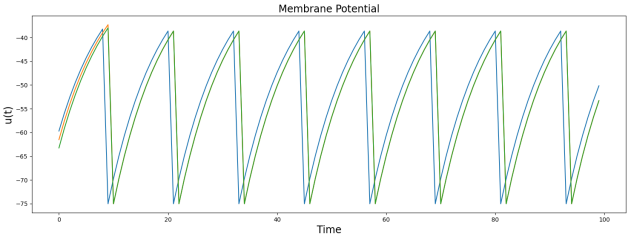
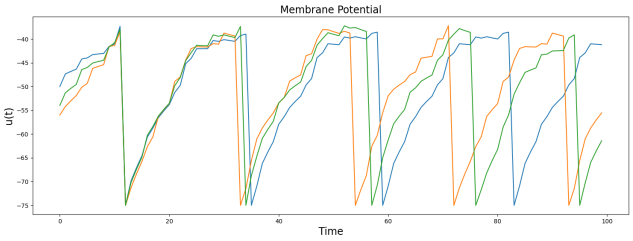
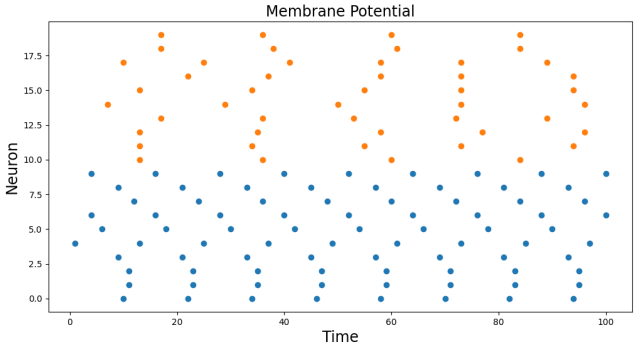
Synapses



(a) Neuron Group 1



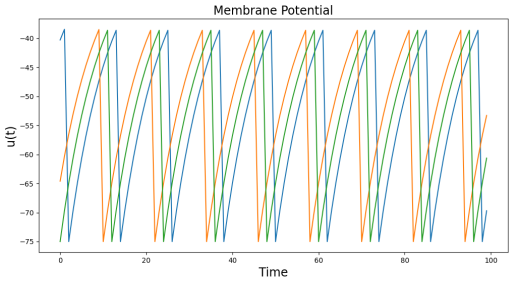
(b) Neuron Group 2



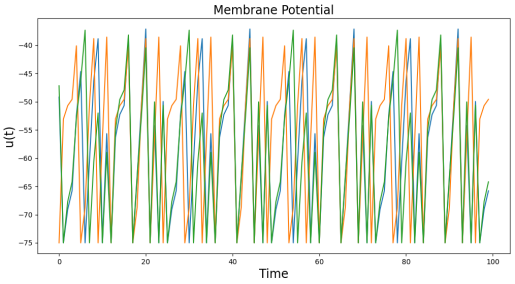
(c) Spikes (All Neurons)

Figure 1: Three random neurons from two population

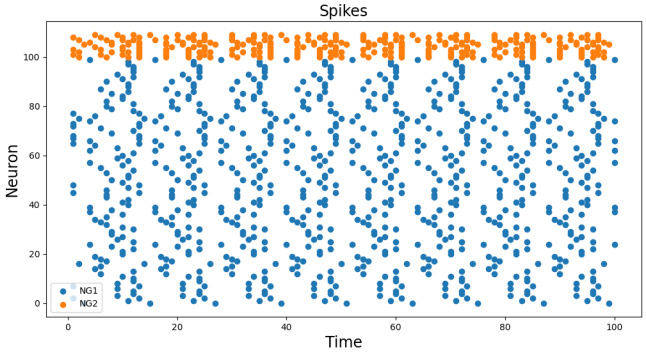
And you can see for the situation with 100 neurons in first neuron group, there is much higher diffrent in memberance potential of neuron group 2. of course due to higher spikes in ng1, there is more impact on memebrance potential of neurons in group 2.



(a) Neuron Group 1



(b) Neuron Group 2



(c) Spikes (All Neurons)

Figure 2: Three random neurons from two population

!!! Important Note: All of these implementations are based on simple LIF with the following parameters:

- $R = 5$

- $threshold = -37$
- $u_{\text{rest}} = -67$
- $u_{\text{reset}} = -75$
- $\tau = 10$

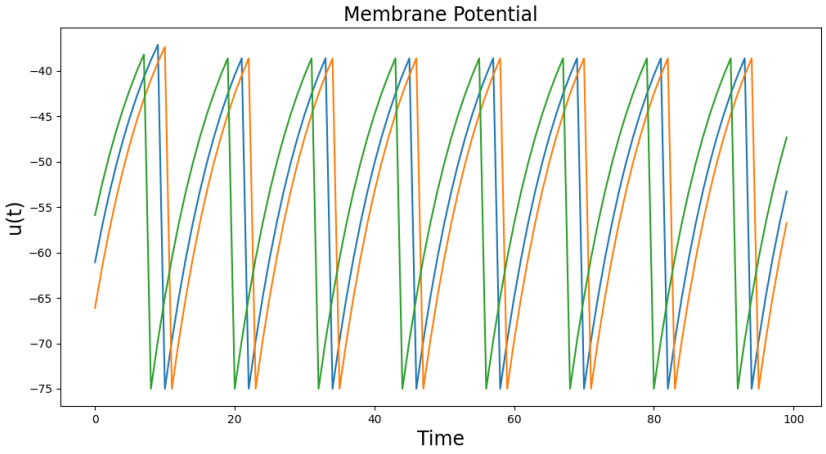
1 Three Different Connectivity

This is some text in the first section.

1.1 Full Connectivity with same Weights

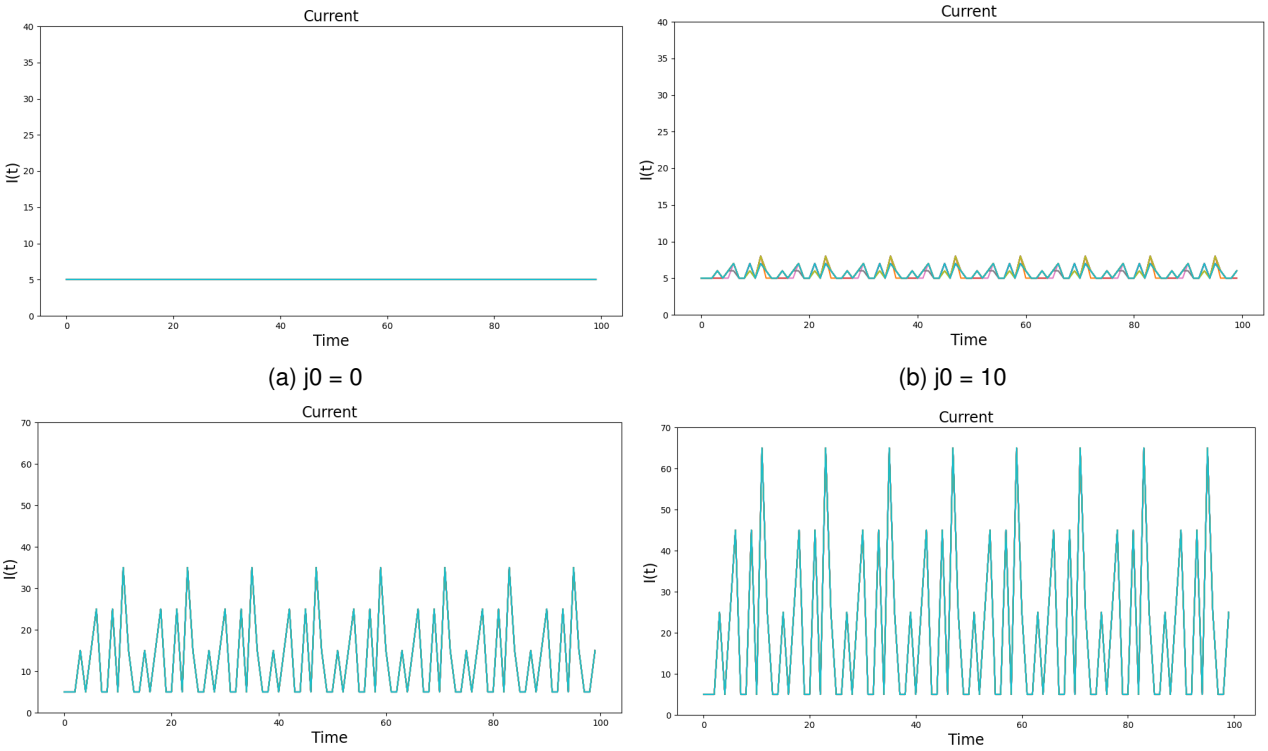
in this method, all destination neruonn are connected to all src neuron group. the weights have same strength, j0/N. In this expriments, fix current for the first neuron group is 9 and for the second neuron group (destiation) is 5.

1.1.1 Neuron Group 1 : 10 Neurons



(a) Neuron Group 1

Figure 3: Three random neuron from ng1



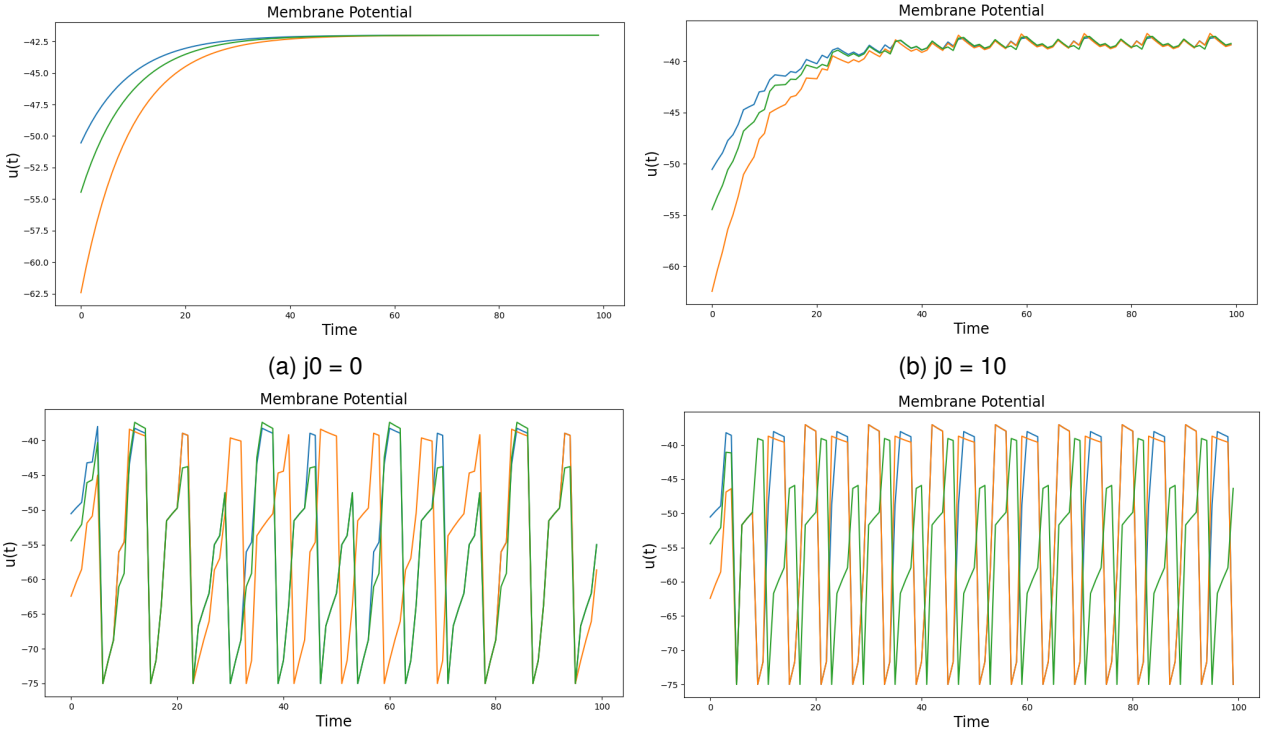
(a) j0 = 0

(b) j0 = 10

(c) j0 = 100

(d) j0 = 200

Figure 4: Impacts of synaps current on neuron group 2 (destination) current with 4 different j0 : 0, 1, 10, 100



(a) j0 = 0

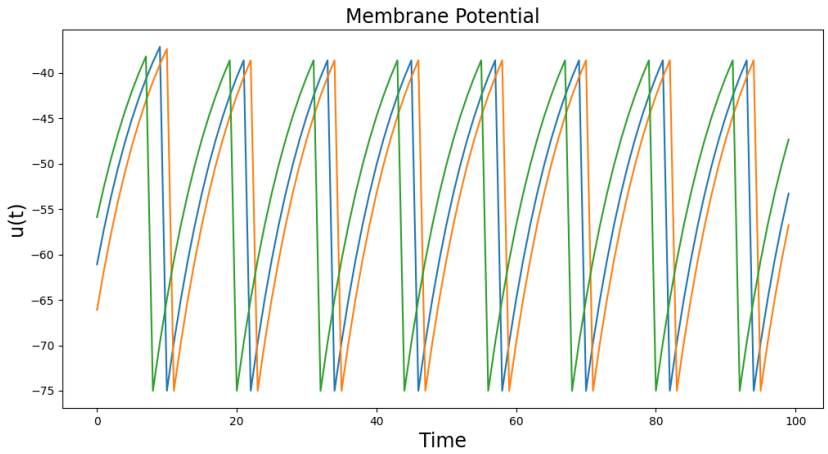
(b) j0 = 10

(c) j0 = 100

(d) j0 = 200

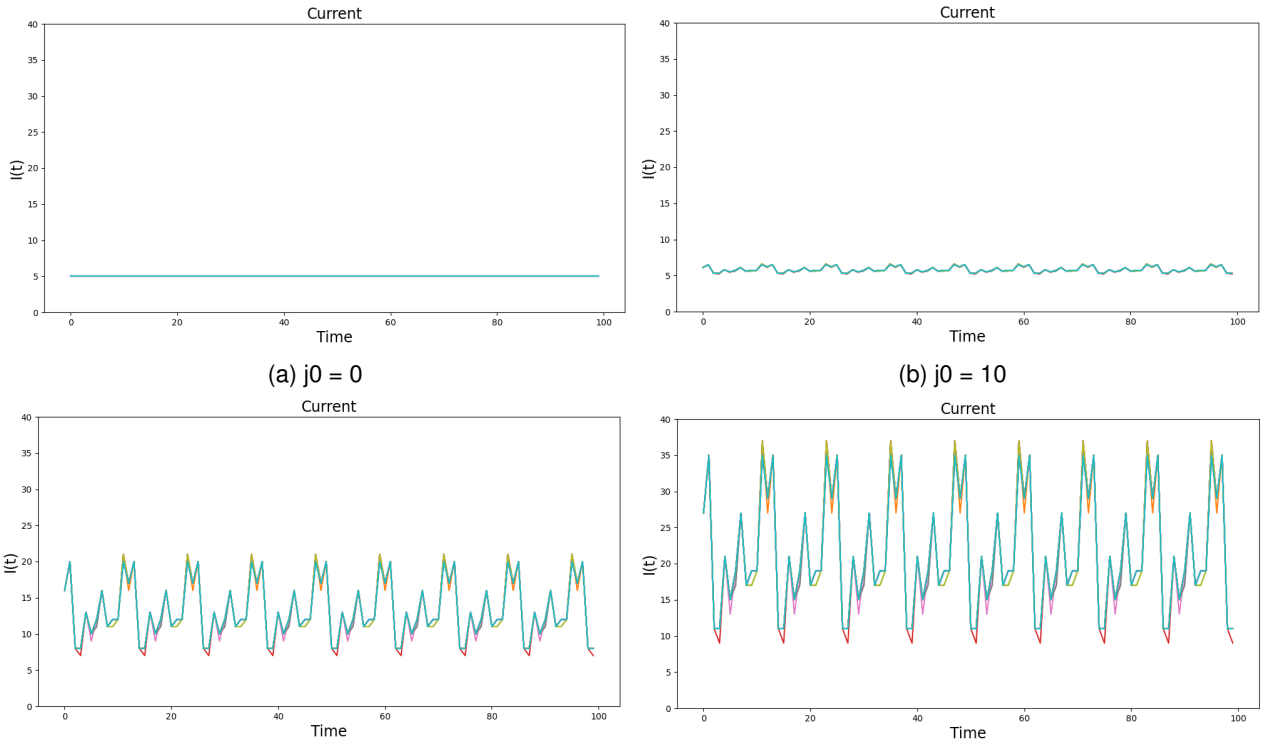
Figure 5: Membrance Plots for three random neurons from neuron group 2 (destination) with 4 different j0 : 0, 1, 10, 100

1.1.2 Neuron Group 1 : 100 Neurons



(a) Neuron Group 1

Figure 6: Three random neuron from ng1



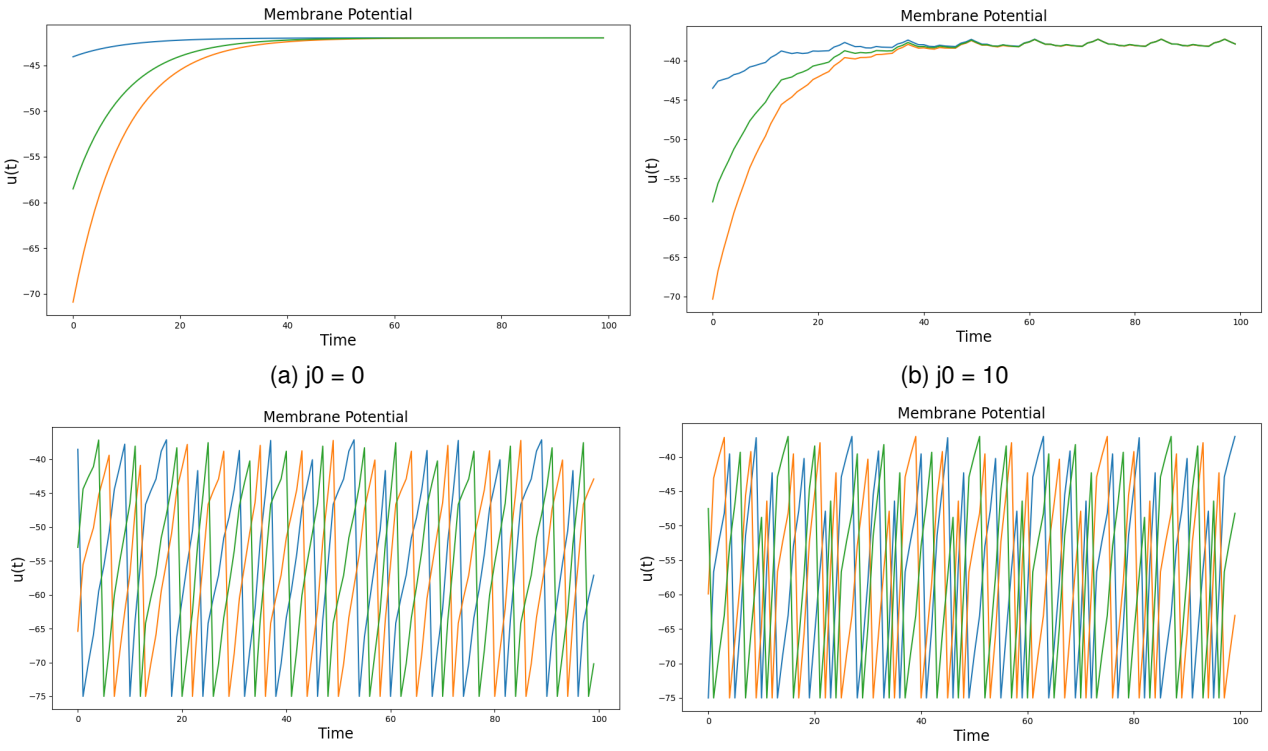
(a) j0 = 0

(b) j0 = 10

(c) j0 = 100

(d) j0 = 200

Figure 7: Impacts of synaps current on neuron group 2 (destination) current with 4 different j0 : 0, 1, 10, 100



(a) j0 = 0

(b) j0 = 10

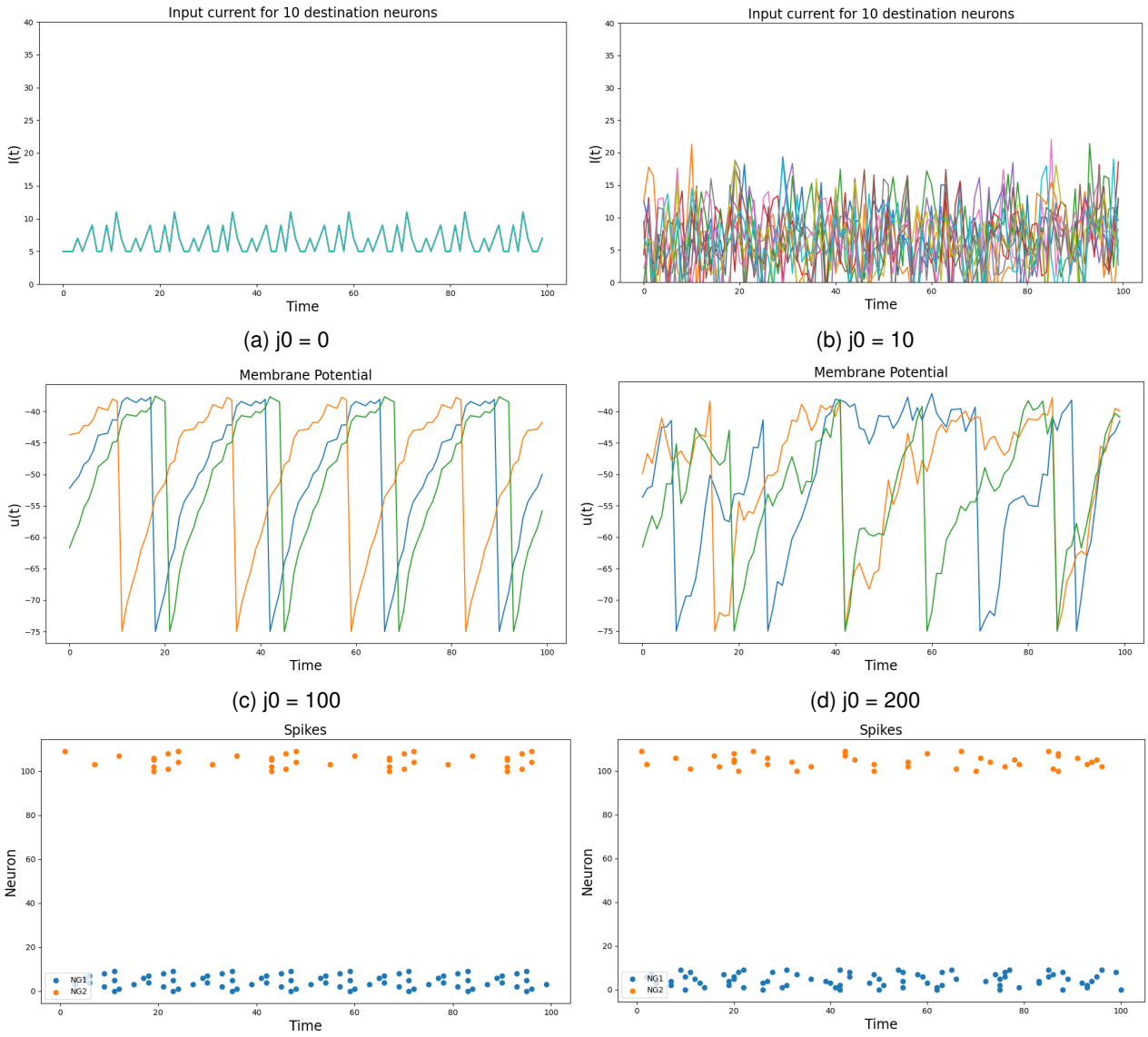
(c) j0 = 100

(d) j0 = 200

Figure 8: Membrance Plots for three random neurons from neuron group 2 (destination) with 4 different j0 : 0, 1, 10, 100

1.1.3 Impact of Noise :

on the synaps current, noise has been implemented : normal(0,1)



(a) j0 = 0

(b) j0 = 10

(c) j0 = 100

(d) j0 = 200

(e) j0 = 200

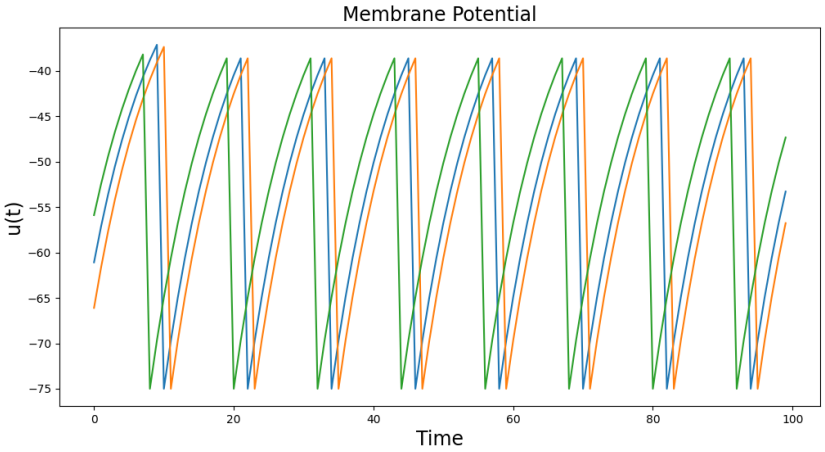
(f) j0 = 200

Figure 9: Membrance Plots for three random neurons from neuron group 2 (destination) with 4 different j0 : 0, 1, 10, 100

1.2 Full Connectivity with Random Weights

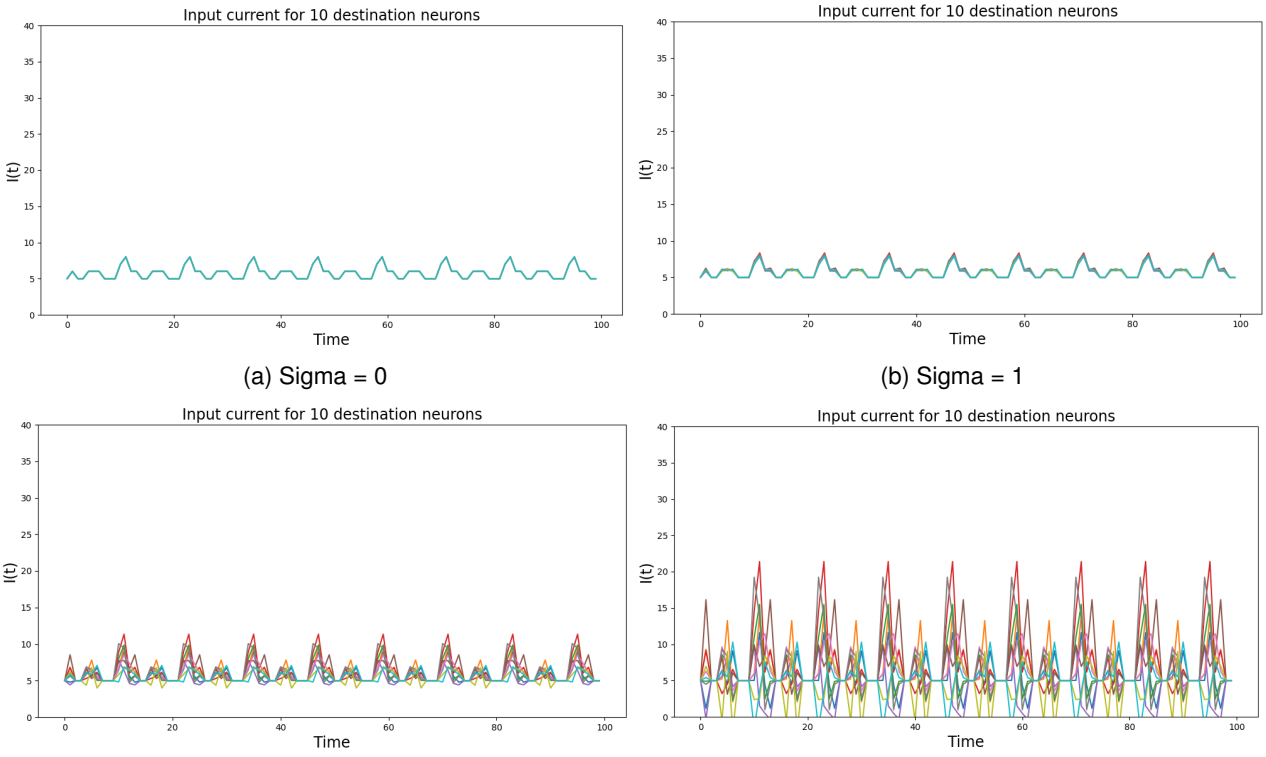
For this imeplementation, these parameters have been set:

- Source Neuron Gruop Size :10
- Destination Neuron Gruop Size : 10
- Input Current for NG1 : 9
- Input Current for NG2 : 5



(a) Neuron Group 1

Figure 10: Three random neuron from ng1



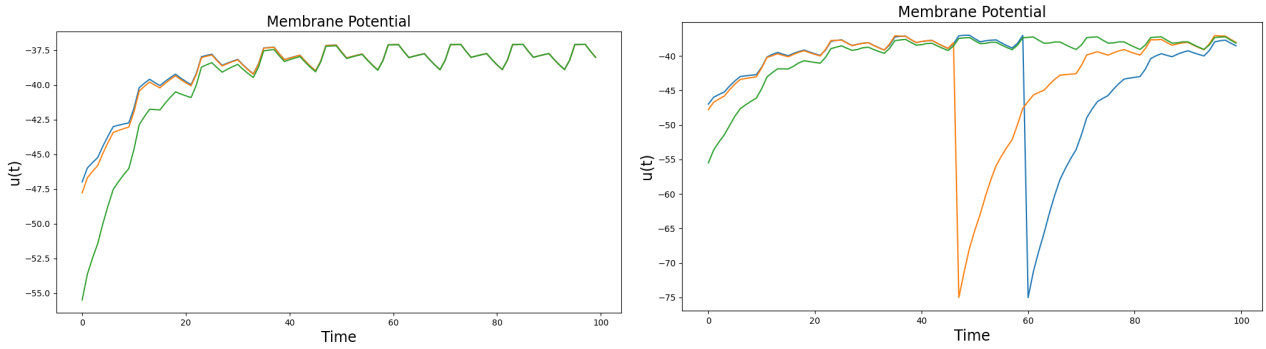
(a) Sigma = 0

(b) Sigma = 1

(c) Sigma = 10

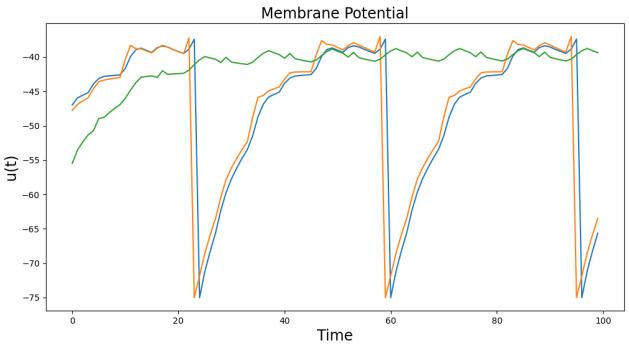
(d) Sigma = 40

Figure 11: Impacts of synaps current on neuron group 2 (destination) current with fix j0=10 and 4 different Sigma : 0, 1, 10, 40

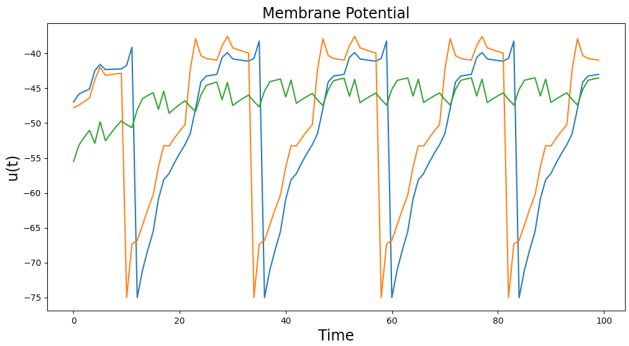


(a) Sigma = 0

(b) Sigma = 1

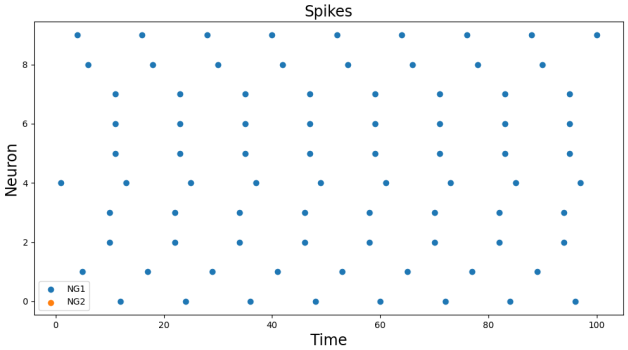


(c) Sigma = 10

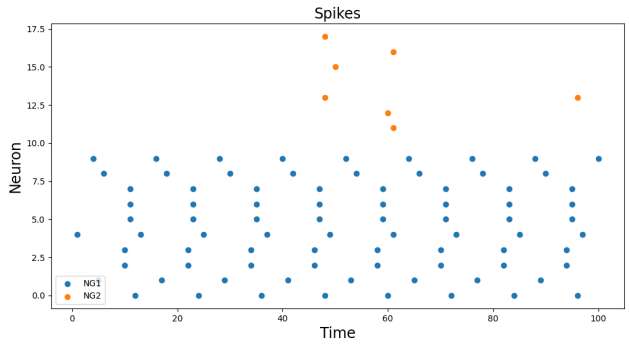


(d) Sigma = 40

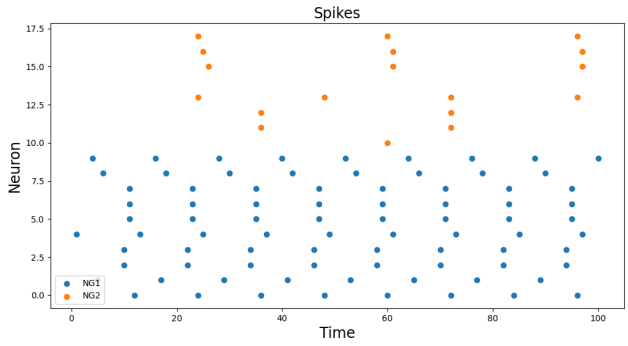
Figure 12: Membrance Plots for three random neurons from neuron group 2 (destination) with fix j0=10 and 4 different Sigma : 0, 1, 10, 40



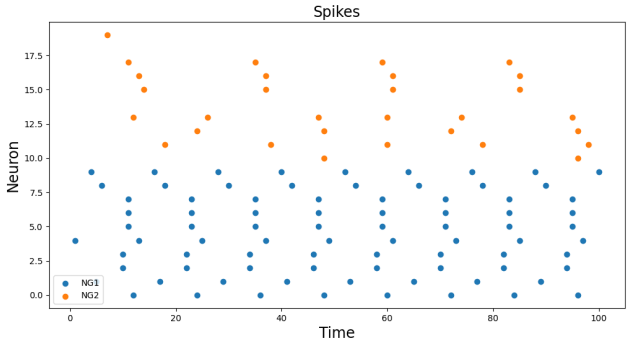
(a) Sigma = 0



(b) Sigma = 1



(c) Sigma = 10



(d) Sigma = 40

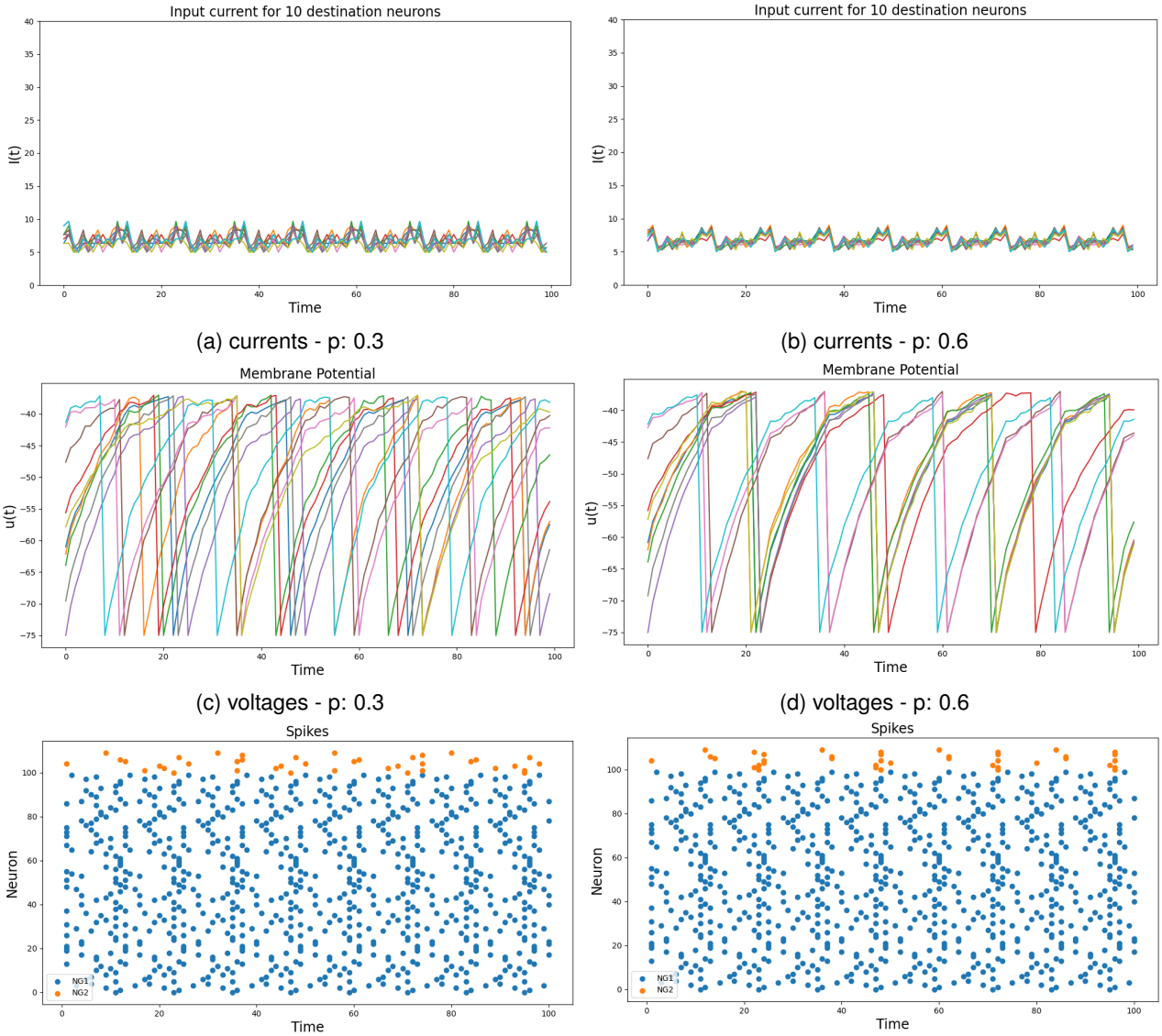
Figure 13: Spikes of all neurons with fix j0=10 and 4 different Sigma : 0, 1, 10, 40

impact of noise:

1.3 Random Connectivity

As the impact of j0 is obvious, I examined the impact of "p" on the netword behavior. As you can see in the figure 14, bahavior of network with higher "p" is smoother than network with low "p". There are some obvious diferents between these two networks. In network with higher p :

- Input currents for all destination neurones are **more similar** than the network with lower p.
- The behavior in this network is **smoother**.
- Spikes are more **group-wise** rather than **sigle-wise**
- There are lower fluctuation in input currents.



(a) currents - p: 0.3

(b) currents - p: 0.6

(c) voltages - p: 0.3

(d) voltages - p: 0.6

(e) spikes - p: 0.3

(f) spikes - p: 0.6

Figure 14: Spikes of all neurons with fix j0=20 and 2 different p : 0.3, 0.6

noise impact:

2 Excitatory-Inhibitory population

In this section, I made two population, excitatory and inhibitory groups in this way:

- **excitatory:** 200 neurons (80 percent)

- **inhibitory:** 50 neurons (20 percent)
- coef : 50
- exc-inh connectivity : 'uniform', density=0.3
- inh-exc connectivity : 'uniform', density=0.3
- exc-exc connectivity : 'uniform', density=0.3

As you can see, at first the inhibitory neurons were not spiking and after a while, that the input current and excitetory neuron group activity has been increased, we are witness the firing pattern for inhibitory neuron group. After a time window, as the inhibitory neuron activity has been increased, they have controlled the excitatory neuron activity and have decreased them.as you can see after about iteration 140, the activity of excitatory neurons decreased significantly and after about iteration of 160, no excitatory neuron has spiked for about 10 iteration. Due to noise in current, suddenly the bahvior of the intraction of these neurons has changed and suddenly, excitatory neuron acitivated, while the inhibitory neurons activity has rised too and again the ihnibitry neuron, inhibite completely the excitatory neurons ativity for some iterations and again, a flactuation in bahavior due to noise and increase in current.

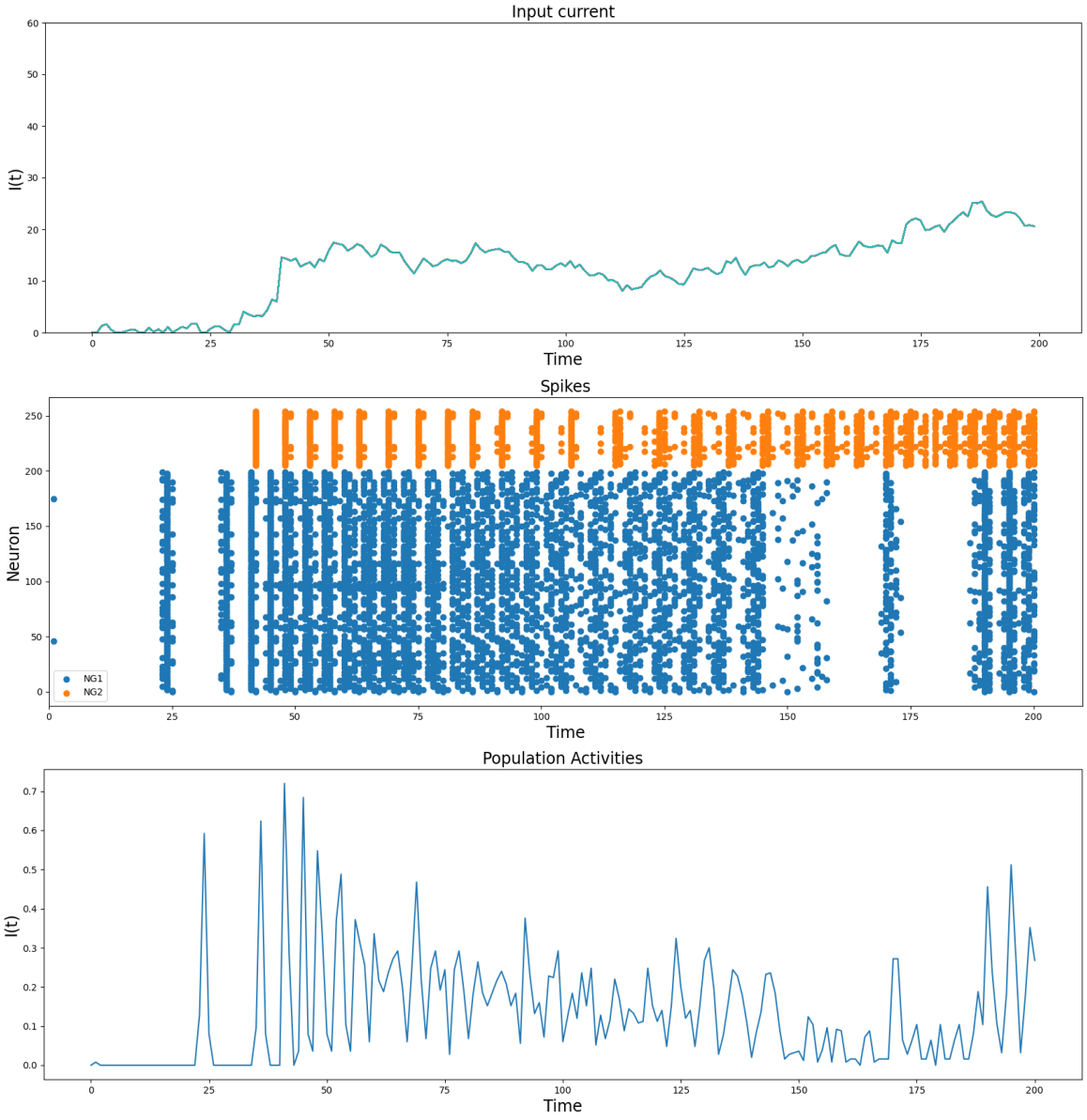
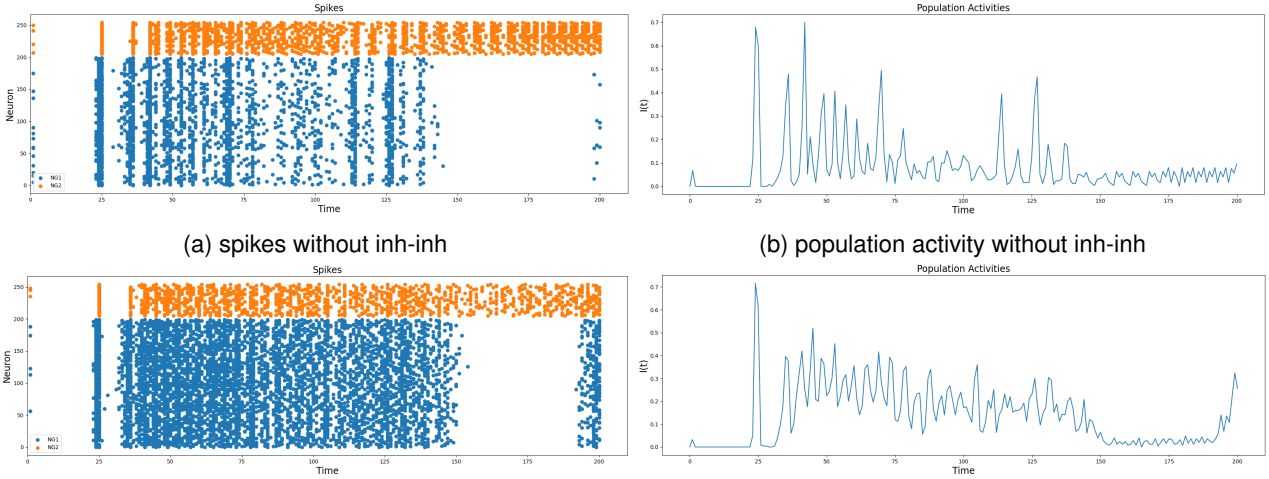


Figure 15: The behavior of Exc and Inh neurons and the whole population activity

Now, I want to check the impact of inh-inh connection. Rationally, this connection should inhibite the inhibitory neurons and consequently, increase the population activity, becasue the major part of neurons in

population are excitatory. As you can see in the Figure 16, this behavior is so obvious. to have a batter experience and obsercation, I inreased the coef to 500 to have more impact of connection in behavior.



(a) spikes without inh-inh

(b) population activity without inh-inh

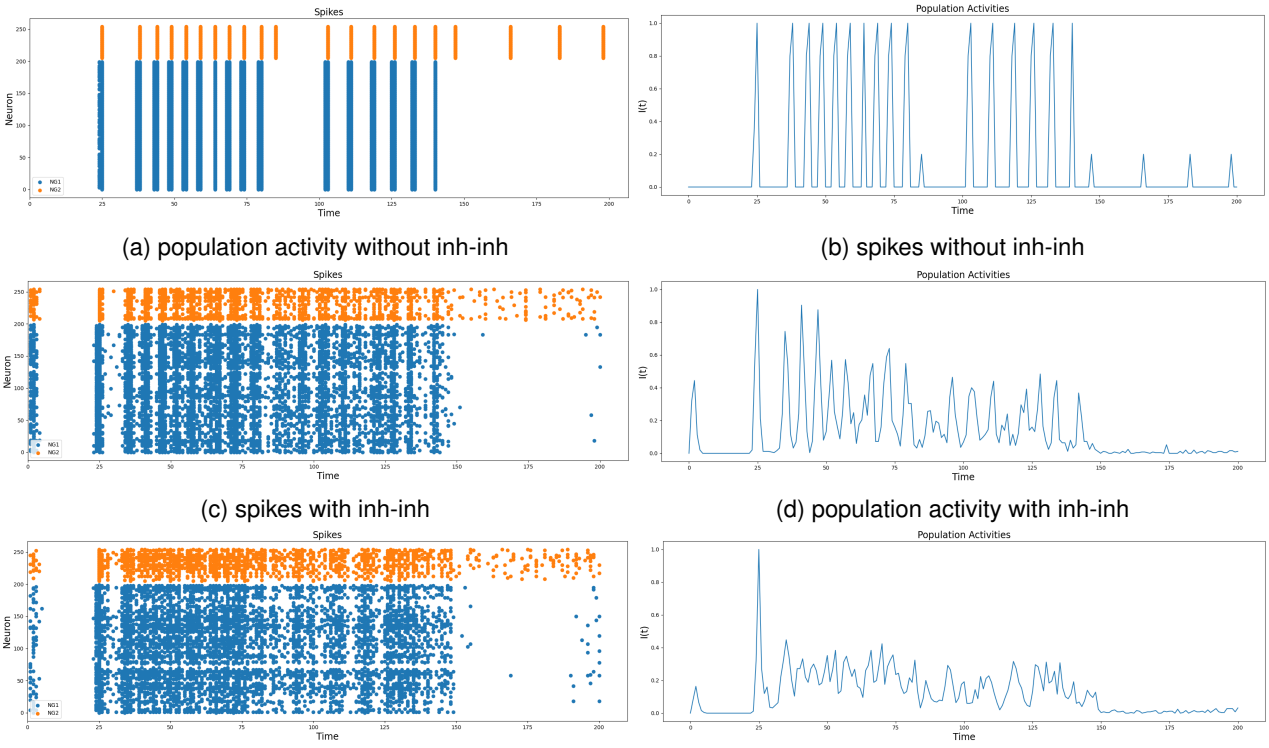
(c) spikes with inh-inh

(d) population activity with inh-inh

Figure 16: Spikes and population activity in two different situation, once without inh-inh connection and once with inh-inh connection.

Now, here I impelemented three method of connectivity between populations:

- Full connectivity with fix weights (j0=1)
- Full connectivity with random weights (j0=1, sigma=1)
- random connectivity with fix weights (j0=1, p=0.3)



(a) population activity without inh-inh

(b) spikes without inh-inh

(c) spikes with inh-inh

(d) population activity with inh-inh

(e) population activity with inh-inh

(f) population activity with inh-inh

Figure 17: Spikes and population activity in two different situation, once without inh-inh connection and once with inh-inh connection.

3 Three population, exc - exc - inh

Now, I implemented three population with their connectivity in the following way:

- j0 = 1
- p = 0.3
- excitatory group 1 : 200 neuron
- excitatory group 2 : 200 neuron
- inhibitory : 100 neuron
- connectivity scheme : random connectivity with fix weight j0/p*N
- there isn't inh-inh connection

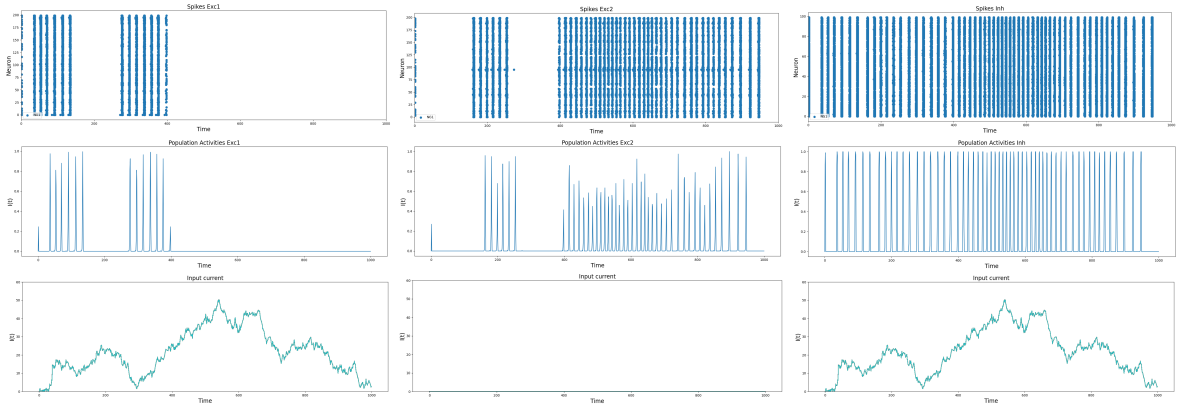


Figure 18: Spikes and population activity in three population

This time with full connectivity fix weight

- j0=1
- excitatory group 1 : 200 neuron
- excitatory group 2 : 200 neuron
- inhibitory : 40 neuron
- connectivity scheme : Full connectivity fix weight
- there isn't inh-inh connection

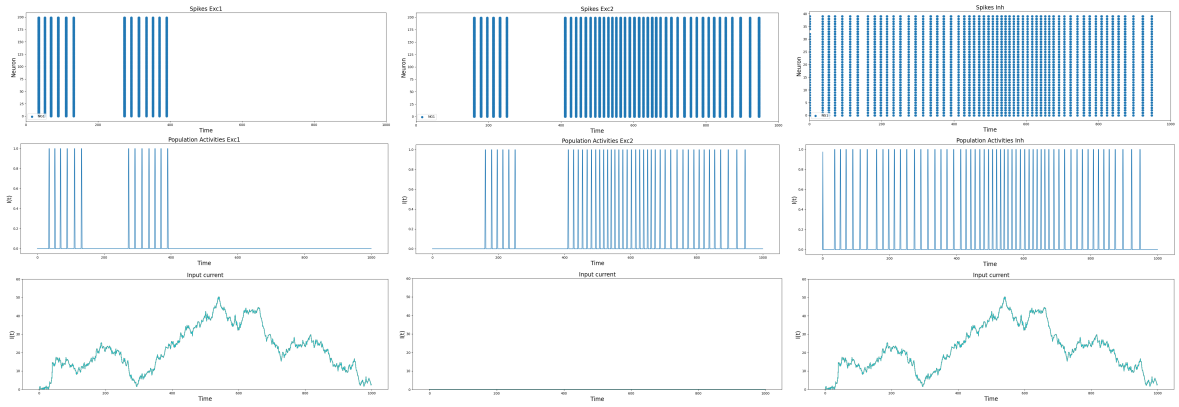


Figure 19: Spikes and population activity in three population

This time with full connectivity random weight

- j0 = 1
- sigma = 3
- excitatory group 1 : 200 neuron
- excitatory group 2 : 200 neuron
- inhibitory : 40 neuron
- connectivity scheme : Full connectivity random weight
- there isn't inh-inh connection

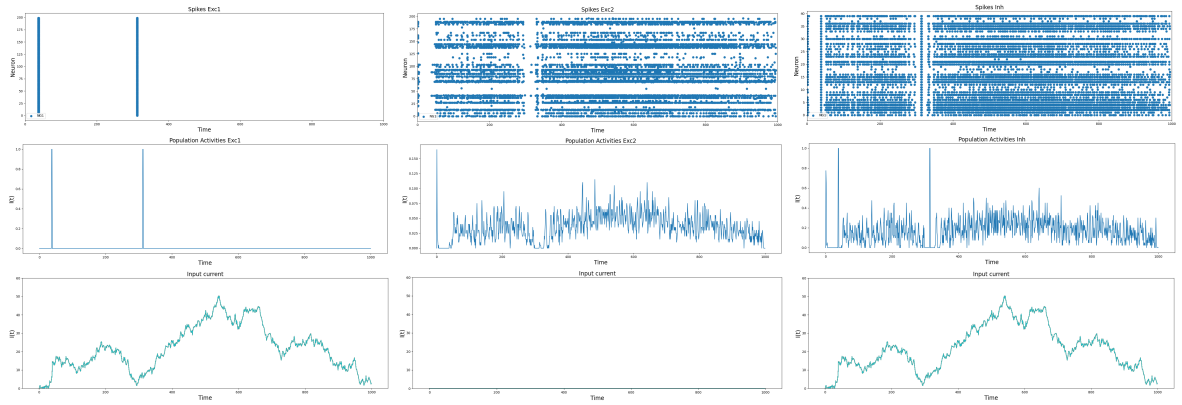


Figure 20: Spikes and population activity in three population

Conclution : As it's obvious, the inhibitory population after a while would fully inhibit one of the excitatory populations. in the first two connectivity, there is same behavior but in the last one we can see the diffrent behavior.