```matlab
close all
clear
clc

r_max=100;
theta_E=-5;
theta_I=0;
alpha_E=0.05;
alpha_I=1;
W_EE=2;
W_EI=2.5;
W_IE=-2.5;
W_II=-2;
t_max=3;
r_E(1)=50;
r_I(1)=50;
dt=0.1e-3;
t=0:dt:t_max;
Istim = zeros(size(t));
ind = find (t > 1 & t < 2);
Istim(ind) = 20;
Ibase_E = 0;
Ibase_I = 0;
tau_E=5e-3;
tau_I=5e-3;
Iapp_E = ones(size(t))*Ibase_E;
Iapp_I = ones(size(t))*Ibase_I+Istim;
r2null = ones(size(t))
for n = 2:length(t)
    I_E(n)=W_EE*r_E(n-1)+W_IE*r_I(n-1)+Iapp_E(n-1);
    I_I(n)=W_EI*r_E(n-1)+W_II*r_I(n-1)+Iapp_I(n-1);
    r_E_temp(n) =  r_E(n-1)+(dt/tau_E)*(-r_E(n-1)+alpha_E*((I_E(n)-
theta_E)^2).*sign(I_E(n)-theta_E));
    r_I_temp(n) =  r_I(n-1)+(dt/tau_I)*(-r_I(n-1)+alpha_I*((I_I(n)-
theta_I)));
    r_E(n) = min(max(r_E_temp(n), 0), r_max);
    r_I(n) = min(max(r_I_temp(n), 0), r_max);
    %r2null(n) = (1/tau_E)*(-r_E(n-1)+alpha_E*((I_E(n)-
theta_E)^2).*sign(I_E(n)-theta_E));

end
% allowed_vals = find((r_E >= 0 ).*( r_E <= r_max ));
% allowed_vals1 = find((r_I>= 0 ).*( r_I <= r_max ));

f1=figure(1);
% subplot(3,1,1);
% plot(t,r_E);
% xlabel('t (sec)')
% ylabel('r_{E} (Hz)')
% grid on
% hold on
% plot(t,r_I);
%
% xlabel('t (sec)')
% ylabel('r_{I} (Hz)')
% plot(t(allowed_vals),r_E(allowed_vals));
```

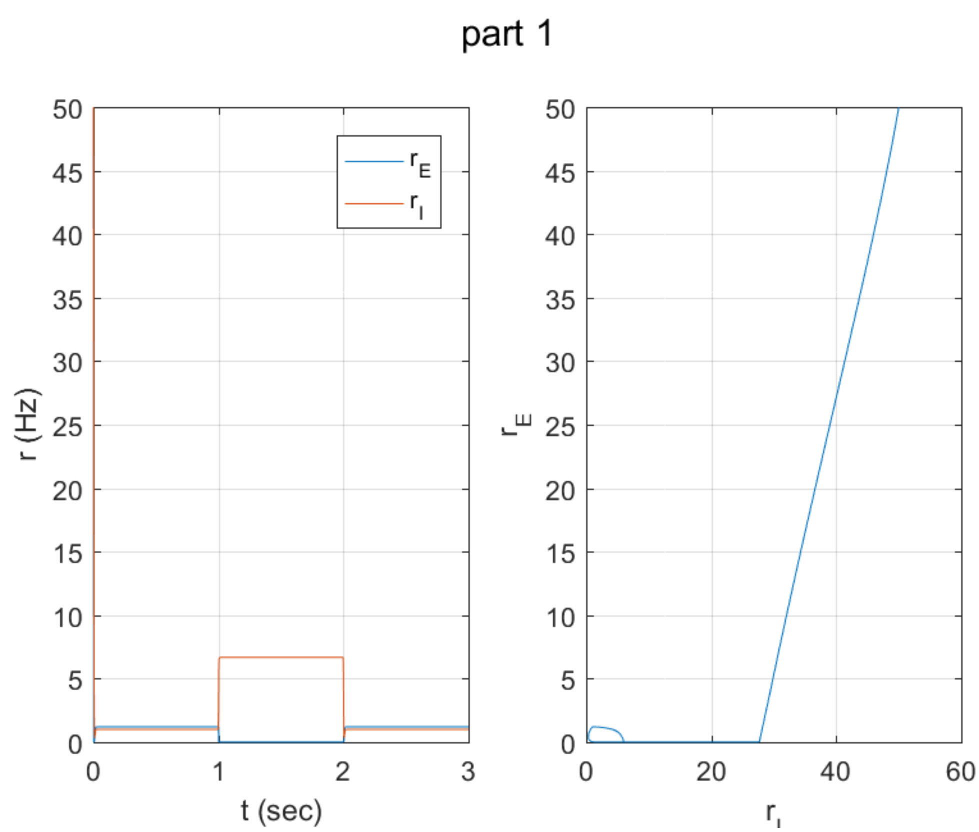
```matlab
subplot(1,2,1)
plot(t,r_E);
xlabel('t (sec)')
ylabel('r (Hz)')
grid on
hold on
%plot(t(allowed_vals1),r_I(allowed_vals1));
plot(t,r_I);
xlabel('t (sec)')
ylabel('r (Hz)')
legend('r_{E}','r_{I}')
grid on

subplot(1,2,2)
plot(r_I,r_E)
ylabel('r_{E}')
xlabel('r_{I}')
% allowed_vals2 = find((r2null > 0 ).*( r2null < r_max ));
% figure(2)
% plot(r_E(allowed_vals2),r2null(allowed_vals2),'k');
% subplot(3,1,3);
% r_E1=1:length(r_I(allowed_vals1))
% plot(t(allowed_vals1),r_I(allowed_vals1))
% hold on
% r_I1=1:length(r_I(allowed_vals))
% plot(r_E(allowed_vals),t(allowed_vals))
% axis([0 t_max 0 r_max])
% xlabel('r_{E} (sec)')
% ylabel('r_{I} (Hz)')
grid on
suptitle('part 1');

saveas(f1, sprintf('1.png'));

%% part2
r_max=100;
theta_E=-5;
theta_I=0;
alpha_E=0.05;
alpha_I=1;
W_EE=2;
W_EI=2.5;
W_IE=-2.5;
W_II=-2;
t_max=3;
r_E(1)=50;
r_I(1)=50;
dt=0.1e-3;
t=0:dt:t_max;
Istim = zeros(size(t));
ind = find (t > 1 & t < 2);
Istim(ind) = 20;
Ibase_E = 25;
Ibase_I = 15;
tau_E=5e-3;
tau_I=5e-3;
```

```
Iapp_E = ones(size(t))*Ibase_E;
Iapp_I = ones(size(t))*Ibase_I+Istim;

for n = 2:length(t)
    I_E(n)=W_EE*r_E(n-1)+W_IE*r_I(n-1)+Iapp_E(n-1);
    I_I(n)=W_EI*r_E(n-1)+W_II*r_I(n-1)+Iapp_I(n-1);
    r_E_temp(n) =  r_E(n-1)+(dt/tau_E)*(-r_E(n-1)+alpha_E*((I_E(n)-
theta_E)^2).*sign(I_E(n)-theta_E));
    r_I_temp(n) =  r_I(n-1)+(dt/tau_I)*(-r_I(n-1)+alpha_I*((I_I(n)-
theta_I)));
    r_E(n) = min(max(r_E_temp(n), 0), r_max);
    r_I(n) = min(max(r_I_temp(n), 0), r_max);

end
allowed_vals = find((r_E >= 0 ).*( r_E <= r_max ));
allowed_vals1 = find((r_I>= 0 ).*( r_I <= r_max ));

f2=figure(2);

subplot(1,2,1)
plot(t,r_E);
xlabel('t (sec)')
ylabel('r (Hz)')
grid on
hold on
%plot(t(allowed_vals1),r_I(allowed_vals1));
plot(t,r_I);
xlabel('t (sec)')
ylabel('r (Hz)')
legend('r_{E}','r_{I}')
grid on

subplot(1,2,2)
plot(r_I,r_E)
ylabel('r_{E}')
xlabel('r_{I}')
% subplot(3,1,3);
% r_E1=1:length(r_I(allowed_vals1))
% plot(t(allowed_vals1),r_I(allowed_vals1))
% hold on
% r_I1=1:length(r_I(allowed_vals))
% plot(r_E(allowed_vals),t(allowed_vals))
% axis([0 t_max 0 r_max])
% xlabel('r_{E} (sec)')
% ylabel('r_{I} (Hz)')
grid on
title('part 2');
%legend('r_{E}','r_{I}')
saveas(f2, sprintf('2.png'));
%% part 3
r_max=100;
theta_E=-5;
theta_I=0;
alpha_E=0.05;
alpha_I=1;
W_EE=2;
```

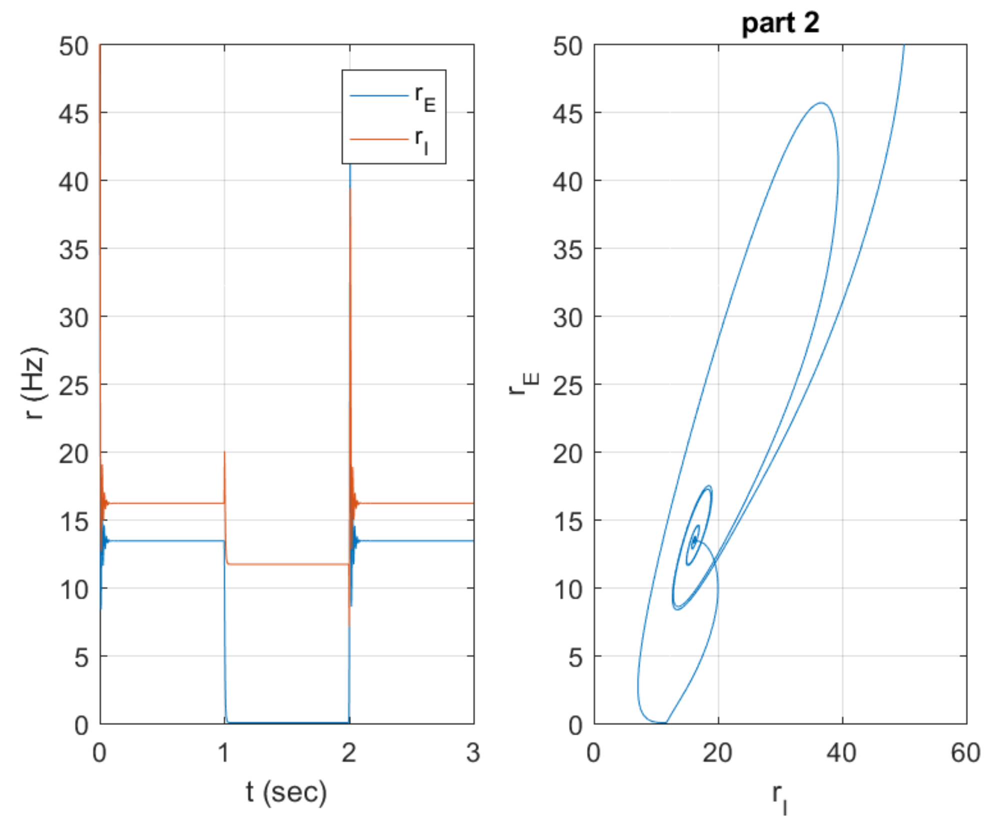
```
W_EI=2.5;
W_IE=-2.5;
W_II=-2;
t_max=3;
r_E(1)=50;
r_I(1)=50;
dt=0.1e-3;
t=0:dt:t_max;
Istim = zeros(size(t));
ind = find (t > 1 & t < 2);
Istim(ind) = 20;
Ibase_E = 0;
Ibase_I = 0;
tau_E=2e-3;
tau_I=10e-3;
Iapp_E = ones(size(t))*Ibase_E;
Iapp_I = ones(size(t))*Ibase_I+Istim;

for n = 2:length(t)
    I_E(n)=W_EE*r_E(n-1)+W_IE*r_I(n-1)+Iapp_E(n-1);
    I_I(n)=W_EI*r_E(n-1)+W_II*r_I(n-1)+Iapp_I(n-1);
    r_E_temp(n) =  r_E(n-1)+(dt/tau_E)*(-r_E(n-1)+alpha_E*((I_E(n)-
theta_E)^2).*sign(I_E(n)-theta_E));
    r_I_temp(n) =  r_I(n-1)+(dt/tau_I)*(-r_I(n-1)+alpha_I*((I_I(n)-
theta_I)));
    r_E(n) = min(max(r_E_temp(n), 0), r_max);
    r_I(n) = min(max(r_I_temp(n), 0), r_max);

end
allowed_vals = find((r_E >= 0 ).*( r_E <= r_max ));
allowed_vals1 = find((r_I>= 0 ).*( r_I <= r_max ));

f3=figure(3);

subplot(1,2,1)
plot(t,r_E);
xlabel('t (sec)')
ylabel('r (Hz)')
grid on
hold on
%plot(t(allowed_vals1),r_I(allowed_vals1));
plot(t,r_I);
xlabel('t (sec)')
ylabel('r (Hz)')
legend('r_{E}','r_{I}')
grid on

subplot(1,2,2)
plot(r_I,r_E)
ylabel('r_{E}')
xlabel('r_{I}')
% subplot(3,1,3);
% r_E1=1:length(r_I(allowed_vals1))
% plot(t(allowed_vals1),r_I(allowed_vals1))
% hold on
% r_I1=1:length(r_I(allowed_vals))
```

```matlab
% plot(r_E(allowed_vals),t(allowed_vals))
% axis([0 t_max 0 r_max])
% xlabel('r_{E} (sec)')
% ylabel('r_{I} (Hz)')
grid on
title('part 3');
%legend('r_{E}','r_{I}')
saveas(f3, sprintf('3.png'));
%% part 4
r_max=100;
theta_E=-5;
theta_I=0;
alpha_E=0.05;
alpha_I=1;
W_EE=2;
W_EI=2.5;
W_IE=-2.5;
W_II=-2;
t_max=3;
r_E(1)=50;
r_I(1)=50;
dt=0.1e-3;
t=0:dt:t_max;
Istim = zeros(size(t));
ind = find (t > 1 & t < 2);
Istim(ind) = 20;
Ibase_E = 25;
Ibase_I = 15;
tau_E=2e-3;
tau_I=10e-3;
Iapp_E = ones(size(t))*Ibase_E;
Iapp_I = ones(size(t))*Ibase_I+Istim;

for n = 2:length(t)
    I_E(n)=W_EE*r_E(n-1)+W_IE*r_I(n-1)+Iapp_E(n-1);
    I_I(n)=W_EI*r_E(n-1)+W_II*r_I(n-1)+Iapp_I(n-1);
    r_E_temp(n) =  r_E(n-1)+(dt/tau_E)*(-r_E(n-1)+alpha_E*((I_E(n)-
theta_E)^2).*sign(I_E(n)-theta_E));
    r_I_temp(n) =  r_I(n-1)+(dt/tau_I)*(-r_I(n-1)+alpha_I*((I_I(n)-
theta_I)));
    r_E(n) = min(max(r_E_temp(n), 0), r_max);
    r_I(n) = min(max(r_I_temp(n), 0), r_max);

end
allowed_vals = find((r_E >= 0 ).*( r_E <= r_max ));
allowed_vals1 = find((r_I>= 0 ).*( r_I <= r_max ));

f4=figure(4);
subplot(1,2,1)
plot(t,r_E);
xlabel('t (sec)')
ylabel('r (Hz)')
grid on
hold on
%plot(t(allowed_vals1),r_I(allowed_vals1));
plot(t,r_I);
```

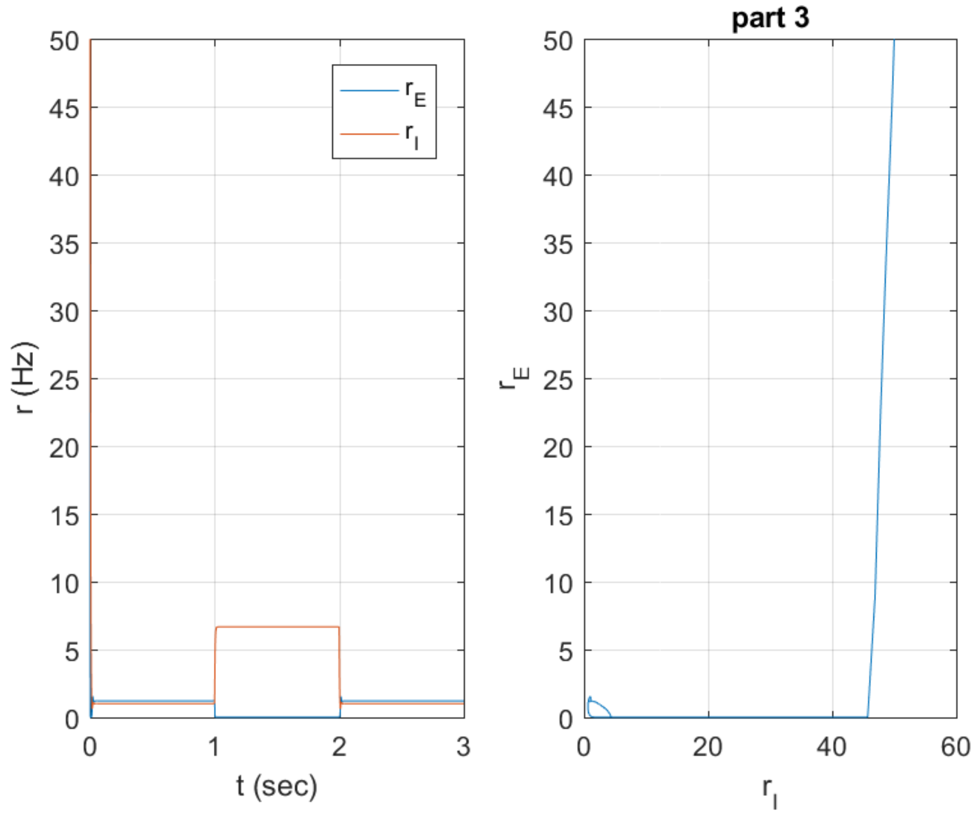
```
xlabel('t (sec)')
ylabel('r (Hz)')
legend('r_{E}','r_{I}')
grid on

subplot(1,2,2)
plot(r_I,r_E)
ylabel('r_{E}')
xlabel('r_{I}')
% subplot(3,1,3);
% plot(t(allowed_vals),r_E(allowed_vals));
% hold on
% plot(t(allowed_vals1),r_I(allowed_vals1));

grid on
title('part 4');
%legend('r_{E}','r_{I}')
saveas(f4, sprintf('4.png'));
```



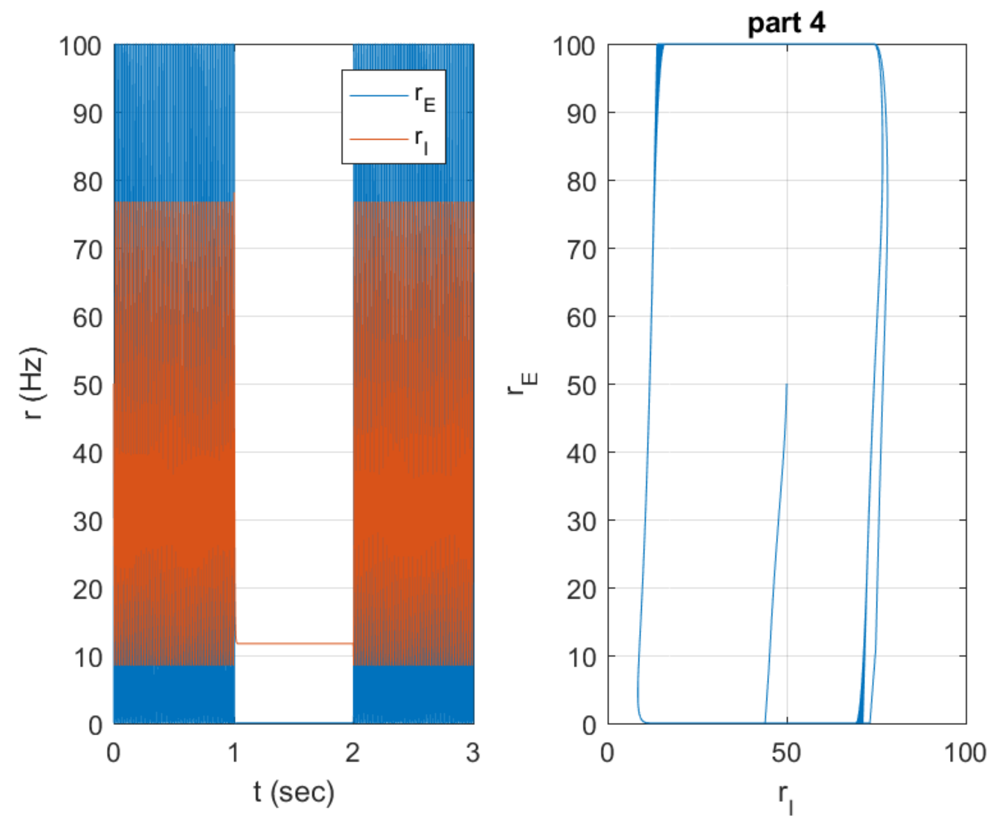
I can see system is stable because effective excitatory feedback is relatively weak . I also can see that increasing inhibitory input cause excitory rate to be zero and when we remove the extra current it once again back to stablity



Here I can see increasing the base line keeps the system still stable but I can see some oscilations before reaching to stability



I can see changing a higher tau_I results in the inhibitory unit's response to changes in its input current being slower. This means the inhibitory influence on the excitatory unit will also be slower to rise and fall. decreasing tau_E causes faster excitation.



I can see the increase of tau along with change in base lines makes the system unstable and increase the firing rate in comparison with part 2