EE230 Homework 1
NGSPICE simulation of RC and RLC circuits

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1 Overview of the experiment

1.1 Aim of the experiment

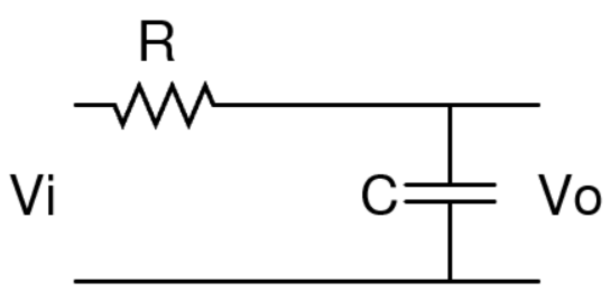
To simulate RC Integrator, RC Differentiator, RC lowpass, RC highpass, RC bandpass and RLC bandpass circuits using NGSPICE and realise the circuit diagrams using XCircuit.

1.2 Method

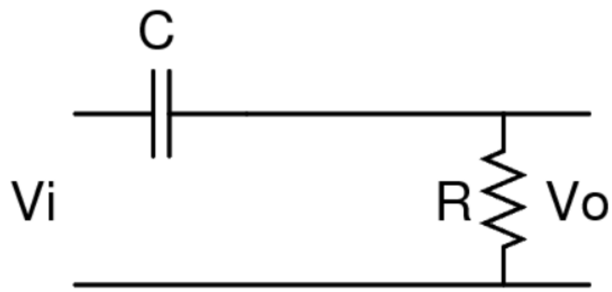
Netlists were made for simulating the circuits in NGSPICE. Xcircuit was used to make the circuit diagrams.

2 Design

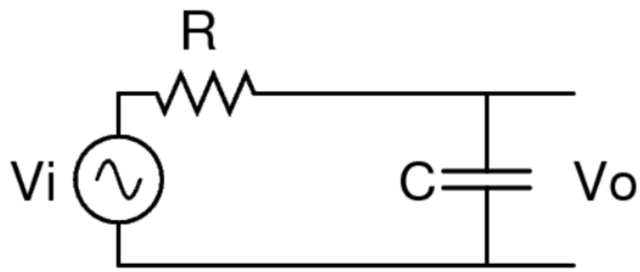
2.1 Circuit Diagrams



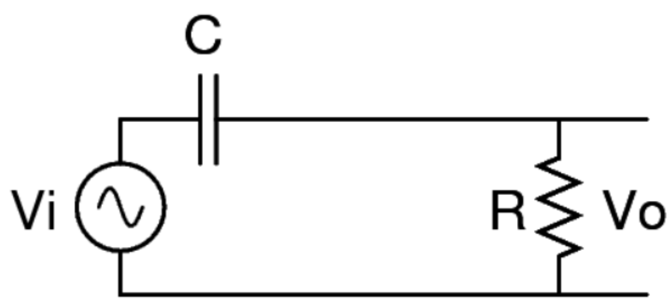
RC Integrator Circuit



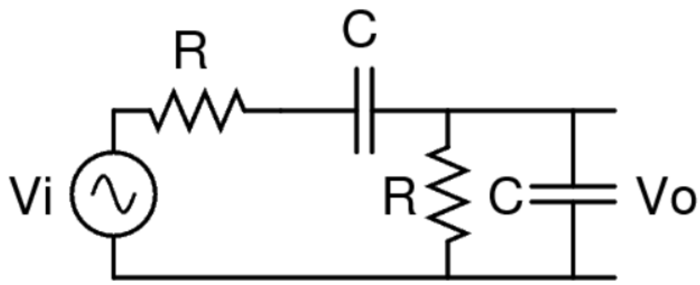
RC Differentiator Circuit



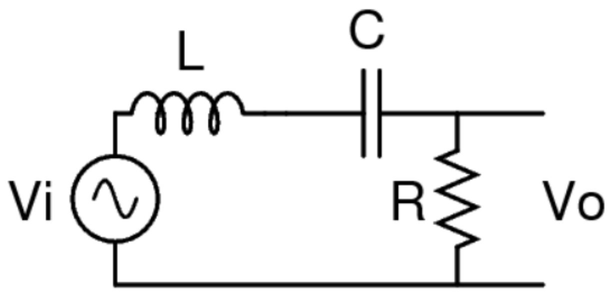
RC Lowpass Filter Circuit



RC Highpass Filter Circuit



RC Bandpass Filter Circuit



RLC Bandpass Filter Circuit

3 Code Snippets

3.1 B1 - RC Integrator

3.1.1 $T = 10\tau$

```
RC Integrator
* Components
r1 1 2 10k
c1 2 0 0.1u
V1 1 0 pulse(0 5 0 0 0 0.01 0.02)
* Analysis Command
.tran 0.01m 0.06
.control
run
plot v(1) v(2)
.endc
.end
```

3.1.2 $T = 5\tau$

```
RC Integrator
* Components
r1 1 2 10k
c1 2 0 0.1u
V1 1 0 pulse(0 5 0 0 0 0.005 0.01)
* Analysis Command
.tran 0.01m 0.03
.control
run
plot v(1) v(2)
.endc
.end
```

3.1.3 $T = \tau$

```
RC Integrator
* Components
r1 1 2 10k
c1 2 0 0.1u
V1 1 0 pulse(0 5 0 0 0 0.001 0.002)
* Analysis Command
.tran 0.001m 0.006
.control
run
plot v(1) v(2)
.endc
.end
```

3.1.4 $T = 0.5\tau$

```
RC Integrator
* Components
r1 1 2 10k
c1 2 0 0.1u
V1 1 0 pulse(0 5 0 0 0 0.0005 0.001)
* Analysis Command
.tran 0.001m 0.003
.control
run
plot v(1) v(2)
.endc
.end
```

3.1.5 $T = 0.1\tau$

```
RC Integrator
* Components
r1 1 2 10k
c1 2 0 0.1u
V1 1 0 pulse(0 5 0 0 0 0.0001 0.0002)
* Analysis Command
.tran 0.0001m 0.0006
.control
run
plot v(1) v(2)
.endc
.end
```

3.1.6 $T = 0.05\tau$

```
RC Integrator
* Components
r1 1 2 10k
c1 2 0 0.1u
V1 1 0 pulse(0 5 0 0 0 0.05m 0.1m)
* Analysis Command
.tran 0.01u 0.3m
.control
run
plot v(1) v(2)
.endc
.end
```

3.2 B2 - RC Differentiator

3.2.1 $T = 10\tau$

```
RC Differentiator
* Components
c1 1 2 0.1u
r1 2 0 10k
V1 1 0 pulse(0 5 0 0 0 10m 20m)
* Analysis Command
.tran 0.02m 60m
.control
run
plot v(1) v(2)
.endc
.end
```

3.2.2 $T = 5\tau$

```
RC Differentiator
* Components
c1 1 2 0.1u
r1 2 0 10k
V1 1 0 pulse(0 5 0 0 0 0.005 0.01)
* Analysis Command
.tran 0.002m 0.03
.control
run
plot v(1) v(2)
.endc
.end
```

3.2.3 $T = \tau$

```
RC Differentiator
* Components
c1 1 2 0.1u
r1 2 0 10k
V1 1 0 pulse(0 5 0 0 0 0.001 0.002)
* Analysis Command
.tran 0.002m 0.006
.control
run
plot v(1) v(2)
.endc
.end
```

3.2.4 $T = 0.5\tau$

```
RC Differentiator
* Components
c1 1 2 0.1u
r1 2 0 10k
V1 1 0 pulse(0 5 0 0 0 0.5m 1m)
* Analysis Command
.tran 0.002m 3m
.control
run
plot v(1) v(2)
.endc
.end
```

3.2.5 $T = 0.1\tau$

```
RC Differentiator
* Components
c1 1 2 0.1u
r1 2 0 10k
V1 1 0 pulse(0 5 0 0 0 0.1m 0.2m)
* Analysis Command
.tran 0.002m 0.6m
.control
run
plot v(1) v(2)
.endc
.end
```

3.2.6 $T = 0.05\tau$

```
RC Differentiator
* Components
c1 1 2 0.1u
r1 2 0 10k
V1 1 0 pulse(0 5 0 0 0 0.05m 0.1m)
* Analysis Command
.tran 0.0001m 0.3m
.control
run
plot v(1) v(2)
.endc
.end
```

3.3 B3 - RC Lowpass Filter

```
RC lowpass filter
*Components
r1 1 2 10k
c1 2 0 0.1u
V1 1 0 dc 0 ac 1 $ac analysis
*Analysis Command
.ac dec 10 1m 100k
.control
run
plot vdb(2)
.endc
.end
```

3.4 B4 - RC Highpass Filter

```
RC highpass filter
*Components
c1 1 2 0.1u
r1 2 0 10k
V1 1 0 dc 0 ac 1 $ac analysis
*Analysis Command
.ac dec 10 1m 100k
.control
run
plot vdb(2)
.endc
.end
```

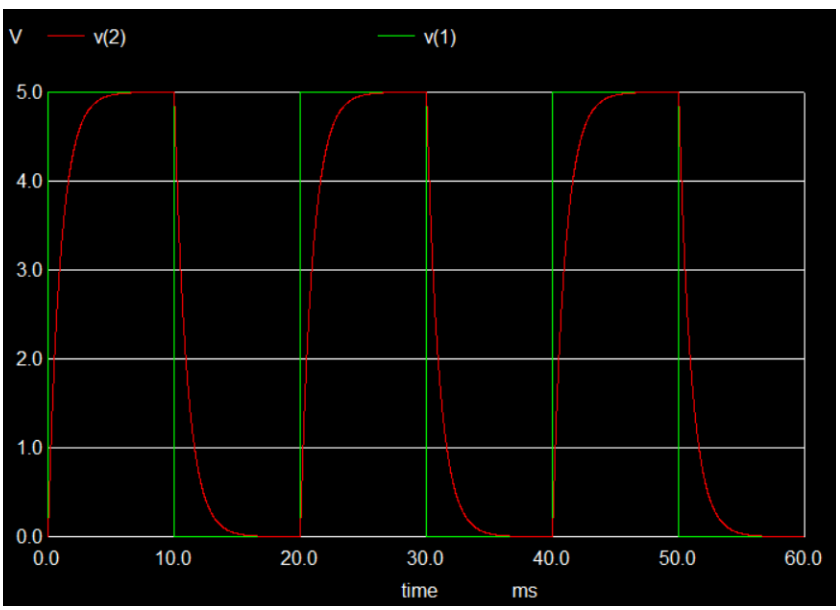
3.5 B5 - RC Bandpass Filter

```
RC bandpass filter
*Components
r1 1 2 10k
c1 2 3 0.1u
r2 3 0 10k
c2 3 0 0.1u
V1 1 0 dc 0 ac 1 $ac analysis
*Analysis Command
.ac dec 500 1m 10Meg
.control
run
plot vdb(3)
print vdb(3)
.endc
.end
```

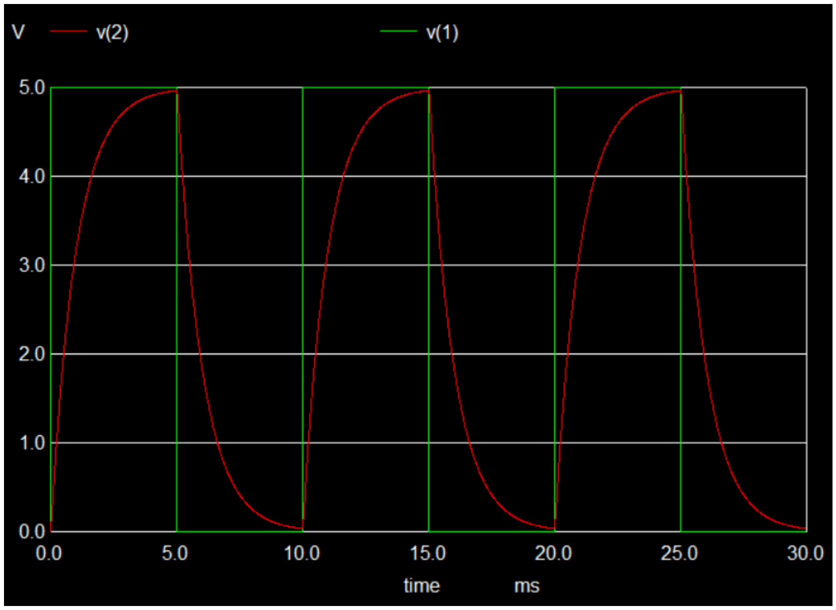
3.6 B5 - RLC Bandpass Filter

```
RLC bandpass filter
*Components
l1 1 2 10m
c1 2 3 0.1u
r2 3 0 1k
V1 1 0 dc 0 ac 1 $ac analysis
*Analysis Command
.ac dec 500 10m 1000Meg
.control
run
plot vdb(3)
print vdb(3)
.endc
.end
```

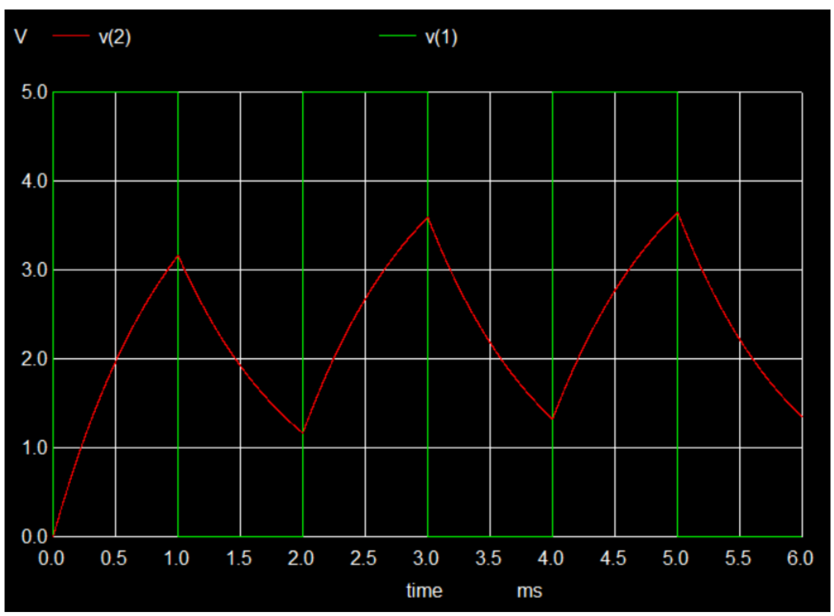
3.7 Simulation Plots



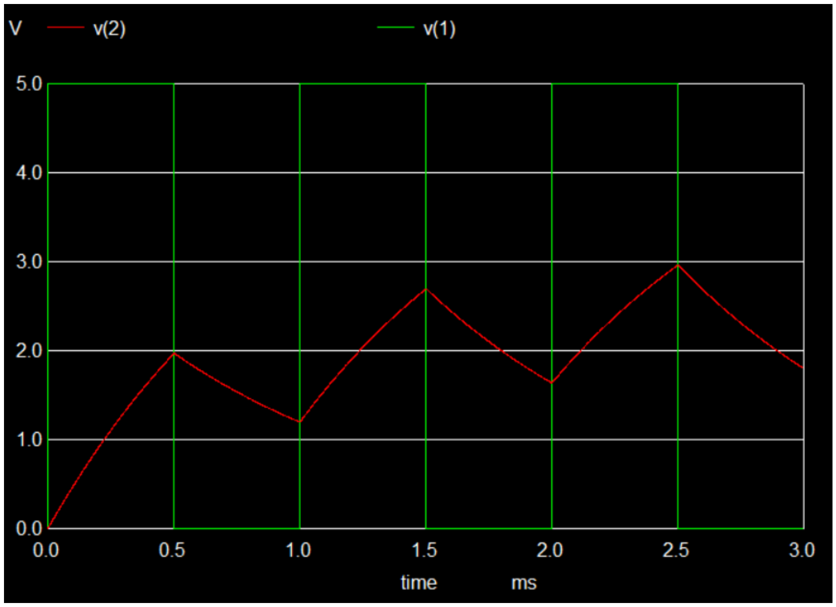
RC Integrator for $T = 10\tau$
V(1): Vin, V(2): Vout



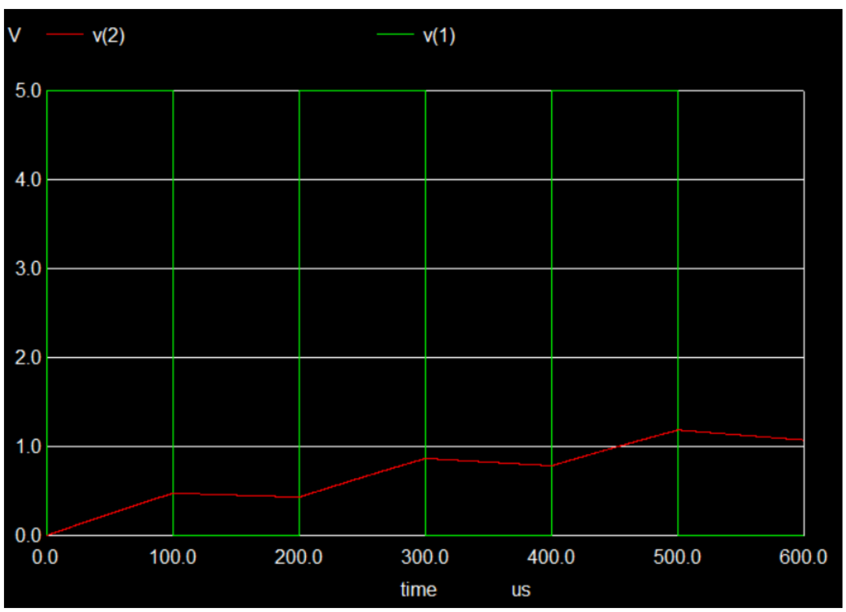
RC Integrator for $T = 5\tau$
V(1): Vin, V(2): Vout



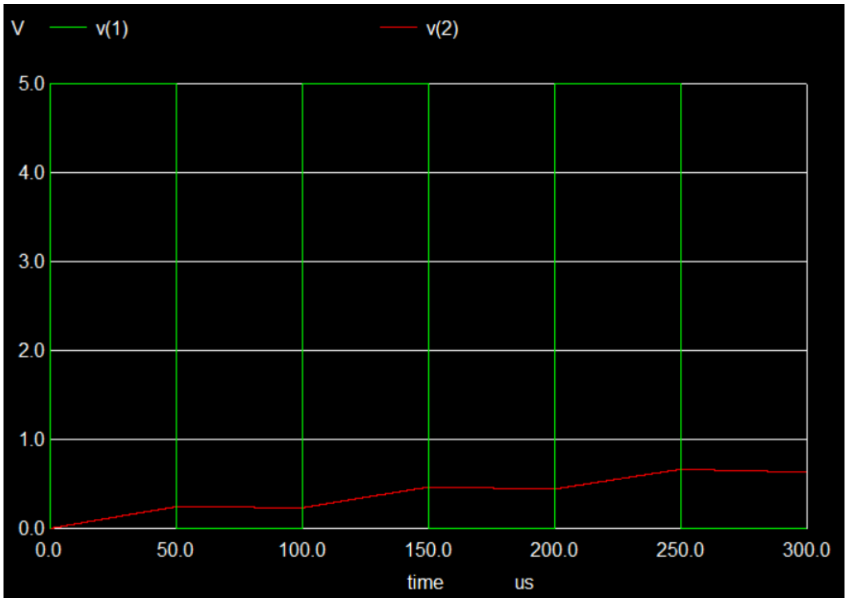
RC Integrator for $T = \tau$
V(1): Vin, V(2): Vout



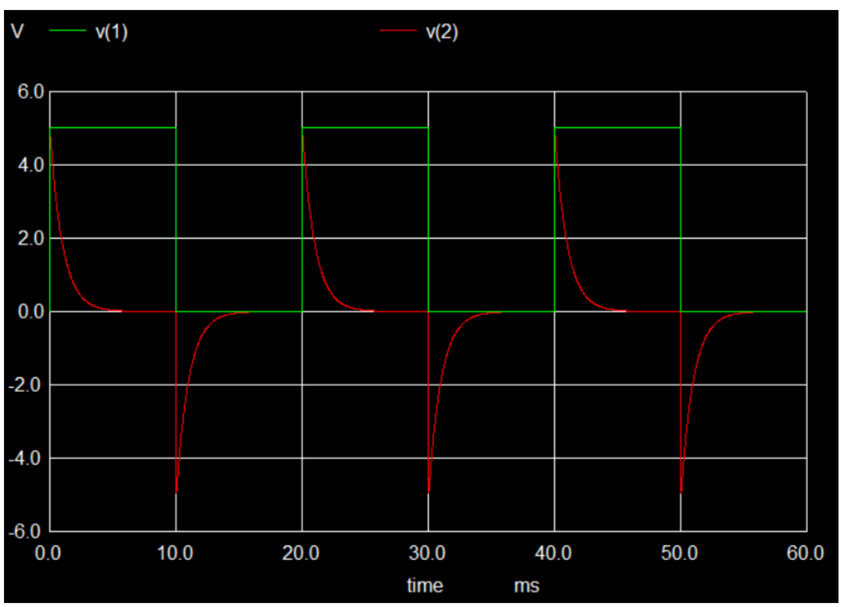
RC Integrator for $T = 0.5\tau$
V(1): Vin, V(2): Vout



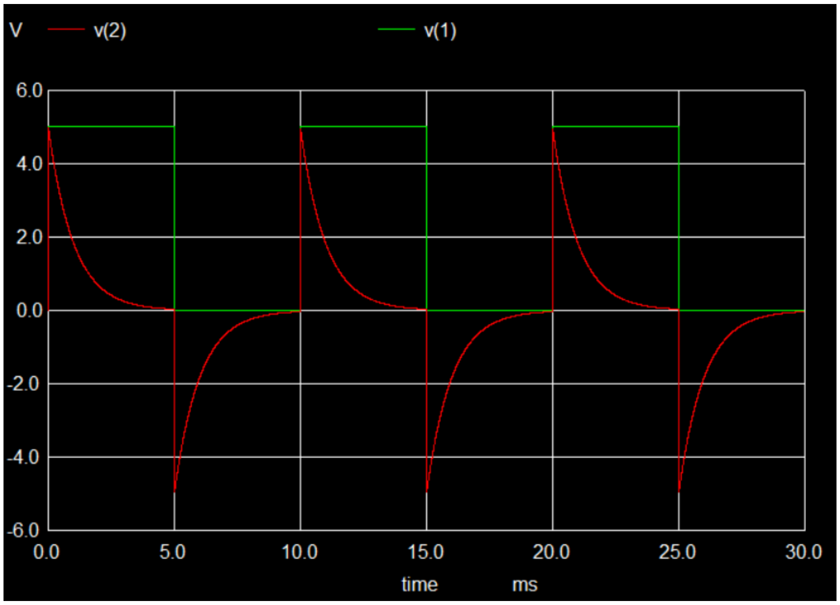
RC Integrator for $T = 0.1\tau$
V(1): Vin, V(2): Vout



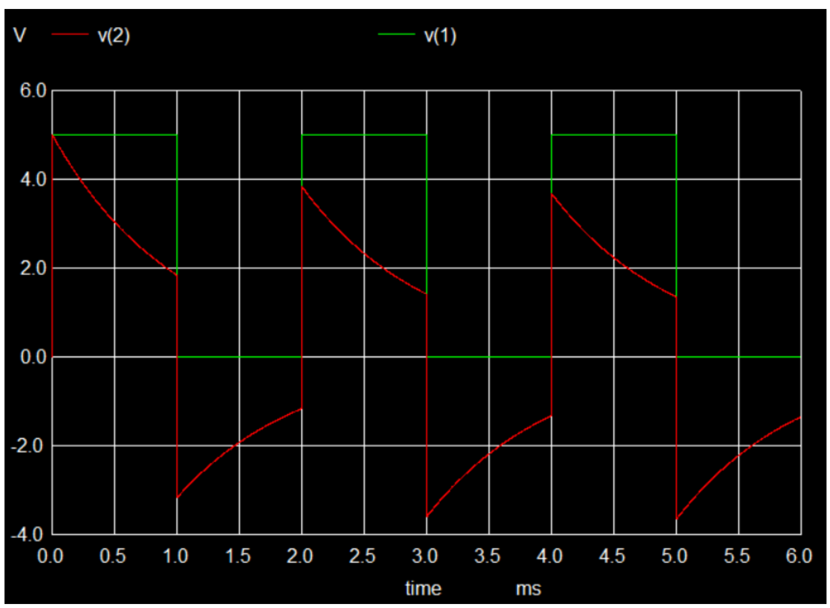
RC Integrator for $T = 0.01\tau$
V(1): Vin, V(2): Vout



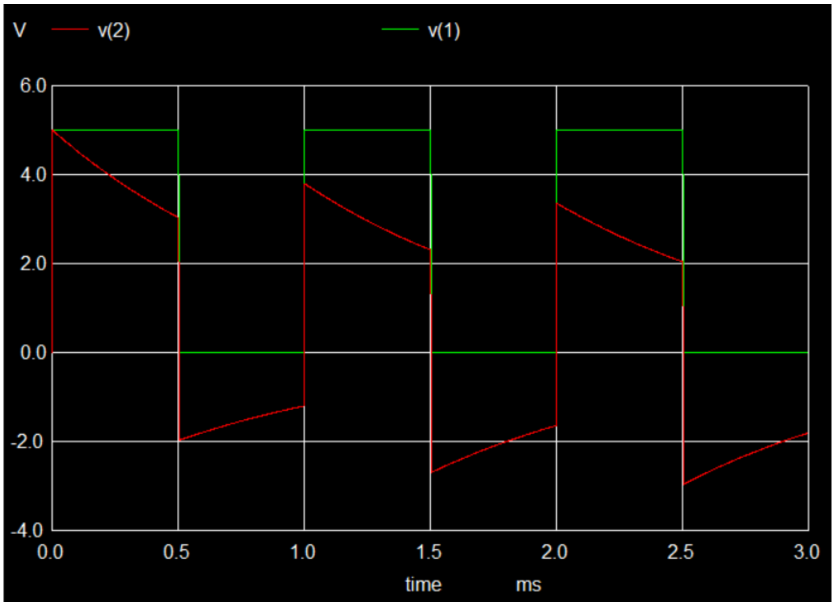
RC Differentiator for $T = 10\tau$
V(1): Vin, V(2): Vout



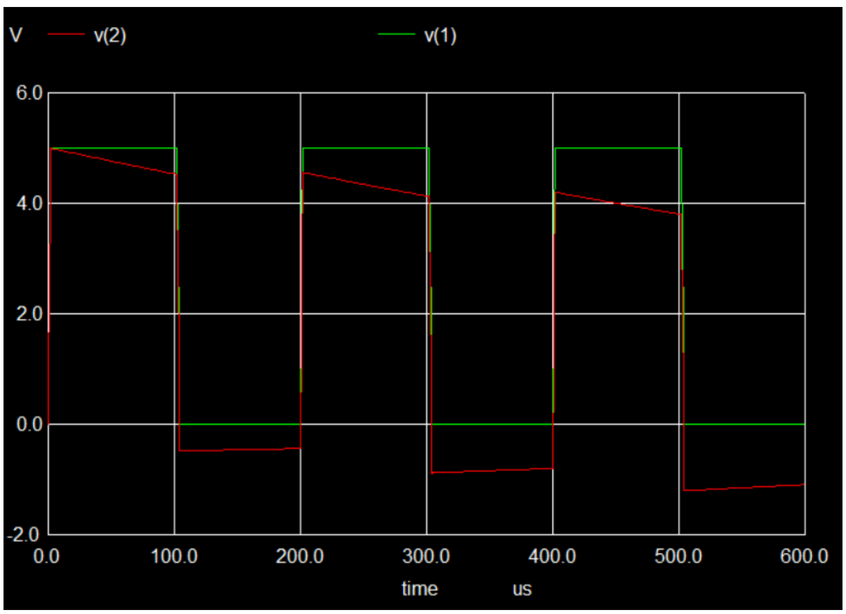
RC Differentiator for $T = 5\tau$
V(1): Vin, V(2): Vout



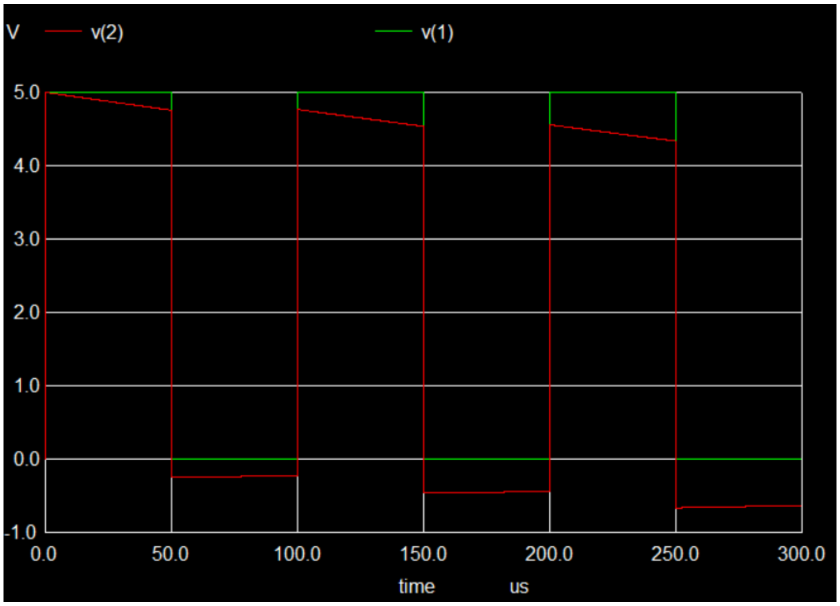
RC Differentiator for $T = \tau$
V(1): Vin, V(2): Vout



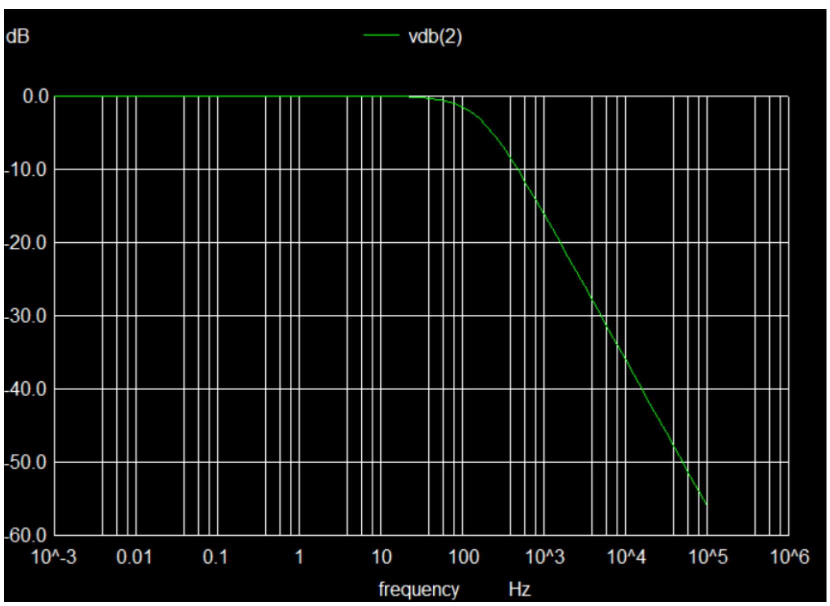
RC Differentiator for $T = 0.5\tau$
V(1): Vin, V(2): Vout



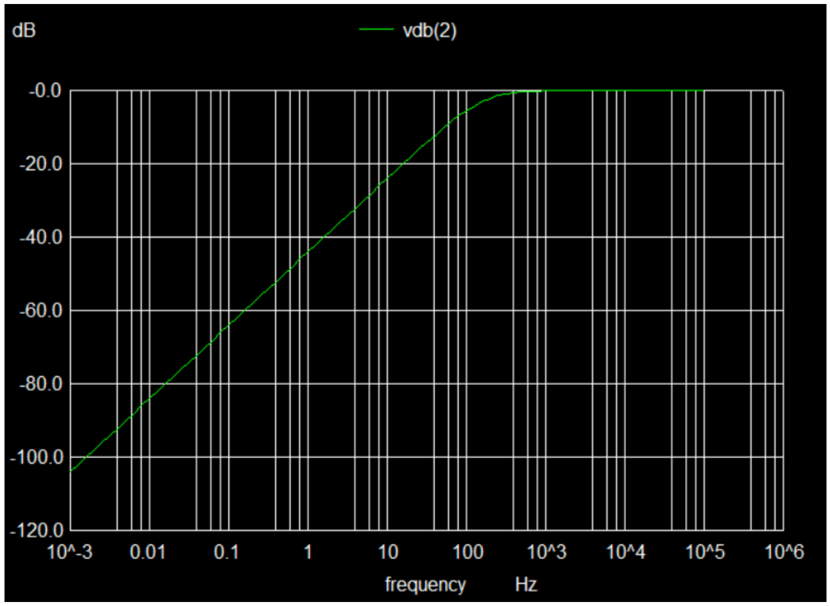
RC Differentiator for $T = 0.1\tau$
V(1): Vin, V(2): Vout



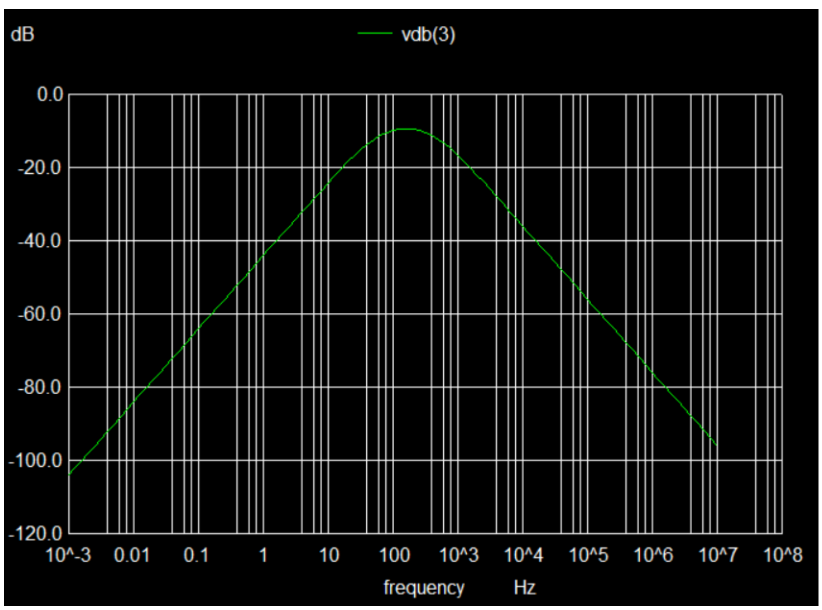
RC Differentiator for $T = 0.01\tau$
V(1): Vin, V(2): Vout



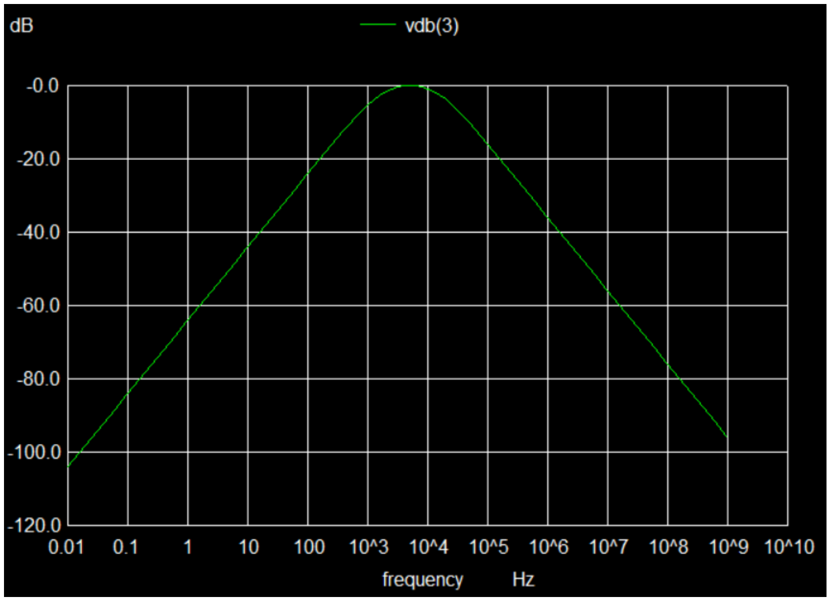
Amplitude Bode Plot for RC Lowpass Filter
vdb(2): $20log_{10}(|V_{out}|)$



Amplitude Bode Plot for RC Highpass Filter
vdb(2): $20log_{10}(|V_{out}|)$



Amplitude Bode Plot for RC Bandpass Filter
vdb(3): $20log_{10}(|V_{out}|)$



Amplitude Bode Plot for RLC Bandpass Filter
vdb(3): $20log_{10}(|V_{out}|)$

4 Experimental Results

4.1 Parameters obtained for RC and RLC Bandpass filters experimentally

4.1.1 RC Bandpass

Peak Amplitude : -9.542 dB
f_{center} : 159.22 Hz
f_{lower} : 48.30 Hz
f_{upper} : 524.81 Hz

4.1.2 RLC Bandpass

Peak Amplitude : -2.97×10^{-7} dB ≈ 0 dB
f_{center} : 5035.01 Hz
f_{lower} : 1465.54 Hz
f_{upper} : 17298.16 Hz

4.2 Parameters obtained for RC and RLC Bandpass filters theoretically

4.2.1 RC Bandpass

Peak Amplitude: -20$log_{10}(3)$ = -9.54 dB
f_{center}: $\frac{1}{2\pi RC}$ = 159.15 Hz
f_{lower}: $\frac{(\sqrt{13}-3)}{4\pi RC}$ = 48.189 Hz
f_{upper}: $\frac{(\sqrt{13}+3)}{4\pi RC}$ = 525.65 Hz

4.2.2 RLC Bandpass

Peak Amplitude: 20$log_{10}(1)$ = 0 dB
f_{center}: $\frac{1}{2\pi\sqrt{LC}} = \frac{10^{4.5}}{2\pi}$ = 5032.93 Hz
f_{lower}: $(\sqrt{\frac{R^2}{4L^2} + \frac{1}{LC}} - \frac{R}{2L})\cdot\frac{1}{2\pi}$ = 1457.99 Hz
f_{upper}: $(\sqrt{\frac{R^2}{4L^2} + \frac{1}{LC}} + \frac{R}{2L})\cdot\frac{1}{2\pi}$= 17373.51 Hz