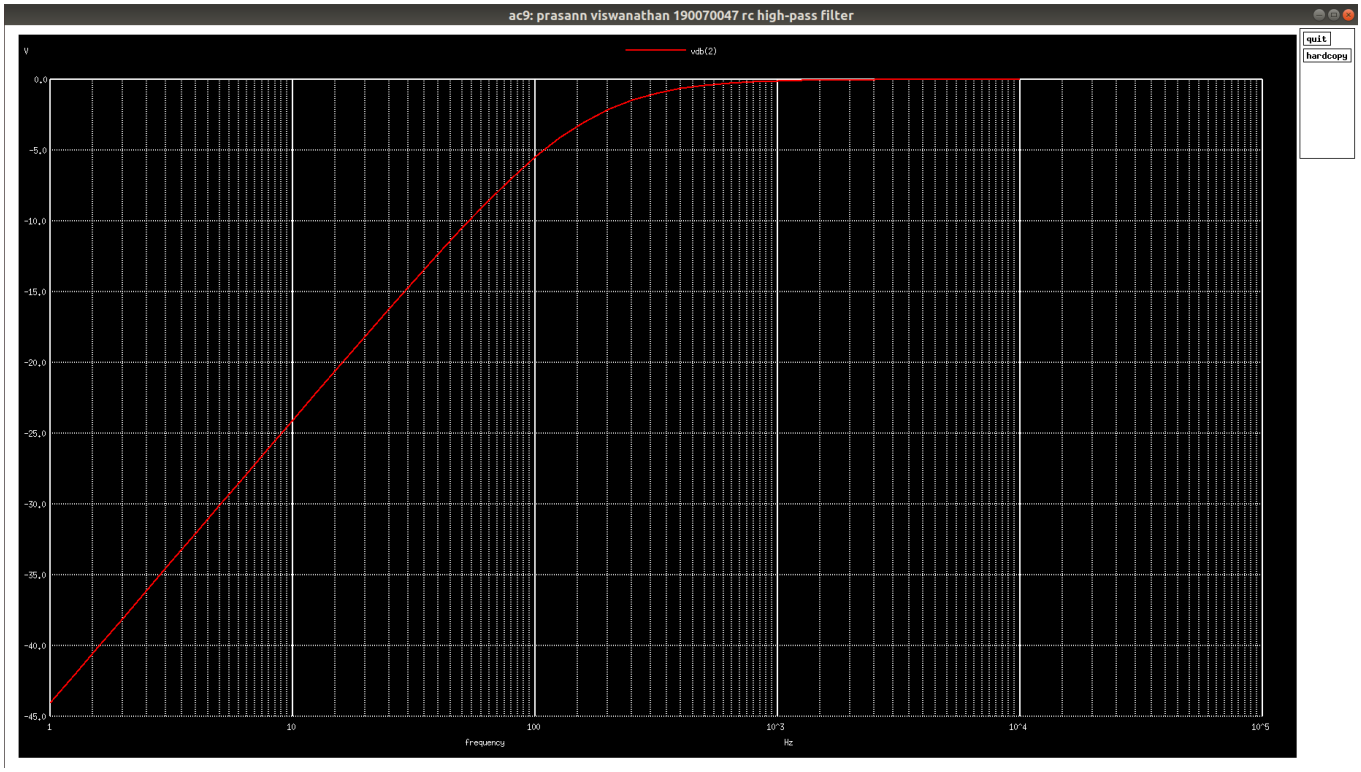
a. Circuit Diagram:



b. ngspice code:

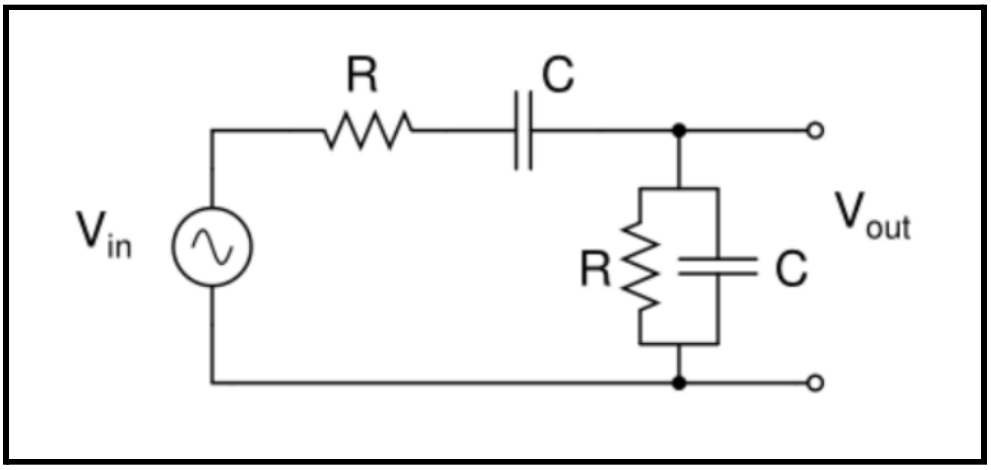
```
Prasann Viswanathan 190070047 RC High-pass Filter

r1 2 0 10k
c1 1 2 0.1u
v_in 1 0 dc 0 ac 1

*analysis command
.ac dec 10 1 10k
.control
run

*display commands
plot vdb(2)
.endc
.end
```

c. Results:


ac9: prasann viswanathan 190070047 rc high-pass filter
quit
hardcopy
V
vdb(2)
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
-40.0
-45.0
1
10
100
10^3
10^4
10^5
Frequency
Hz

5. RC Band-pass Filter

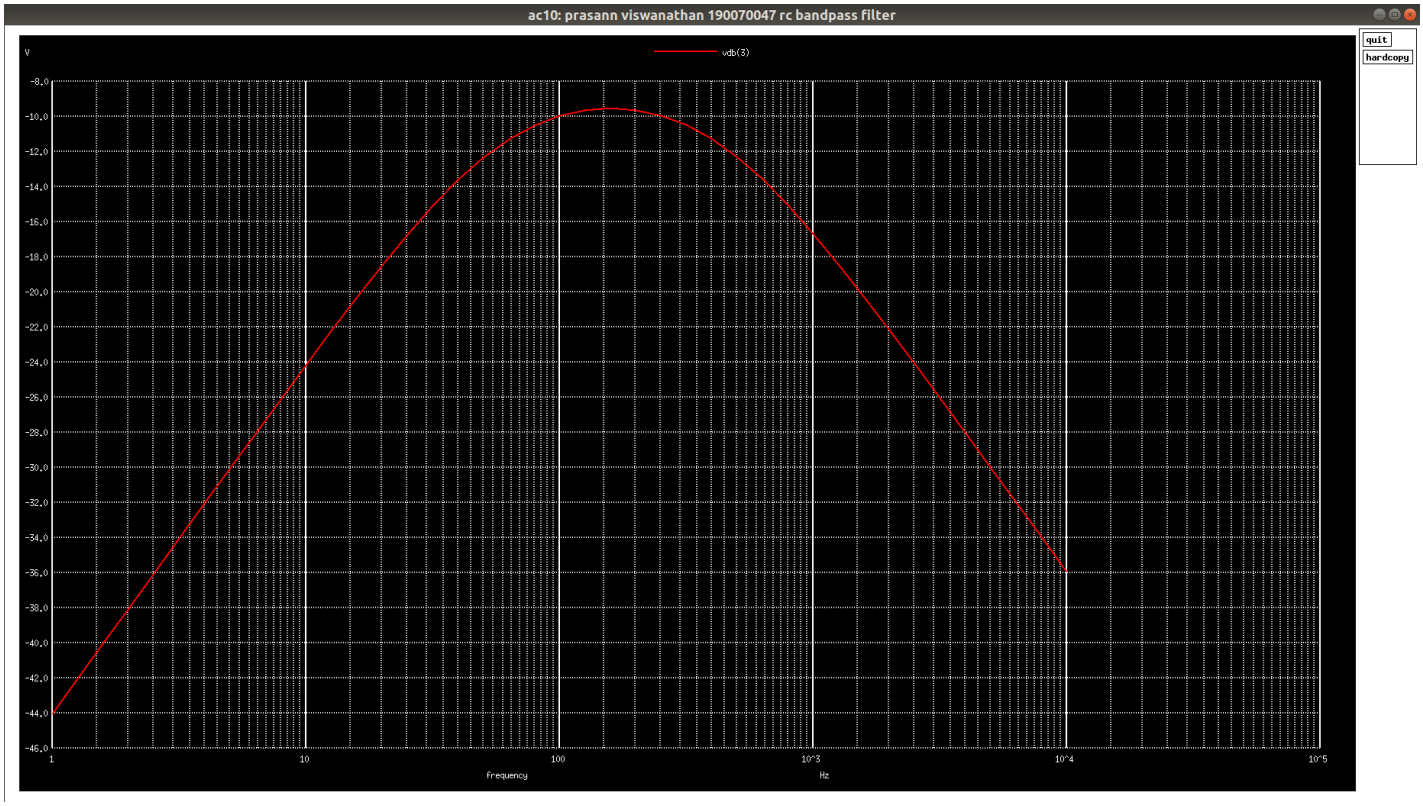
a. Circuit Diagram:



b. ngspice code:

```
Prasann Viswanathan 190070047 RC Bandpass Filter

r1 1 2 10k
r2 3 0 10k
c1 2 3 0.1u
c2 3 0 0.1u
v_in 1 0 dc 0 ac 1

*analysis command
.ac dec 10 1 10k
.meas ac var max vdb(3)
.control
run

*display commands
plot vdb(3)
.endc
.end
```

c. Results:



d. Theoretical result:

$$\frac{V_o}{V_{in}} = \frac{\frac{R}{1+sRC}}{\frac{R}{1+sRC} + \frac{1}{sC} + R} = \frac{RsC}{RsC + 1 + sRC + RsC(1+sRC)}$$

$$= \frac{sRC}{1 + 3sRC + s^2R^2C^2}$$

Putting $s = j\omega$ and equating denominator to 0 (Real part)

$\Rightarrow \omega = 1/RC \Rightarrow f_0 = 1/2\pi RC = 159.15$ Hz

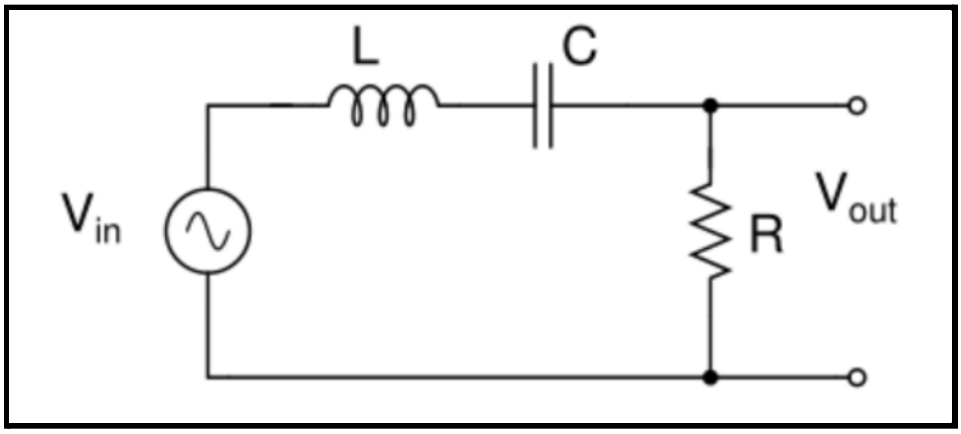
Peak Amplitude $= 20 \log(1/3) = -9.54$ dB

And cutoff frequency $\Rightarrow$ Re(Denom.) = Im(Denom.)

$\Rightarrow f_L = 48.18$ Hz $\quad f_H = 525.65$ Hz

6. RLC Band-pass Filter

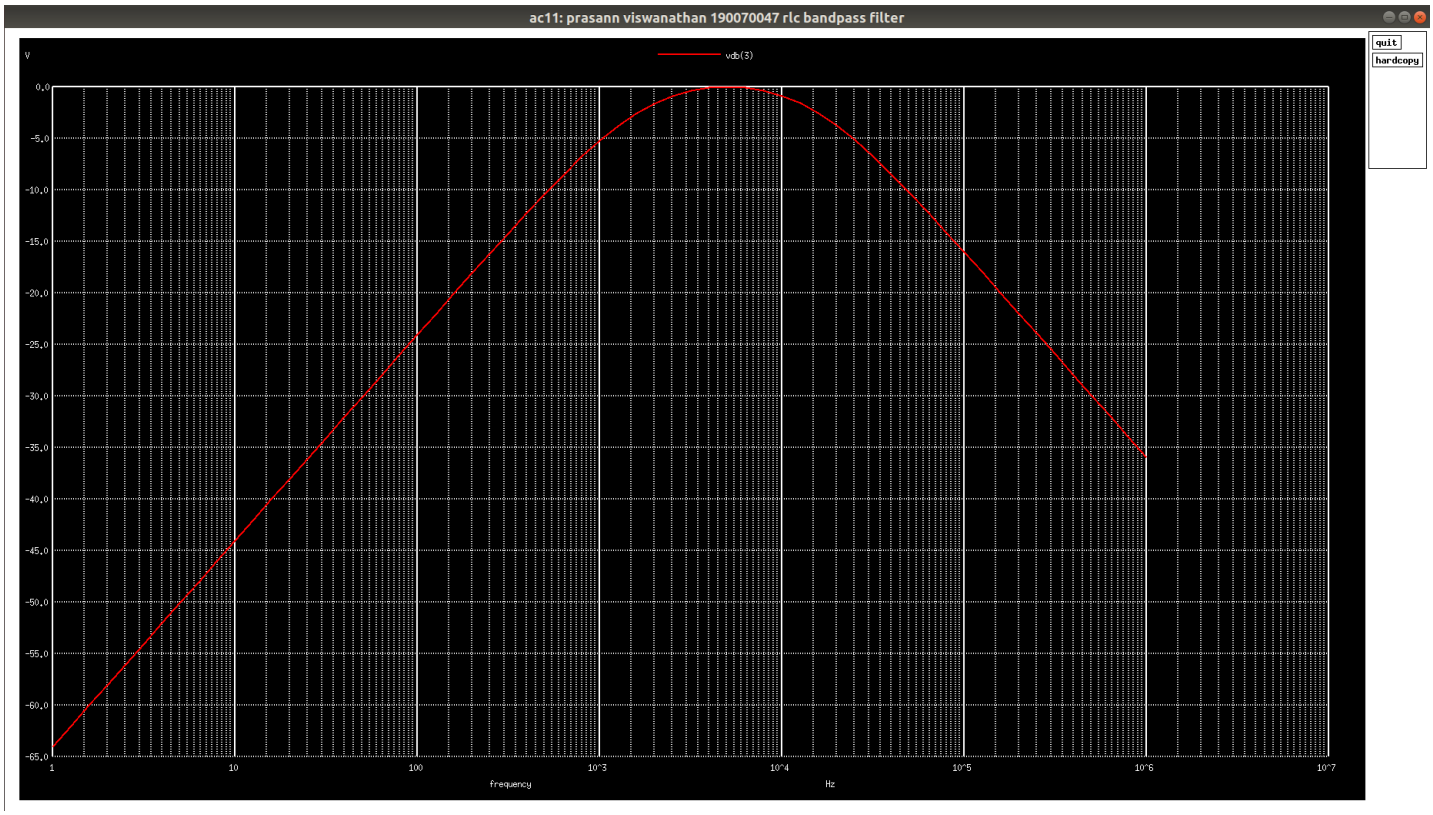
a. Circuit Diagram:



b. ngspice code:

```
Prasann Viswanathan 190070047 RLC Bandpass Filter

r1 3 0 1k
c1 2 3 0.1u
l1 1 2 10m
v_in 1 0 dc 0 ac 1

*analysis command
.ac dec 10 1 1000k
.meas ac var max vdb(3)
.control
run

*display commands
plot vdb(3)
.endc
.end
```

c. Results:



d. Theoretical result:

$$\frac{V_o}{V_{in}} = \frac{R}{R + sL + \frac{1}{sC}} = \frac{sRC}{sRC + s^2LC + 1}$$

$$= \frac{j\omega RC}{1 + j\omega RC - \omega^2 LC}$$

$$\Rightarrow f_o = \frac{1}{2\pi\sqrt{LC}} = 5032.9\,Hz$$

Peak amplitude $= 20\log(1) = 0\,dB$

And $f_L = 1457.98\,Hz$ $f_H = 17373.48\,Hz$

Major Learnings from this experiment:

1. Learnt ngspice syntax

2. Comparing simulations and theoretical results.

Challenges Faced:

1. Had to research .meas command for cutoff frequency values

Questions or Clarifications:

None