# EE230: Homework-1
# Familiarization with NGSPICE Circuit Simulator and Lab Equipment

Prateek Garg, 20D070060

January 16, 2022

## 1 Overview of the experiment

### 1.1 Aim of the experiment

Ngspice is a mixed-signal circuit Simulator. This experiment aims to implement some basic circuits namely :

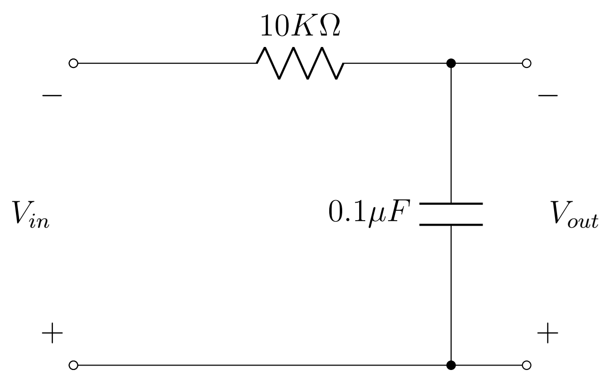
- RC Integrator
- RC Differentiator
- RC Lowpass Filter
- RC Highpass Filter
- RC Bandpass Filter
- RLC Bandpass Filter

in Ngspice and plot their characteristics.

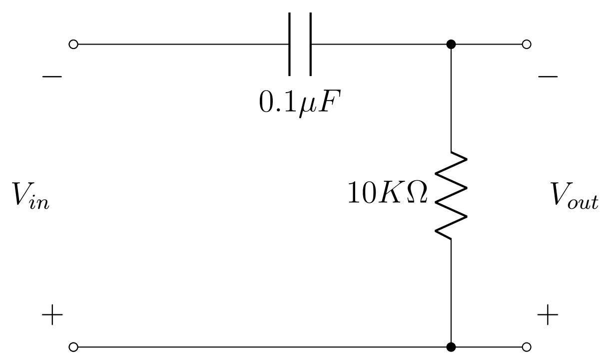
### 1.2 Methods

We start by creating a netlist for each circuit, simulating on Ngspice and exporting the values to a python script to plot them using Matplotlib.

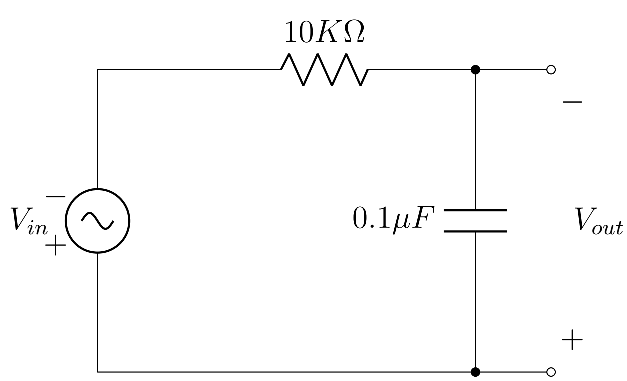
# 2 Design



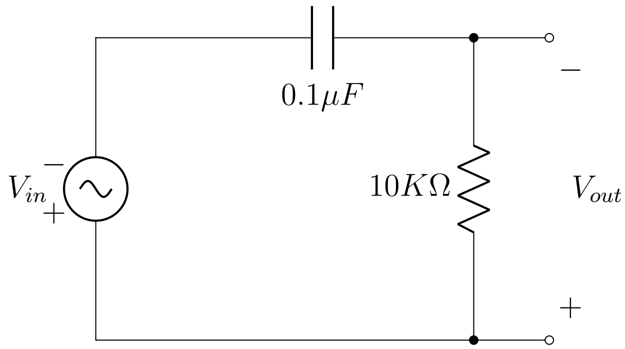

RC Integrator Circuit



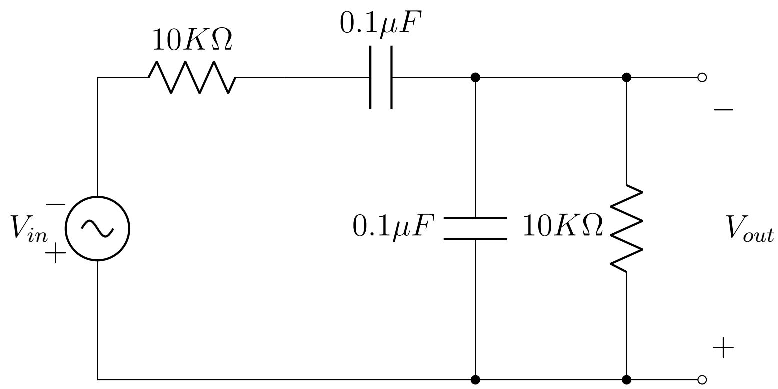

RC Differentiator Circuit



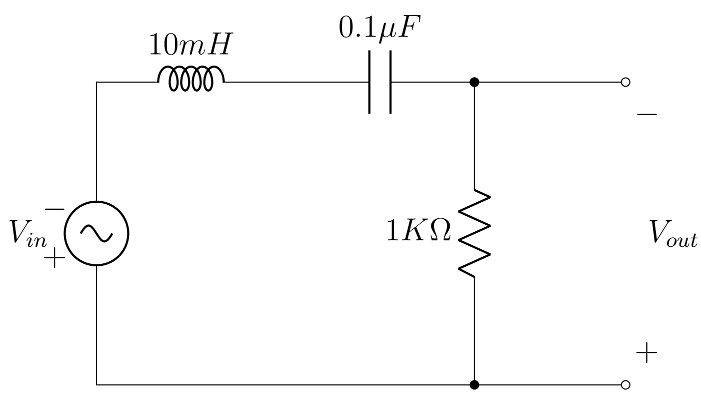

RC Lowpass Filter



RC Lowpass Filter



RC Bandpass Filter



RLC Bandpass Filter

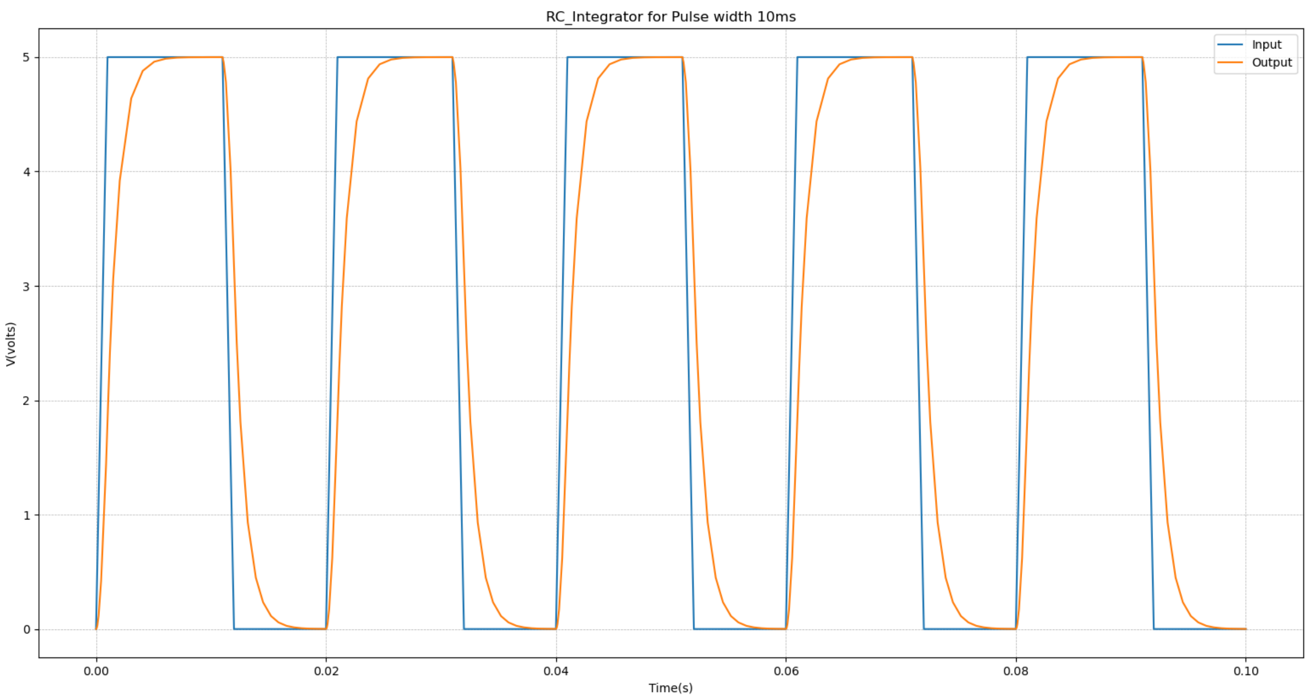
# 3 Simulation results

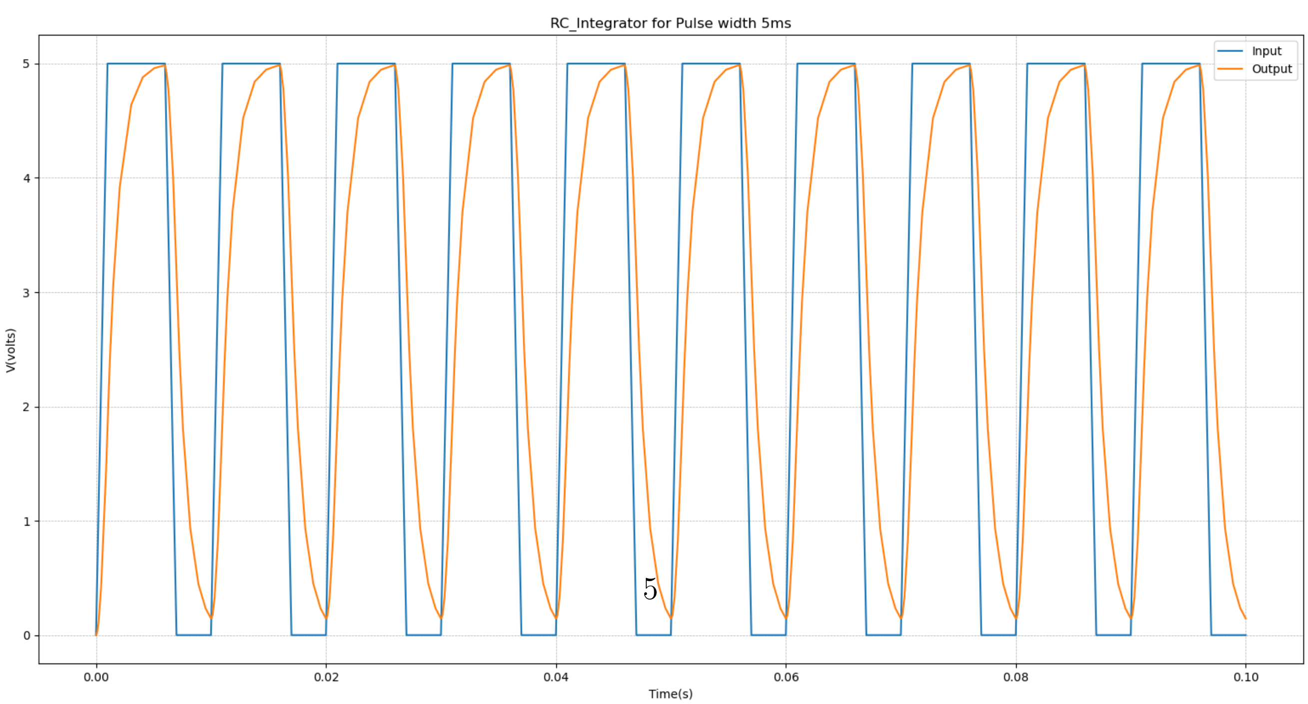
## 3.1 RC Integrator

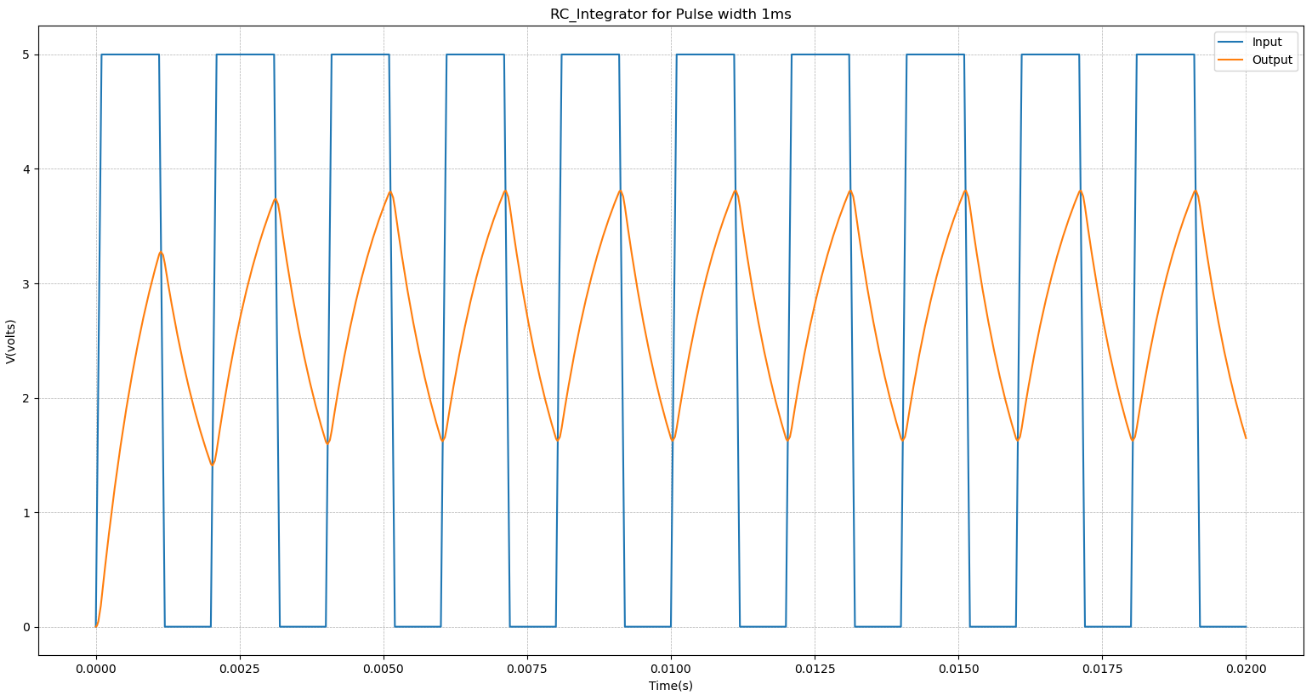
### 3.1.1 Code snippet

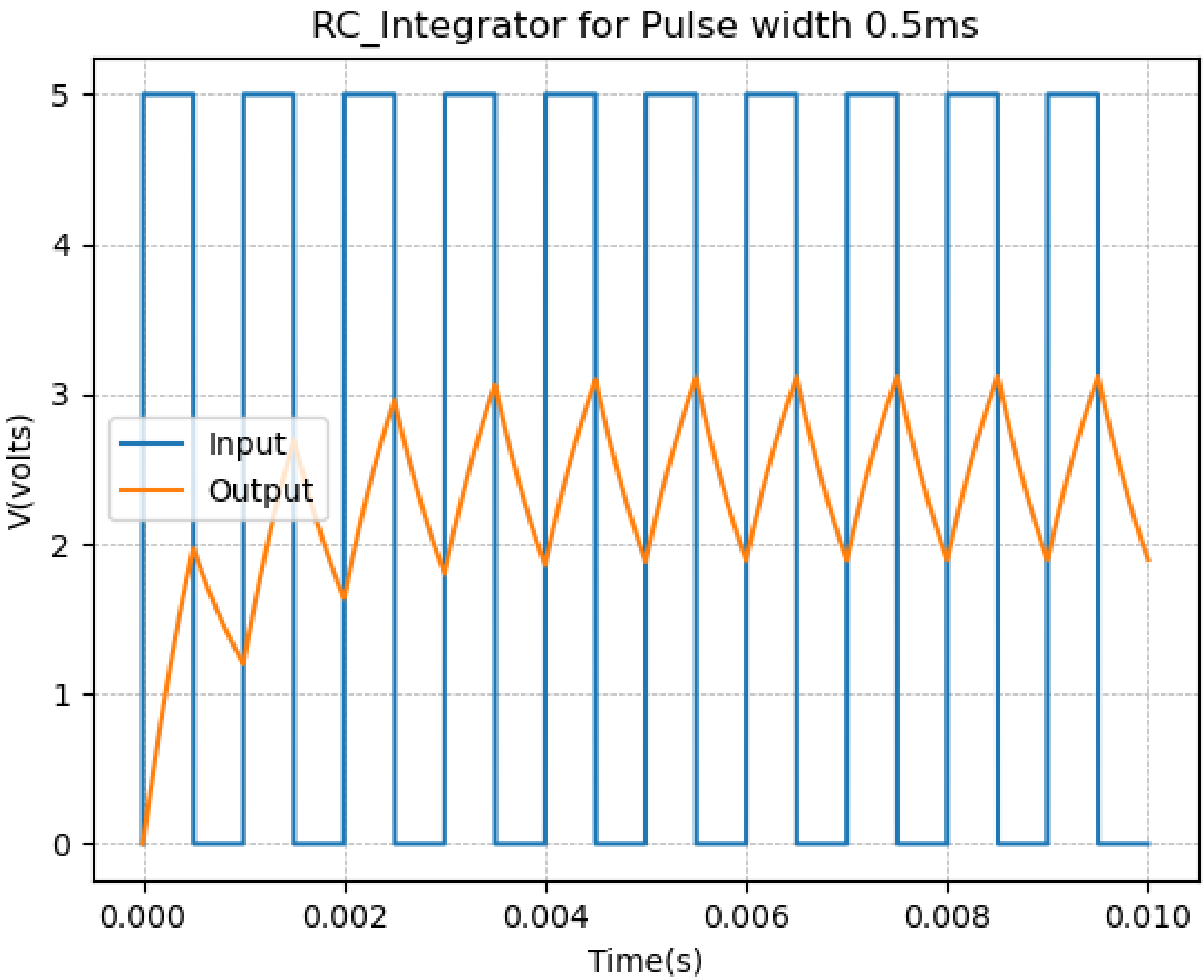
```
RC Integrator circuit transient analysis
*tau =1m #Time Period

*describe circuit
* <element-name> <nodes> <value/nodel>
r 1 2 10k
c 2 0 0.1u
*v 1 0 pulse(0 5 0 0 0 10m 20m) $10*tau
*v 1 0 pulse(0 5 0 0 0 10m 20m) $5*tau
*v 1 0 pulse(0 5 0 0 0 10m 20m) $1*tau
*v 1 0 pulse(0 5 0 0 0 10m 20m) $0.5*tau
*v 1 0 pulse(0 5 0 0 0 10m 20m) $0.1*tau
v 1 0 pulse(0 5 0 0 0 0.05m 0.1m) $0.05*tau
*analysis command
.tran 0.011m 10m

.control
run

*display cmd
plot v(1) v(2)
print v(1) v(2)
*end control mode
.endc

*end netlist
.end
```

### 3.1.2 Simulation results

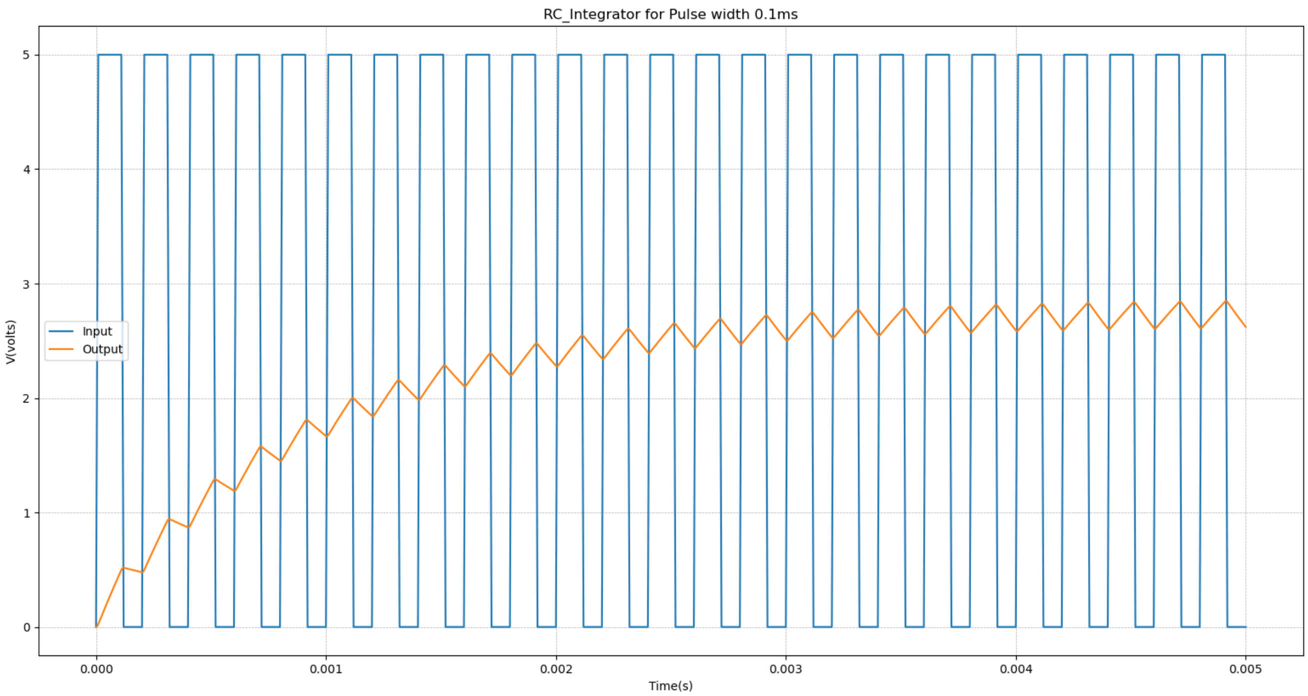


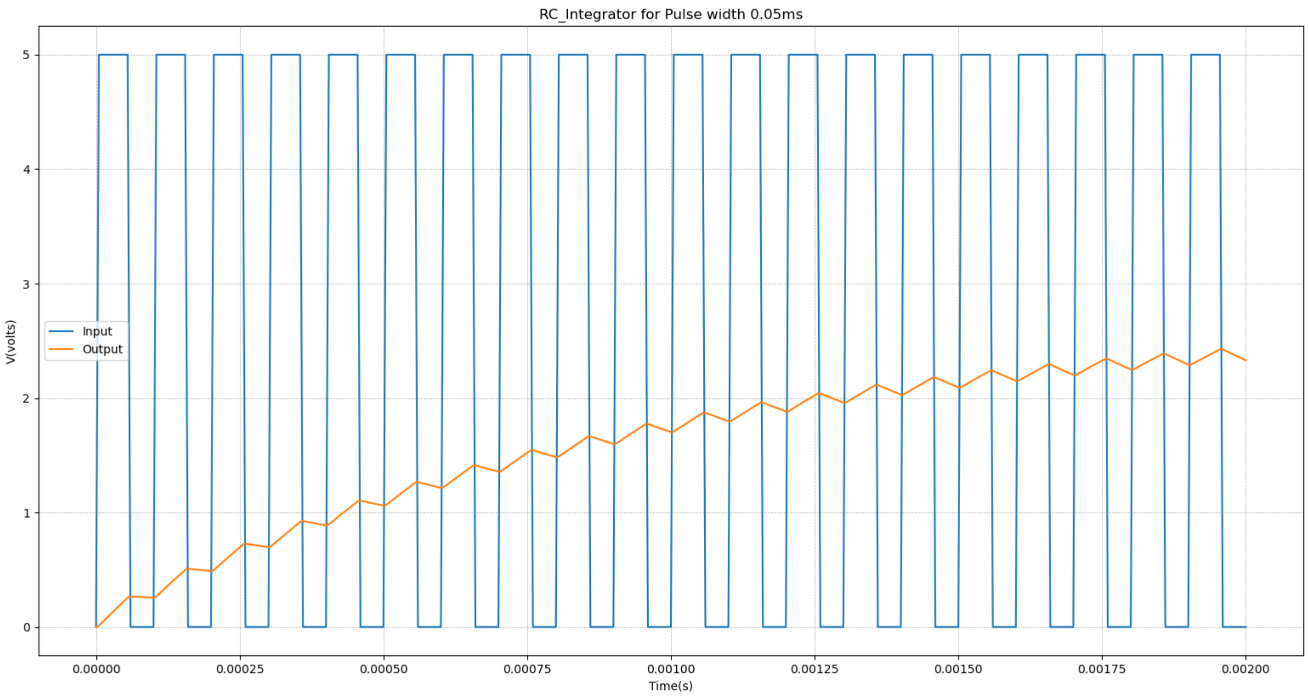




RC_Integrator for Pulse width 1ms
Input
Output
V(volts)
Time(s)
0
1
2
3
4
5
0.0000
0.0025
0.0050
0.0075
0.0100
0.0125
0.0150
0.0175
0.0200



RC_Integrator for Pulse width 0.5ms
Input
Output
V(volts)
Time(s)
0
1
2
3
4
5
0.000
0.002
0.004
0.006
0.008
0.010


RC_Integrator for Pulse width 0.1ms
Input
Output
V(volts)
Time(s)
0
1
2
3
4
5
0.000
0.001
0.002
0.003
0.004
0.005



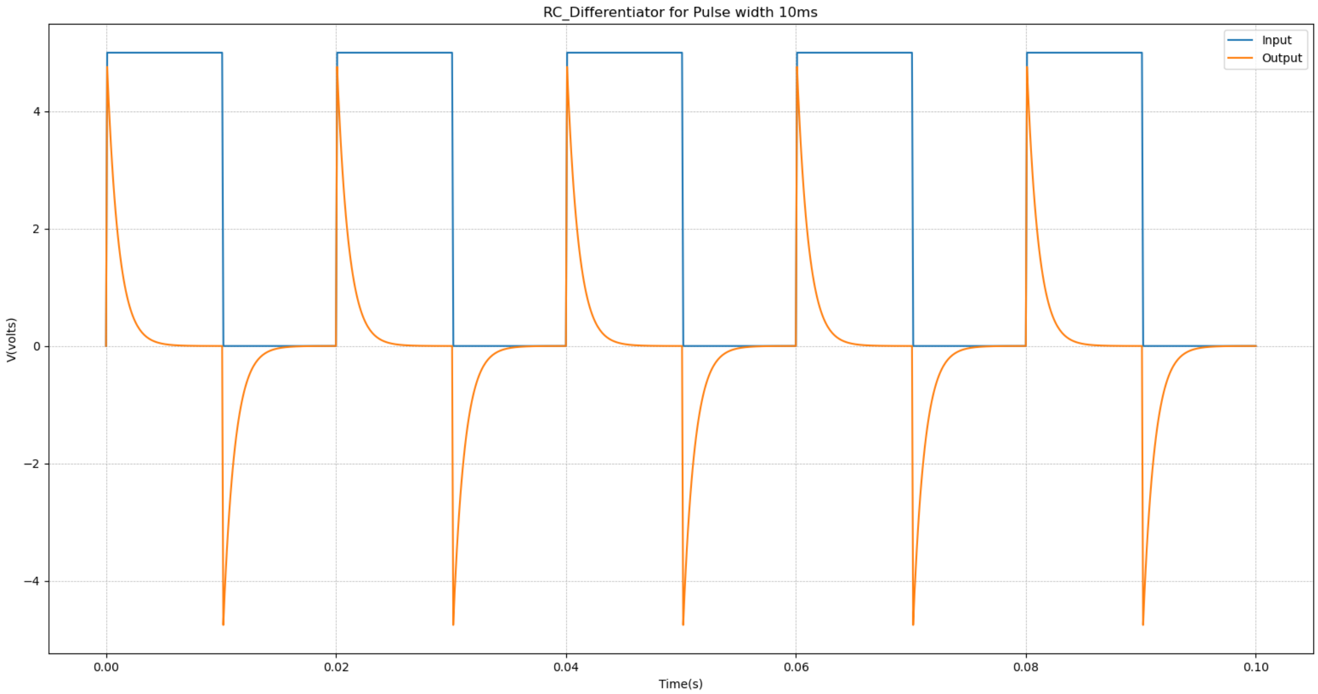

## 3.2 RC Differentiator

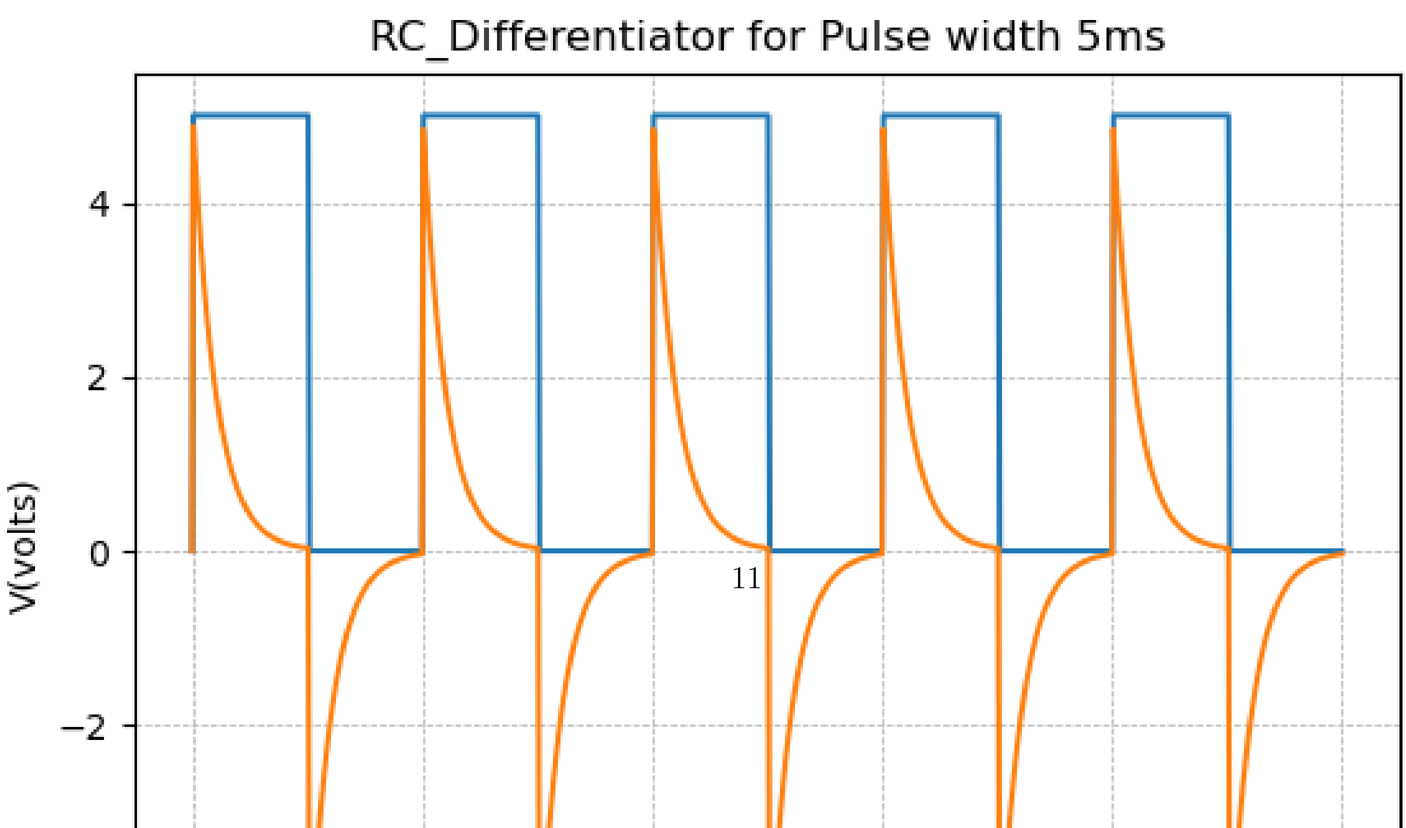
### 3.2.1 Code snippet

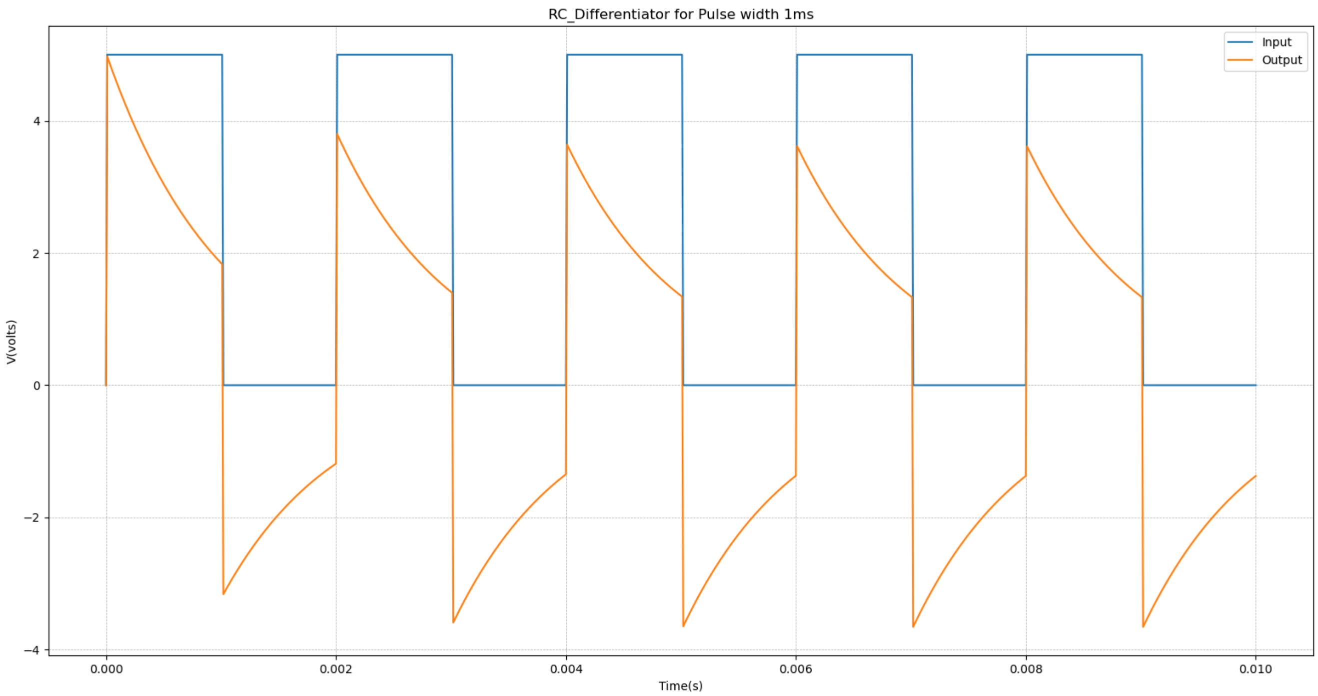
```
RC DIfferentiator circuit transient analysis
*tau =1m #Time Period

*describe circuit
* <element-name> <nodes> <value/nodel>
r 2 0 10k
c 1 2 0.1u
v 1 0 pulse(0 5 0 0 0 10m 20m) $10*tau
*v 1 0 pulse(0 5 0 0 0 10m 20m) $5*tau
*v 1 0 pulse(0 5 0 0 0 10m 20m) $1*tau
*v 1 0 pulse(0 5 0 0 0 10m 20m) $0.5*tau
*v 1 0 pulse(0 5 0 0 0 10m 20m) $0.1*tau
*v 1 0 pulse(0 5 0 0 0 10m 20m) $0.05*tau
*analysis command
```

```
.tran 0.1m 100m

.control
run

*display cmd
plot v(2) v(1)
print v(1) v(2)
*end control mode
.endc

*end netlist
.end
```

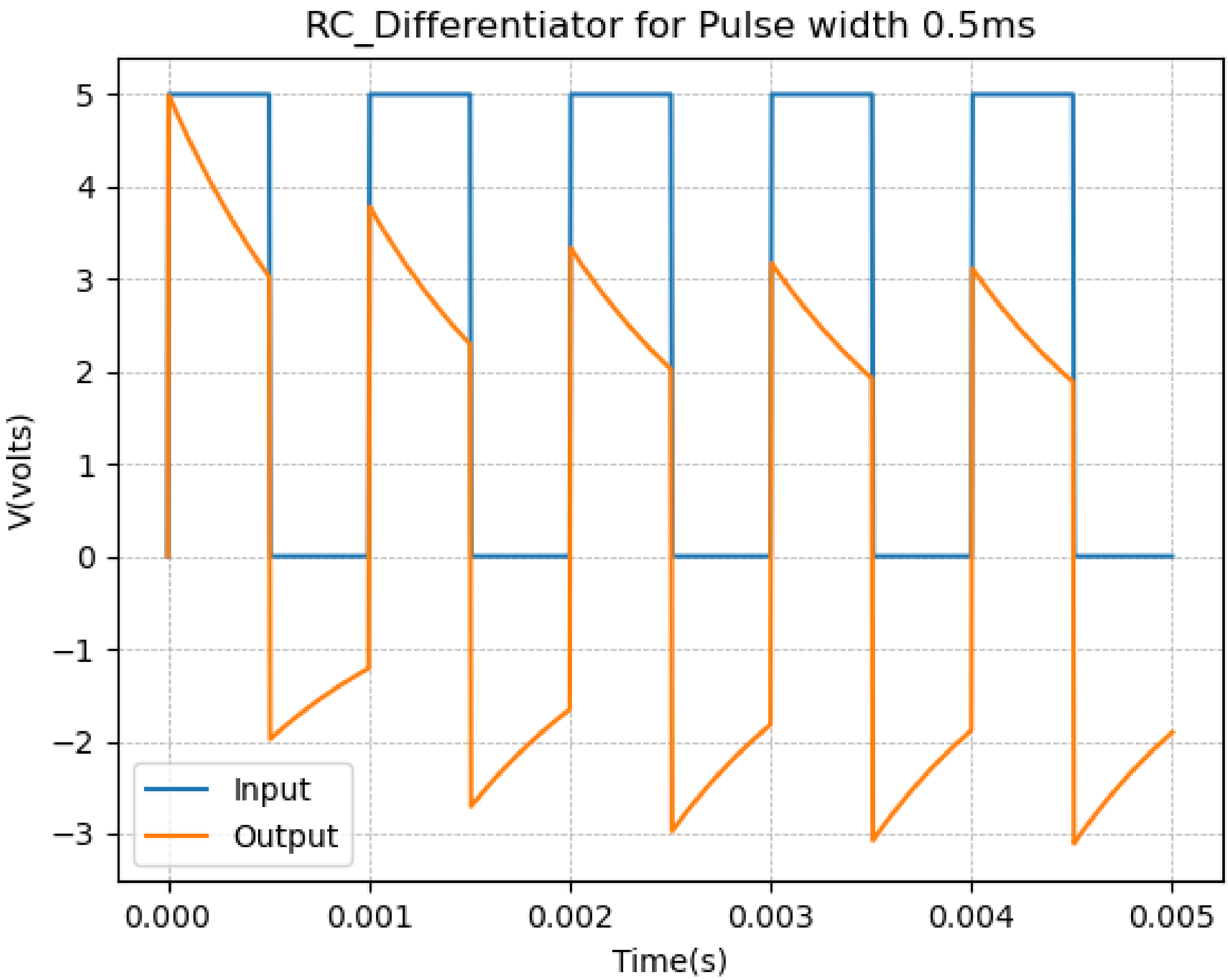
### 3.2.2 Simulation results

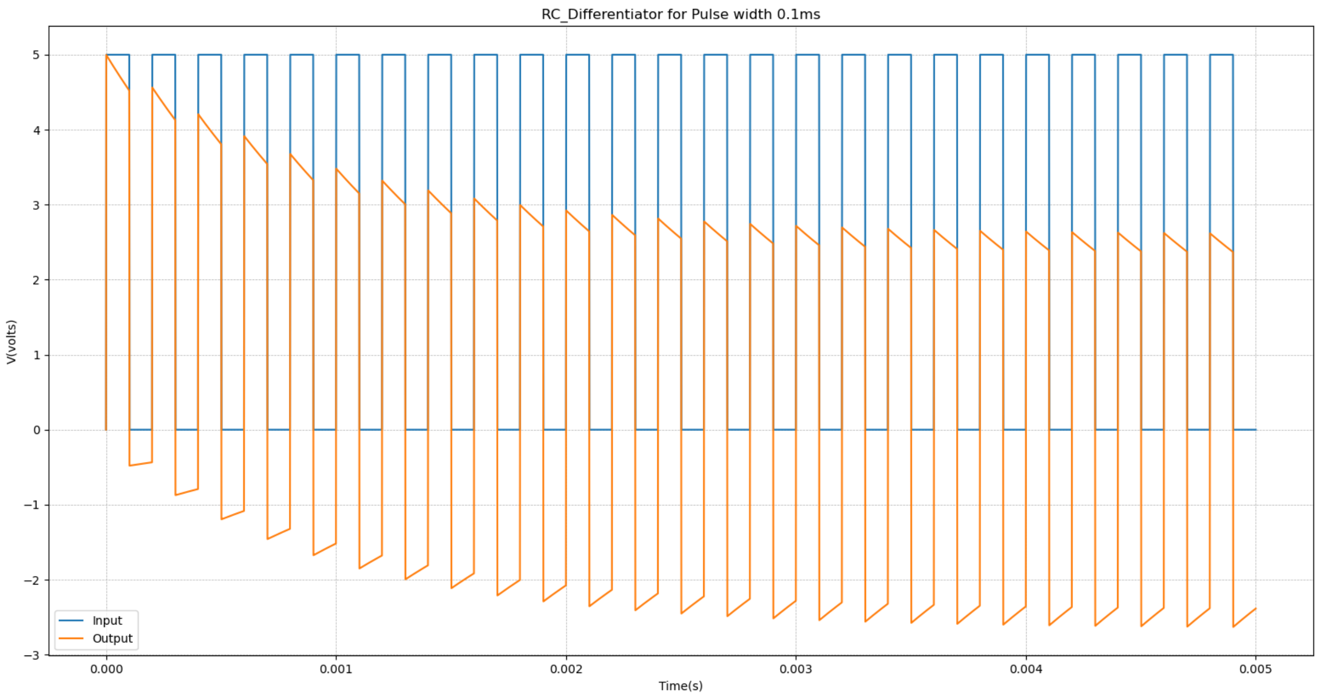


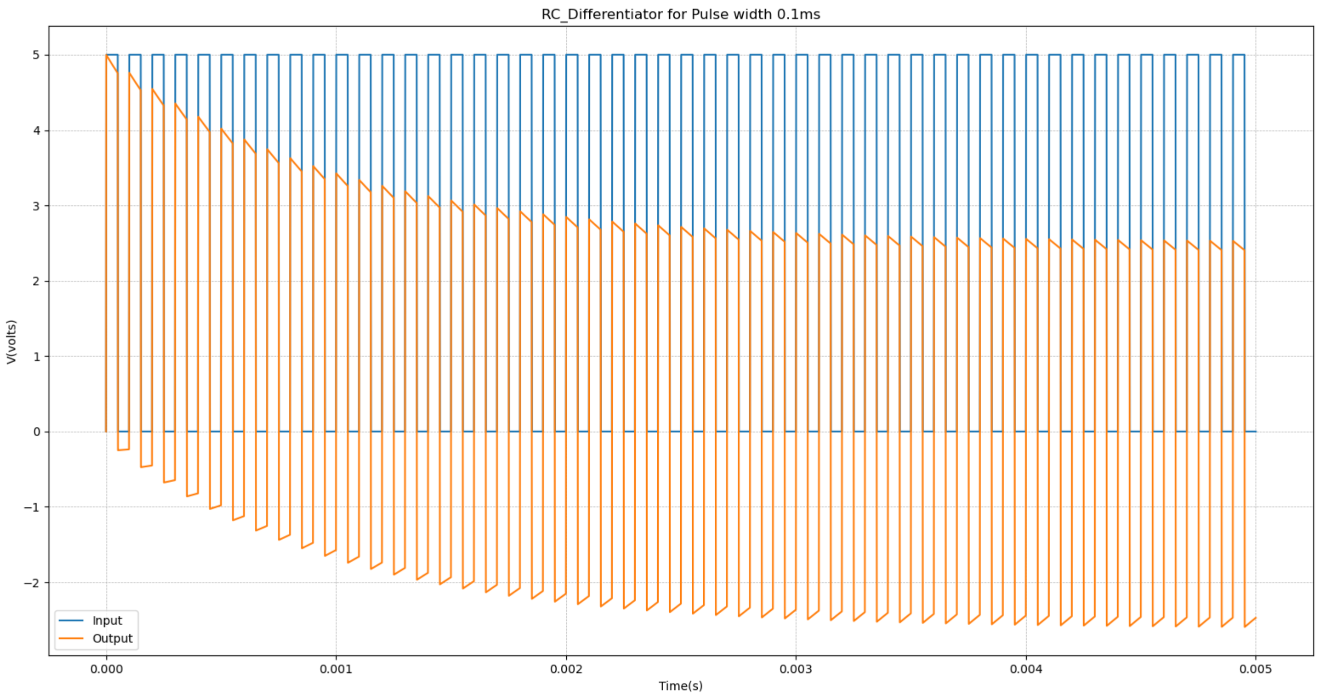





RC_Differentiator for Pulse width 1ms
Input
Output
V(volts)
Time(s)
4
2
0
−2
−4
0.000
0.002
0.004
0.006
0.008
0.010


RC_Differentiator for Pulse width 0.5ms
V(volts)
Time(s)
Input
Output
5
4
3
2
1
0
−1
−2
−3
0.000
0.001
0.002
0.003
0.004
0.005


RC_Differentiator for Pulse width 0.1ms
V(volts)
Time(s)
Input
Output
5
4
3
2
1
0
−1
−2
−3
0.000
0.001
0.002
0.003
0.004
0.005



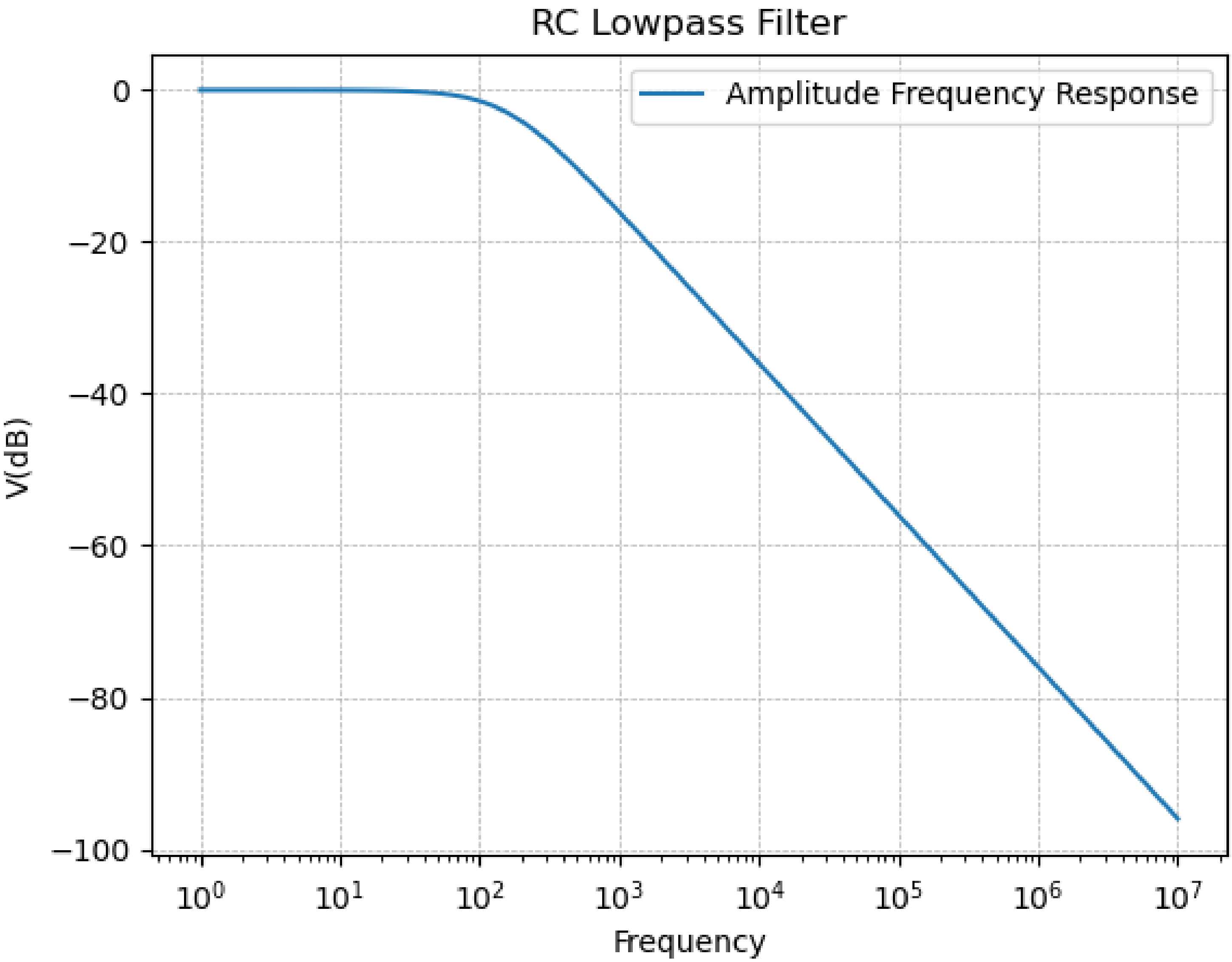

## 3.3 RC Lowpass Filter

### 3.3.1 Code snippet

```
RC Lowpass Filter

*describe circuit
* <element-name> <nodes> <value/nodel>
r 1 2 10k
c 2 0 0.1u
vin 1 0 dc 0 ac 1 $ac analysis
*analysis command
.ac dec 10 1 10Meg

.control
run

*display cmd
```

```
plot vdb(2)
print vdb(2)
*end control mode
.endc

*end netlist
.end
```

#### 3.3.2 Simulation results

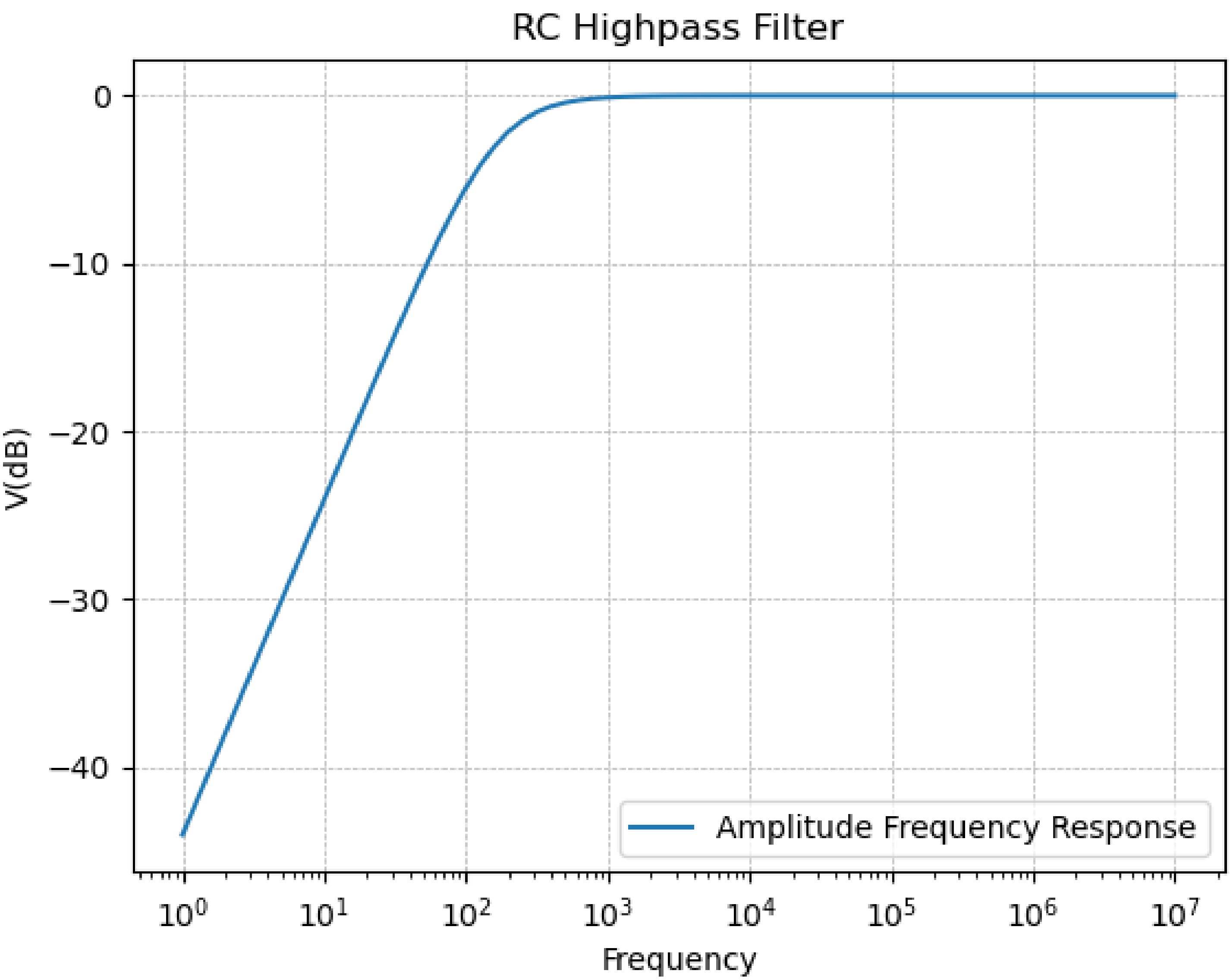



### 3.4 RC Highpass Filter

#### 3.4.1 Code snippet

```
RC Highpass Filter
*describe circuit
* <element-name> <nodes> <value/nodel>
c 1 2 0.1u
r 2 0 10k
v 1 0 dc 0 ac 1 $ac analysis
*analysis command
.ac dec 10 1 10Meg

.control
run

*display cmd
plot vdb(2)
print vdb(2)
*end control mode
.endc

*end netlist
.end
```

### 3.4.2 Simulation results

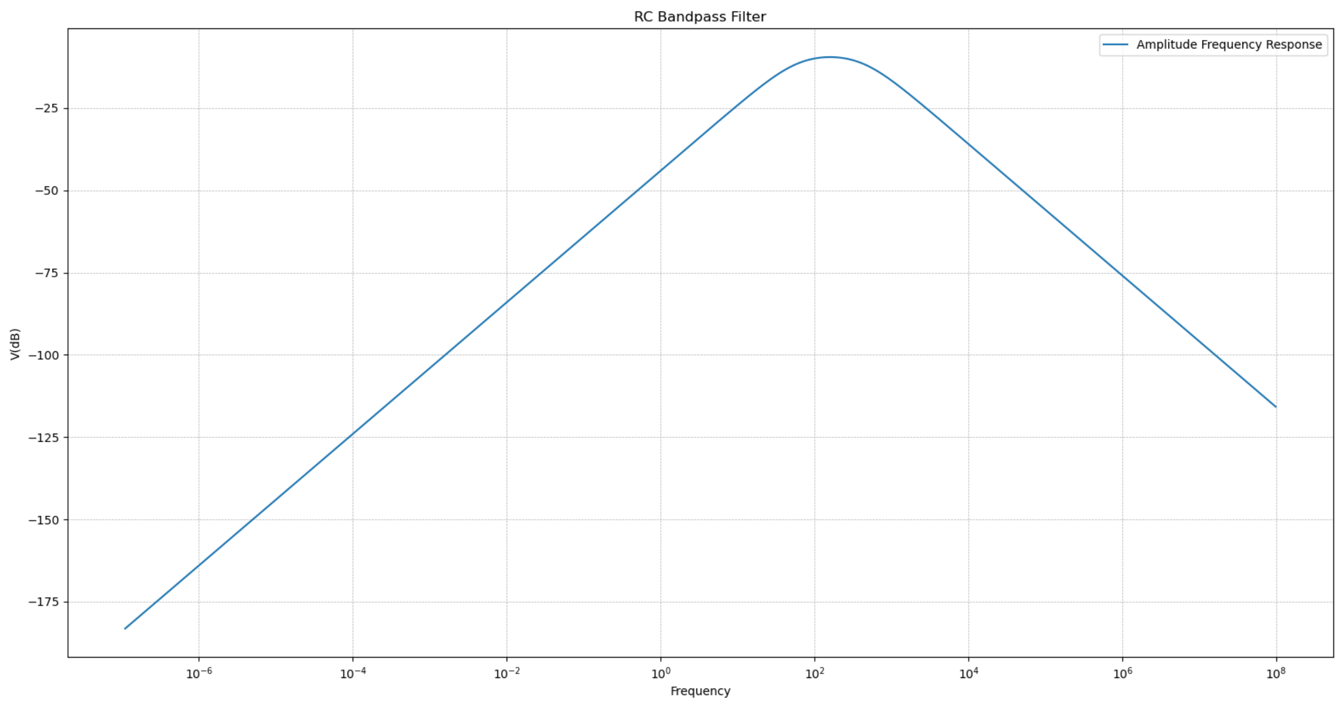



## 3.5 RC Bandpass Filter

### 3.5.1 Code snippet

```
RC Bandpass Filter
*describe circuit
* <element-name> <nodes> <value/nodel>
r1 1 2 10k
c1 2 3 0.1u
r2 3 0 10k
c2 3 0 0.1u
v 1 0 dc 0 ac 1 $ac analysis
*analysis command
.ac dec 20 0.1u 100Meg

.control
run

*display cmd
plot vdb(3)
*print vdb(3)
*end control mode
.endc

*end netlist
.end
```

### 3.5.2 Simulation results



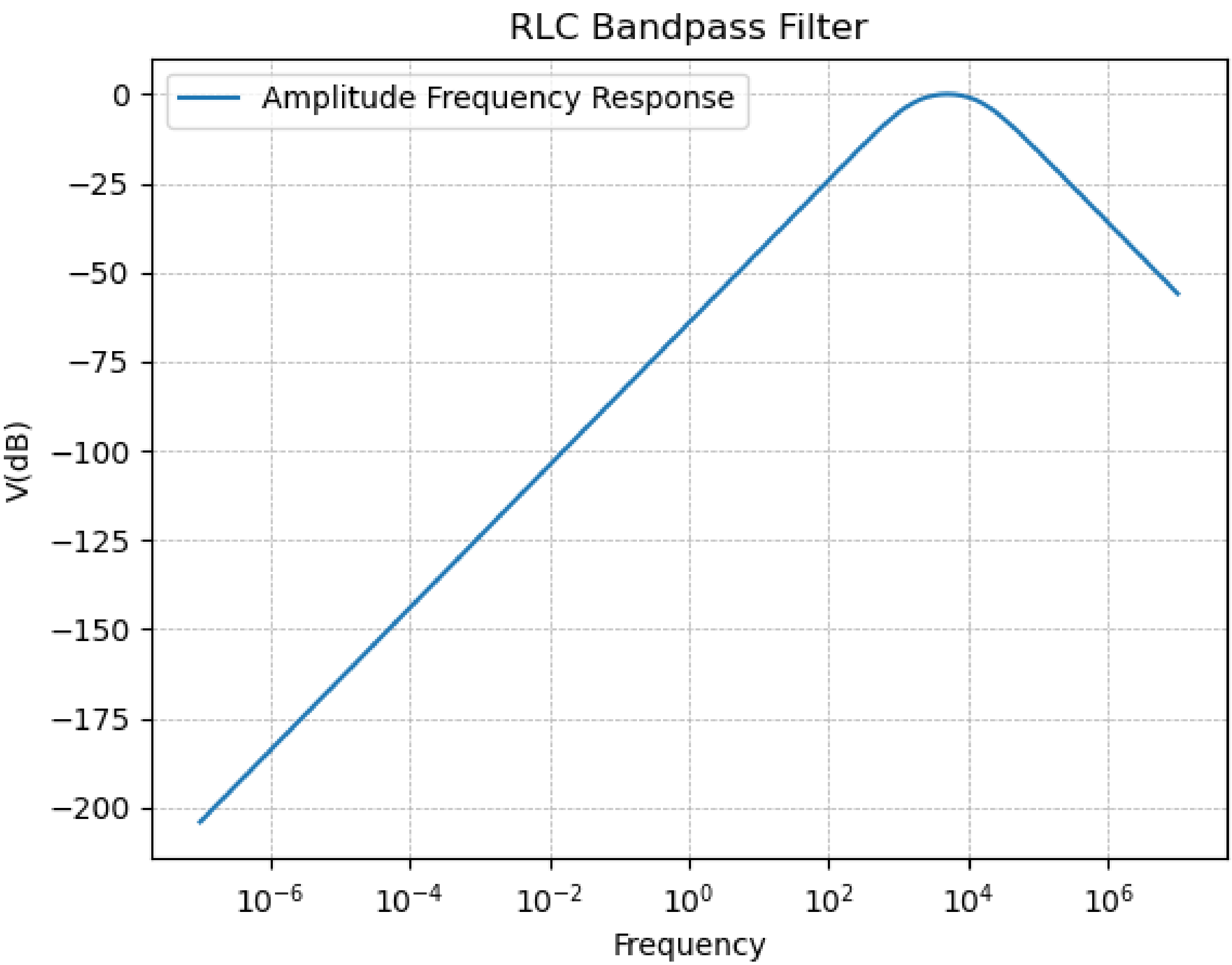

## 3.6 RLC Bandpass Filter

### 3.6.1 Code snippet

```
RLC Bandpass Filter
*describe circuit
* <element-name> <nodes> <value/nodel>
l 1 2 10m
c 2 3 0.1u
r 3 0 1k

v 1 0 dc 0 ac 1 $ac analysis
*analysis command
.ac dec 20 0.1u 100Meg

.control
```

```
run

*display cmd
plot vdb(3)
print vdb(3)
*end control mode
.endc

*end netlist
.end
```

#### 3.6.2 Simulation results



# 4 Experimental results

## 4.1 RC Integrator

$\tau = RC = 10K\Omega \cdot 0.1\mu F = 1ms$ The circuit is simulated for pulsewidth $T$, where $T = \{10\tau, 5\tau, \tau, 0.5\tau, 0.1\tau, 0.01\tau\}$

## 4.2 RC Differentiator

$\tau = RC = 10K\Omega \cdot 0.1\mu F = 1ms$ The circuit is simulated for pulsewidth $T$, where $T = \{10\tau, 5\tau, \tau, 0.5\tau, 0.1\tau, 0.01\tau\}$

## 4.3 RC Lowpass Filter

The Transfer Function is

$$G(s) = \frac{1}{1 + sRC}$$

The 3db frequency is expected to be

$$f_{3db} = \frac{1}{2\pi} \cdot \frac{1}{RC} = 159.16Hz$$

The experimental value follows it quite closely.

## 4.4 RC Highpass Filter

The Transfer Function is

$$G(s) = \frac{sRC}{1 + sRC}$$

The 3db frequency is expected to be

$$f_{3db} = \frac{1}{2\pi} \cdot \frac{1}{RC} = 159.16Hz$$

The experimental value follows it quite closely.

## 4.5 RC Bandpass Filter

The Transfer Function is

$$G(s) = \frac{1}{3 + sRC + \frac{1}{sRC}}$$

The peak frequency is expected to be

$$f_{peak} = \frac{1}{2\pi} \cdot \frac{1}{RC} = 159.16Hz$$

The lower and higher frequencies are expected to be

$$f_L = \frac{\sqrt{13} - 3}{2} \cdot \frac{1}{2\pi} \cdot \frac{1}{RC} = 48.189Hz$$

$$f_H = \frac{\sqrt{13} + 3}{2} \cdot \frac{1}{2\pi} \cdot \frac{1}{RC} = 525.67Hz$$

The experimental values are

$f_L = 49.33Hz$,$f_H = 532.9Hz$ with $f_{peak} = 162.1Hz$ and peak amplitude = -9.5 db

They follow theoretical values follows it quite closely.

## 4.6 RLC Bandpass Filter

The Transfer Function is

$$G(s) = \frac{R}{R + sC + \frac{1}{sL}}$$

The peak frequency is expected to be

$$f_{peak} = \frac{1}{2\pi} \cdot \frac{1}{\sqrt{LC}} = 5.032KHz$$

The lower and higher frequencies are expected to be

$$f_L = \frac{1}{2\pi} \cdot \frac{\sqrt{(RC)^2 + 4LC} - RC}{2LC} = 1.46KHz$$

$$f_H = \frac{1}{2\pi} \cdot \frac{\sqrt{(RC)^2 + 4LC} + RC}{2LC} = 17.37KHz$$

The experimental values are

$f_L = 1.448Hz$,$f_H = 17.339Hz$ with $f_{peak} = 5.035KHz$.

They follow theoretical values follows it quite closely.

# 5 Experiment completion status

All the sections were completed