Advanced Neuroscience **Homework #1**

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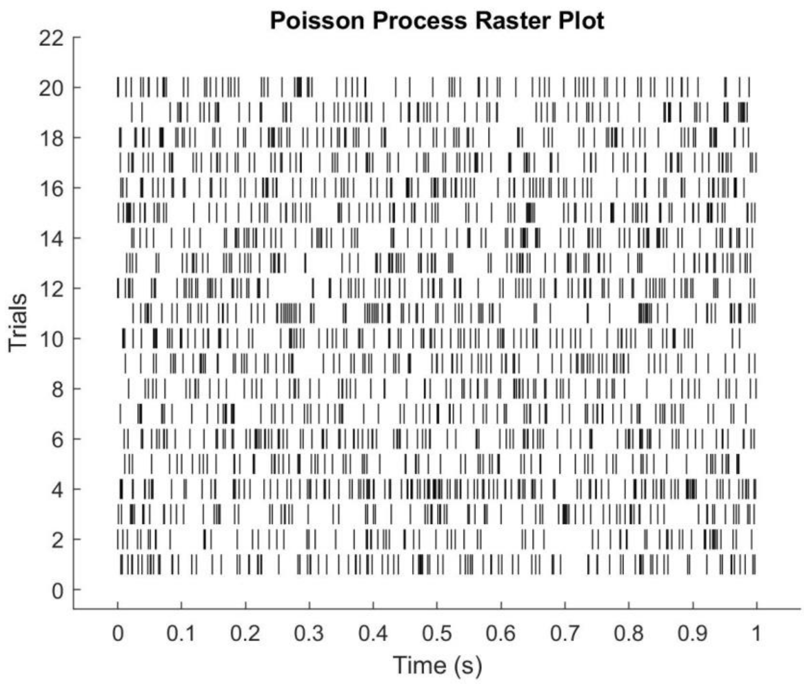
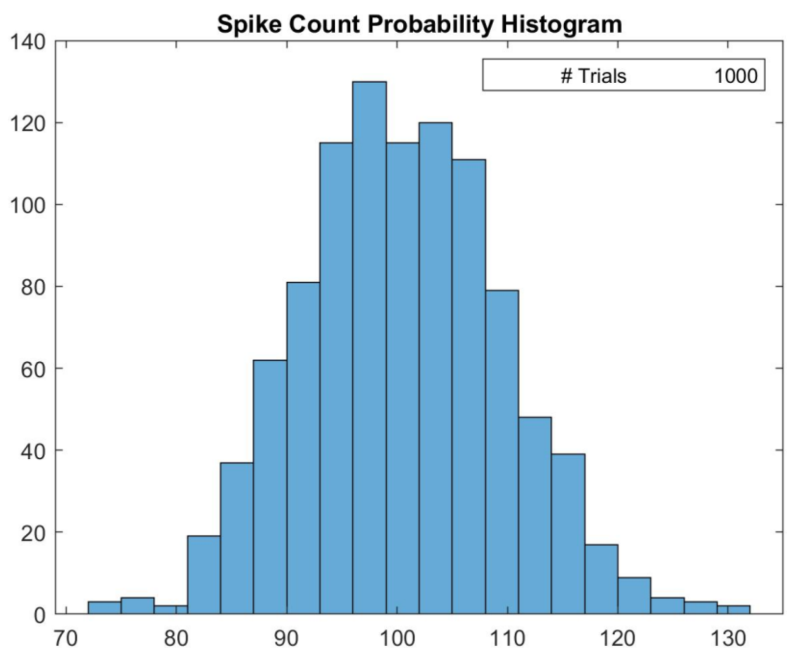
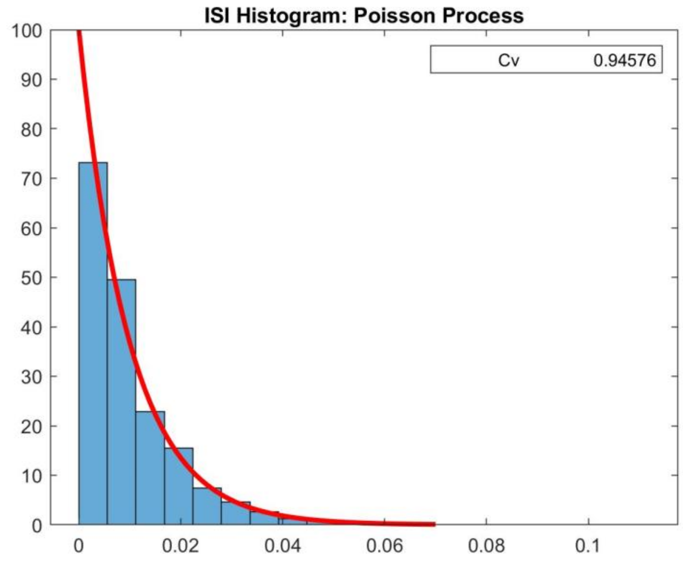
- **1-a-**



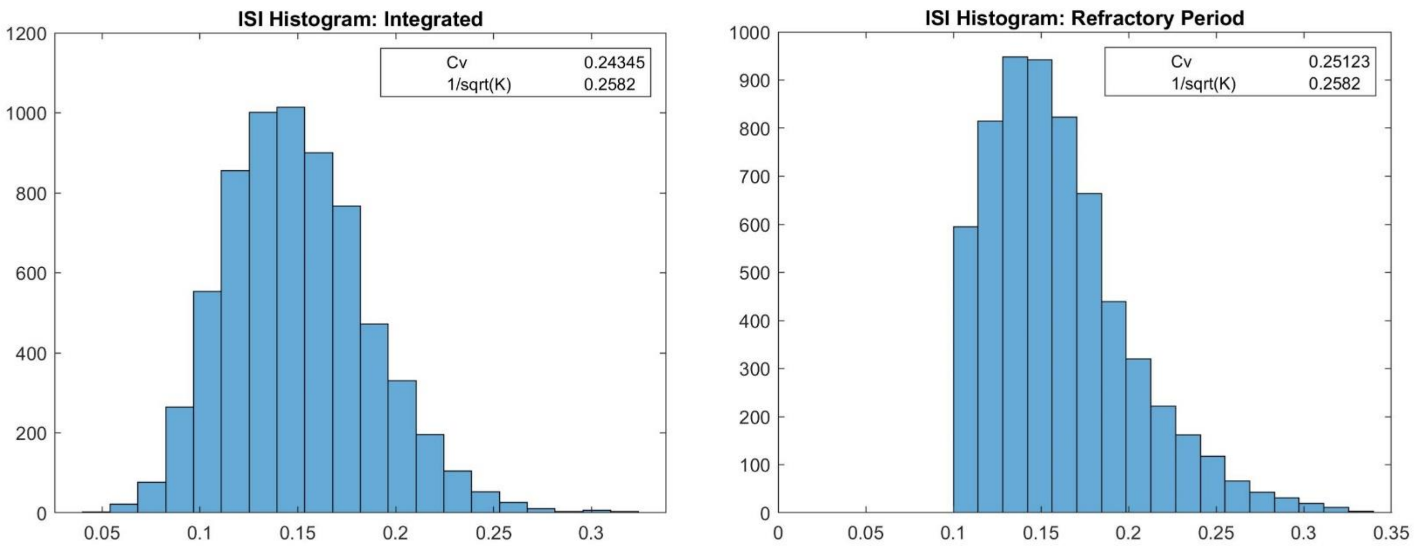
- **1-b-**



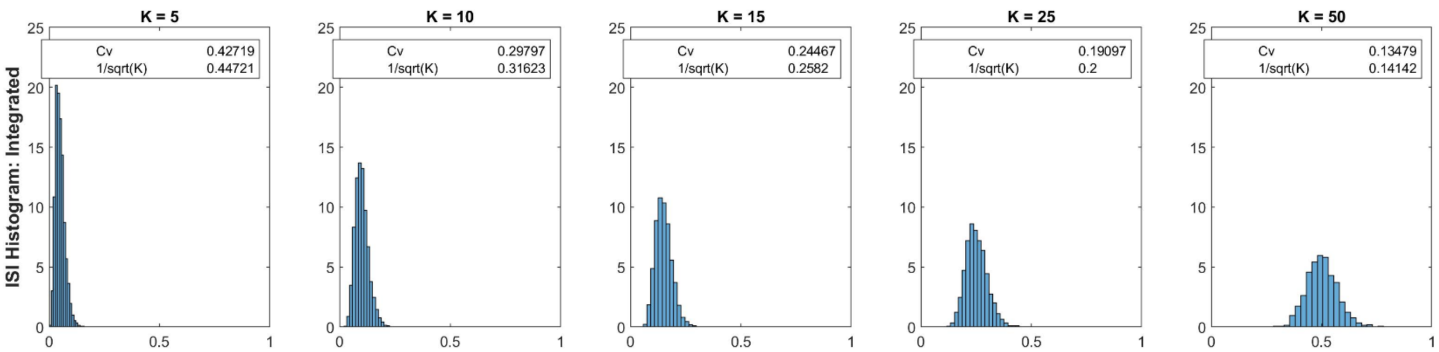
- **1-c-**



- **1-d-**



ISI Histogram for K=15 & RP=0.1



- **1-e-**

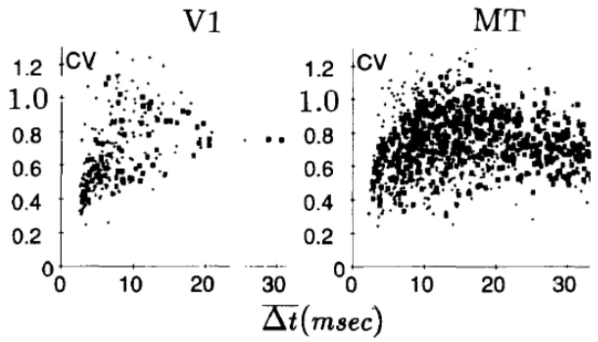
$$X_i \sim \mathrm{Exp}(\lambda)$$

$$\tau = \sum_{i}^{k} X_i \sim \mathrm{Erlang}(k, \lambda)$$

$$f(x; k, \lambda) = \frac{\lambda^k x^{k-1} e^{-\lambda x}}{(k-1)!} \text{ for } x, \lambda \geq 0,$$

$$C_v = \frac{\mathrm{std}(\tau)}{E(\tau)} = \frac{\left(\frac{\sqrt[2]{k}}{\lambda}\right)}{\left(\frac{k}{\lambda}\right)} = \frac{1}{\sqrt{k}}$$

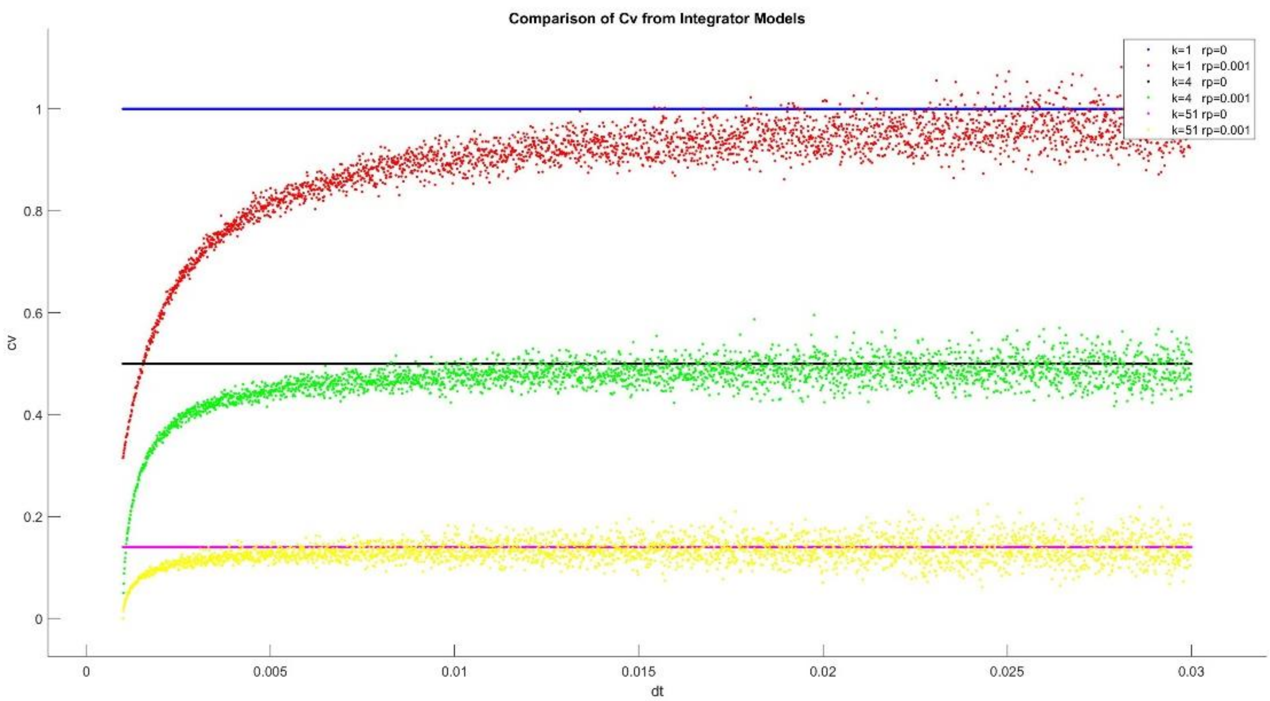
- **1-f-**



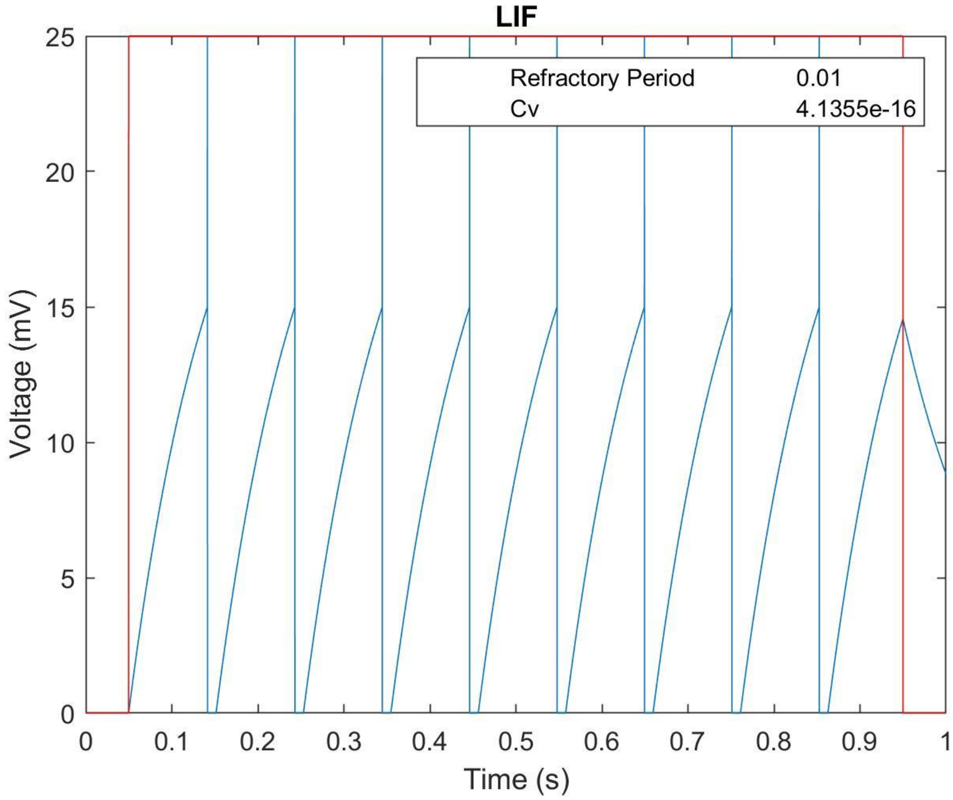
Higher firing rate lowers Cv. It causes absolutely periodic spikes which has zero variance (Cv=0).

Integration causes firing rate to become regularized which has same ISIs and lowers Variance and Cv.

- **1-g-**



- **2-a-**



- **2-b-**

$$\tau_m \frac{dv}{dt} = -v(t) + RI \rightarrow v(t) = Ae^{-\frac{t}{\tau_m}} + B$$

$$v(0) = 0 \quad \rightarrow A = -B \rightarrow v(t) = Ae^{-\frac{t}{\tau_m}} - A$$

$$v(\infty) = RI \rightarrow A = -RI \quad \rightarrow v(t) = -RIe^{-\frac{1}{\tau_m}} + RI$$

$$\rightarrow \quad v(t) = RI\left(1 - e^{-\frac{t}{\tau_m}}\right)$$

$$v(t_{isi}) = V_{th} \rightarrow V_{th} \quad = RI\left(1 - e^{-\frac{t}{\tau_m}}\right)$$

$$1 - \frac{V_{th}}{RI} \quad = e^{-\frac{t_{sin}}{\tau_m}}$$

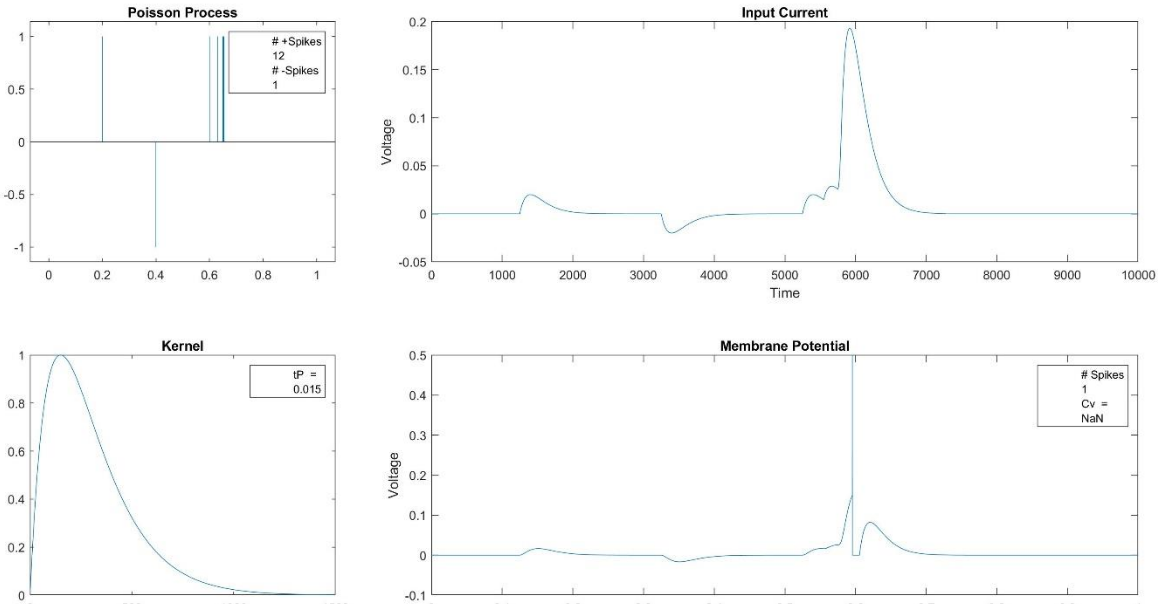
$$-\frac{t_{isi}}{\tau_m} \quad = \ln\left(1 - \frac{V_{th}}{RI}\right)$$

$$t_{isi} \quad = -\tau_m \ln\left(1 - \frac{V_{th}}{RI}\right)$$

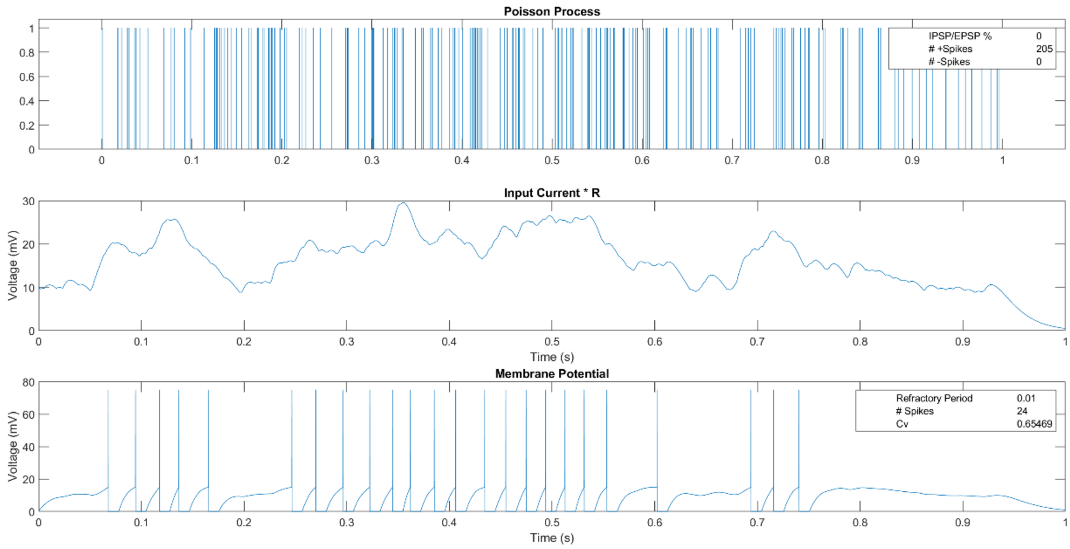
$$t_{isi} \quad = \tau_{mm} \ln\left(\frac{RI}{RI - V_{th}}\right)$$

$$FR = \frac{1}{t_{isi} + \Delta t_r} \quad = \frac{1}{\tau_m \ln\left(\frac{RI}{RI - V_{th}}\right) + \Delta t_r}$$

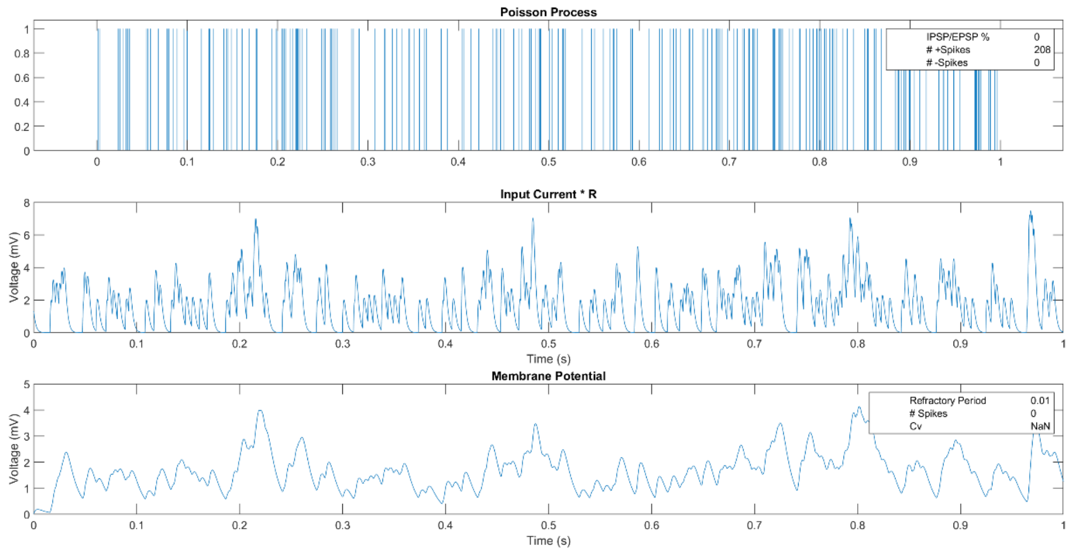
- **2-c-**

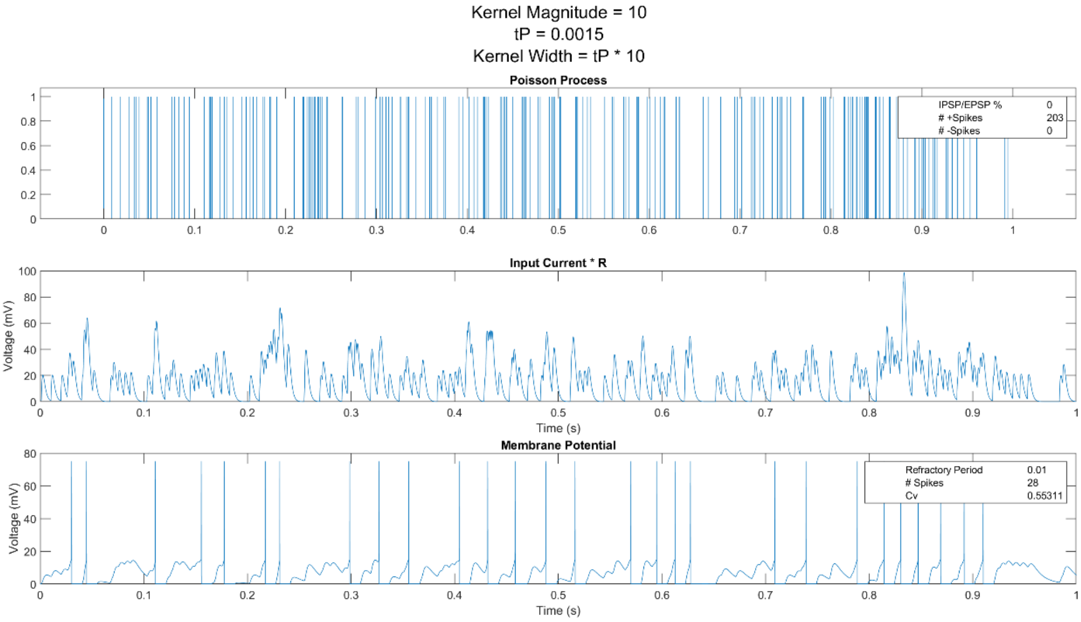


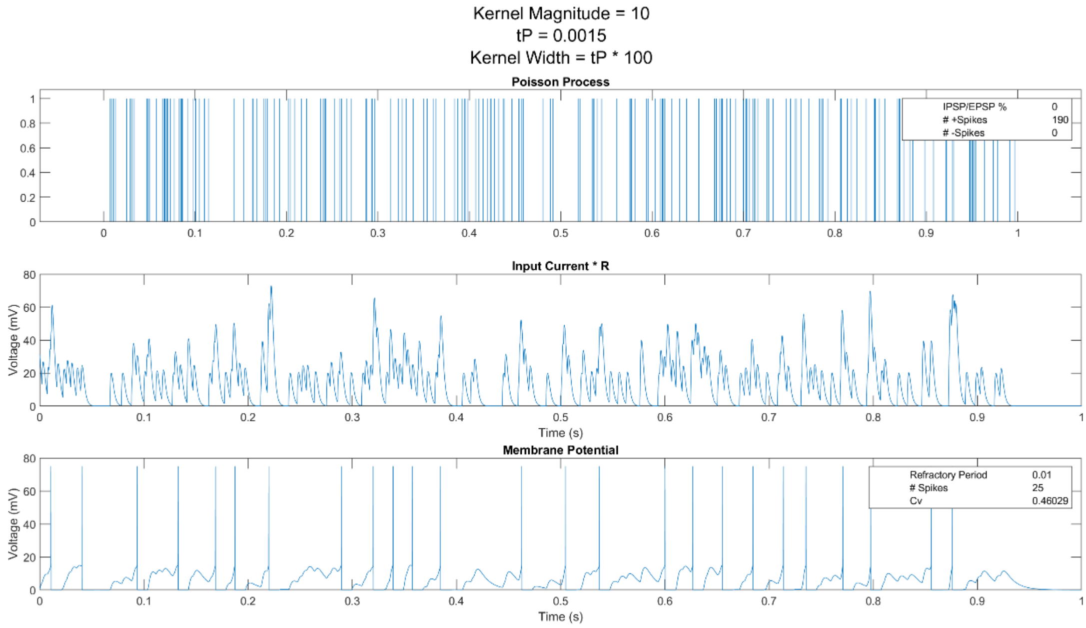
Kernel Magnitude = 1
tP = 0.015
Kernel Width = tP * 10

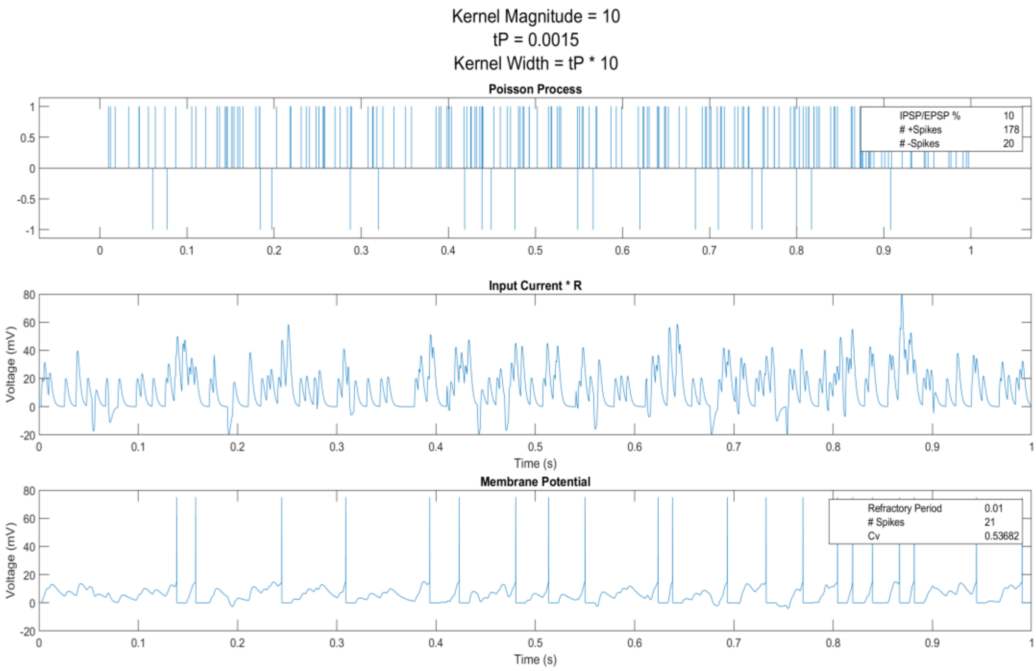


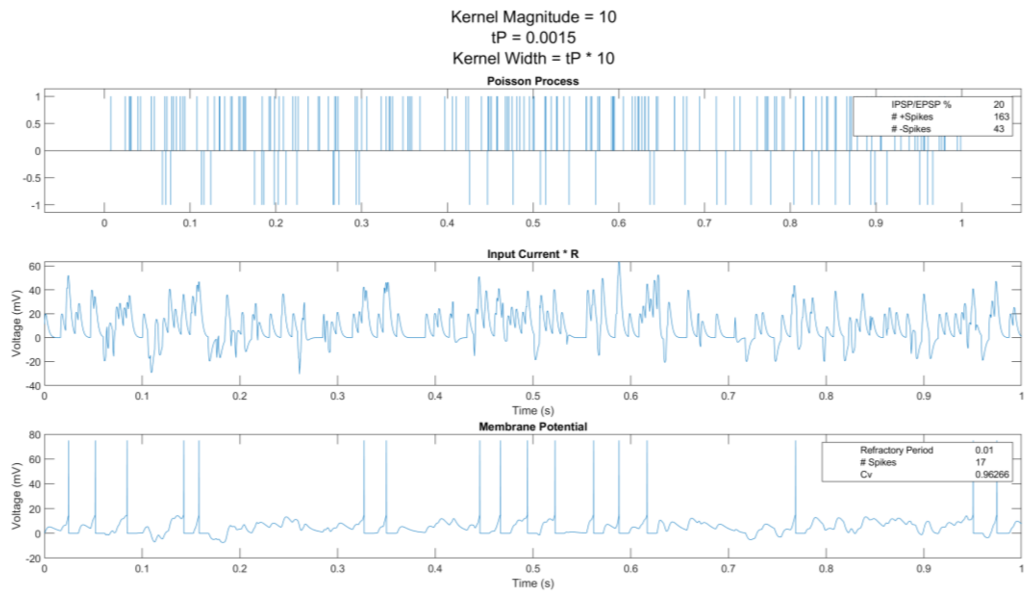
Kernel Magnitude = 1
tP = 0.0015
Kernel Width = tP * 10

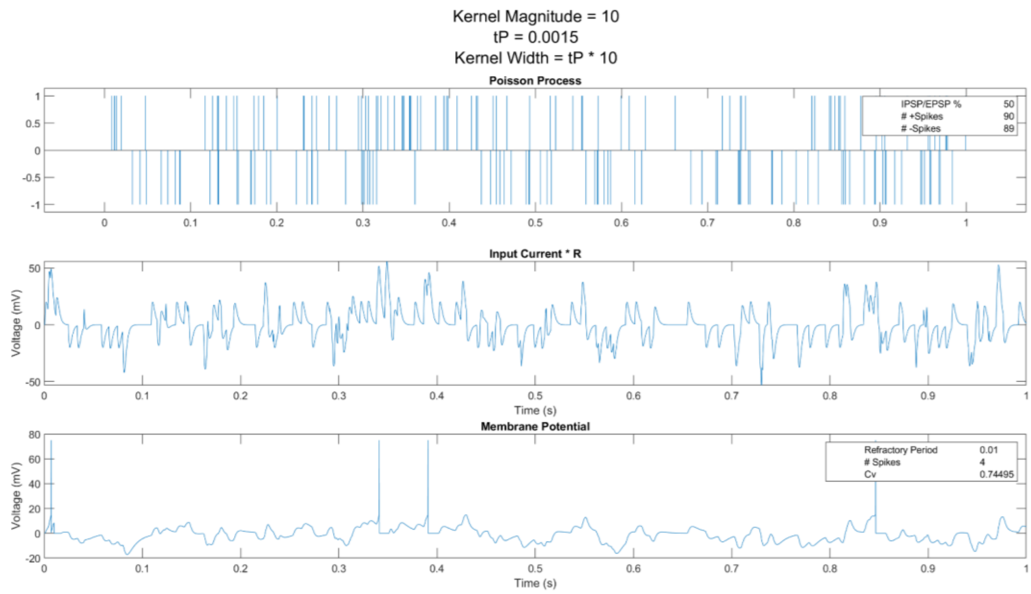



Kernel Magnitude = 10
tP = 0.0015
Kernel Width = tP * 10
Poisson Process
IPSP/EPSP % 0
+Spikes 203
-Spikes 0
Input Current * R
Voltage (mV)
Time (s)
Membrane Potential
Refractory Period 0.01
Spikes 28
Cv 0.55311
Voltage (mV)
Time (s)

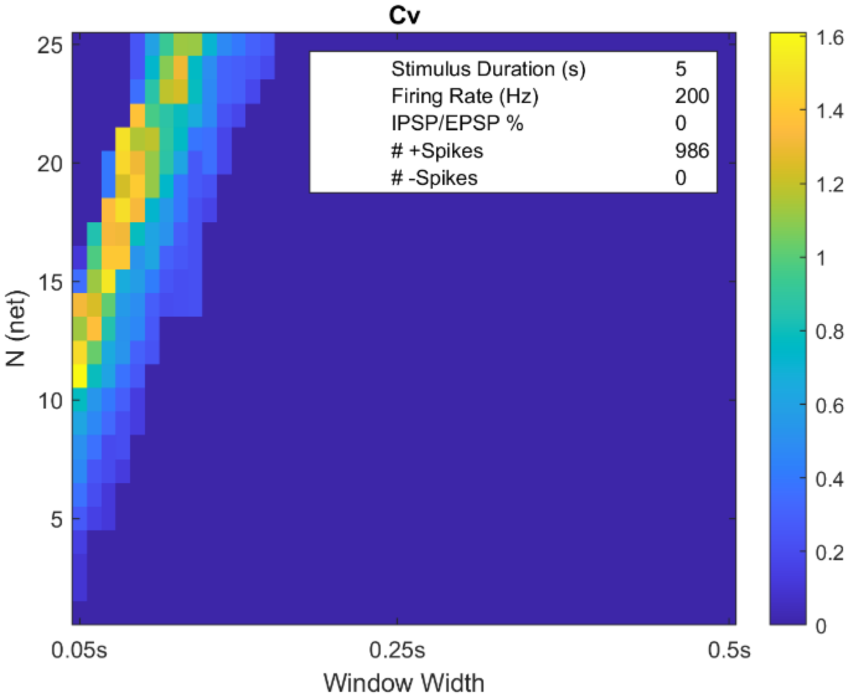

Kernel Magnitude = 10
tP = 0.0015
Kernel Width = tP * 100
Poisson Process
IPSP/EPSP % 0
+Spikes 190
-Spikes 0
Input Current * R
Voltage (mV)
Time (s)
Membrane Potential
Refractory Period 0.01
Spikes 25
Cv 0.46029
Voltage (mV)
Time (s)


Kernel Magnitude = 10
tP = 0.0015
Kernel Width = tP * 10
Poisson Process
IPSP/EPSP % 10
+Spikes 178
-Spikes 20
Input Current * R
Voltage (mV)
Time (s)
Membrane Potential
Refractory Period 0.01
Spikes 21
Cv 0.53682


Kernel Magnitude = 10
tP = 0.0015
Kernel Width = tP * 10
Poisson Process
IPSP/EPSP % 20
+Spikes 163
-Spikes 43
Input Current * R
Voltage (mV)
Time (s)
Membrane Potential
Refractory Period 0.01
Spikes 17
Cv 0.96266

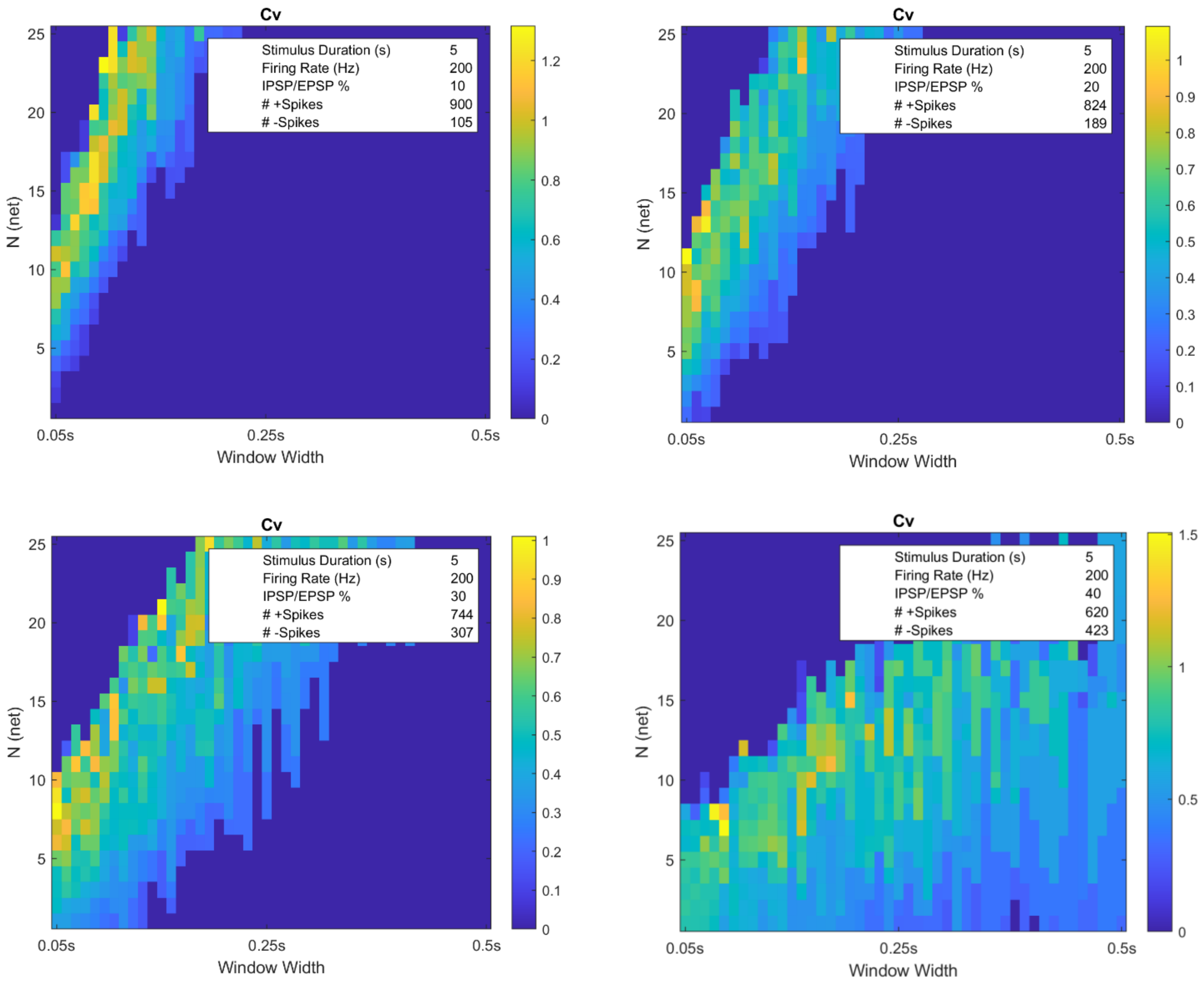

Kernel Magnitude = 10
tP = 0.0015
Kernel Width = tP * 10
Poisson Process
IPSP/EPSP % 50
+Spikes 90
-Spikes 89
Input Current * R
Voltage (mV)
Time (s)
Membrane Potential
Refractory Period 0.01
Spikes 4
Cv 0.74495

- **2-e-**



Cv
Stimulus Duration (s) 5
Firing Rate (Hz) 200
IPSP/EPSP % 0
+Spikes 986
-Spikes 0
N (net)
Window Width
0.05s
0.25s
0.5s

- **2-f-**



Cv
Stimulus Duration (s) 5
Firing Rate (Hz) 200
IPSP/EPSP % 10
+Spikes 900
-Spikes 105
Cv
Stimulus Duration (s) 5
Firing Rate (Hz) 200
IPSP/EPSP % 20
+Spikes 824
-Spikes 189
Cv
Stimulus Duration (s) 5
Firing Rate (Hz) 200
IPSP/EPSP % 30
+Spikes 744
-Spikes 307
Cv
Stimulus Duration (s) 5
Firing Rate (Hz) 200
IPSP/EPSP % 40
+Spikes 620
-Spikes 423
N (net)
Window Width
0.05s
0.25s
0.5s