

# EE230: Homework-1

## Familiarization with NGSPICE Circuit Simulator and Lab Equipment

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## 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 :

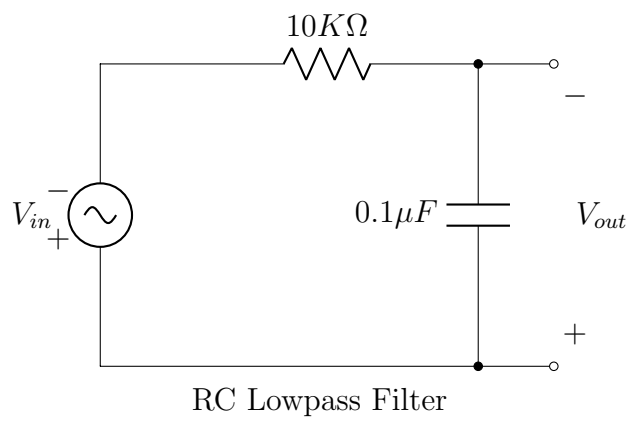
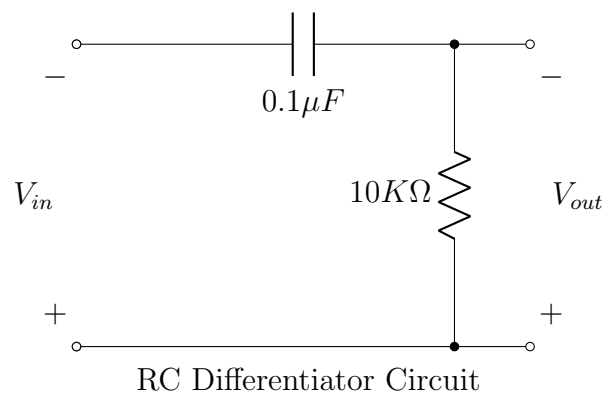
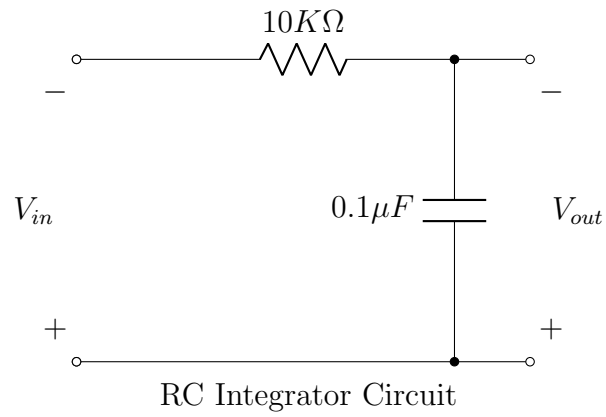
- RC Integrator
- RC Differentiator
- RC Lowpass Filter
- RC Highpass Filter
- RC Bandpass Filter
- RLC Bandpass Filter

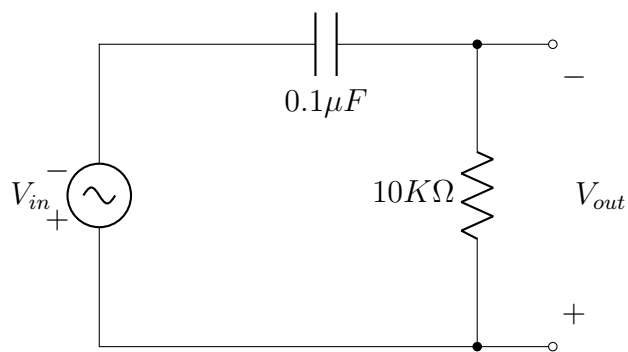
in Ngspice and plot their characteristics.

### 1.2 Methods

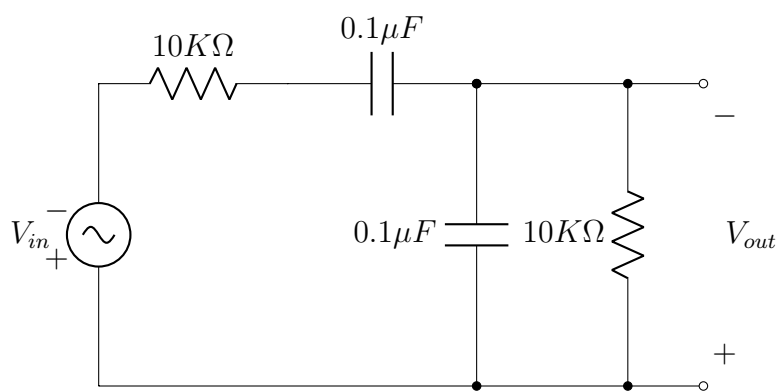
We start by creating a netlist for each circuit, simulating on Ngspice and exporting the values to a python script to plot them using Matplotlib.

## 2 Design

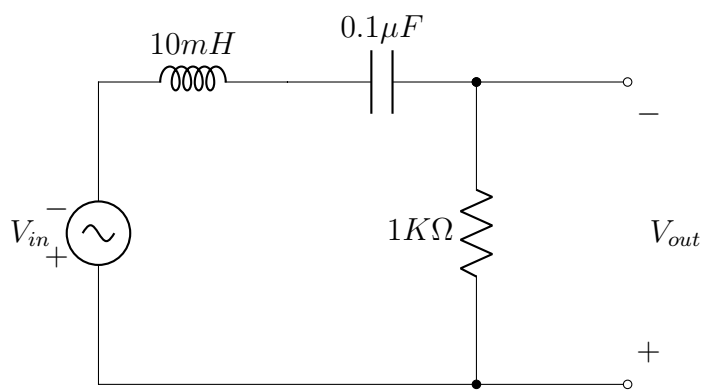




RC Lowpass Filter



RC Bandpass Filter



RLC Bandpass Filter

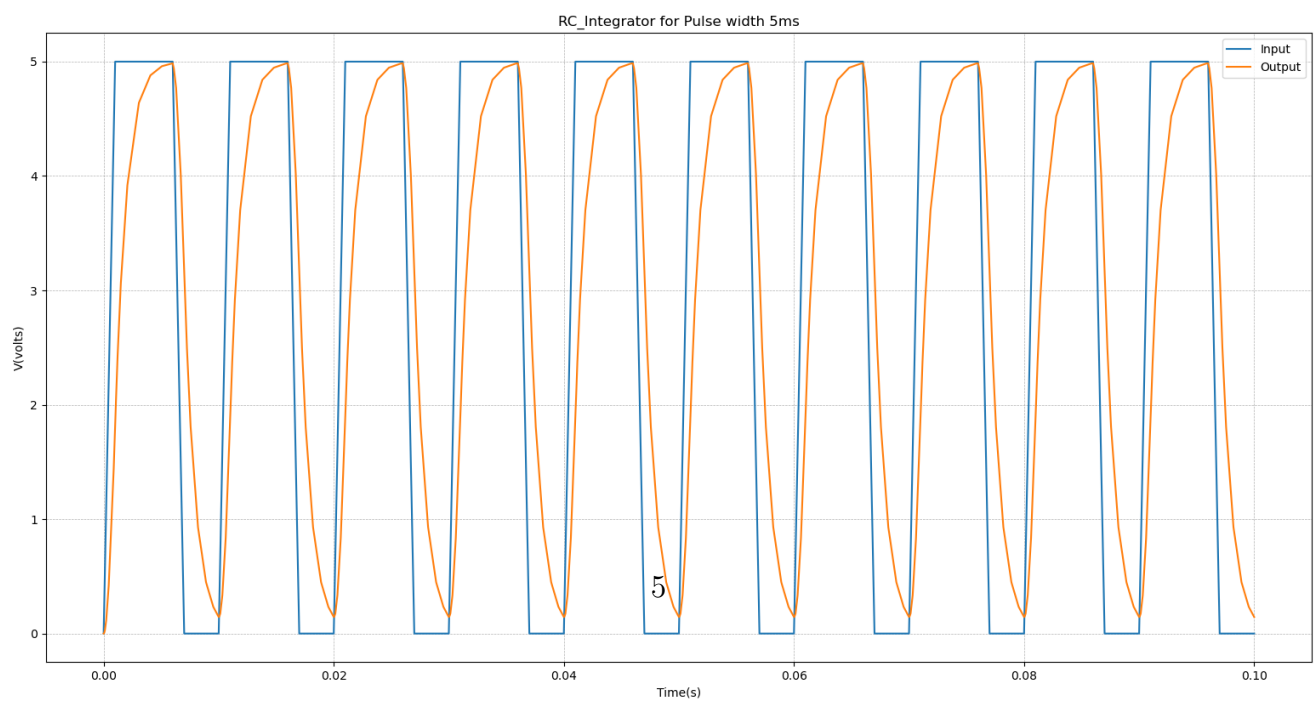
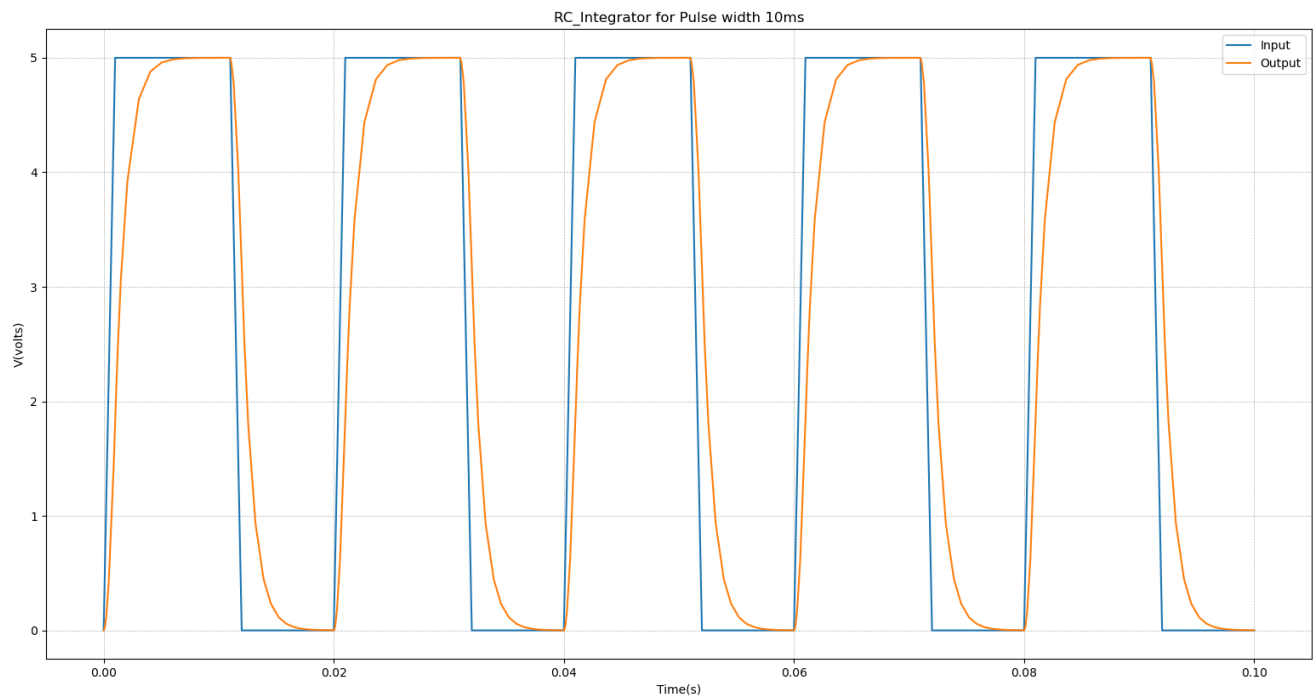
## 3 Simulation results

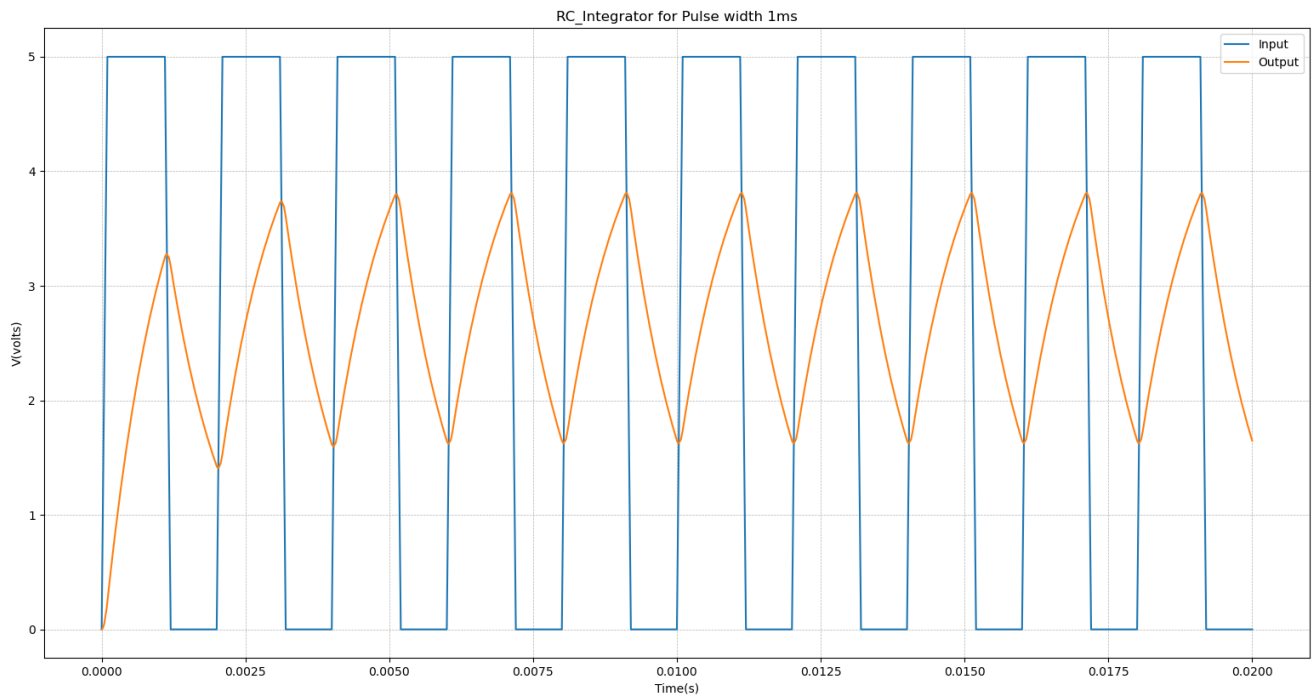
### 3.1 RC Integrator

#### 3.1.1 Code snippet

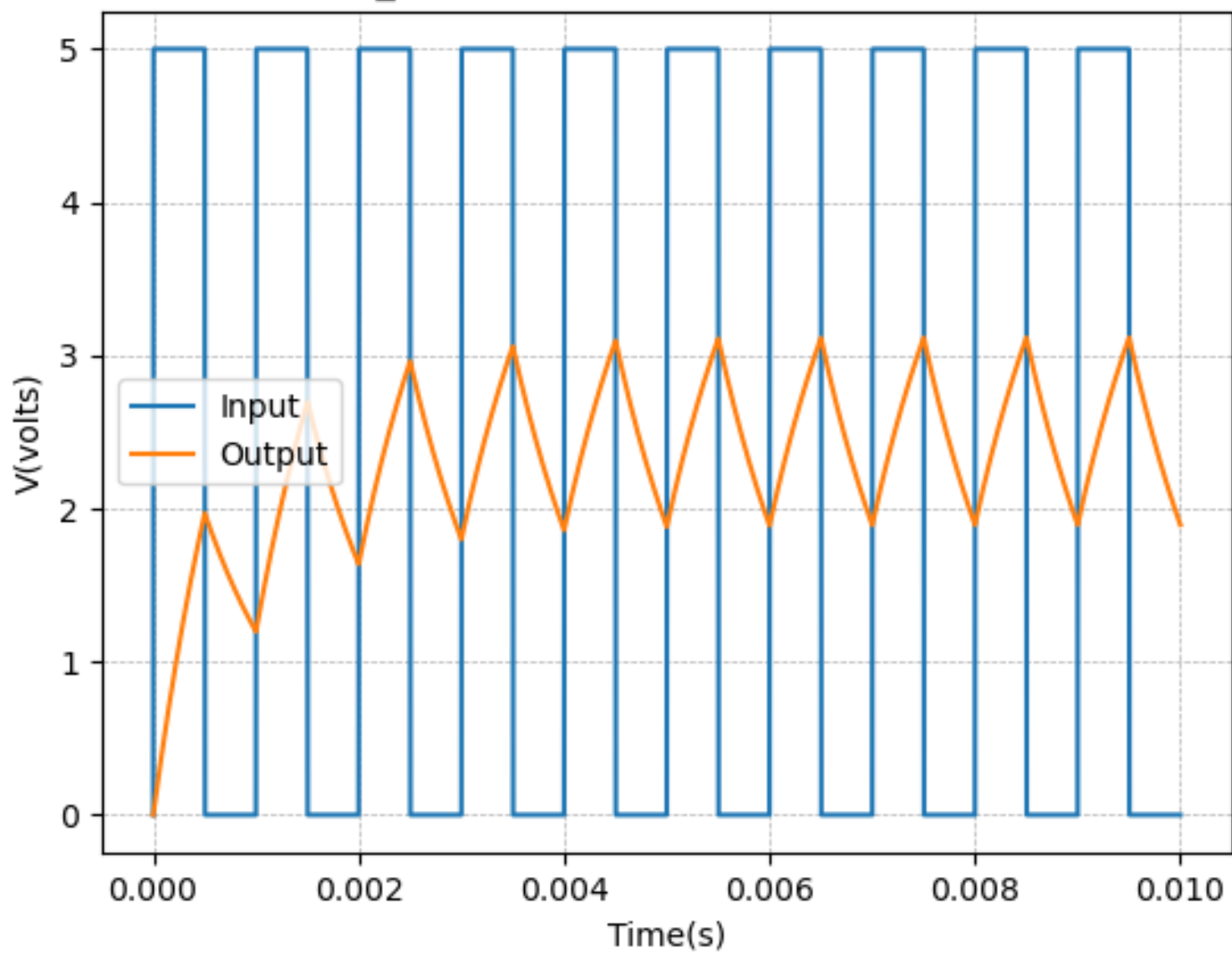
```
1 RC Integrator circuit transient analysis
2 *tau =1m #Time Period
3
4 *describe circuit
5 * <element-name> <nodes> <value/nodel>
6 r 1 2 10k
7 c 2 0 0.1u
8 *v 1 0 pulse(0 5 0 0 0 10m 20m) $10*tau
9 *v 1 0 pulse(0 5 0 0 0 10m 20m) $5*tau
10 *v 1 0 pulse(0 5 0 0 0 10m 20m) $1*tau
11 *v 1 0 pulse(0 5 0 0 0 10m 20m) $0.5*tau
12 *v 1 0 pulse(0 5 0 0 0 10m 20m) $0.1*tau
13 v 1 0 pulse(0 5 0 0 0 0.05m 0.1m) $0.05*tau
14 *analysis command
15 .tran 0.011m 10m
16
17 .control
18 run
19
20 *display cmd
21 plot v(1) v(2)
22 print v(1) v(2)
23 *end control mode
24 .endc
25
26 *end netlist
27 .end
```

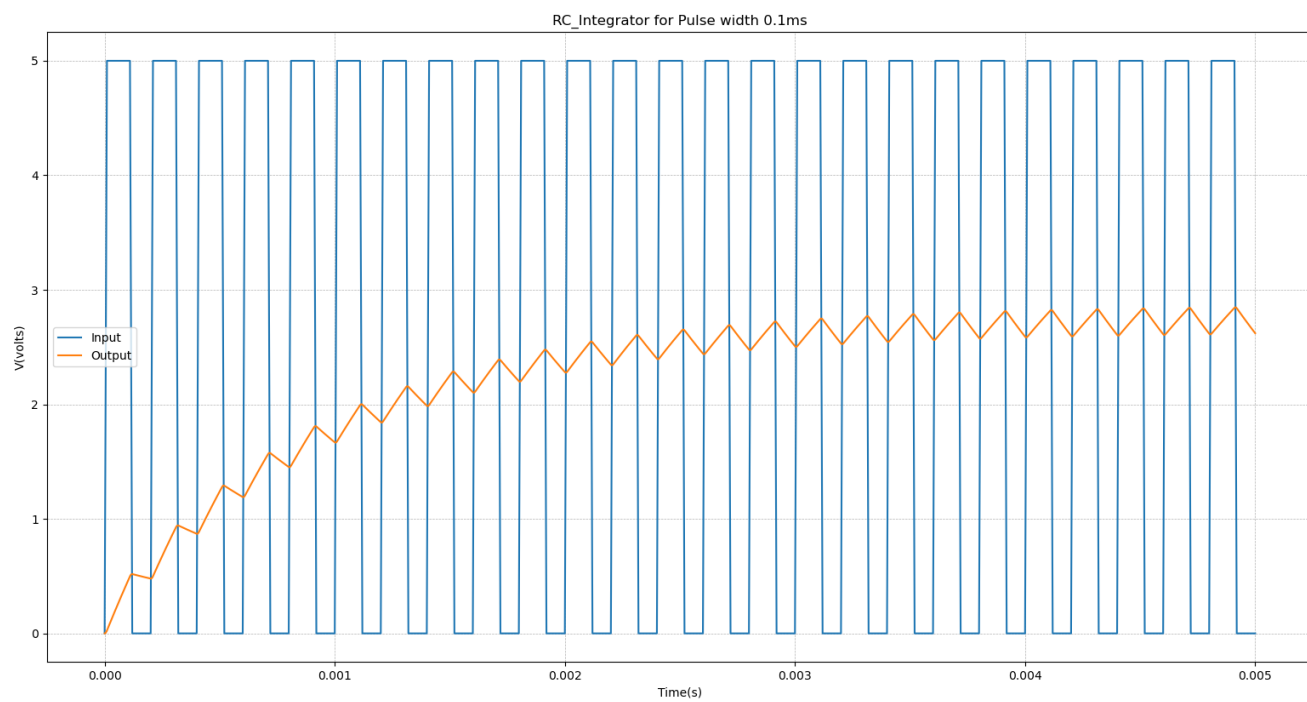
### 3.1.2 Simulation results



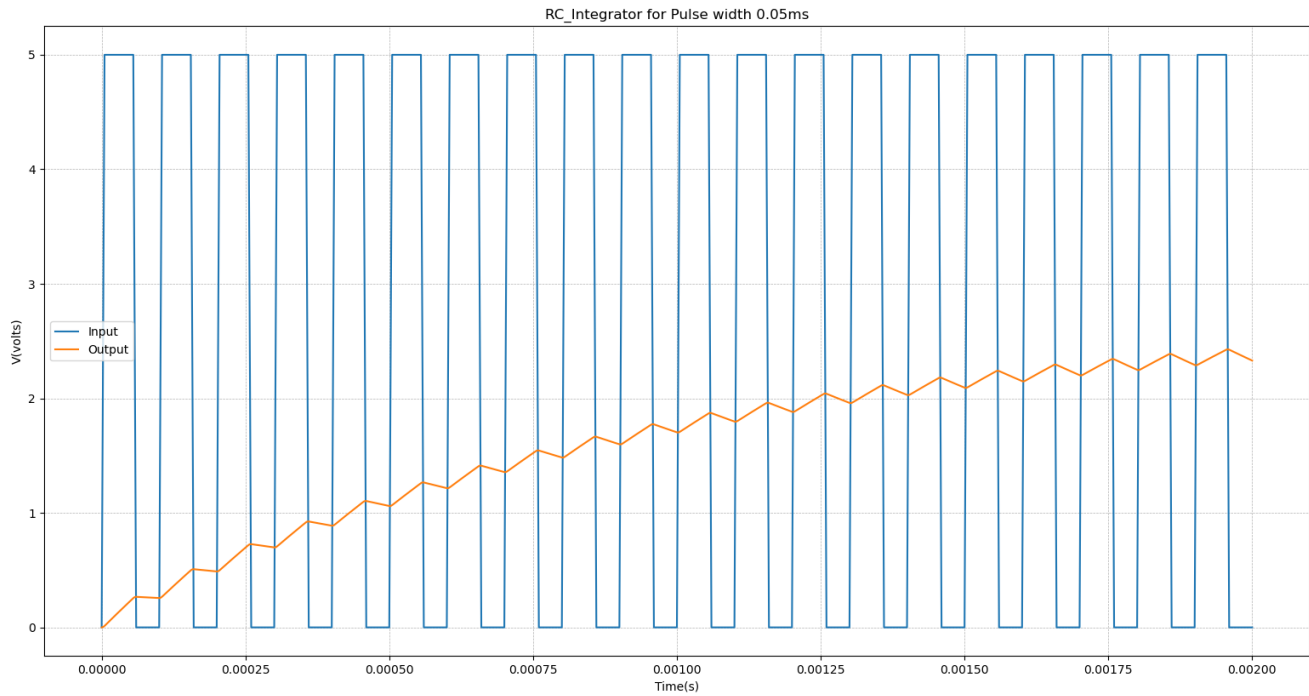


RC\_Integrator for Pulse width 0.5ms









## 3.2 RC Differentiator

### 3.2.1 Code snippet

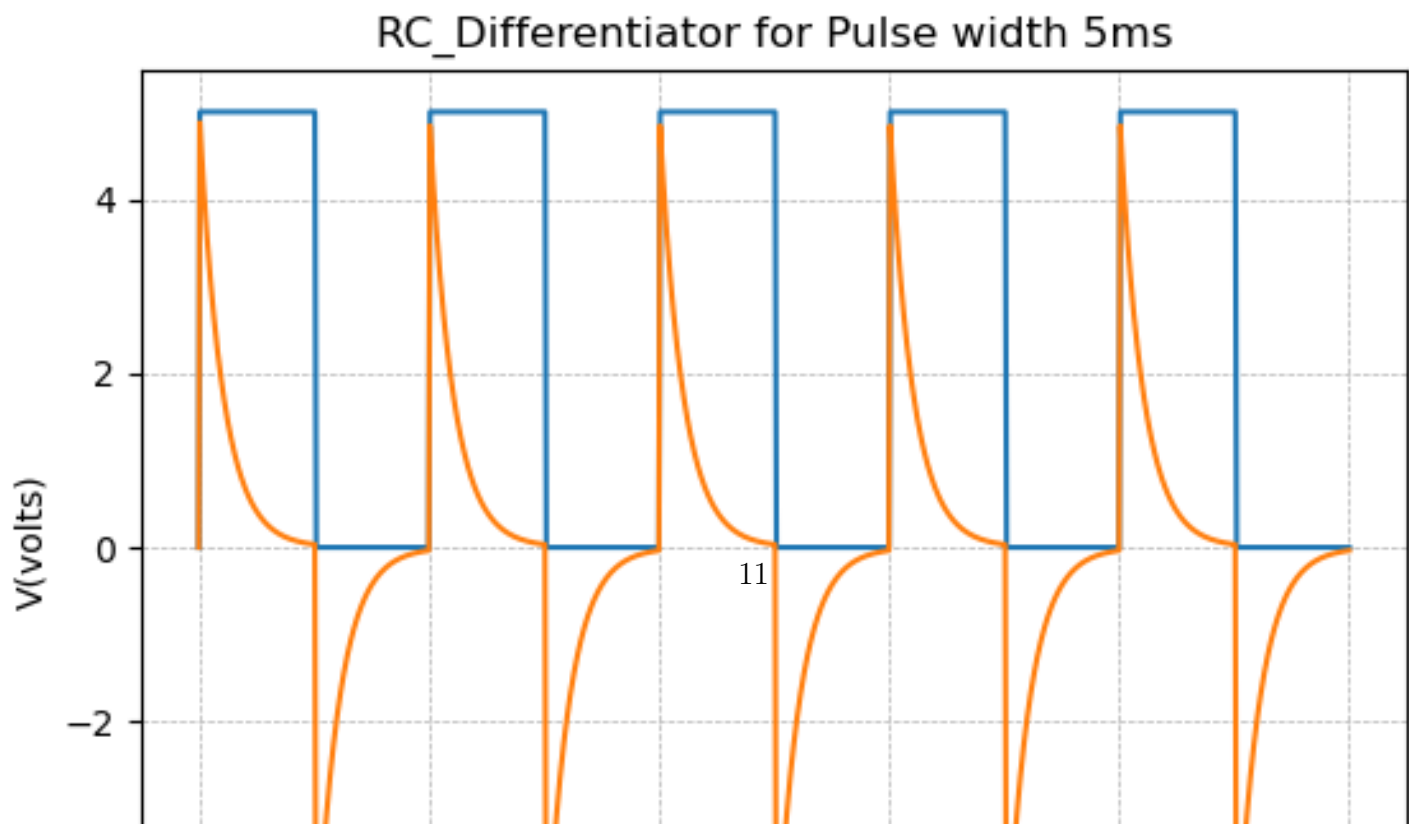
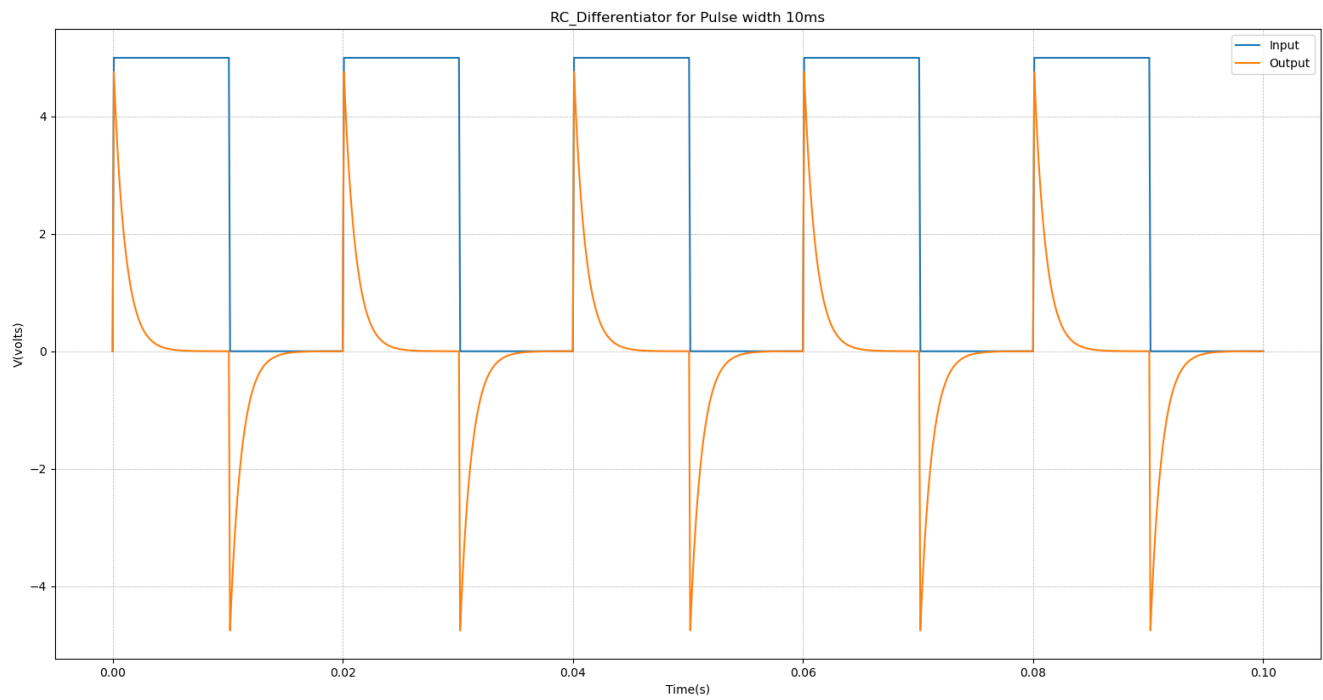
```

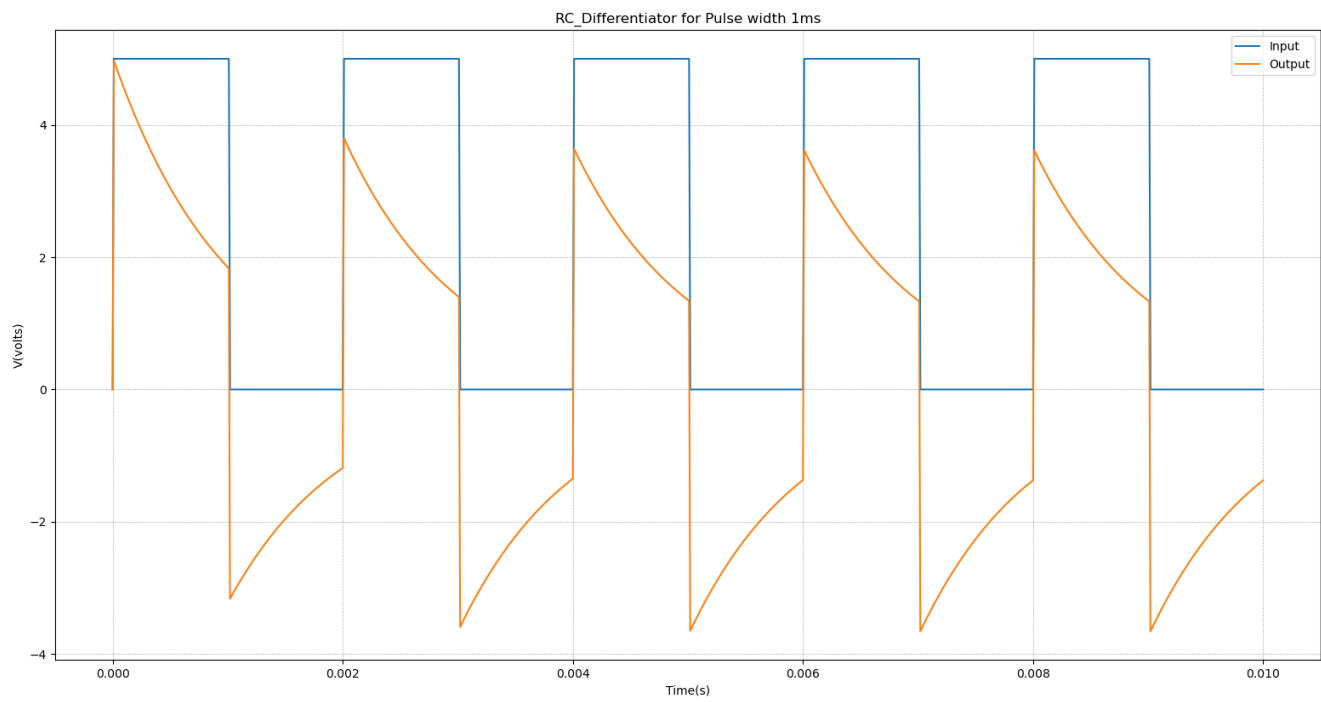
1 RC Differentiator circuit transient analysis
2 *tau =1m #Time Period
3
4 *describe circuit
5 * <element-name> <nodes> <value/nodel>
6 r 2 0 10k
7 c 1 2 0.1u
8 v 1 0 pulse(0 5 0 0 0 10m 20m) $10*tau
9 *v 1 0 pulse(0 5 0 0 0 10m 20m) $5*tau
10 *v 1 0 pulse(0 5 0 0 0 10m 20m) $1*tau
11 *v 1 0 pulse(0 5 0 0 0 10m 20m) $0.5*tau
12 *v 1 0 pulse(0 5 0 0 0 10m 20m) $0.1*tau
13 *v 1 0 pulse(0 5 0 0 0 10m 20m) $0.05*tau
14 *analysis command

```

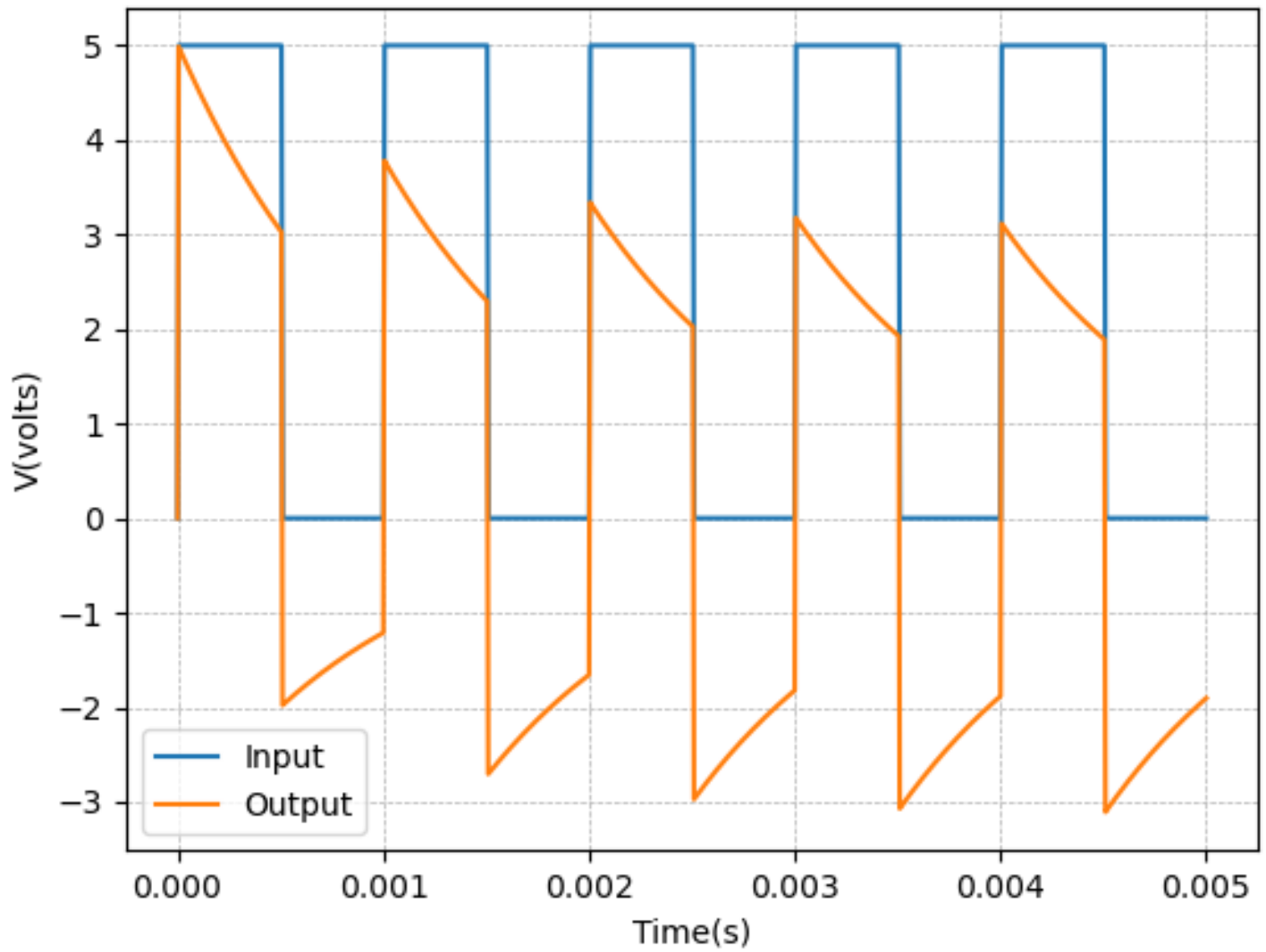
```
15 .tran 0.1m 100m
16
17 .control
18 run
19
20 *display cmd
21 plot v(2) v(1)
22 print v(1) v(2)
23 *end control mode
24 .endc
25
26 *end netlist
27 .end
```

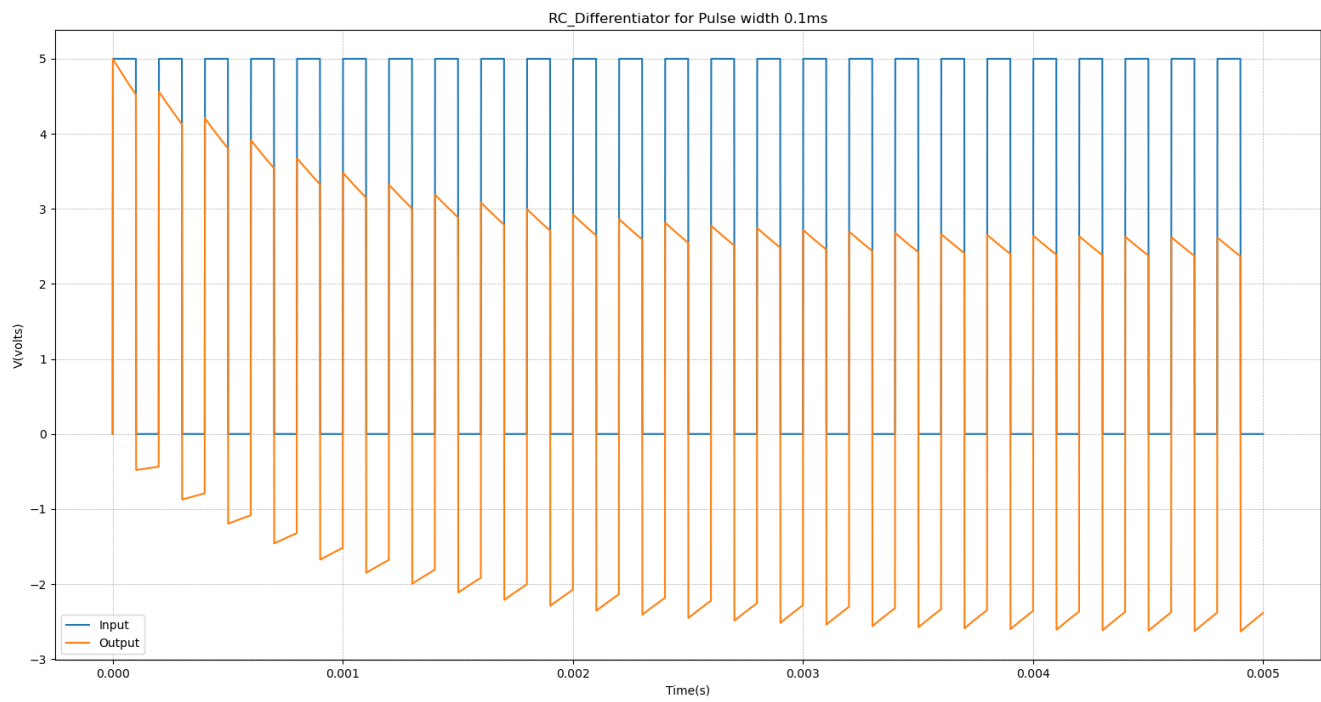
### 3.2.2 Simulation results

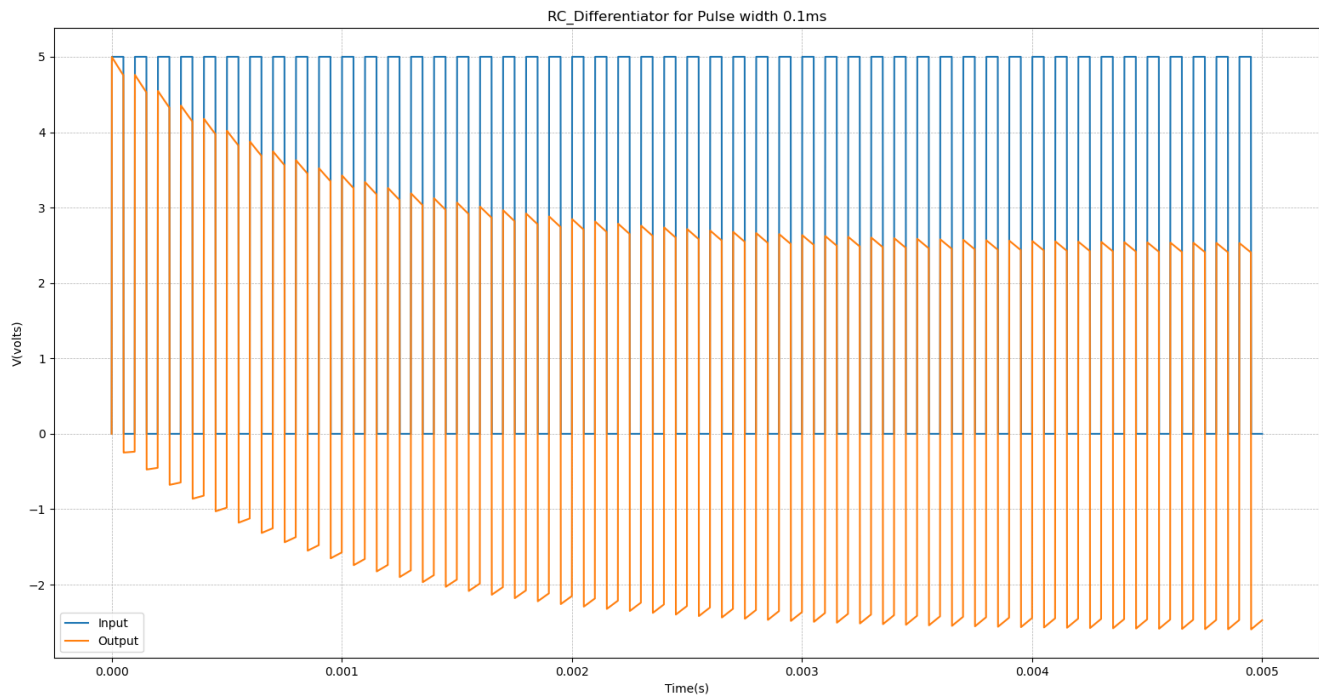




RC\_Differentiator for Pulse width 0.5ms







## 3.3 RC Lowpass Filter

### 3.3.1 Code snippet

```

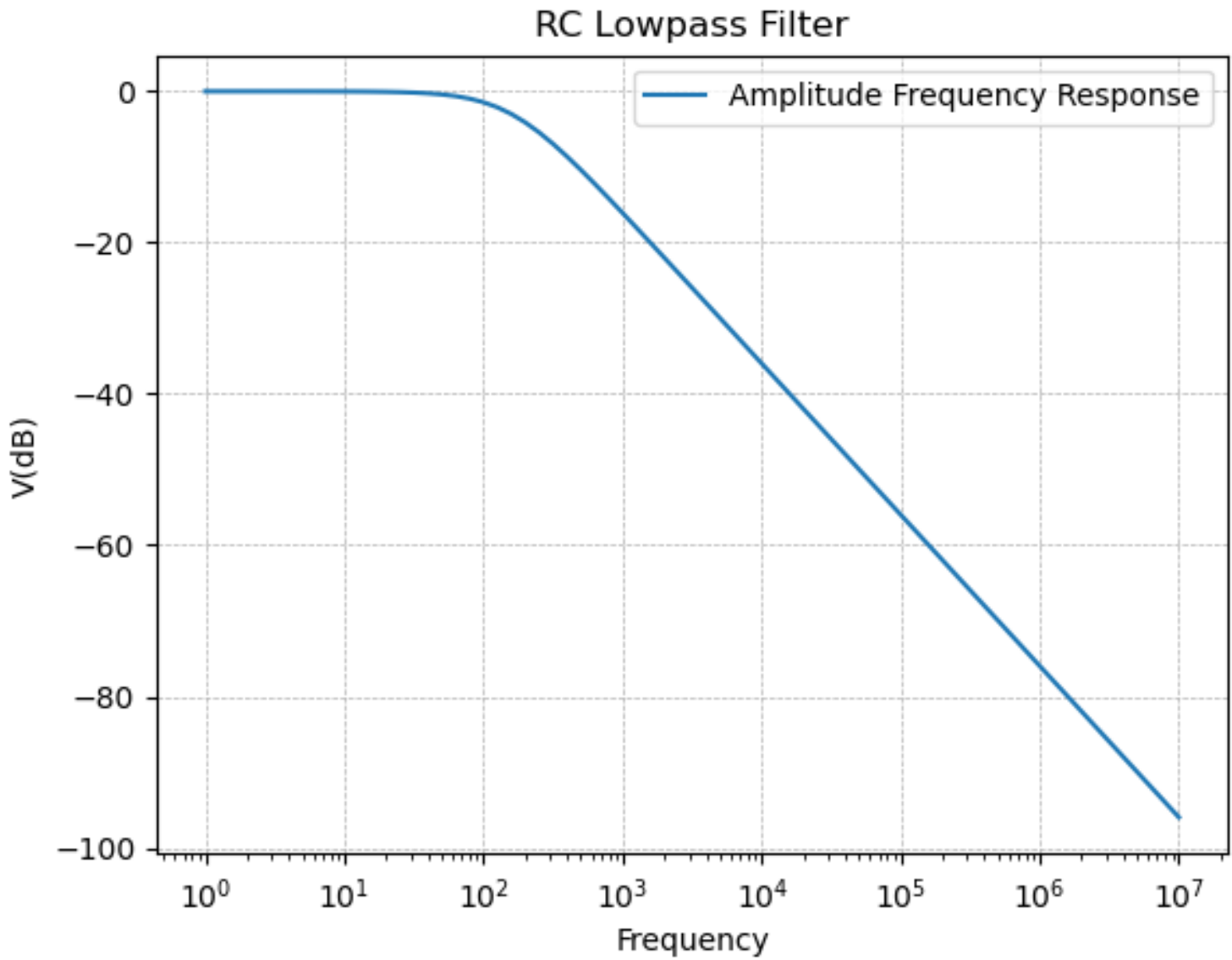
1 RC Lowpass Filter
2
3 *describe circuit
4 * <element-name> <nodes> <value/nodel>
5 r 1 2 10k
6 c 2 0 0.1u
7 vin 1 0 dc 0 ac 1 $ac analysis
8 *analysis command
9 .ac dec 10 1 10Meg
10
11 .control
12 run
13
14 *display cmd

```

```
15 plot vdb(2)
16 print vdb(2)
17 *end control mode
18 .endc
19
20 *end netlist
21 .end
```



### 3.3.2 Simulation results

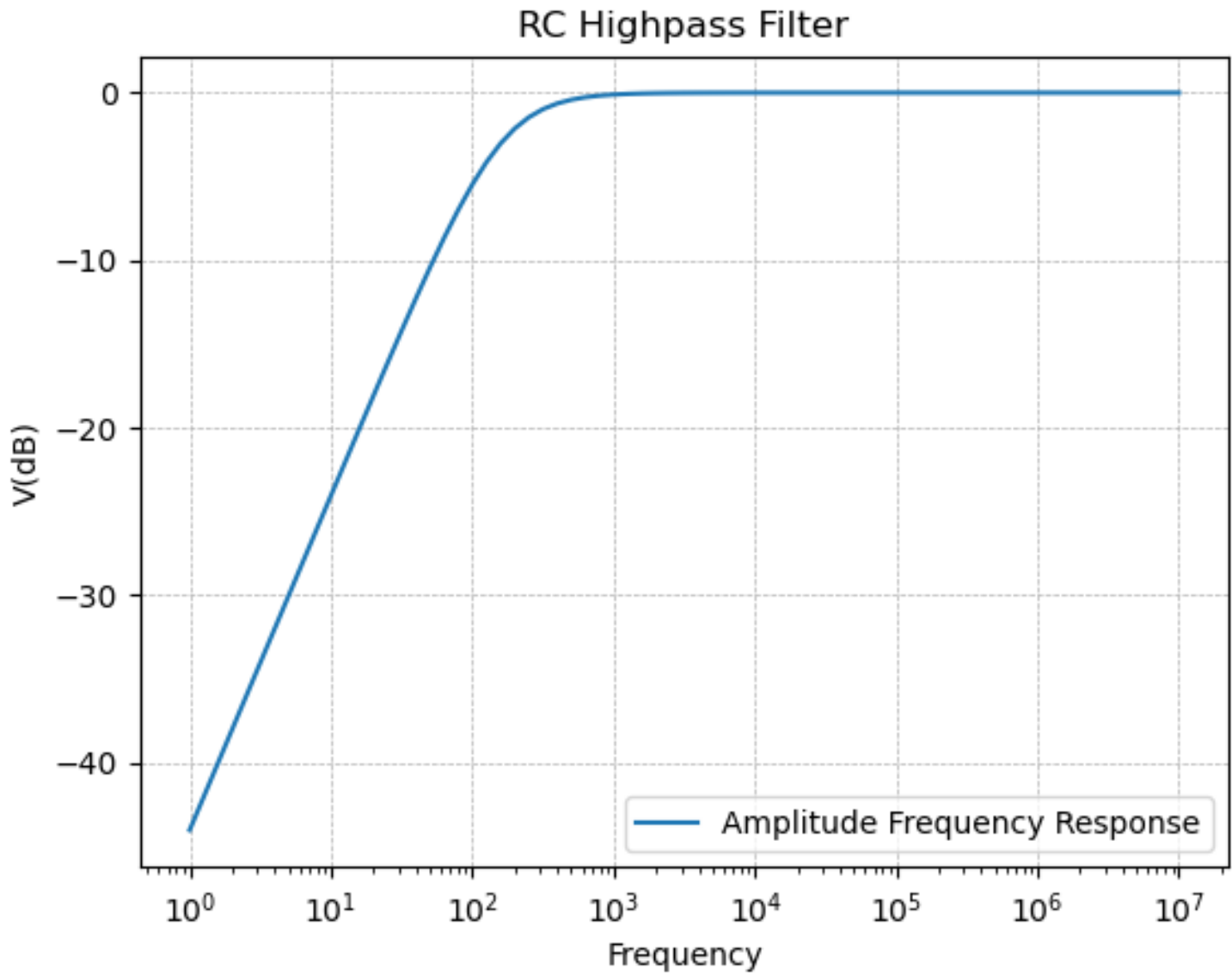


## 3.4 RC Highpass Filter

### 3.4.1 Code snippet

```
1 RC Highpass Filter
2 *describe circuit
3 * <element-name> <nodes> <value/nodel>
4 c 1 2 0.1u
5 r 2 0 10k
6 v 1 0 dc 0 ac 1 $ac analysis
7 *analysis command
8 .ac dec 10 1 10Meg
9
10 .control
11 run
12
13 *display cmd
14 plot vdb(2)
15 print vdb(2)
16 *end control mode
17 .endc
18
19 *end netlist
20 .end
```

### 3.4.2 Simulation results



## 3.5 RC Bandpass Filter

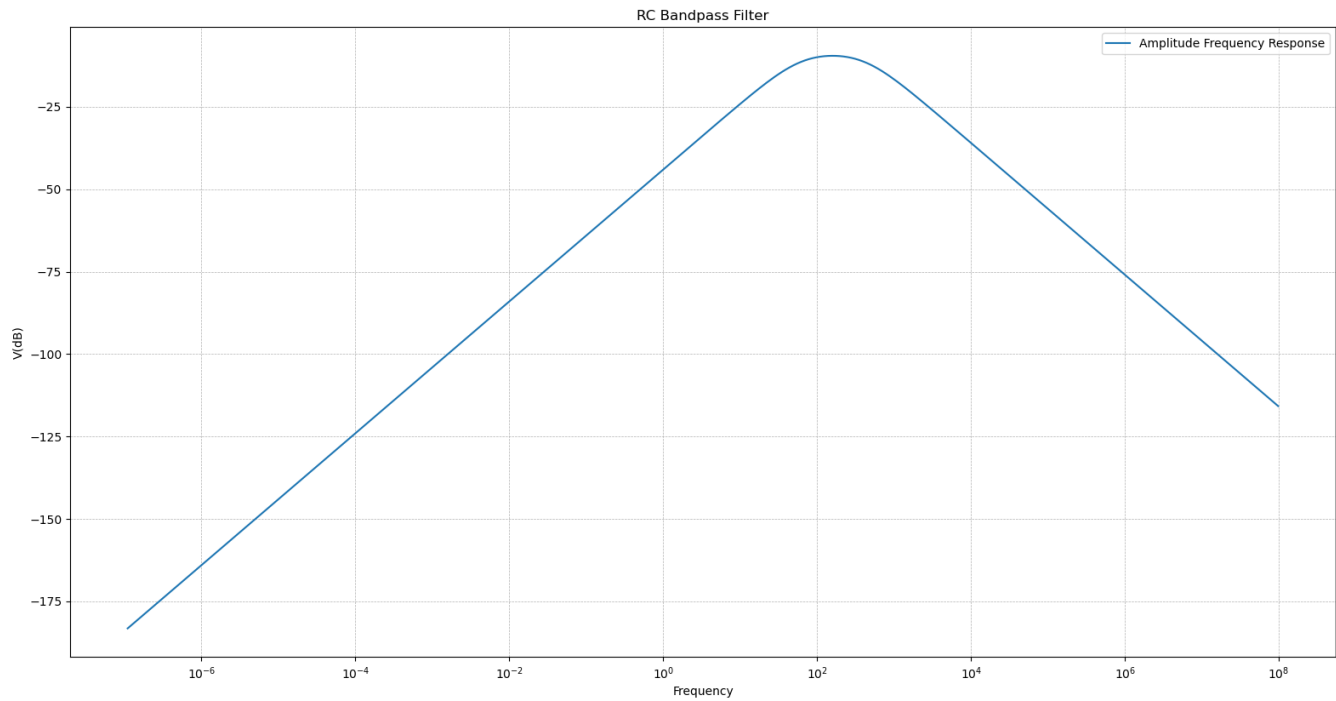
### 3.5.1 Code snippet

```

1 RC Bandpass Filter
2 *describe circuit
3 * <element-name> <nodes> <value/nodel>
4 r1 1 2 10k
5 c1 2 3 0.1u
6 r2 3 0 10k
7 c2 3 0 0.1u
8 v 1 0 dc 0 ac 1 $ac analysis
9 *analysis command
10 .ac dec 20 0.1u 100Meg
11
12 .control
13 run
14
15 *display cmd
16 plot vdb(3)
17 *print vdb(3)
18 *end control mode
19 .endc
20
21 *end netlist
22 .end

```

### 3.5.2 Simulation results



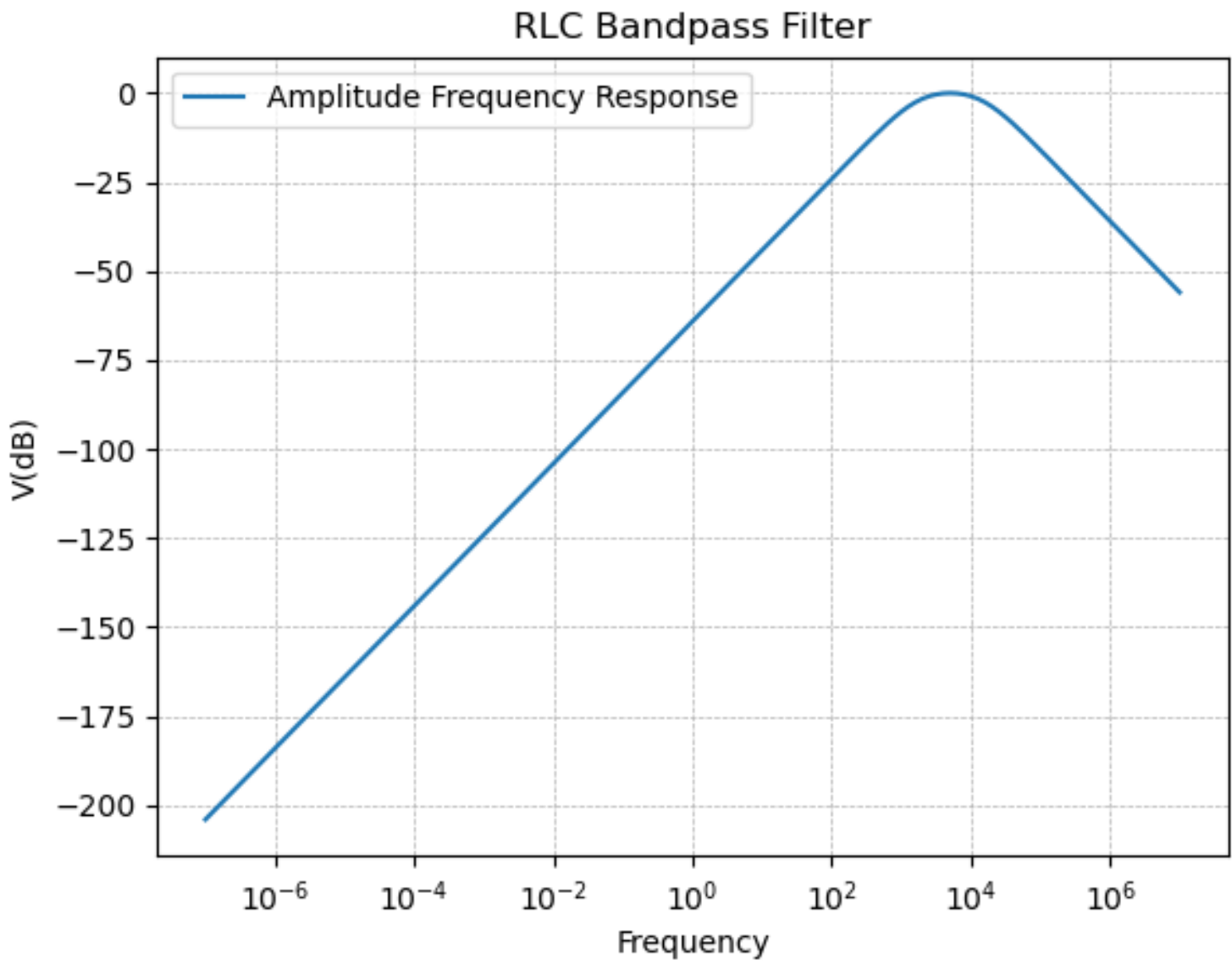
## 3.6 RLC Bandpass Filter

### 3.6.1 Code snippet

```
1 RLC Bandpass Filter
2 *describe circuit
3 * <element-name> <nodes> <value/nodel>
4 l 1 2 10m
5 c 2 3 0.1u
6 r 3 0 1k
7
8 v 1 0 dc 0 ac 1 $ac analysis
9 *analysis command
10 .ac dec 20 0.1u 100Meg
11
12 .control
```

```
13 run
14
15 *display cmd
16 plot vdb(3)
17 print vdb(3)
18 *end control mode
19 .endc
20
21 *end netlist
22 .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