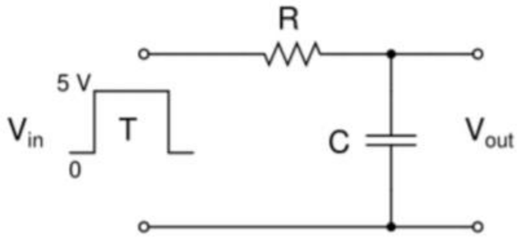
1. RC Integrator:

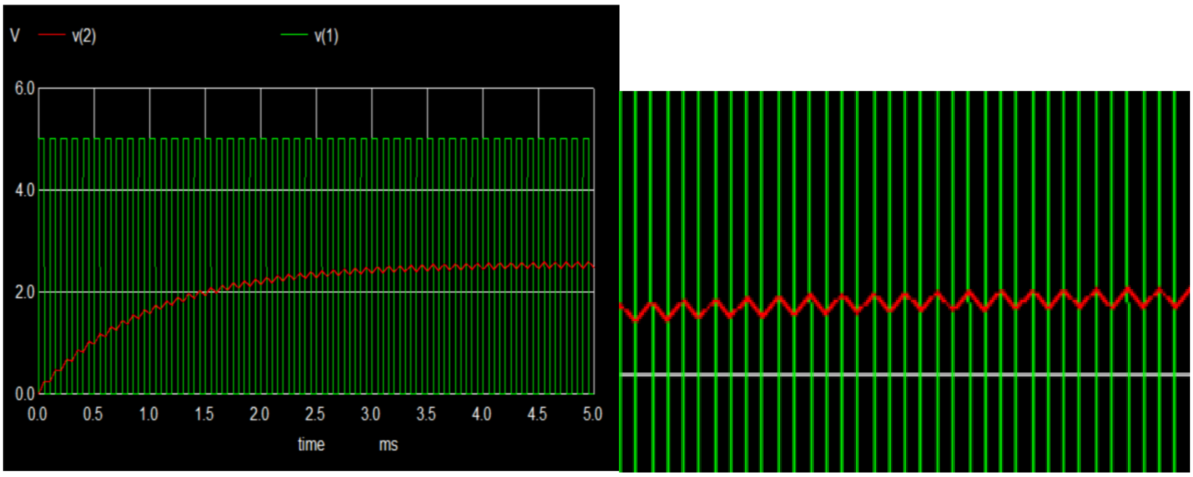
   Tau = R*C = 10k * 0.1u = 1m

Cases: i) T = 10τ ; ii) T = 5τ ; iii) T = τ ; iv) T = 0.1 τ ; vi) T = 0.05 τ

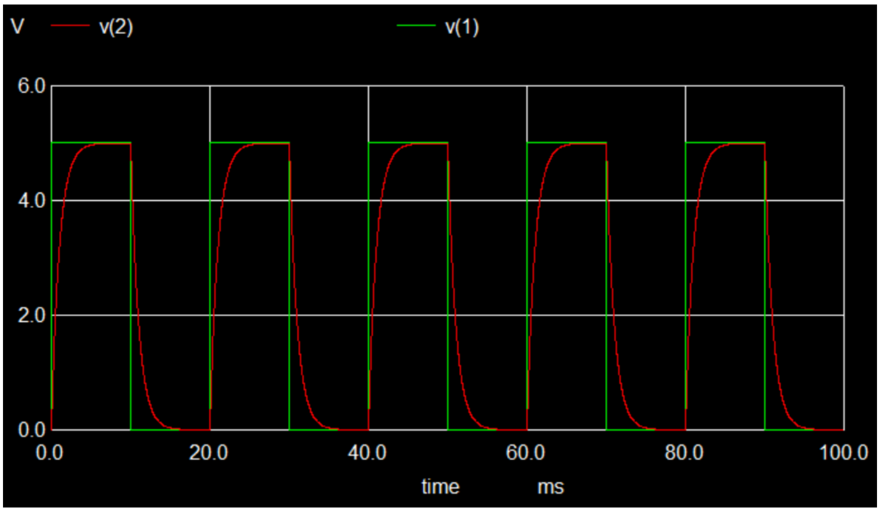



```
19D070052 Sheel Shah Expt1 RC Integrator
r0 2 1 10k
c0 2 0 0.1u
v0 1 0 pulse(0 5 0 0 0 0.05m 0.1m)
.tran 1u 5m
.control
run
plot v(1) v(2)
.endc
.end
```

T = 0.05*tau: (good integrator)



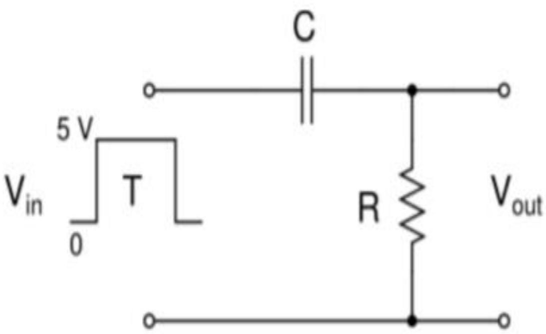

T = 10*tau: (bad integrator)



2. RC Differentiator:

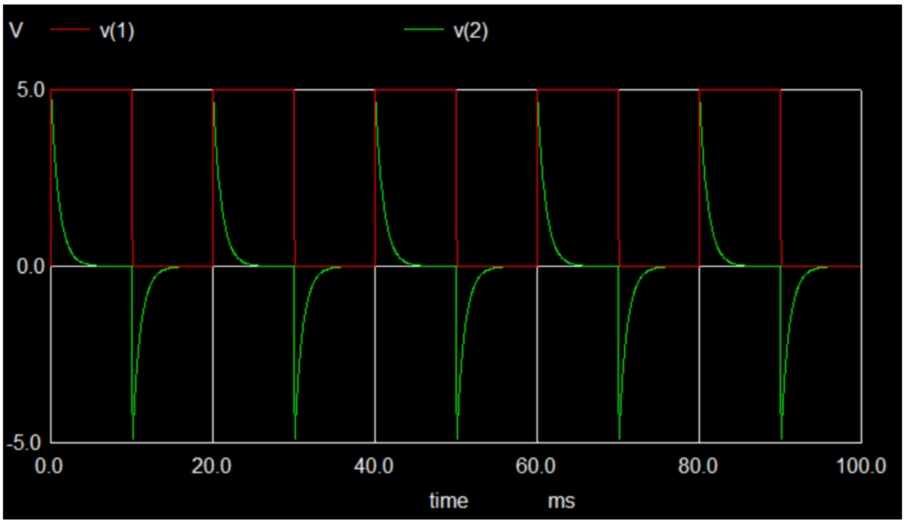
Tau is same as calculated above.

Cases: i) T = 10 τ ; ii) T = 5 τ ; iii) T = 1 τ ; iv) T = 0.5 τ ; v) T = 0.1 τ ; vi) T = 0.05 τ

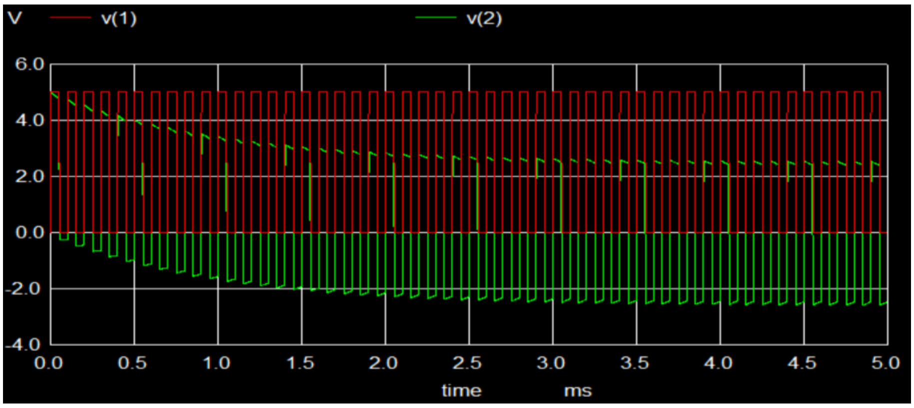



```
19D070052 Sheel Shah  Expt1 RC differentiator
c0 1 2 0.1u
r0 2 0 10k
v0 1 0 pulse(0 5 0 0 0 0.05m 0.1m)
.tran 1u 5m
.control
run
plot v(2) v(1)
.endc
.end
```

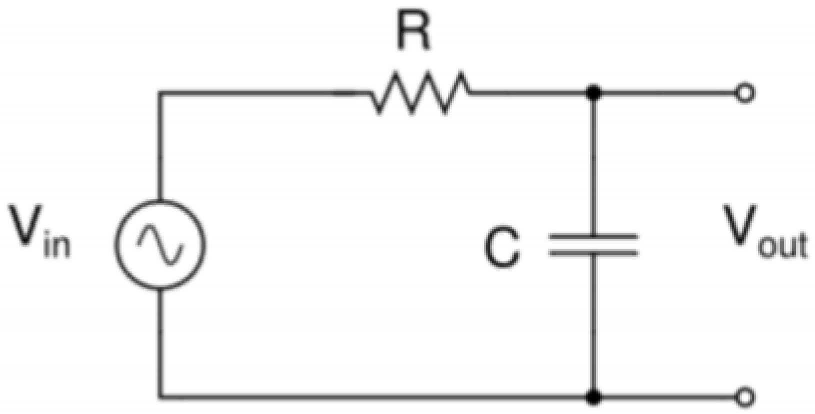
T = 10*tau: (good differentiator)



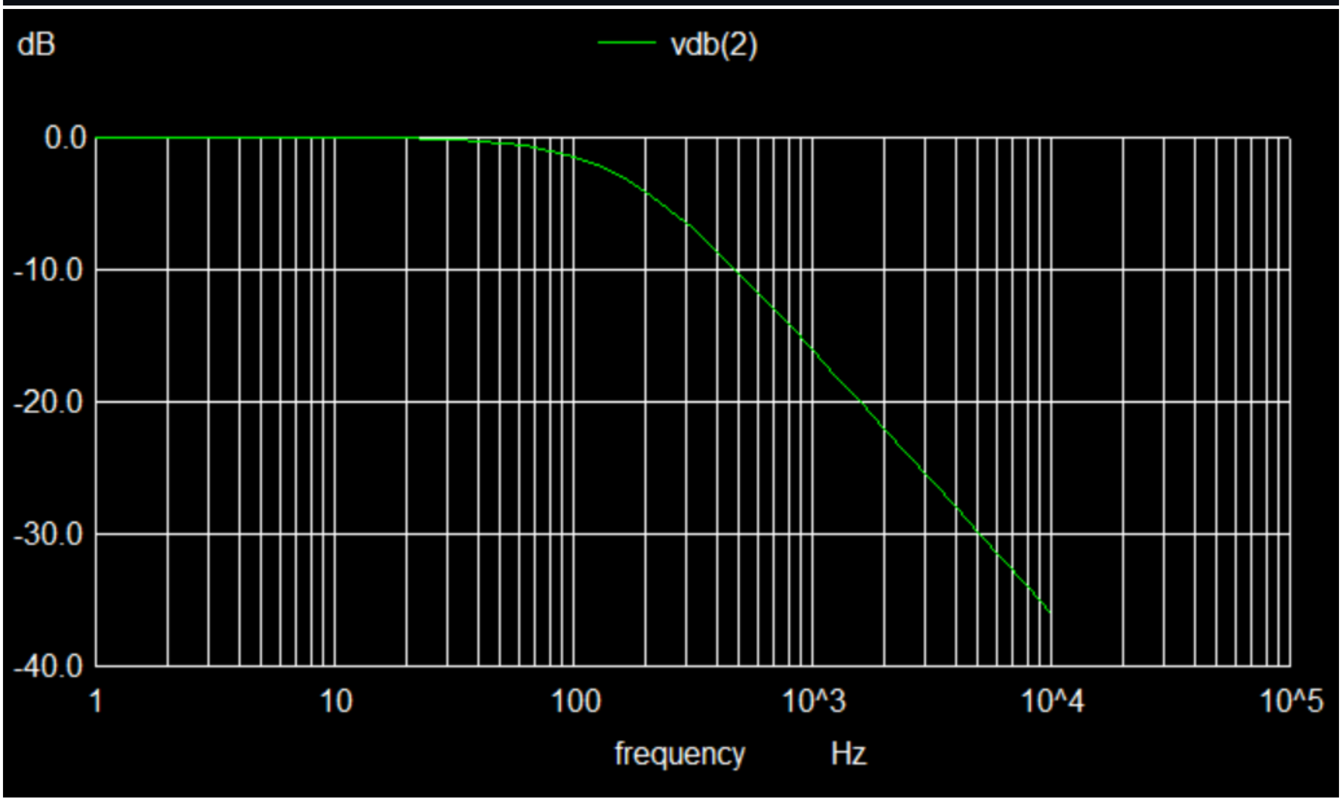

T = 0.05*tau: (bad differentiator)



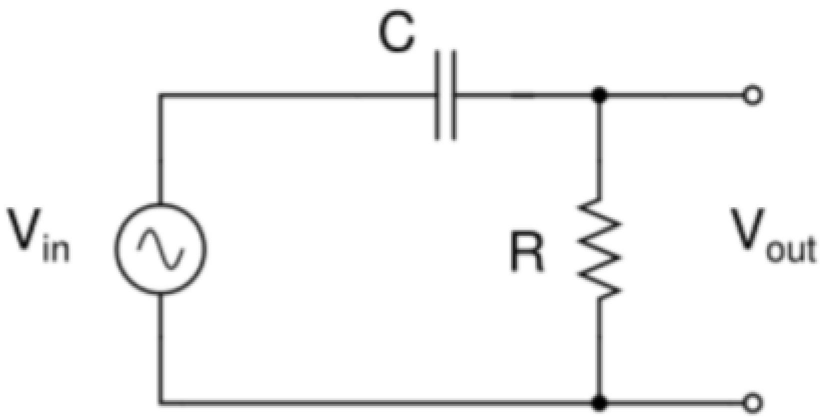
3. RC Lowpass filter



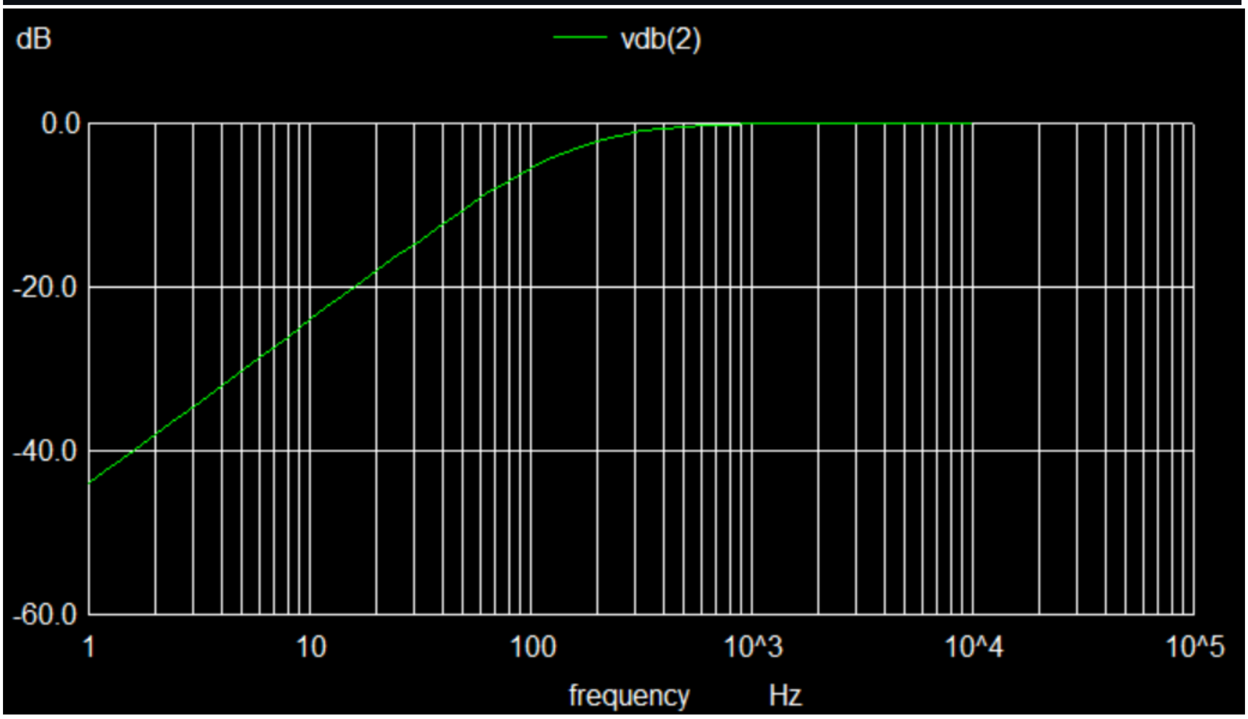

```
19D070052 Sheel Shah Expt1 RC Low pass filter
r0 2 1 10k
c0 2 0 0.1u
v0 1 0 dc 0 ac 1
.ac dec 10 1 10k
.control
run
plot vdb(2)
.endc
.end
```



4. RC Highpass filter




```
19D070052 Sheel Shah Expt1 RC high pass filter
r0 2 0 10k
c0 2 1 0.1u
v0 1 0 dc 0 ac 1
.ac dec 10 1 10k
.control
run
plot vdb(2)
.endc
.end
```



5. RC bandpass filter

   Trivial analysis gives us the transfer function T(s) as sRC / (1 + (s*s*R*C)^2 + 3sRC)

   For peak, we set the real part of the denominator to 0 => w_peak = 1 / (RC)

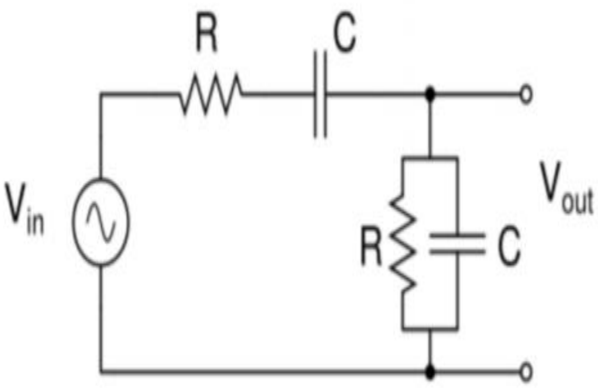
   F_peak = w_peak / 2pi = 159 Hz

   For -3dB points, magnitude is 1/root(2)

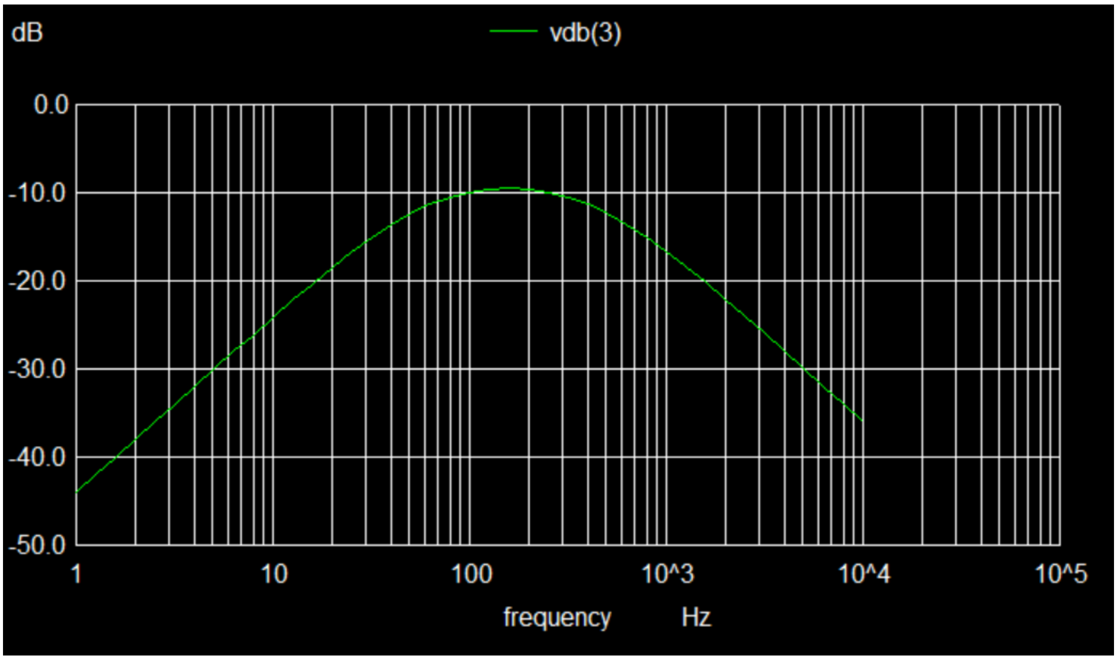
   Hence 1 –(wRC)^2 = +/- 3wRC

   Hence w_l = (root(13) – 3) / (2RC) and w_h = (root(13) + 3) / (2RC)

   This gives fl = 48Hz, fh = 526Hz




```
19D070052 Sheel Shah Expt1 RC bandpass filter
r1 1 2 10k
c1 2 3 0.1u
r2 3 0 10k
c2 3 0 0.1u
v0 1 0 dc 0 ac 1
.ac dec 10 1 10k
.control
run
plot vdb(3)
meas ac peak MAX vmag(3)
meas ac fpeak WHEN vmag(3)=peak
let f3db = peak/sqrt(2)
meas ac fl WHEN vmag(3)=f3db RISE=1
meas ac fh WHEN vmag(3)=f3db FALL=1
.endc
.end
```



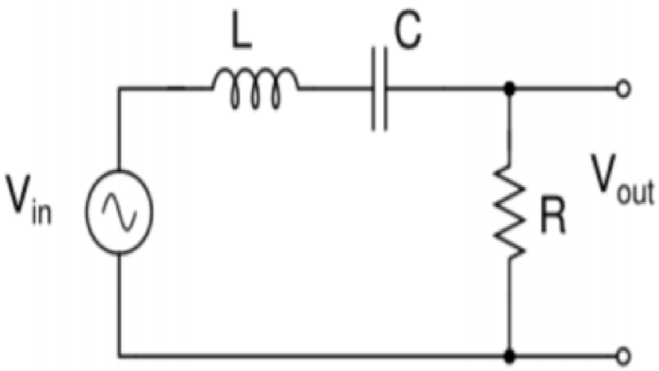

```
peak                    =   3.333320e-01 at=   1.584893e+02
fpeak                   =   1.584891e+02
fl                      =   4.838534e+01
fh                      =   5.276607e+02
```

6. RLC bandpass filter

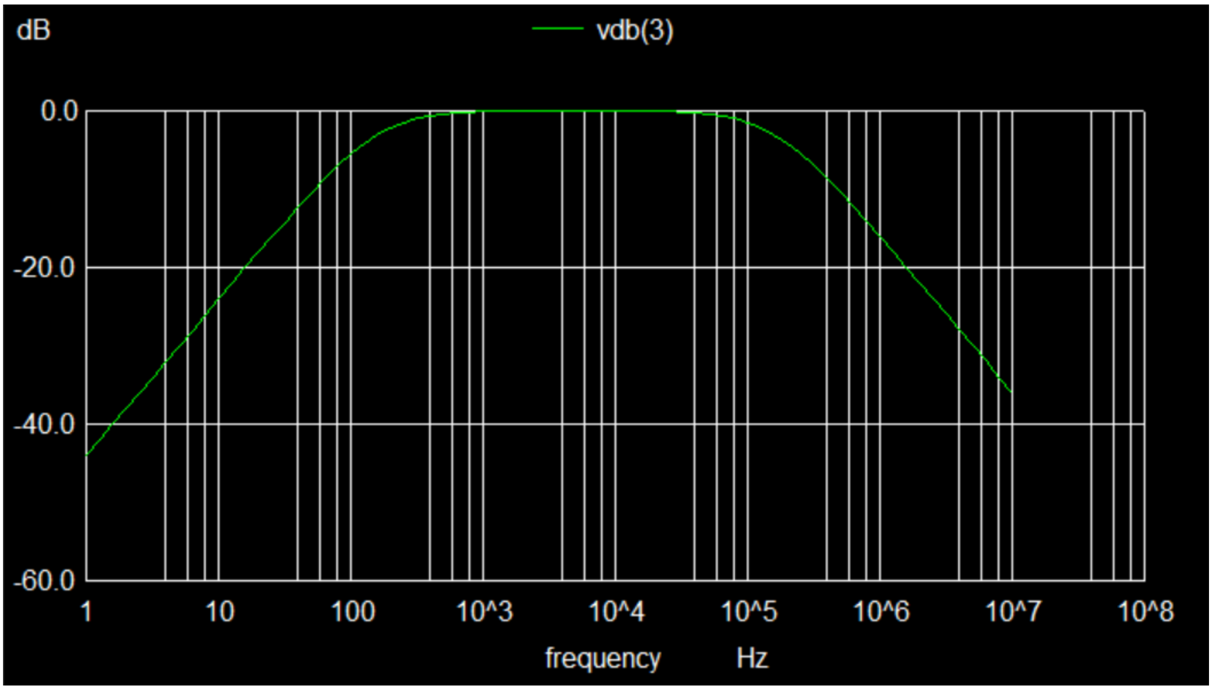
Transfer function is: Vout = R* Vin / (R + s*L + (1 / (s*C)))
So: T(s) = (s / (s^2 + (R/L)*s + 1/(L*C))) * (R/L)
Now with s = j*w we have T(jw) = (Rjw/L)(1 / ((Rjw/L) + (1/LC – w^2)))
Maxima is attained when the denominator is minimum and hence (1/LC -w^2) is 0
Hence w_peak = 1/root(LC) = 31.6 krad/s => f_peak is 5.035 kHz
At f_l and f_h, magnitude should be -3db or 1/root(2).
Hence (1/LC -w^2) is +/- Rw/L
Solving this quadratic gives

w_l = root((R/2L)^2 + 1/LC) – R/2L
w_h = root((R/2L)^2 + 1/LC) + R/2L

Hence fl = 1458Hz, 17373 Hz




```
19D070052 Sheel Shah Expt1 RLC bandpass filter
l1 1 2 10m
c1 2 3 0.1u
r1 3 0 10k
v0 1 0 dc 0 ac 1
.ac dec 10 1 0.01g
.control
run
plot vdb(3)
meas ac peak MAX vmag(3)
let almost_peak = peak - 1u
meas ac fpeak WHEN vmag(3)=almost_peak
let f3db = peak/sqrt(2)
meas ac fl WHEN vmag(3)=f3db RISE=1
meas ac fh WHEN vmag(3)=f3db FALL=1
.endc
.end
```




```
peak                    =    1.000000e+00 at=   5.011872e+03
fpeak                   =    5.002985e+03
fl                      =    1.590984e+02
fh                      =    1.593745e+05
```

Major learnings:

I really came to like ngSpice and found the method fairly intuitive. It was good to see that mathematical analysis matched so close to simulations. I also understood (hands on) that mathematical analysis was not perfect, and that in the experiment, it would deviate even more than the simulation.

Challenges faced:

I did not like the plain look of .cir files, and hence wrote Sublime Text syntax highlighting for it. This took quite some time, and a lot of effort but I can't really complain as this was my personal choice. The report also took quite some time, and it looks really bad too. However I don't know how Latex works so this was my only choice.

Questions/Clarifications:

If you want to see the code/the plots in.ps, please contact me at 19D070052@iitb.ac.in and I will share a zip.