Excercise 1:

Contents

question

Exercises: Hands-on #1

SNS 2023

A) Simulate two LIF neurons:

$$\tau \frac{dr_1}{dt} = -r_1 + I_1$$

$$\tau \frac{dr_2}{dt} = -r_2 + I_2$$

a) Simulate the equation for T = 100, when the external input has a constant value of I_1 = 1, I_2 = 2, and time constant τ = 10 ms. Choose an appropriate time resolution, dt, for simulations.

b) Plot the activity of both neurons in **one plot**.

B) Now assume that the two neurons are also coupled together, in a recurrent manner. In order to simulate that, we need to solve the following equations:

$$\tau \frac{dr_1}{dt} = -r_1 + \alpha r_2 + I_1$$

$$\tau \frac{dr_2}{dt} = -r_2 + \beta r_1 + I_2$$

α and β are coupling strength.

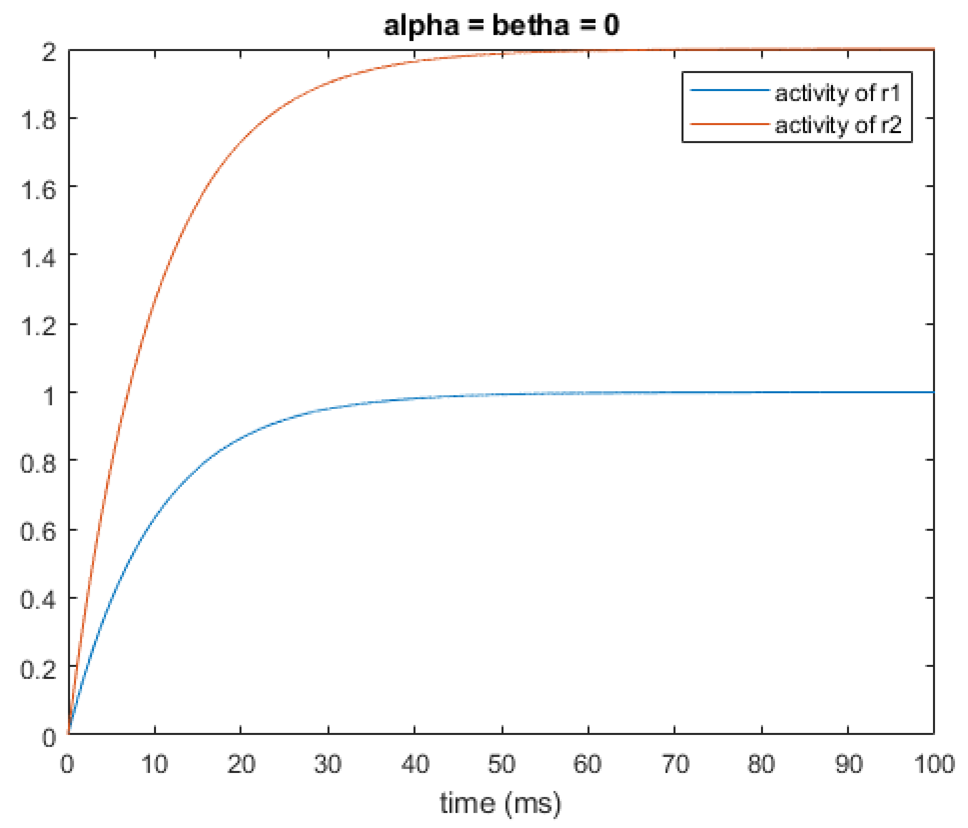
a) Simulate the equation for T = 100, I_1 = 1, I_2 = 2, and the recurrent coupling is: α = 0.5, β = 0.5

b) Plot the activity of both neurons in one plot and compare it with the activity without recurrent.

Try these values: α = 0.5, β = 1 ; α = 1, β = 1 ; α = 0.5, β = -0.5 ; α = 1, β = -1 ; α = 5, β = -5

Part A

```
clc
close all
clear

Taw = 10;  %in ms
I1 = 1;     I2 = 2;
T = 100;  %total simulation time
dt = 0.01; %time step

alpha = 0;      betha = 0;
[r1, r2 , t] = neuron_act(alpha, betha, Taw, I1, I2, T, dt);
figure
plot(t,r1),     hold on,        plot(t,r2),     xlabel('time (ms)'),        title('alpha = betha = 0')
legend('activity of r1', 'activity of r2')
```



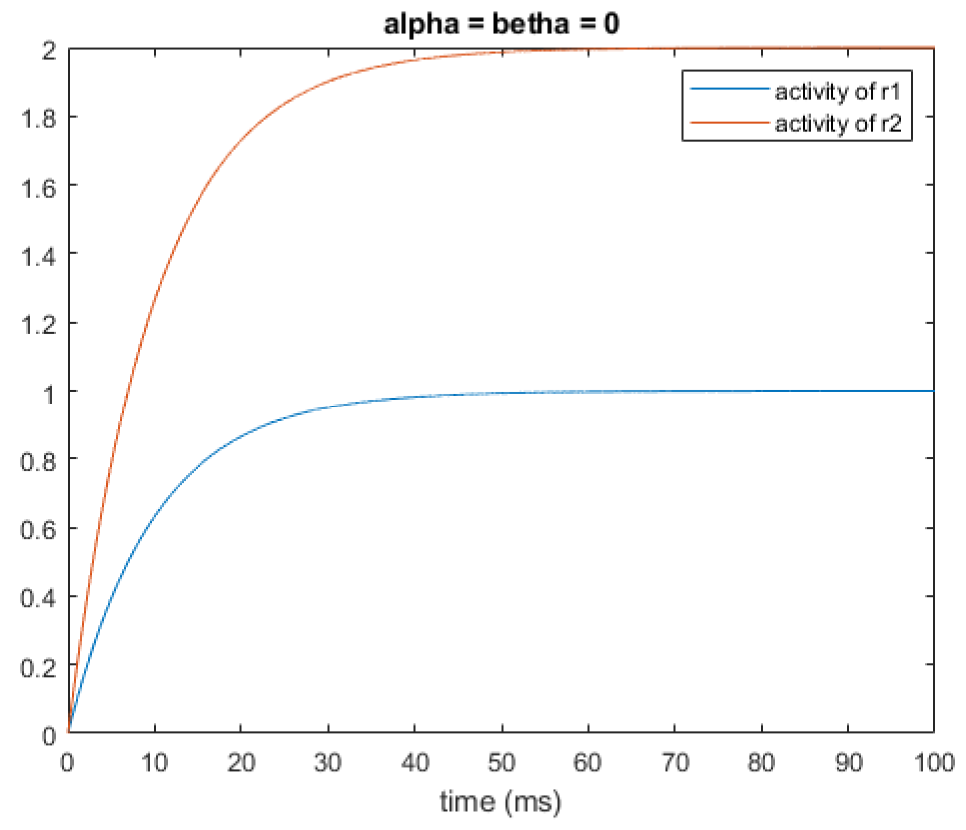
here, the 2 neurons are independant(recurrent term equals to zero)

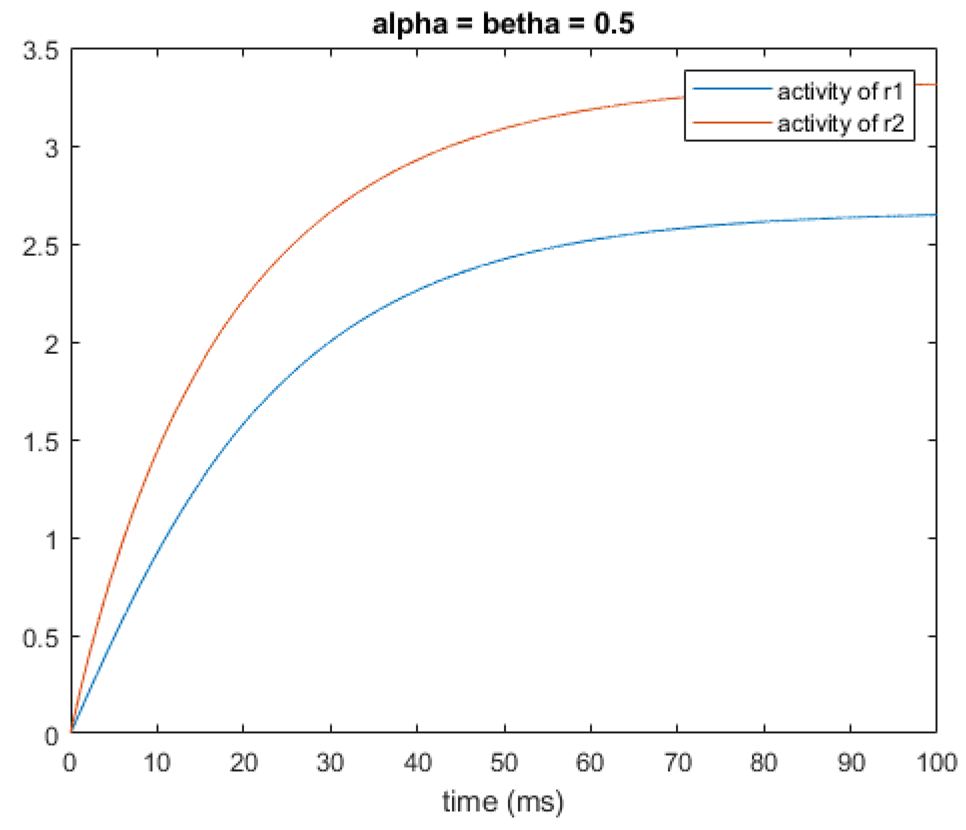
so every neuron reaches its steady state value (I1 & I2)

Part B_a

```
alpha = 0.5;      betha = 0.5;
[r1, r2 , t] = neuron_act(alpha, betha, Taw, I1, I2, T, dt);
```

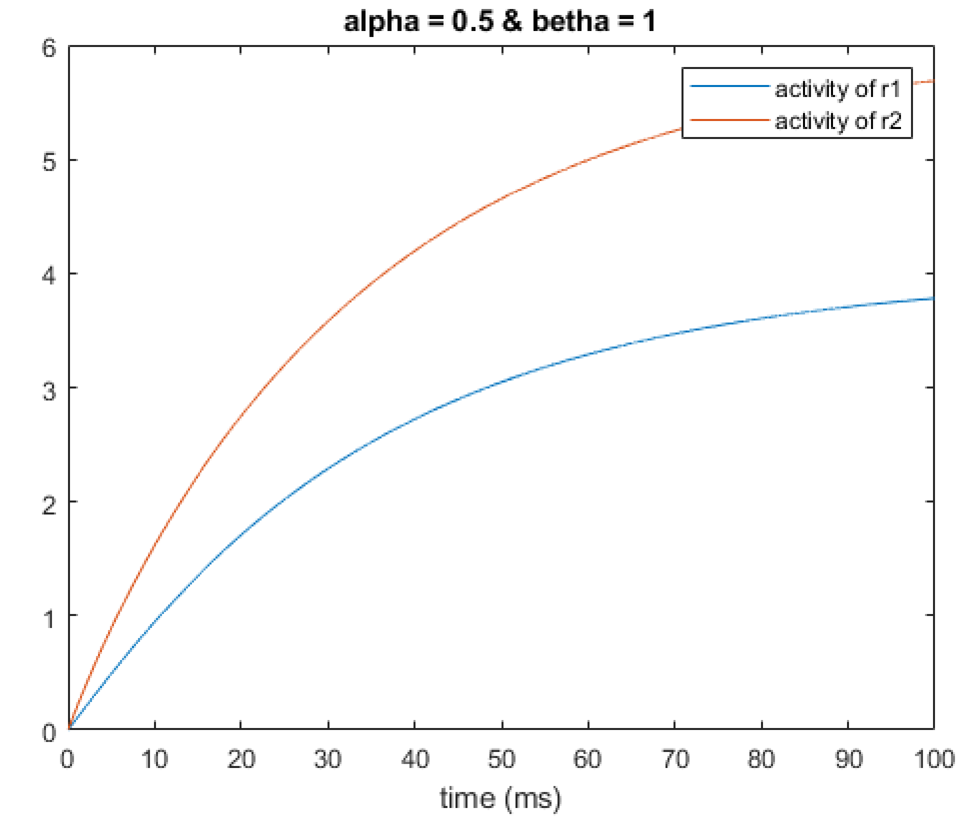
```
figure
plot(t,r1),     hold on,        plot(t,r2),     xlabel('time (ms)'),        title('alpha = betha = 0.5')
legend('activity of r1', 'activity of r2')
```

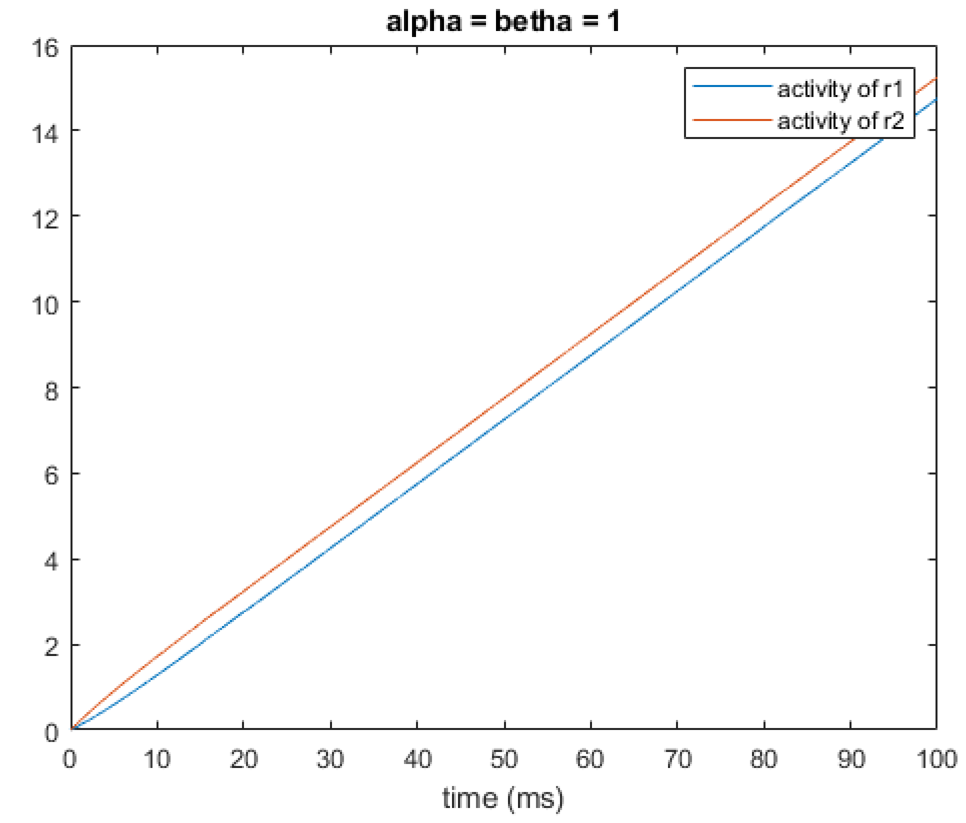


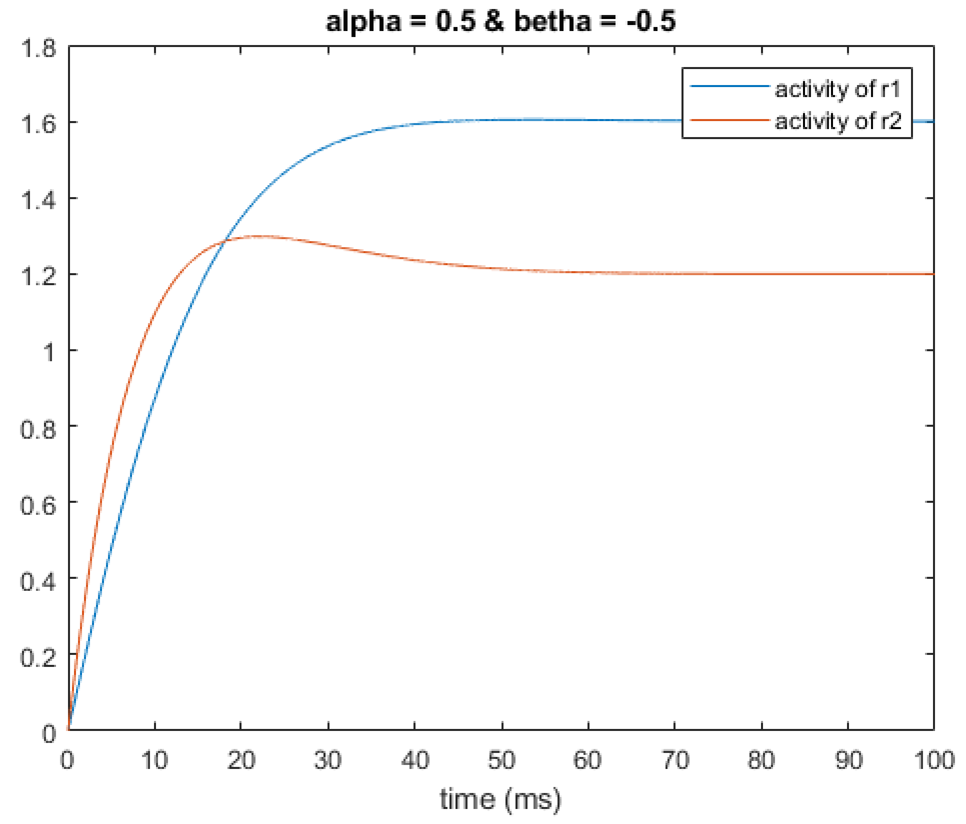


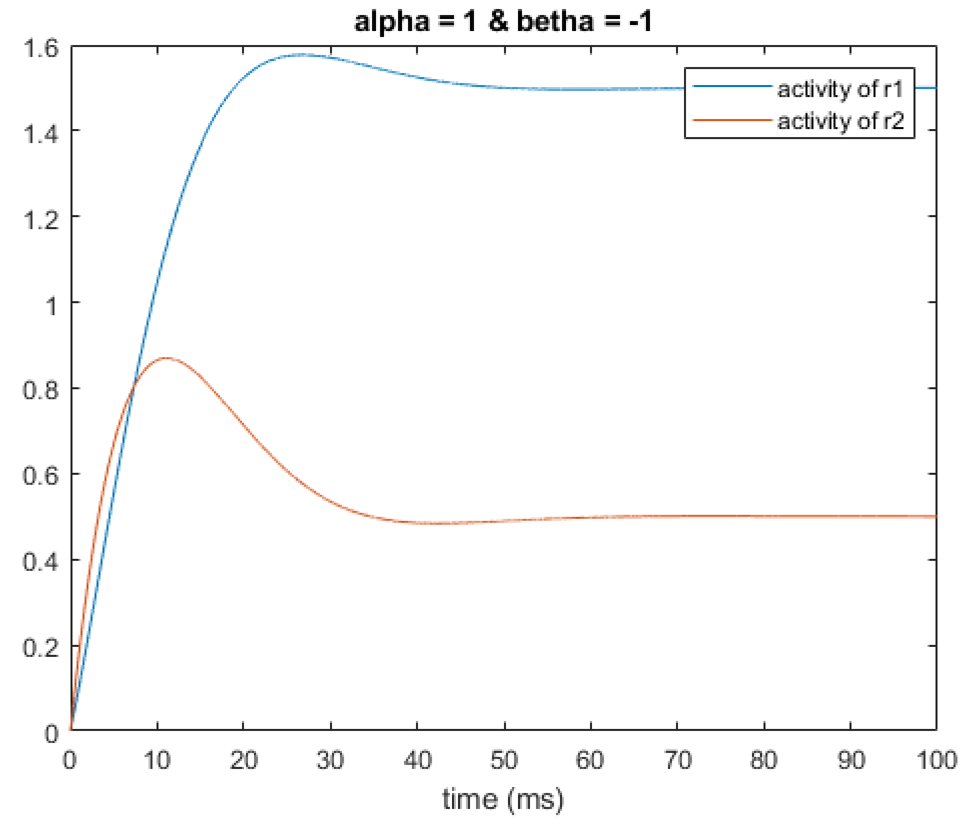
Part B_b

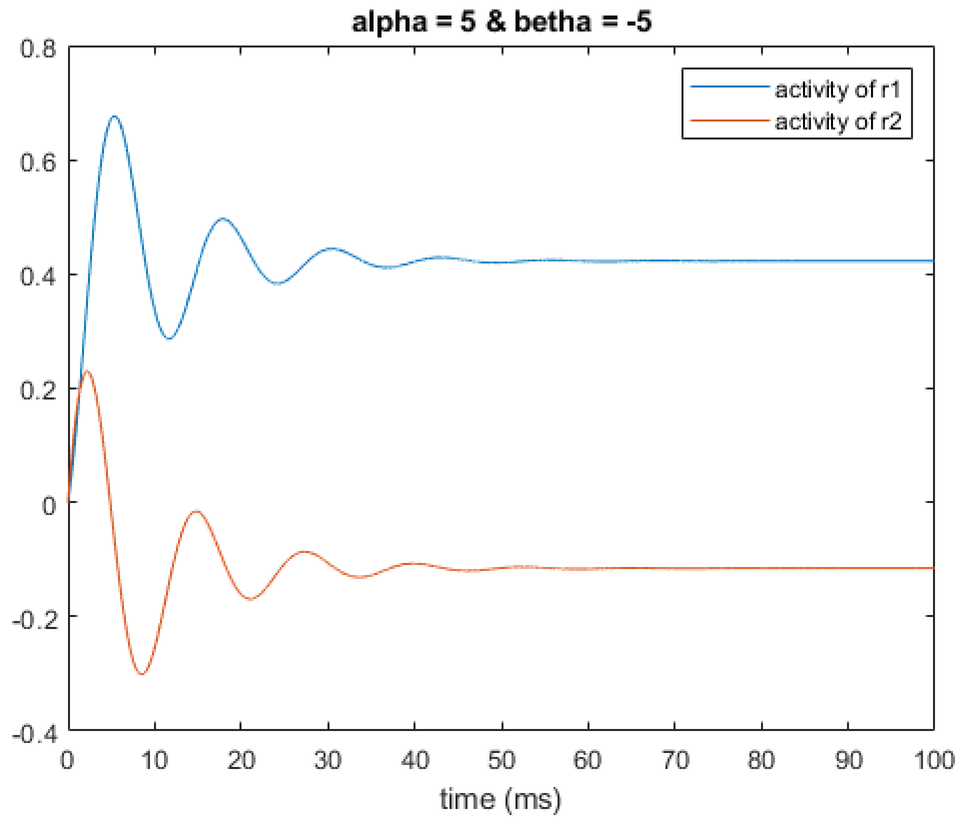
```
alpha = 0.5;      betha = 1;
[r1, r2 , t] = neuron_act(alpha, betha, Taw, I1, I2, T, dt);
figure
plot(t,r1),     hold on,        plot(t,r2),     xlabel('time (ms)'),        title('alpha = 0.5 & betha = 1')
legend('activity of r1', 'activity of r2')

alpha = 1;      betha = 1;
[r1, r2 , t] = neuron_act(alpha, betha, Taw, I1, I2, T, dt);
figure
plot(t,r1),     hold on,        plot(t,r2),     xlabel('time (ms)'),        title('alpha = betha = 1')
legend('activity of r1', 'activity of r2')

alpha = 0.5;      betha = -0.5;
[r1, r2 , t] = neuron_act(alpha, betha, Taw, I1, I2, T, dt);
figure
plot(t,r1),     hold on,        plot(t,r2),     xlabel('time (ms)'),        title('alpha = 0.5 & betha = -0.5')
legend('activity of r1', 'activity of r2')

alpha = 1;      betha = -1;
[r1, r2 , t] = neuron_act(alpha, betha, Taw, I1, I2, T, dt);
figure
plot(t,r1),     hold on,        plot(t,r2),     xlabel('time (ms)'),        title('alpha = 1 & betha = -1')
legend('activity of r1', 'activity of r2')

alpha = 5;      betha = -5;
[r1, r2 , t] = neuron_act(alpha, betha, Taw, I1, I2, T, dt);
figure
plot(t,r1),     hold on,        plot(t,r2),     xlabel('time (ms)'),        title('alpha = 5 & betha = -5')
legend('activity of r1', 'activity of r2')
```











Result:

```
disp('')
```

When recurrent is present, different behaviors can be seen: ocilation, divergance, increasing linearly and stability.

Behavior is varient due to different eigenvalues (lambda1 & llambda2)These values are determined by alpha and betha

Lamda1_2 = alpha +- betha

```
function [r1, r2, time] = neuron_act(alpha, betha, Taw, I1, I2, Simulation_time, time_step)
      total_data_points = Simulation_time / time_step;

      time = (0:total_data_points)*time_step;

      r1 = zeros(1, total_data_points);
      r2 = zeros(1, total_data_points);

      for i = 1:total_data_points
            r1(i+1) = r1(i) + (time_step/Taw) * (-r1(i) + alpha*r2(i) + I1);
            r2(i+1) = r2(i) + (time_step/Taw) * (-r2(i) + betha*r1(i) + I2);
      end
end
```

Published with MATLAB® R2023a