TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
PULCHOWK CAMPUS
LALITPUR, NEPAL

A
LAB REPORT
ON

Simulation of R-C Amplifier Circuit (Continuous System)

SUBMITTED BY:

REBATI RAMAN GAIRE

073BCT533

SUBMITTED TO:

SIMULATION AND MODELLING

DEPARTMENT OF ELECTRONICS AND COMPUTER ENGINEERING
INSTITUTE OF ENGINEERING, PULCHOWK CAMPUS
LALITPUR, NEPAL

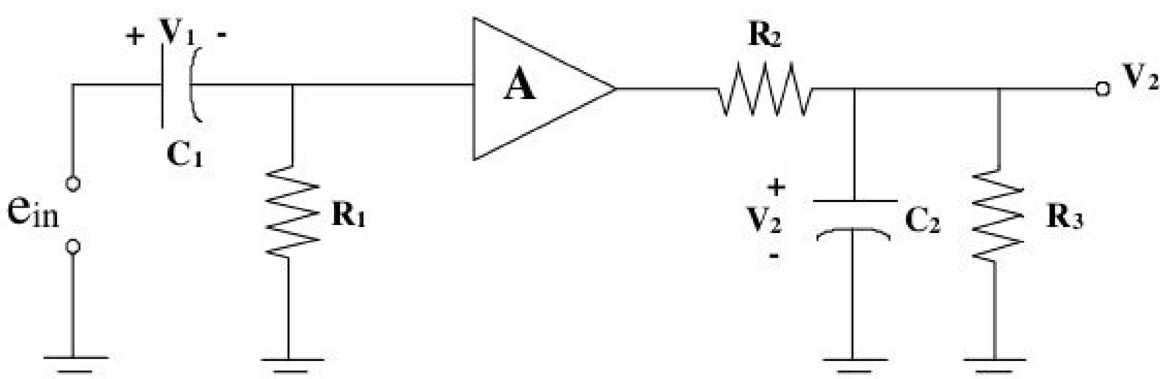
OBJECTIVE:

1. To develop the mathematical modeling of the continuous system.
2. To determine the state of the system i.e. the value of input voltage and output voltage at different points of time.

THEORY

Simulation and modeling are used for building and analyzing of physical systems. They are mostly used in engineering design and analysis. Simulation and modeling enable us to predict the behavior of a system before it is actually built.

A continuous system is one in which the predominant activities of the system cause smooth changes in the attributes of the system entities. When such a system is modeled mathematically, the variables of the model representing the attributes are controlled by continuous functions. More generally, in continuous systems, the relationships describe the rates at which attributes change, so that the model consists of a differential equation. Here we have used the R-C amplifier circuit, which is a continuous system.



The system can be described by the following two differential equations. i.e mathematical modeling:

Current entering through the capacitor *C1*, at the input side, is

$$C1 \, (dV1 / dt) = (ein - V) / R1$$
$$dV1 / dt = (ein - V) / R1.C1$$

Current entering through capacitor *C2*, at the output side, is

$$C2 \, (dV2 / dt) = A / R2 \, (ein - V1) - V2 \, (R2 + R3) / R2 \, . \, R3$$

Hence we can get the two equations for simulation,

$$dV1 / dt = A11 \, . \, V1 + B1 \, . \, ein$$
$$dV2 / dt = A21 \, . \, V1 + A22 \, . \, V2 + B2 \, . \, ein$$

Where,

$$A11 = -1 / (R1 \, . \, C1) = - B1$$
$$A21 = - A / (R2 \, . \, C2) = - B2$$
$$A22 = - (R2 + R3) / (R2 \, . \, R3 \, . \, C2)$$

By providing the values of these constant we can calculate the value of V1 and V2 .
For the calculation of the equation values, we use the Runge – Kutta - 4 methods,

$$m1 = f(xi , yi)$$
$$m2 = f(xi + h/2, yi + m1 \, . \, h/2)$$
$$m3 = f(xi + h/2 , yi + m2 \, . \, h/2)$$
$$m4 = f(xi + h, yi + m3 \, . \, h)$$
$$yi+1 = yi + ((m1 + 2m2 + 2m3 + m4) / 6) \, . \, h$$

Initial condition

For t = 0, V 1 = 0 and V 2 = 0

h = 0.0002 and e in = 1.5 V (t >= 0)

= 0 V

{ n = 500 data points }

(t < 0)

A11 = -50 sec -1

A21 = - 10000 sec -1

A22 = -21.5 sec -1

SOURCE CODE FOR SIMULATION

Now I’ve used python programming language with framework numpy, scipy, and matplotlib libraries to simulate the above mathematical model to determine the value of both input and output voltages at different points of time.

```
# import libraries
import numpy as np
from scipy.integrate import odeint
import matplotlib.pyplot as plt
% matplotlib inline
```

```
# Initilization of Constants
h = 0.0002
V1 = V2 = 0
A11, A21, A22 = -50, -19000, -21.5
ein = 1.5
n = 800
t = np.arange(0, .16, h)
V1_list = []
V2_list = []
```

```
def func1(V1):
 return A11 * V1 - A11 * ein
```

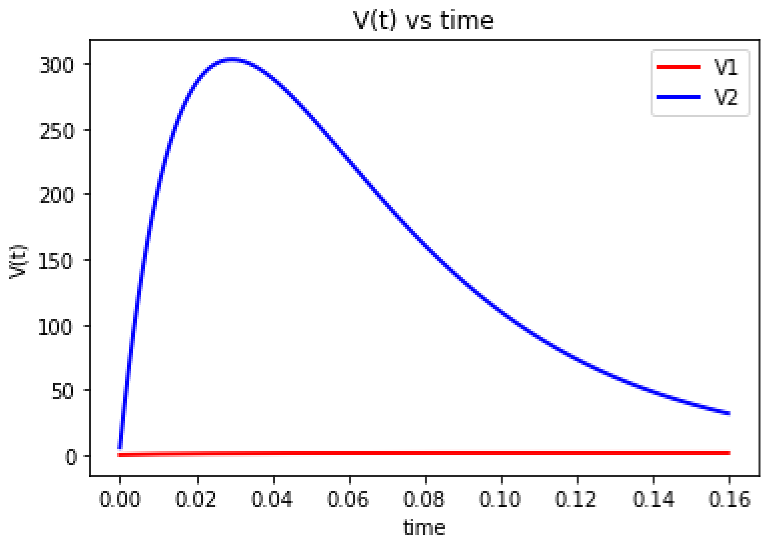
```
def func2(V1, V2):
 return A21 * V1 + A22 * V2 - A21 * ein
```

```
for i in range(n):
  m11 = func1(V1)
 m21 = func1(V1+m11*h/2)
 m31 = func1(V1+m21*h/2)
 m41 = func1(V1+m31*h)

 m12 = func2(V1, V2)
 m22 = func2(V1+h/2, V2+m12*h/2)
 m32 = func2(V1+h/2, V2+m22*h/2)
 m42 = func2(V1+h, V2+m32*h)

 V1 = V1 + ((m11 + 2*m21 + 2*m31 + m41)/6) * h
 V2 = V2 + ((m12 + 2*m22 + 2*m32 + m42)/6) * h

 V1_list.append(V1)
 V2_list.append(V2)
```

```
# plot results
plt.plot(t, V1_list, 'r-', linewidth=2, label='V1')
plt.plot(t, V2_list, 'b-', linewidth=2, label='V2')
plt.title(f'V(t) vs time')
plt.xlabel('time')
plt.ylabel('V(t)')
plt.legend()
plt.show()
```

RESULT AND VISUALIZATION

After running the script, the following curve was obtained which shows the time along the x-axis and the value of input and output volatages V1 and V2 respectively along the y-axis.



DISCUSSION AND CONCLUSION

From this lab session, we became familiar with the concept of a continuous system. We explored the topic with an example of a R-C Amplifier Circuit. We also learned to develop the mathematical model of the circuit and expressed the rate of change of volatges of input and output using differential equations. We wrote a script in python programming language to simulate the model of the amplifier circuit. We used python's numpy library as a data structure to store an array of values, Runge-Kutta 4 method to solve the ordinary differential equation, and matplotlib to visualize the graph showing the variation of input and output voltages over a period of time.