

Network Project (Summer 2021)

$$\begin{aligned}
\dot{v}_i &= 0.04v_i^2 + 5v_i + 140 - u_i + I_i + \xi_i \\
\dot{u}_i &= a(bv_i - u_i) \\
I_i(t) &= G_i^{\text{exc}}(t) (V_E - v_i(t)) - G_i^{\text{inh}}(t) (v_i(t) - V_I) \\
\frac{dG_i^{\text{exc}}}{dt} &= -\frac{G_i^{\text{exc}}}{\tau_{\text{exc}}} + \beta \sum_{j=1, g_{ij}>0}^N g_{ij} \sum_k \delta(t - t_{j,k}) \\
\frac{dG_i^{\text{inh}}}{dt} &= -\frac{G_i^{\text{inh}}}{\tau_{\text{inh}}} + \beta \sum_{j=1, g_{ij}<0}^N |g_{ij}| \sum_k \delta(t - t_{j,k}) \\
\Rightarrow G_i^{\text{exc}} &= \beta \sum_{j=1, g_{ij}>0} g_{ij} \sum_k e^{-\frac{(t-t_{j,k})}{\tau_{\text{exc}}}} \theta(t - t_{j,k}) \\
G_i^{\text{inh}} &= \beta \sum_{j=1, g_{ij}<0} |g_{ij}| \sum_k e^{-\frac{(t-t_{j,k})}{\tau_{\text{inh}}}} \theta(t - t_{j,k})
\end{aligned}$$

If $v_i \geq 30$, $v_i \rightarrow c$, $u_i \rightarrow u_i + d$

$$V_E = 0, V_I = -80, \tau_{\text{exc}} = 5, \tau_{\text{inh}} = 6$$

$$\text{Non - I Nodes : } a = 0.02, b = 0.2, c = -65, d = 8$$

$$\text{I Nodes : } a = 0.1, b = 0.2, c = -65, d = 2$$

Euler–Maruyama method :

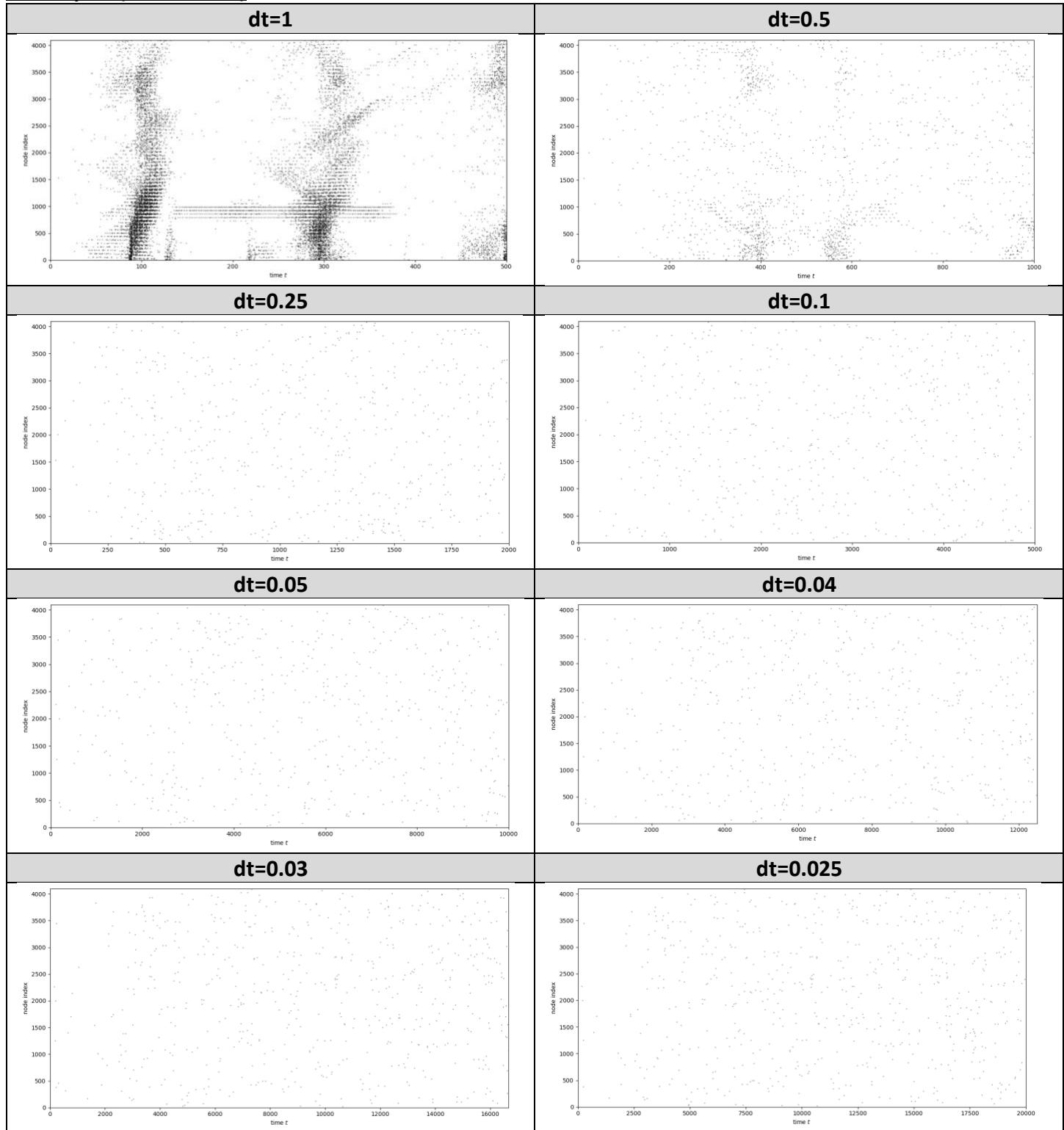
$$\begin{aligned}
v(t + \Delta t) &= v(t) + [0.04v(t)^2 + 5v(t) + 140 - u(t) + I(t)] * \Delta t + \sqrt{\Delta t} \xi \\
u(t + \Delta t) &= u(t) + [a(bv(t) - u(t))] * \Delta t
\end{aligned}$$

Convergence check

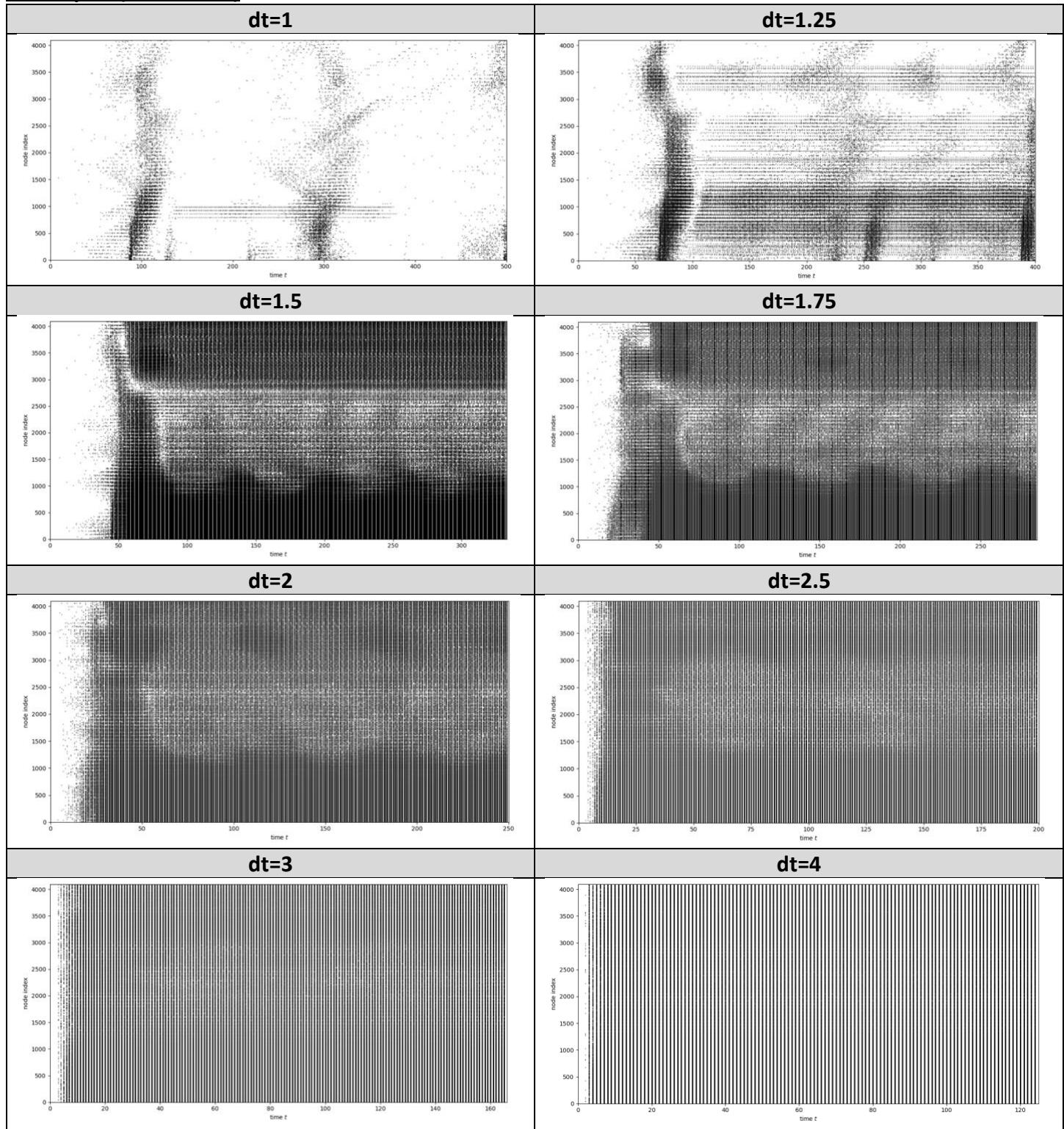
Config: DIV25, beta=2, sigma=3

Maintain total iteration time 500 ms, same initial seed of 0

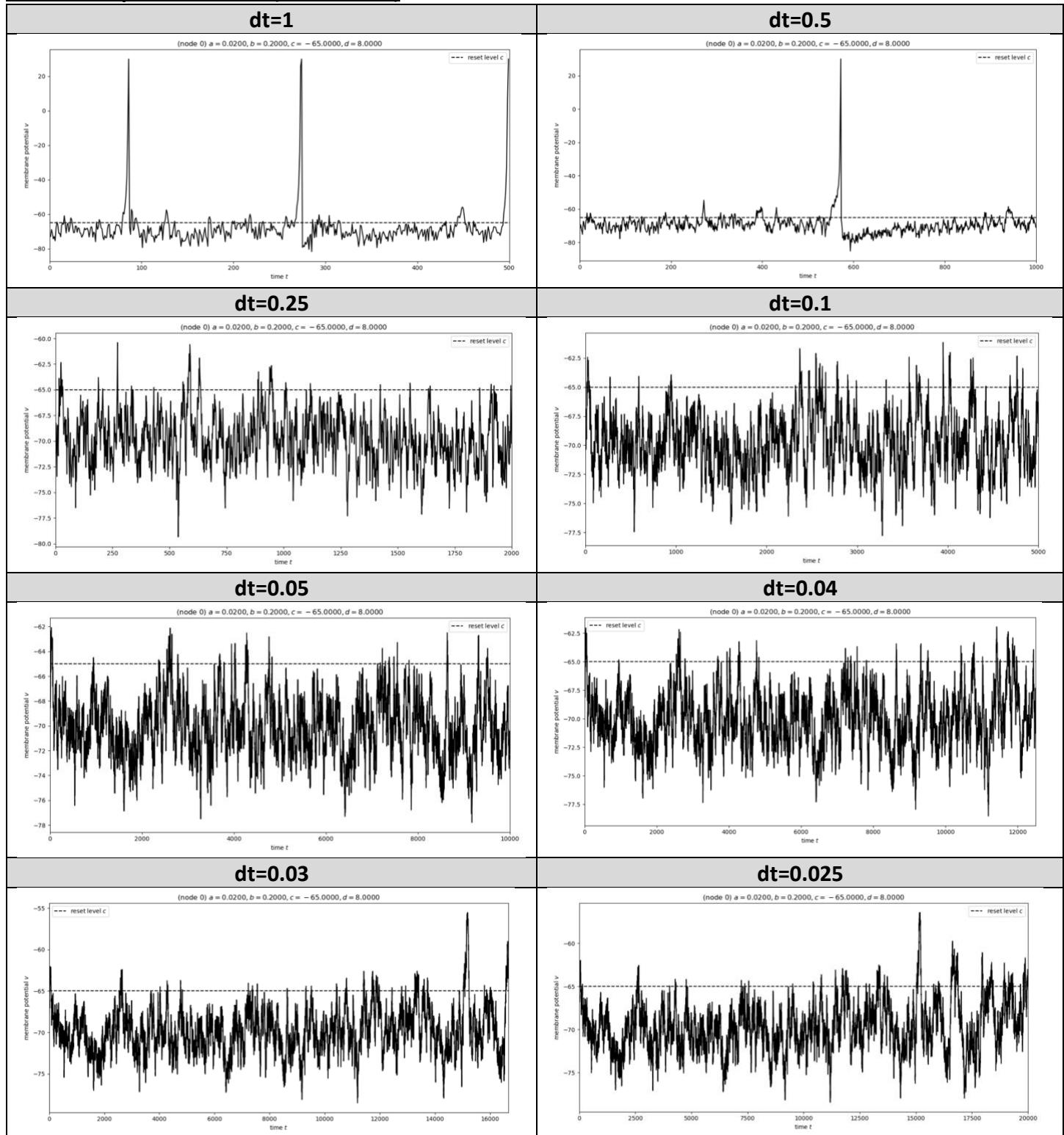
Raster plot (decrease dt)



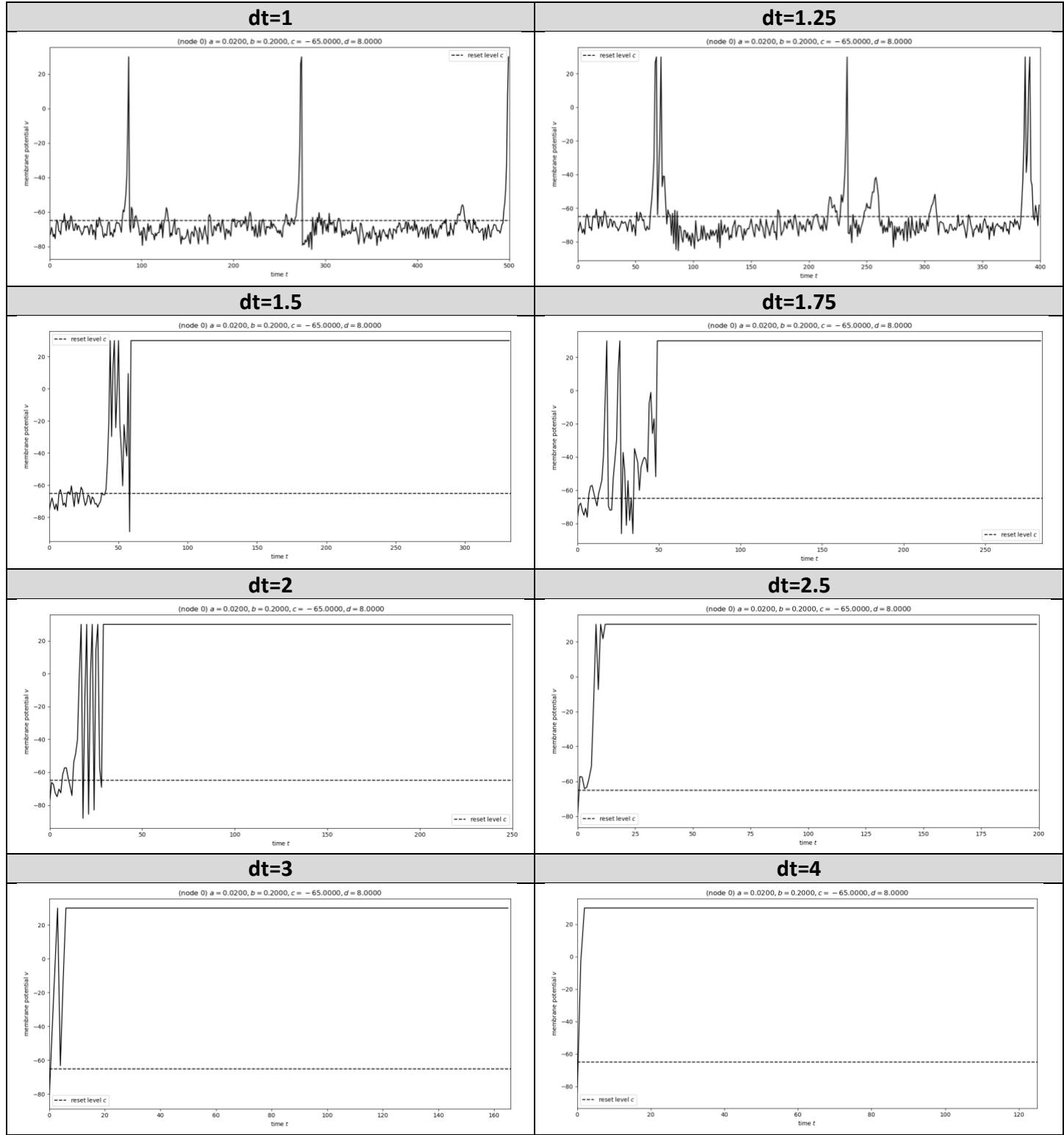
Raster plot (increase dt)



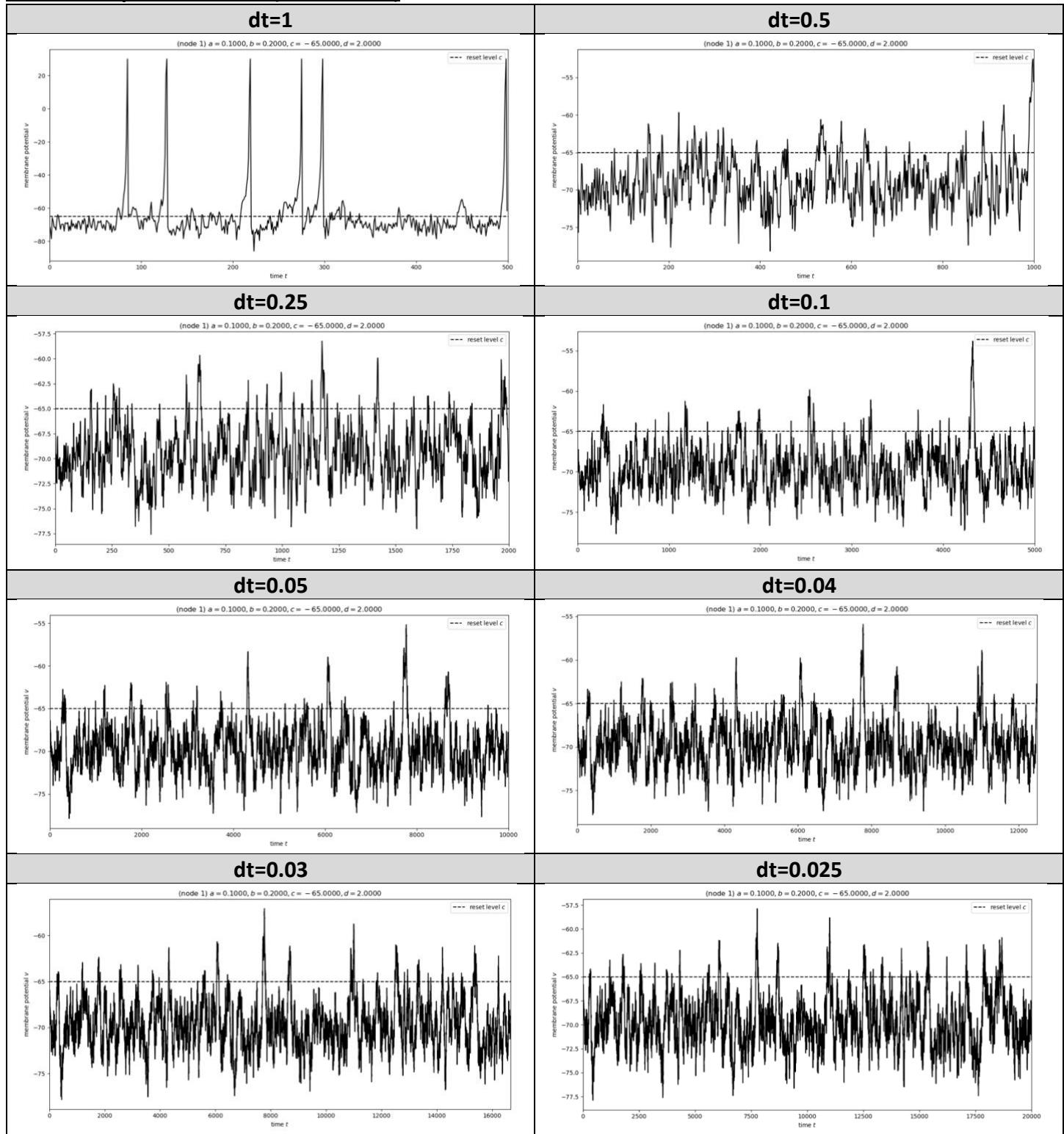
Time series plot for node 0 (decrease dt)



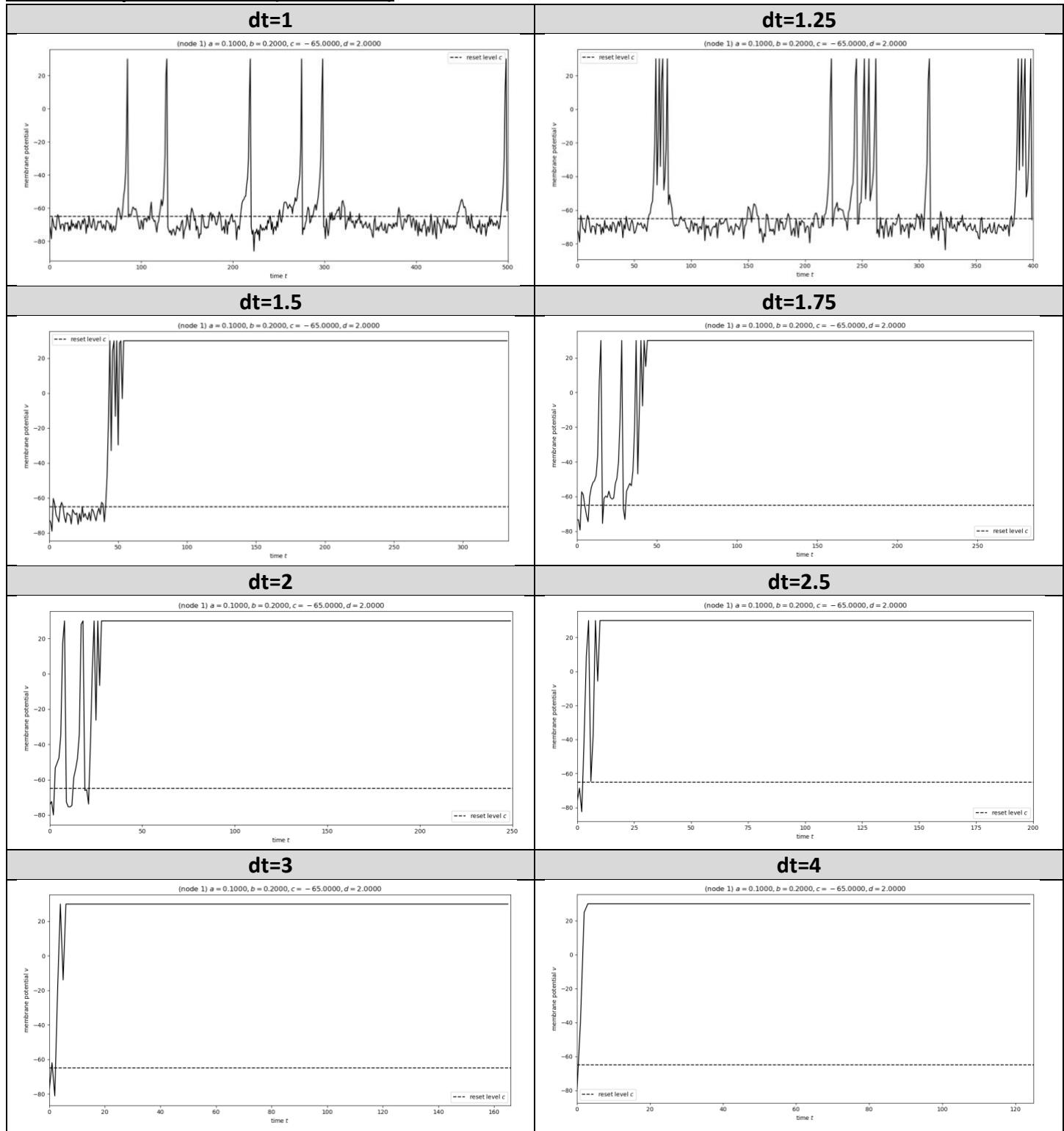
Time series plot for node 0 (increase dt)



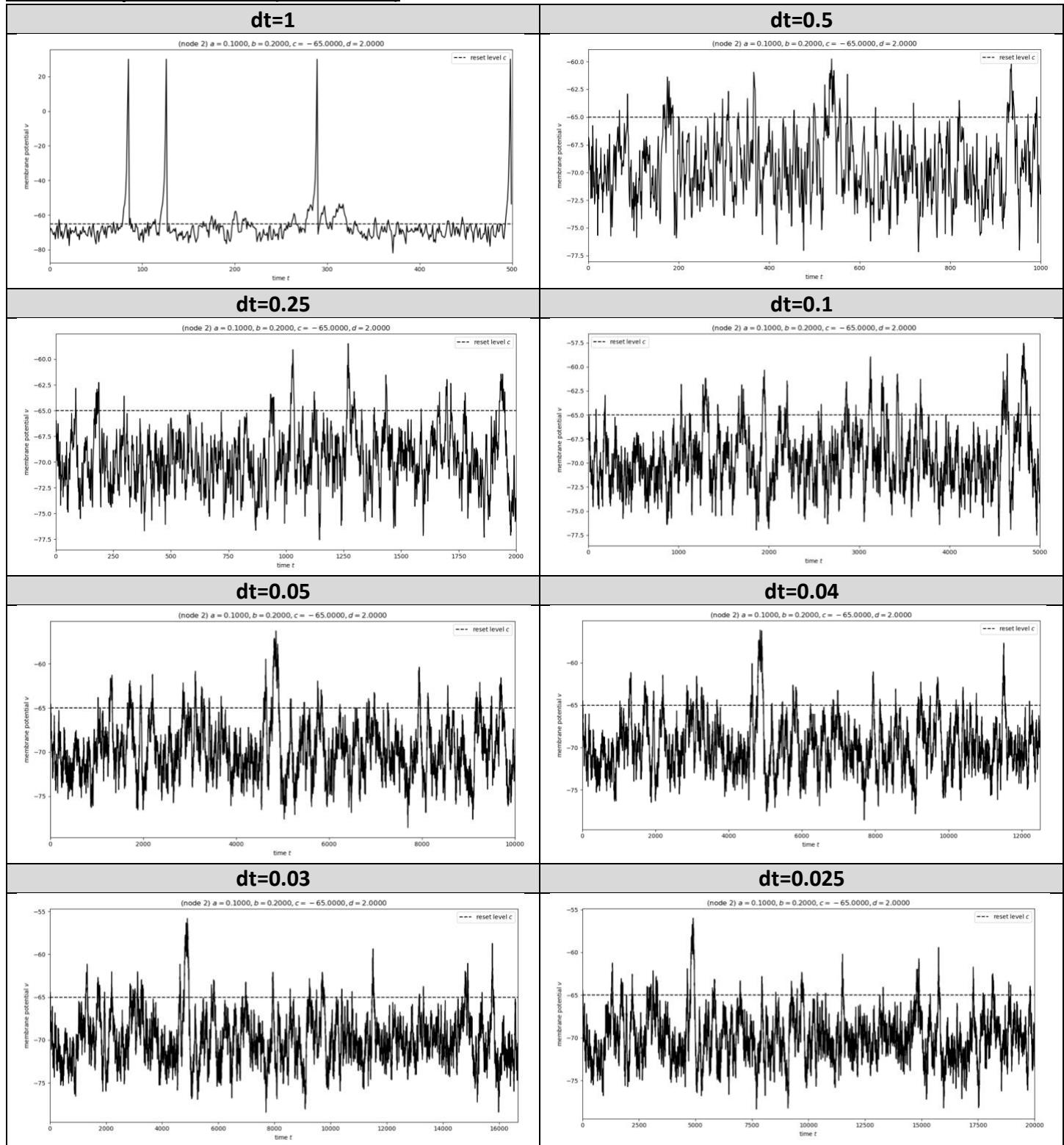
Time series plot for node 1 (decrease dt)



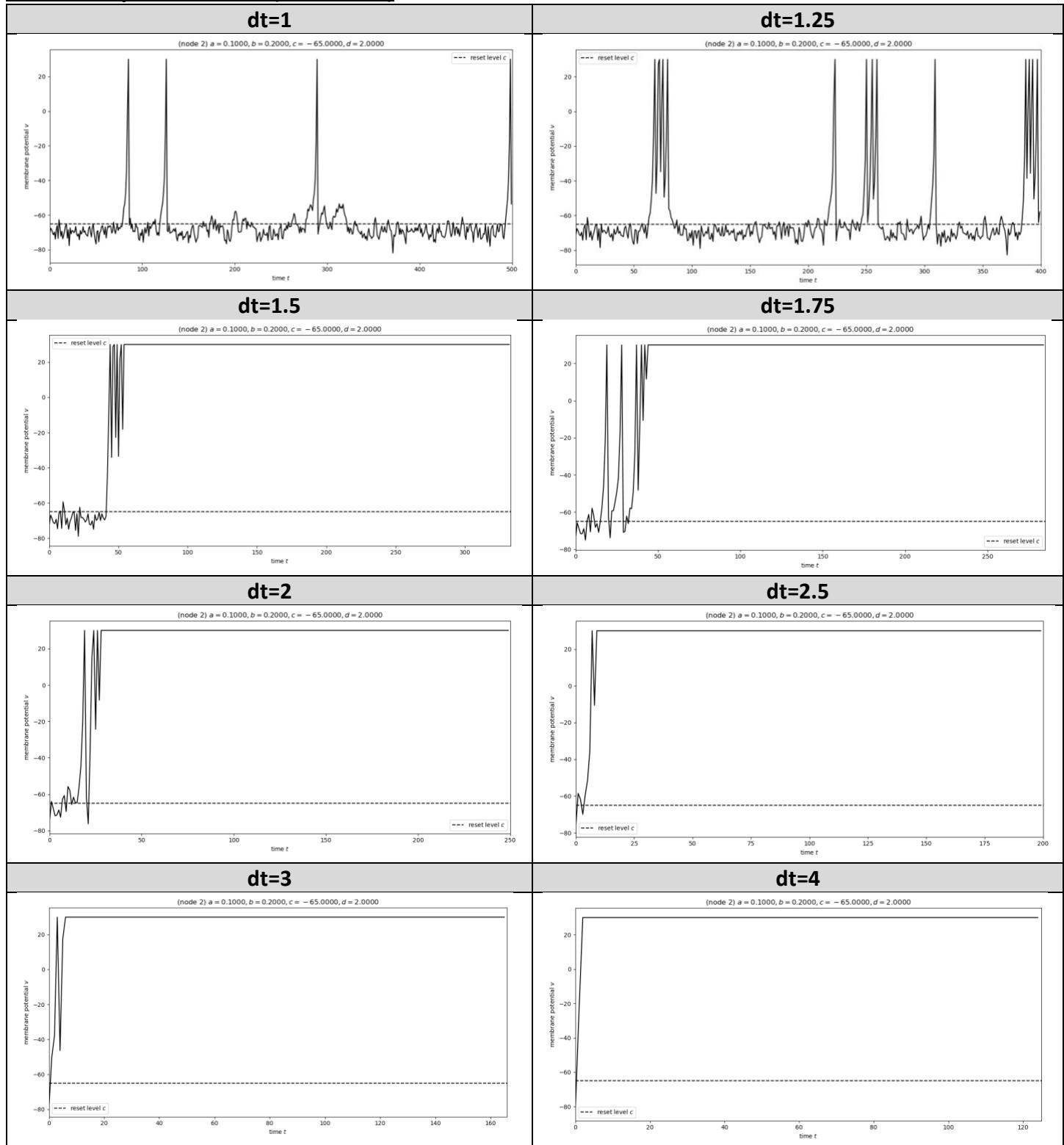
Time series plot for node 1 (increase dt)



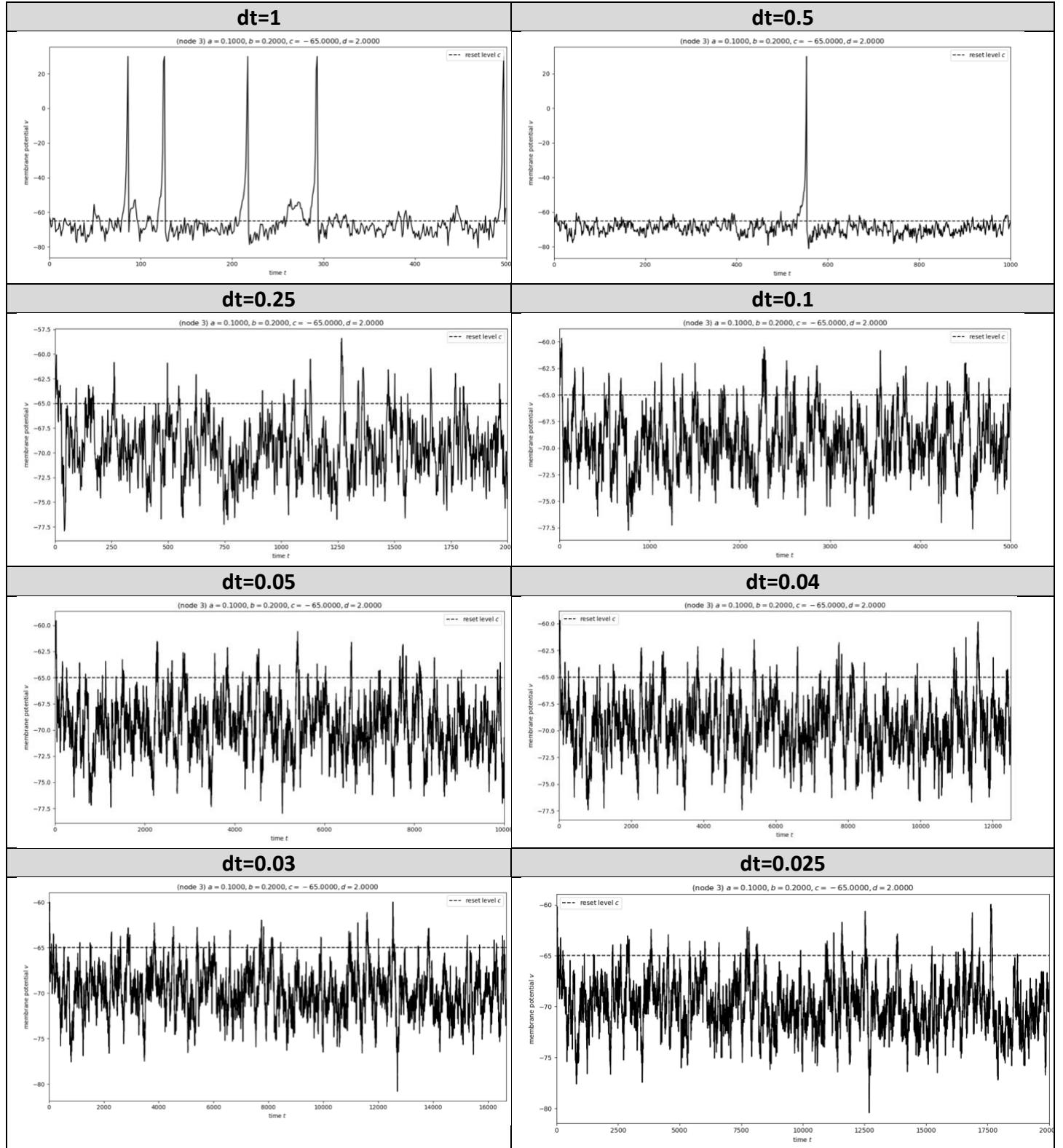
Time series plot for node 2 (decrease dt)



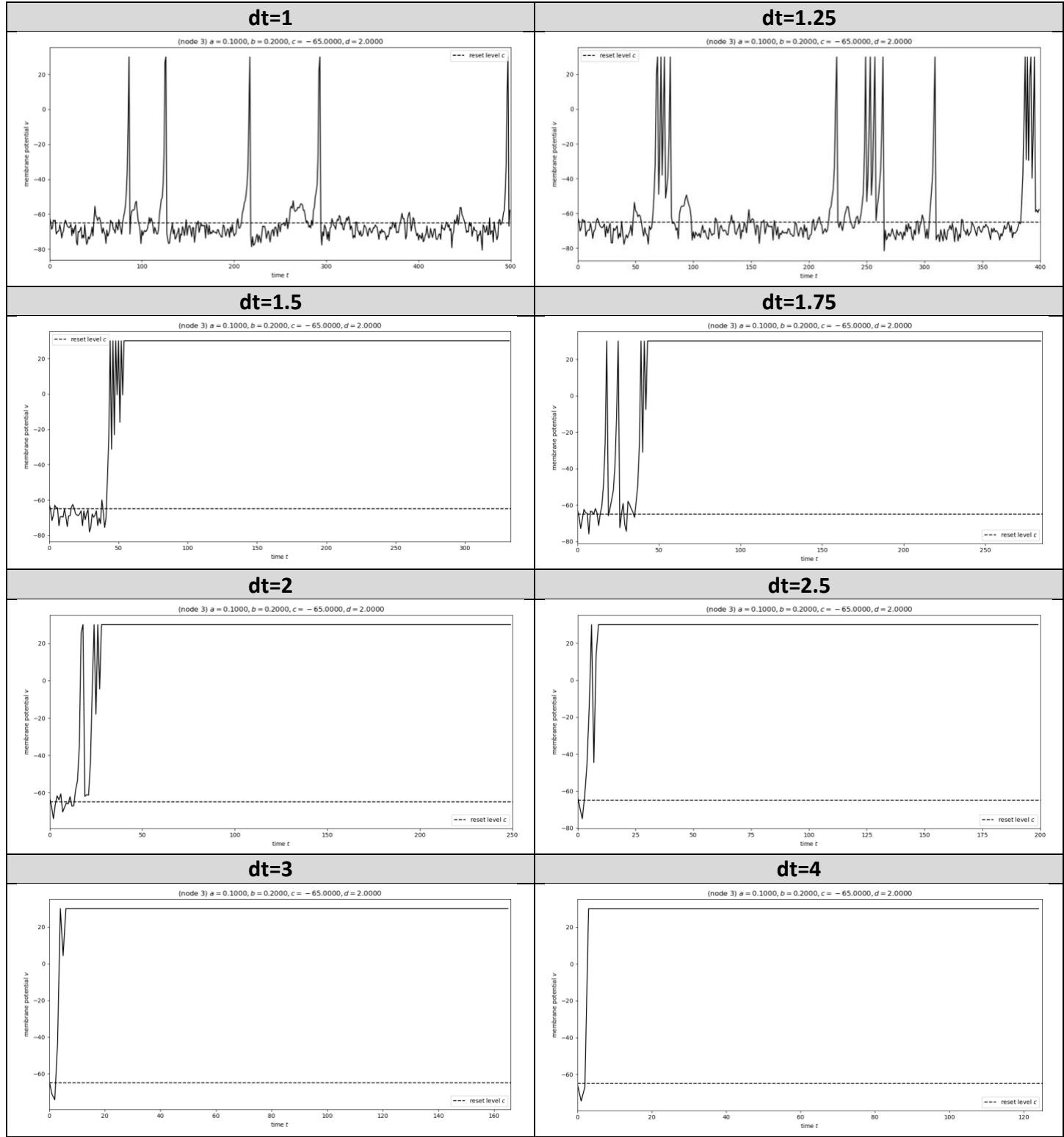
Time series plot for node 2 (increase dt)



Time series plot for node 3 (decrease dt)



Time series plot for node 3 (increase dt)



Observation

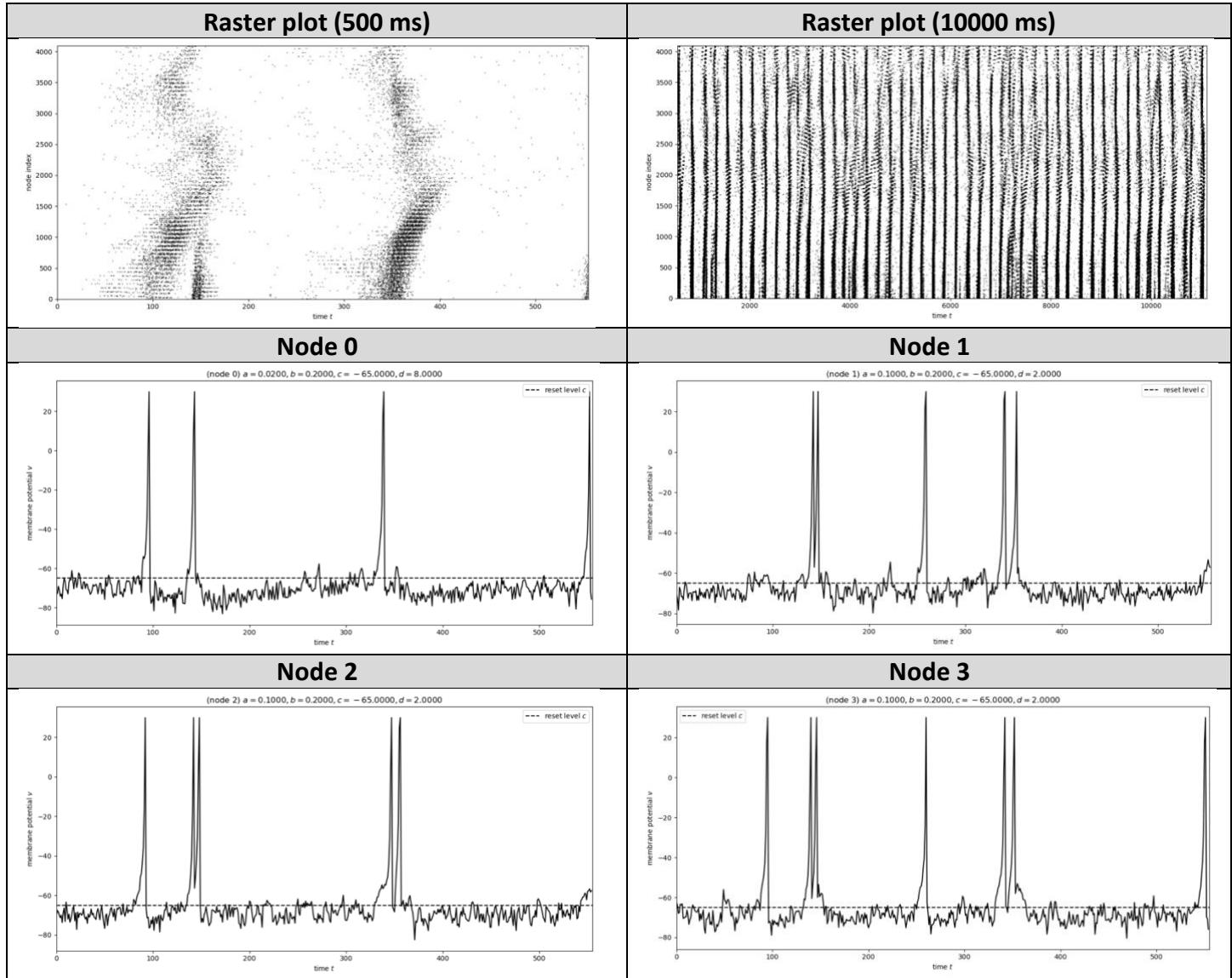
Spiking activity increases with dt

Convergence as $dt \rightarrow 0$ but spiking is rare

Explanation: Fixing total simulation time (500 ms), for smaller dt noise term is added more frequently, increasing the probability Σ noise locates around zero. But spiking relies on the largeness of v , which (roughly) depends on Σ noise, hence less spiking

“Best-looking” config.

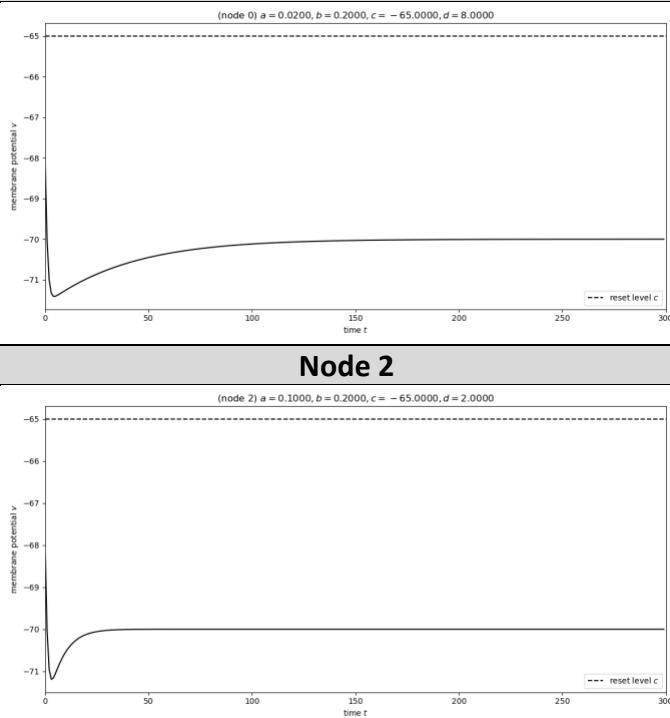
DIV25, beta=2, sigma=3, $dt=0.9$



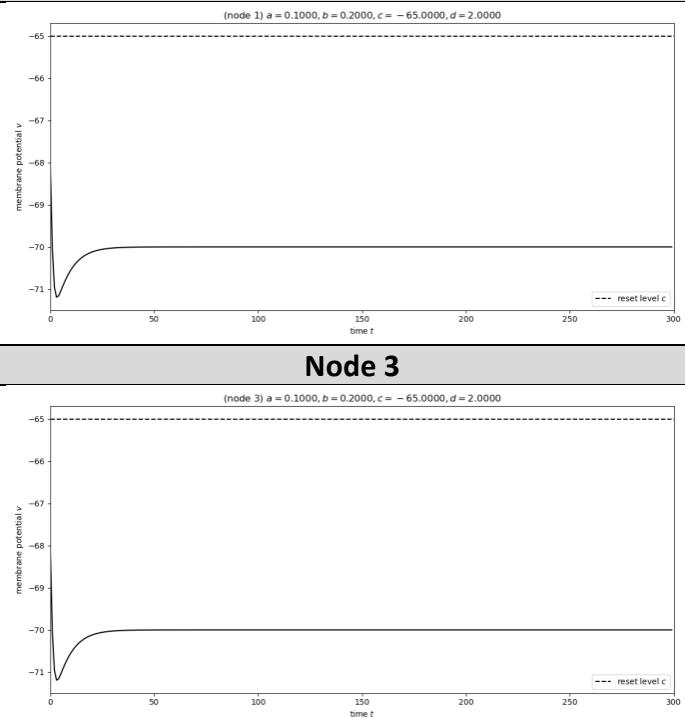
Noise-free dynamics

beta=1

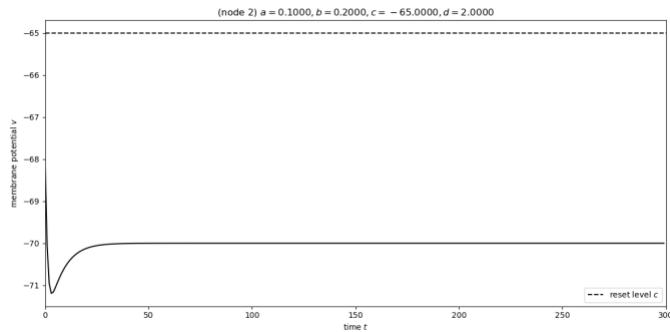
Node 0



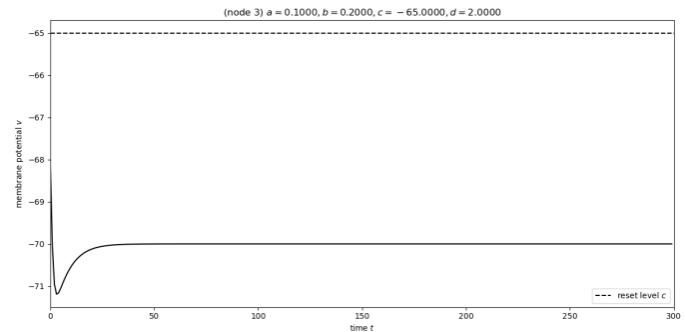
Node 1



Node 2

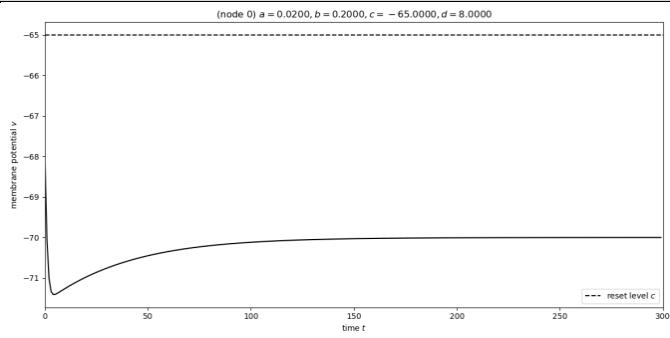


Node 3

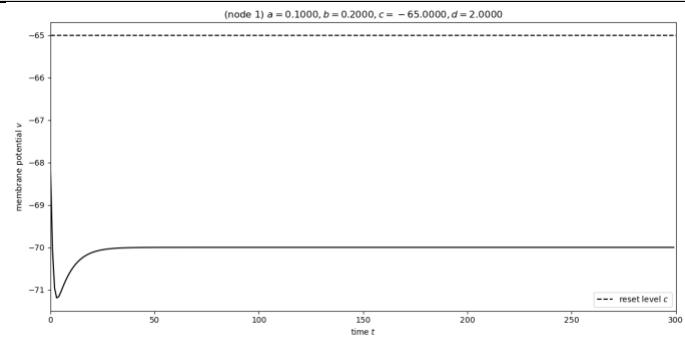


beta=2

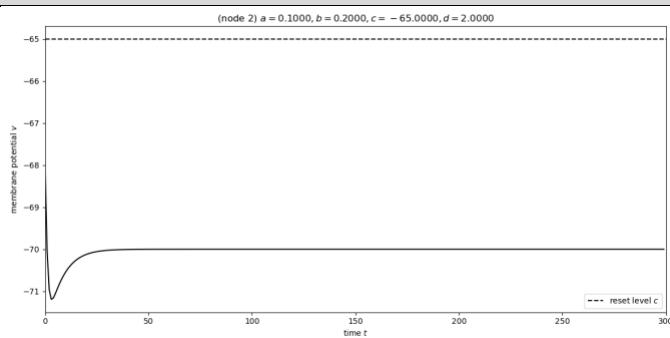
Node 0



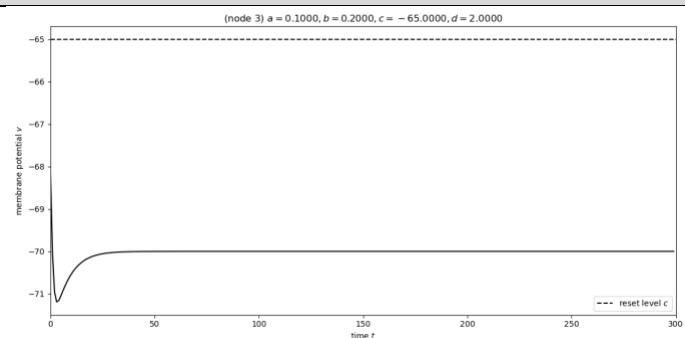
Node 1



Node 2



Node 3

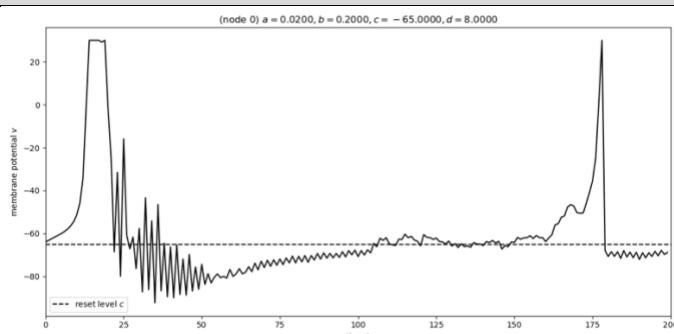


Noise-free dynamics (driven)

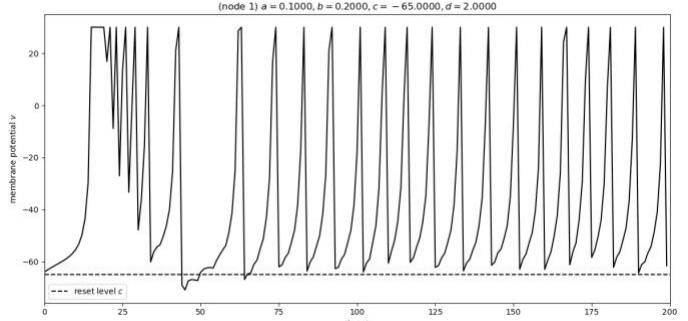
$dt=1, 200 \text{ ms}$

$I=4$ (neutral point)

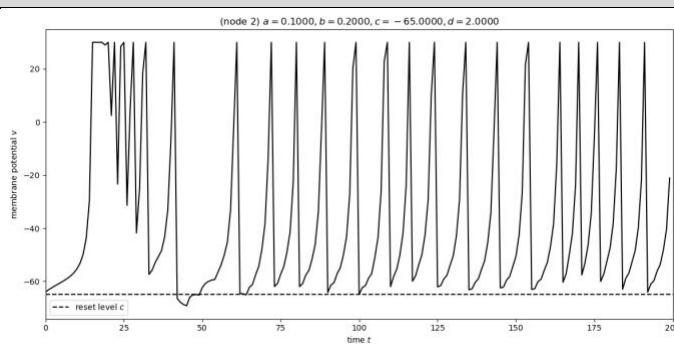
Node 0



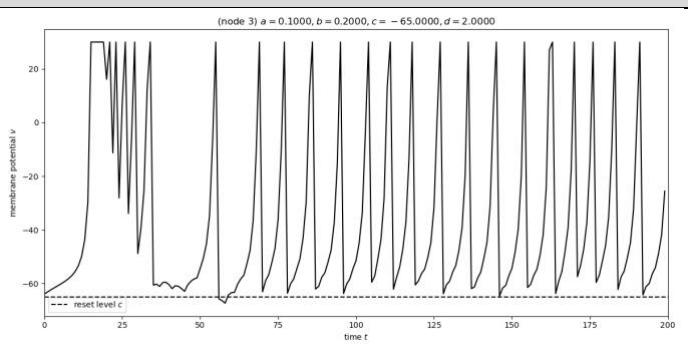
Node 1



Node 2

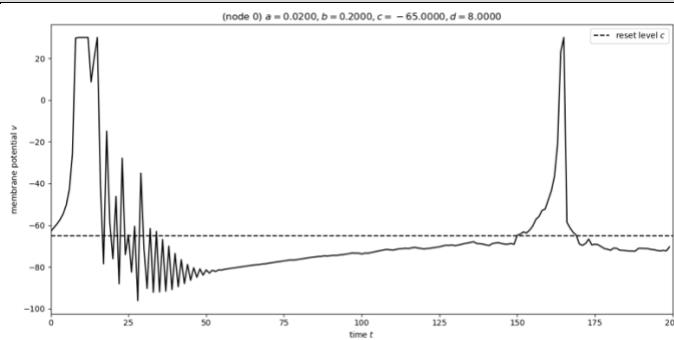


Node 3

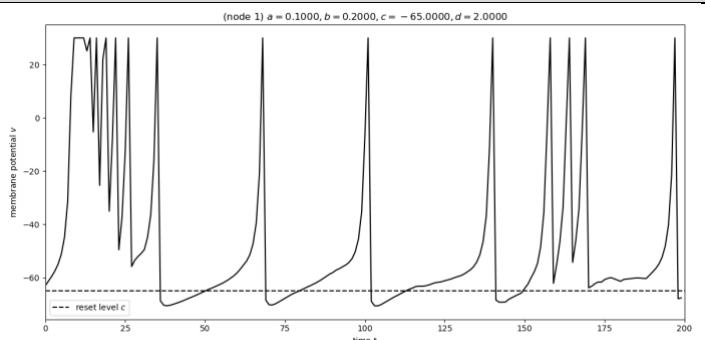


$I=5$ (no steady point)

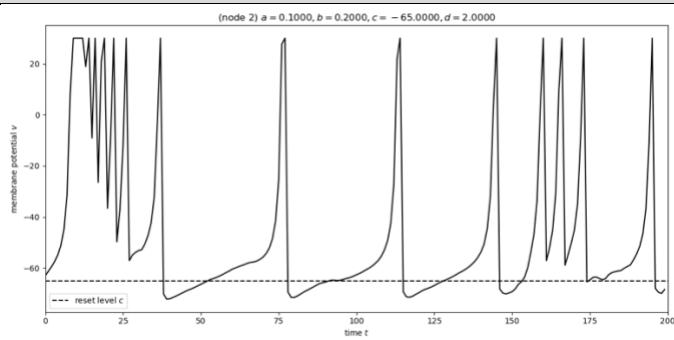
Node 0



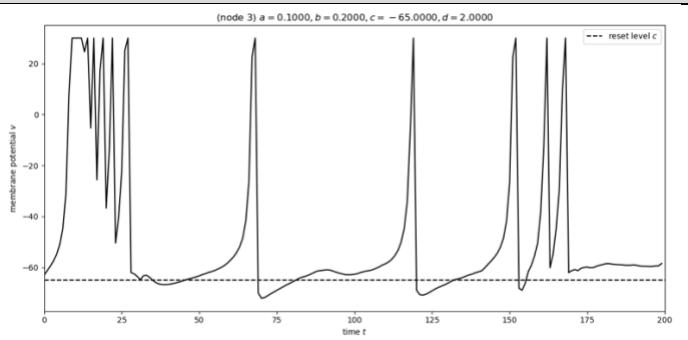
Node 1



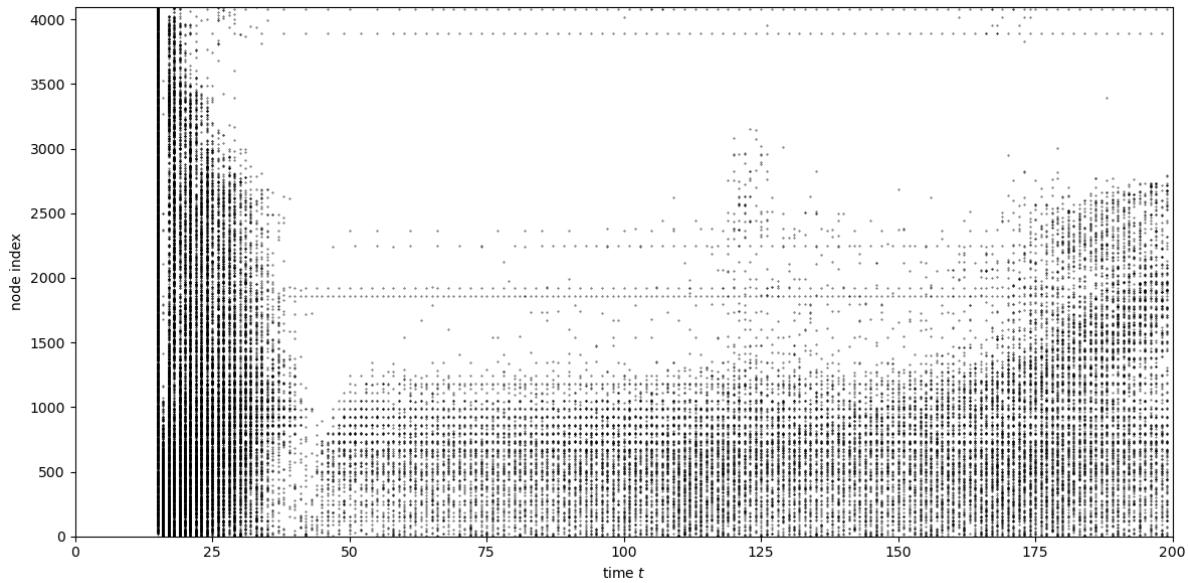
Node 2



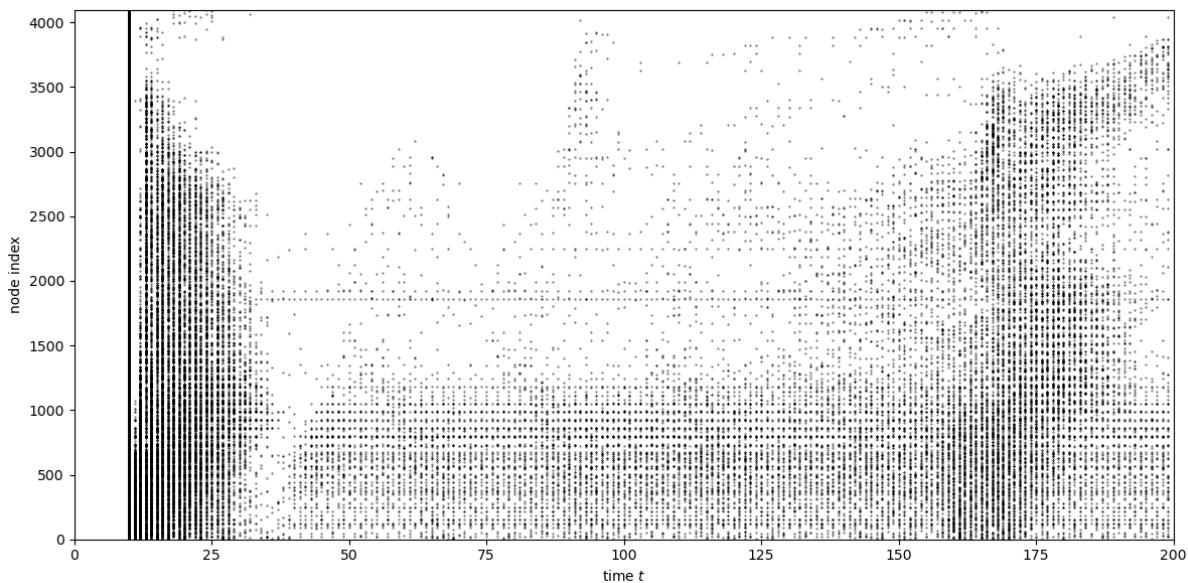
Node 3



I=4 (neutral point)



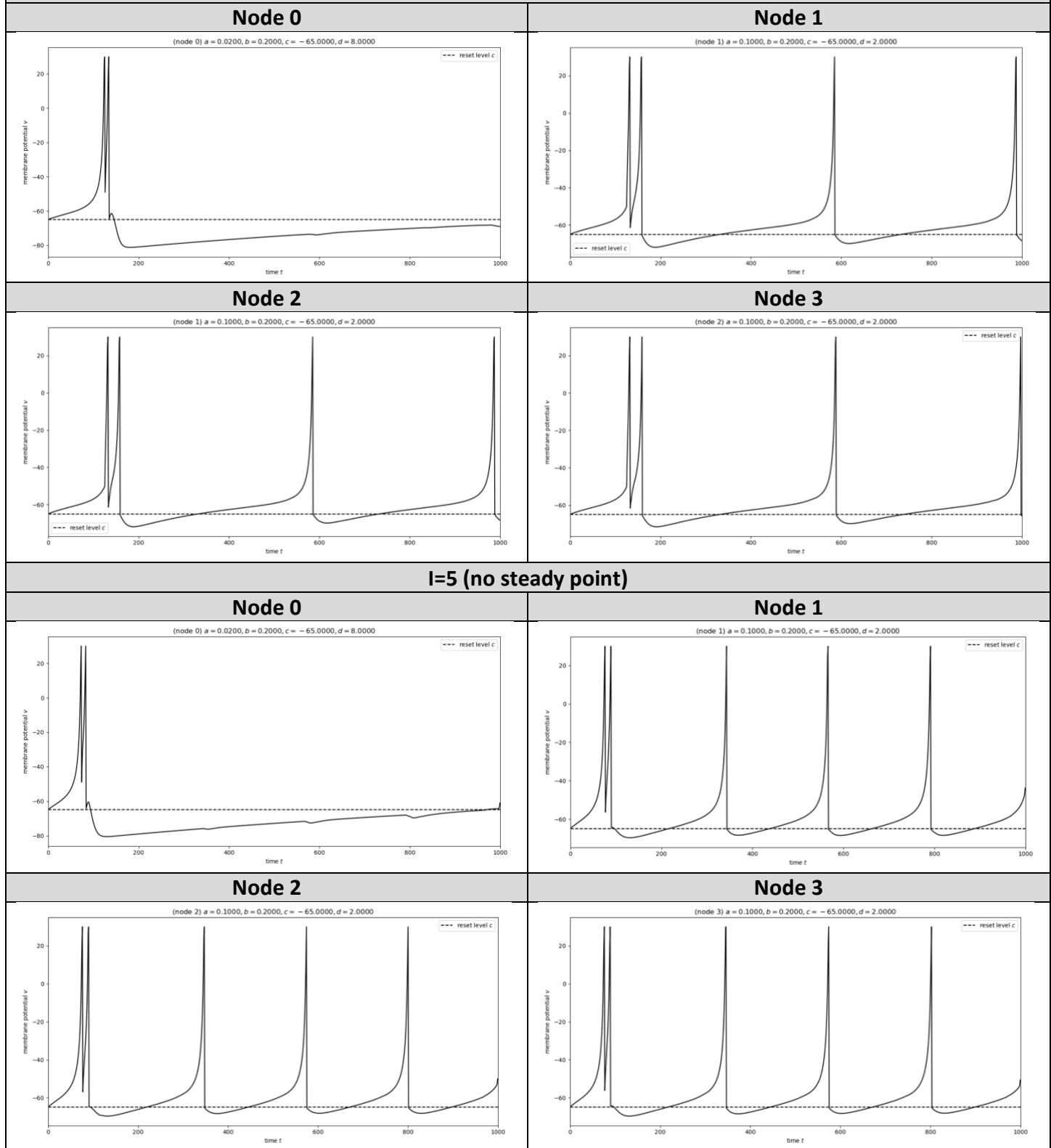
I=5 (neutral point)



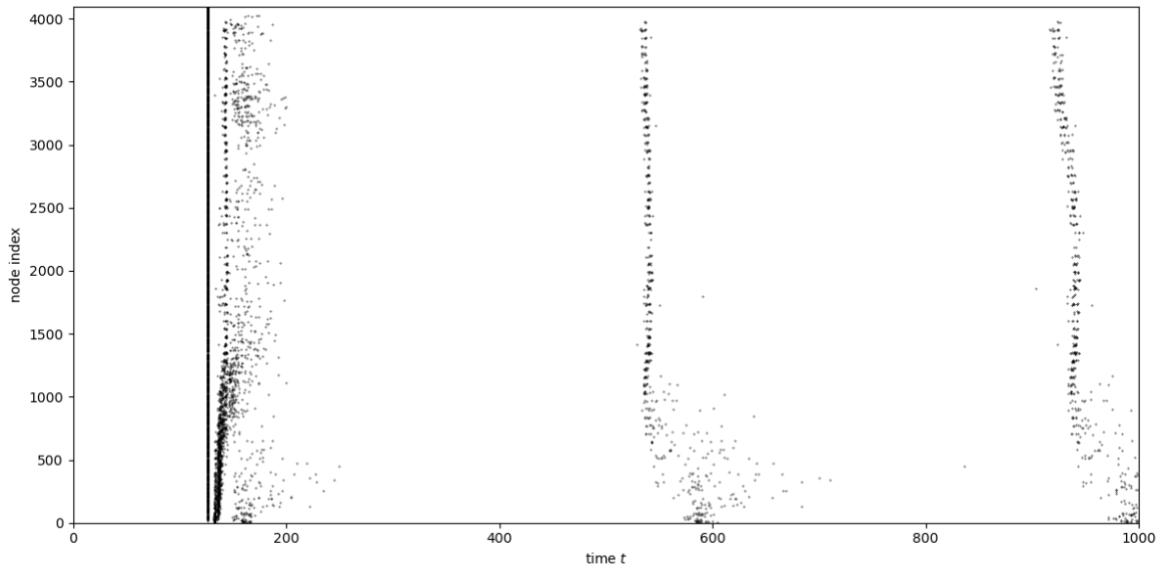
Noise-free dynamics (driven)

dt=0.1, 100 ms

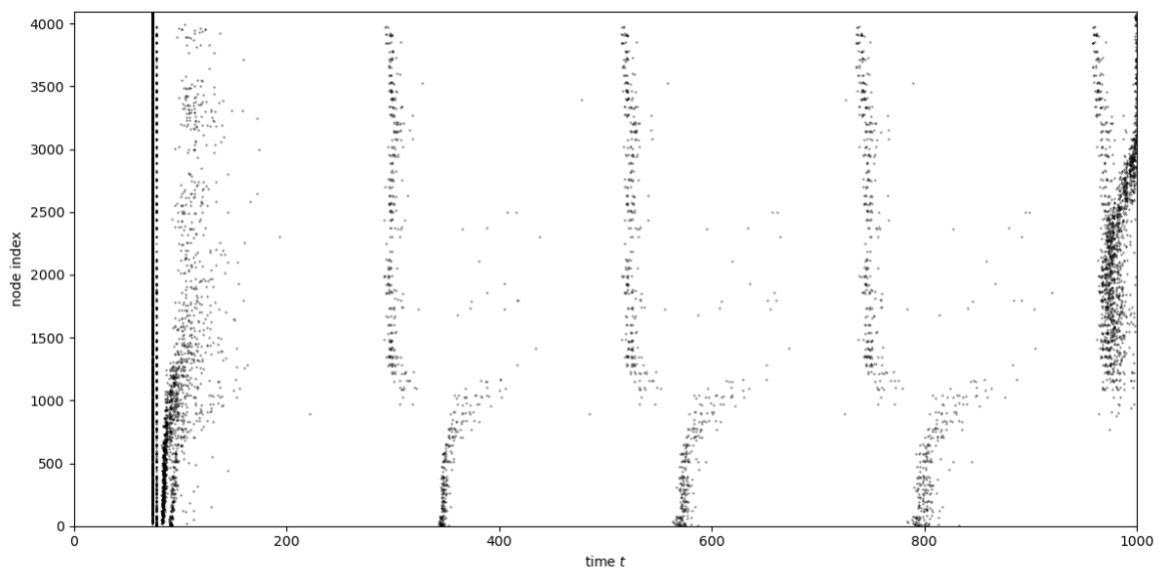
I=4 (neutral point)



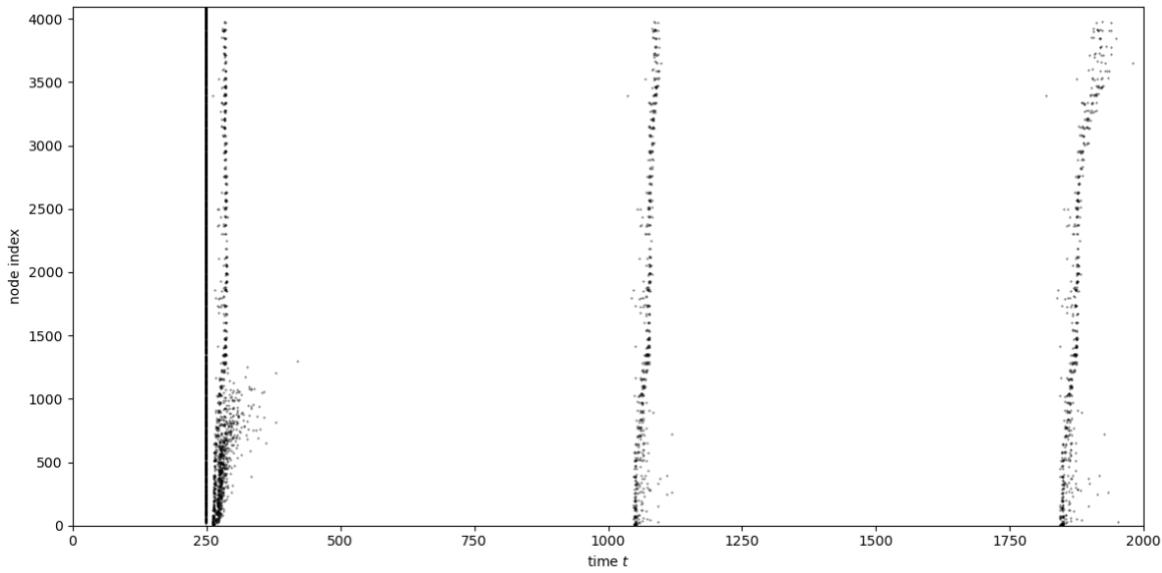
I=4 (neutral point)



I=5 (neutral point)

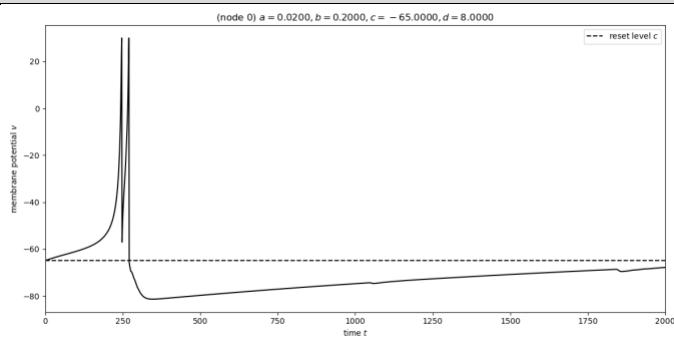


dt=0.05, 100 ms

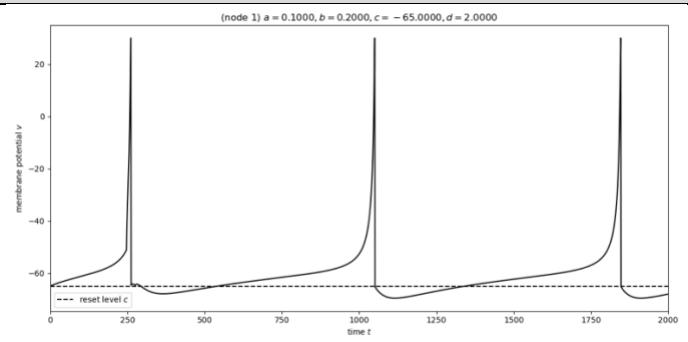


I=4 (neutral point)

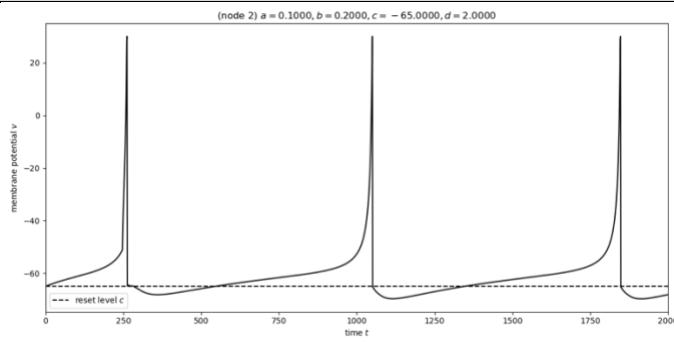
Node 0



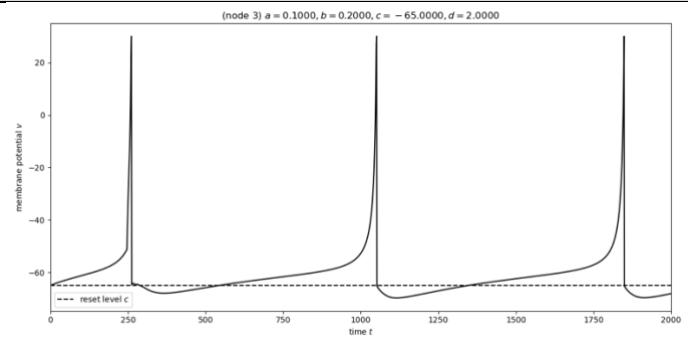
Node 1



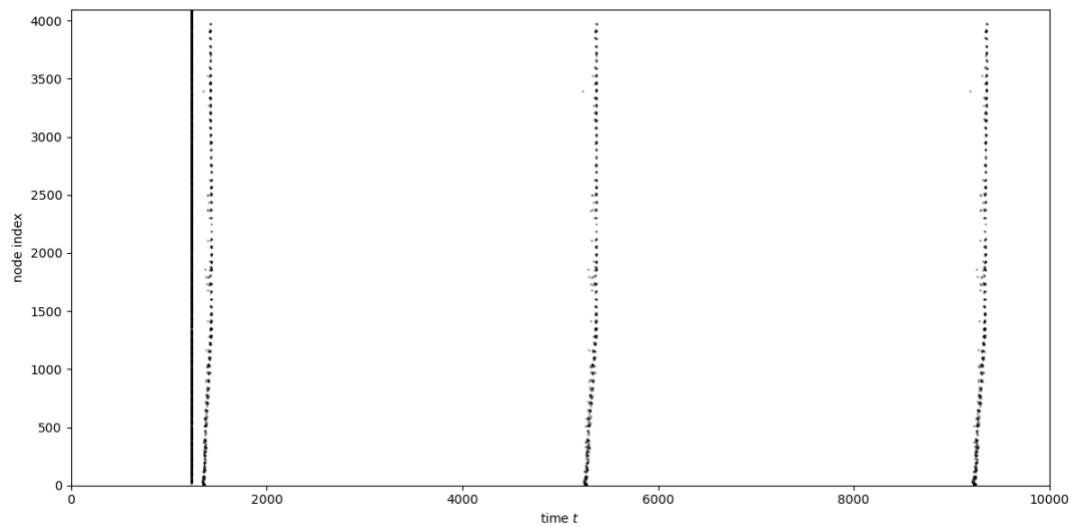
Node 2



Node 3

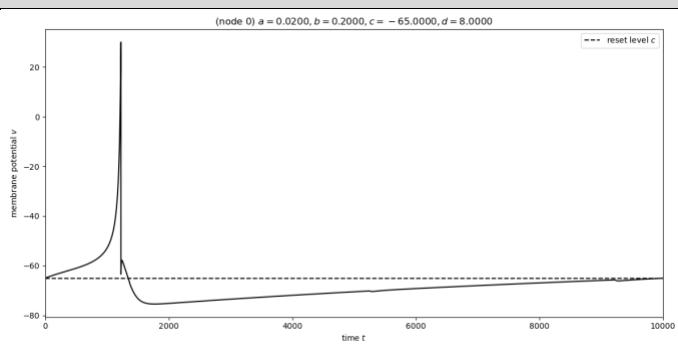


dt=0.01, 100 ms

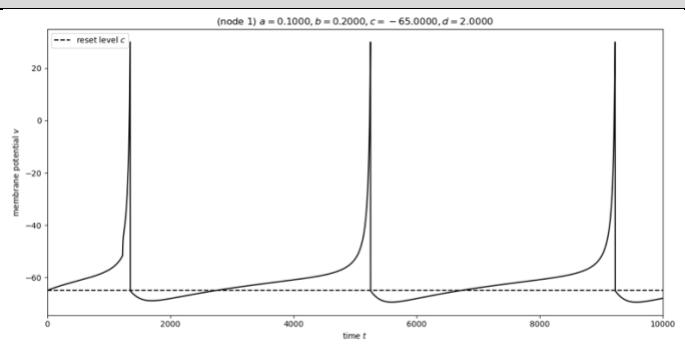


I=4 (neutral point)

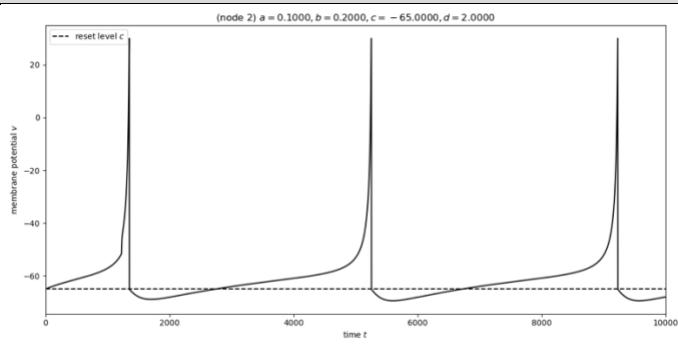
Node 0



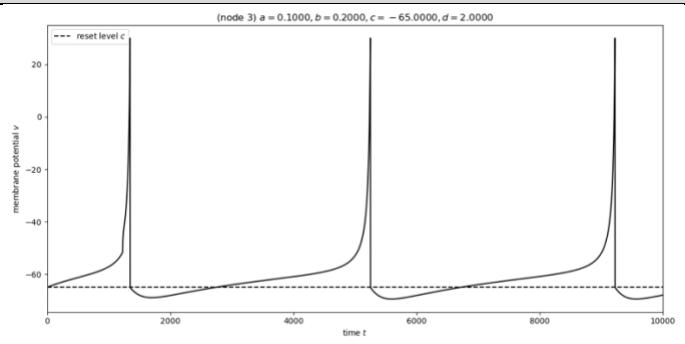
Node 1



Node 2



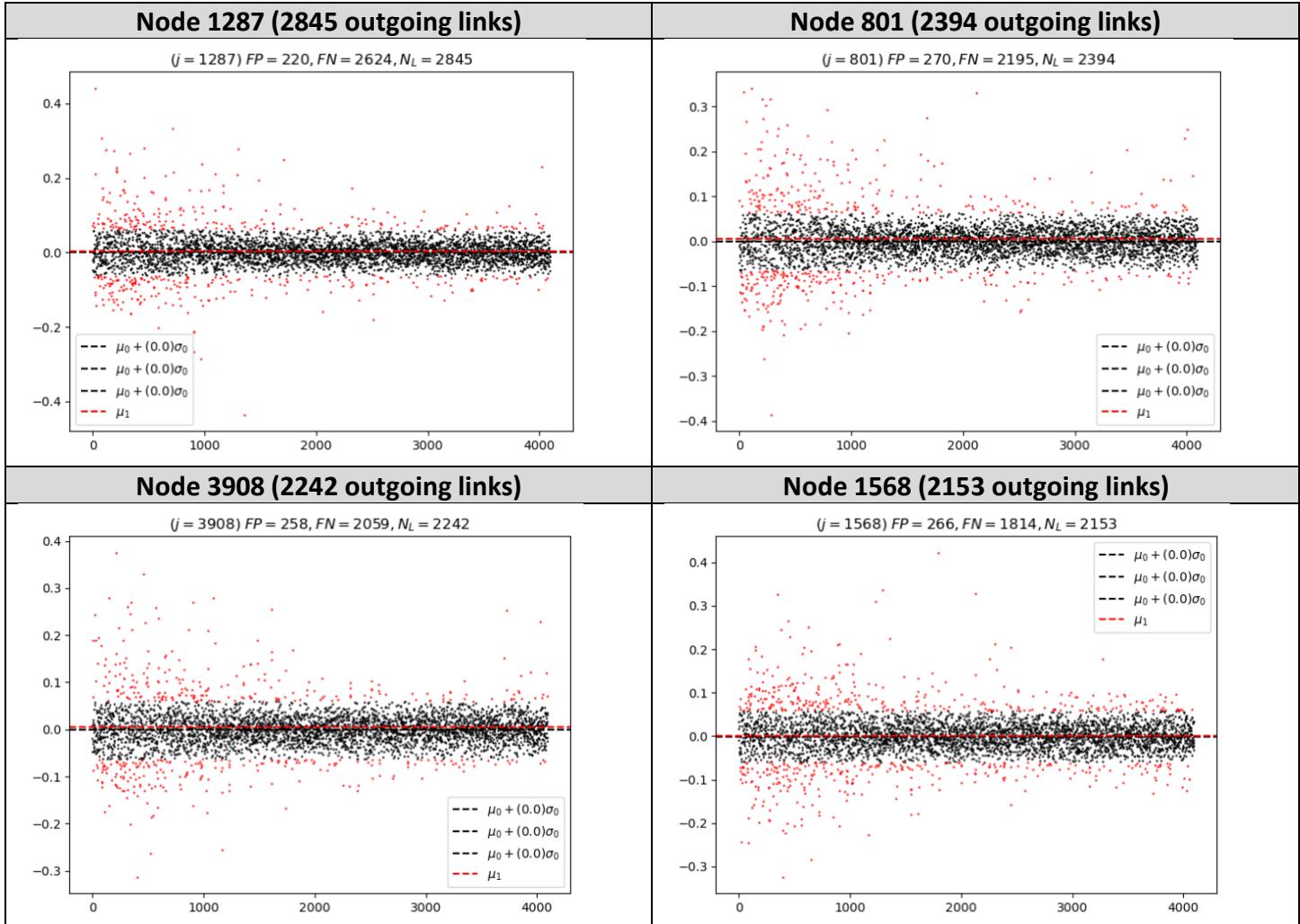
Node 3



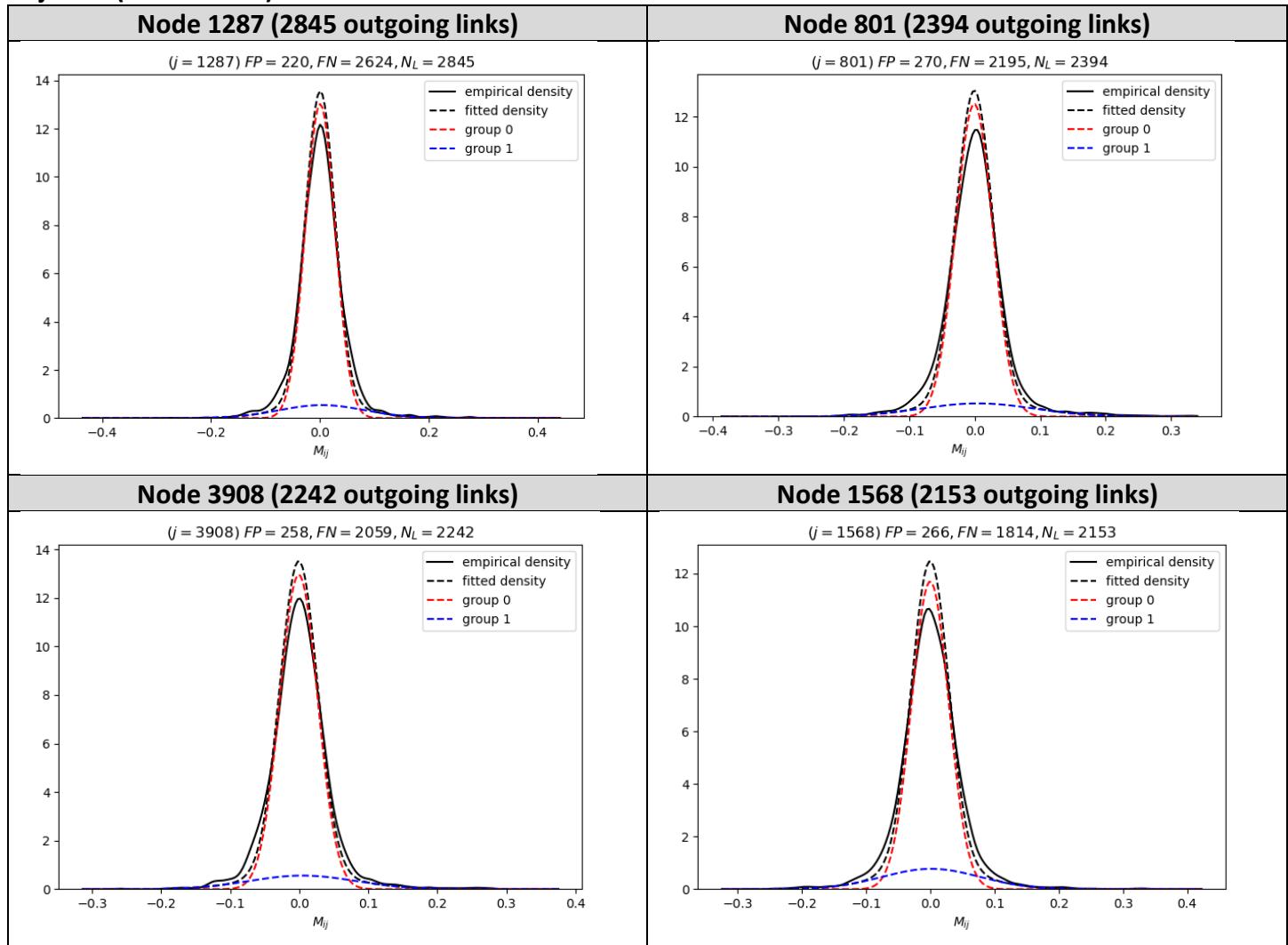
Covariance Method on DIV66 Series (7500ms)

Params	Accuracy
p=0.4, std=0.5	{'sensitivity': 0.037686342345143925, 'specificity': 0.9783107554516308, 'error_FN': 0.9623136576548561, 'error_FP': 1.3917669238693124}
p=0.5, std=0.5	{'sensitivity': 0.04788633845795028, 'specificity': 0.9651261004351006, 'error_FN': 0.9521136615420497, 'error_FP': 2.237806845348001}
p=0.6, std=0.5	{'sensitivity': 0.059816135740801926, 'specificity': 0.9498452689430825, 'error_FN': 0.9401838642591981, 'error_FP': 3.218355328370683}
p=0.4, std=1.0	{'sensitivity': 0.0058424520417484594, 'specificity': 0.9973993309172855, 'error_FN': 0.9941575479582515, 'error_FP': 0.16688111018250373}
p=0.5, std=1.0	{'sensitivity': 0.006048473304697674, 'specificity': 0.9971761014194912, 'error_FN': 0.9939515266953023, 'error_FP': 0.18120541874793492}
p=0.6, std=1.0	{'sensitivity': 0.006285592116771297, 'specificity': 0.9968910219034479, 'error_FN': 0.9937144078832287, 'error_FP': 0.1994985520203689}
p=0.4, std=1.5	{'sensitivity': 7.385667917047288e-05, 'specificity': 0.9999508713371205, 'error_FN': 0.9999261433208295, 'error_FP': 0.0031525140424870264}
p=0.5, std=1.5	{'sensitivity': 7.385667917047288e-05, 'specificity': 0.9999459645286207, 'error_FN': 0.9999261433208295, 'error_FP': 0.003467376727371674}
p=0.6, std=1.5	{'sensitivity': 7.774387281102408e-05, 'specificity': 0.9999409365643557, 'error_FN': 0.999922256127189, 'error_FP': 0.0037900137995374237}

Mij Data (Classification)

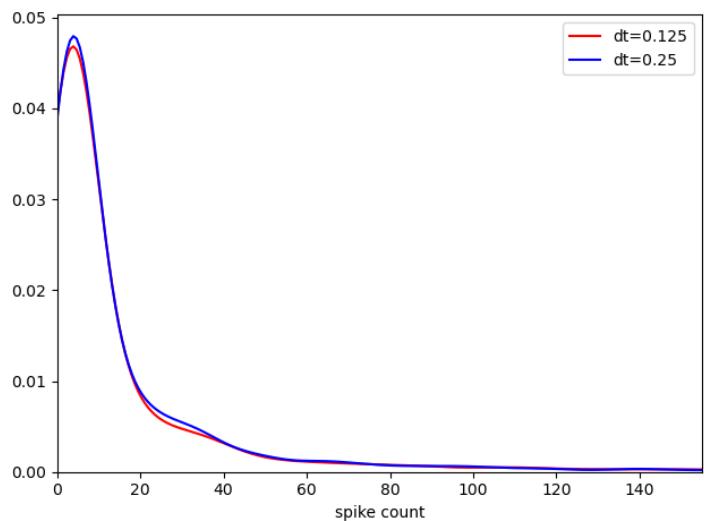


Mij Data (Distribution)



DIV66 Spike Distribution

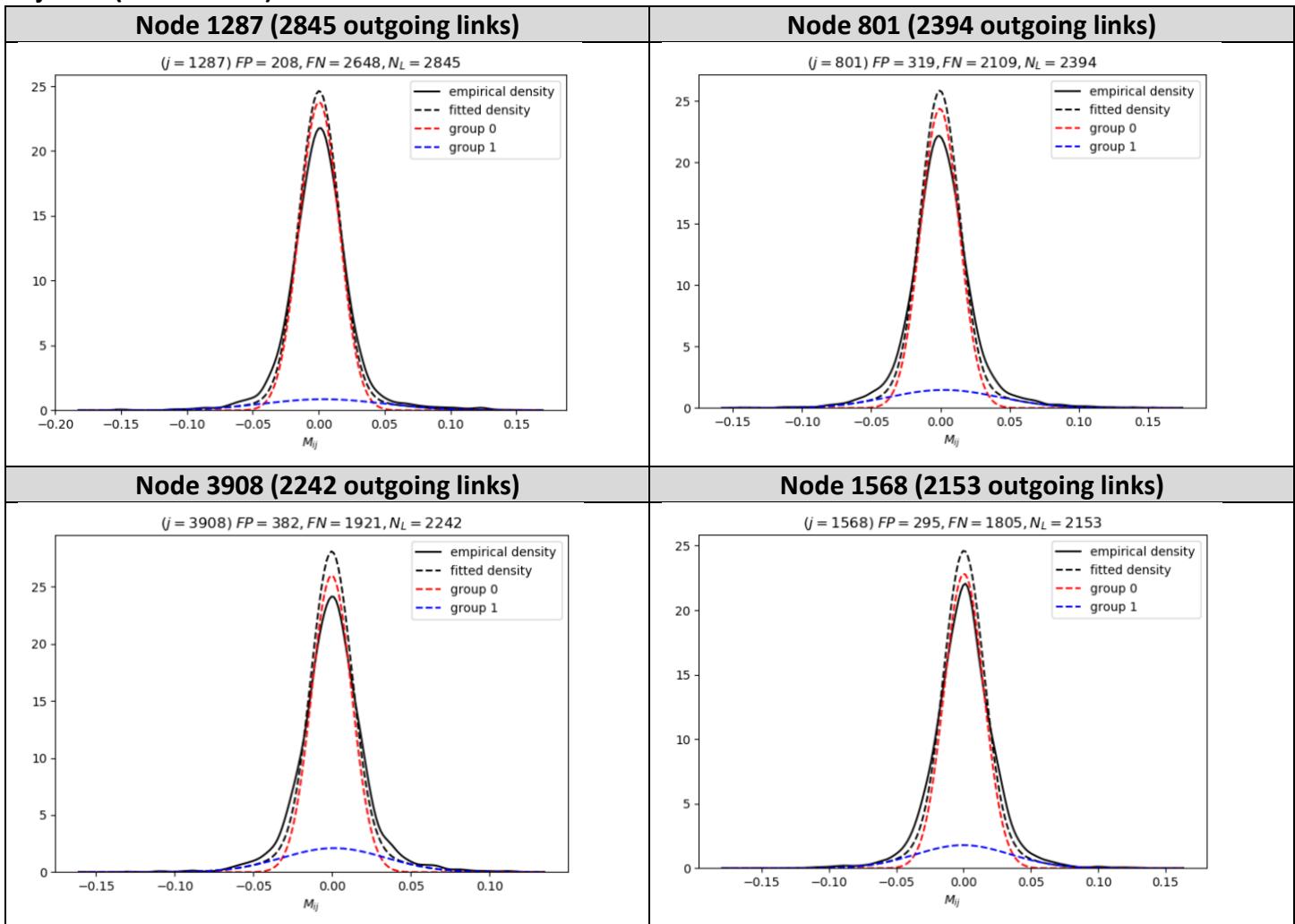
dt=0.125	dt=0.25
min: 0.0	min: 0.0
max: 374.0	max: 337.0
median: 5.0	median: 5.0
mean: 15.448840048840049	mean: 15.55091575091575
skew: 4.3286932591498966	skew: 4.119768642695203
kurt: 25.030331821556242	kurt: 22.775692455344018



Covariance Method on DIV66 Series (15000ms)

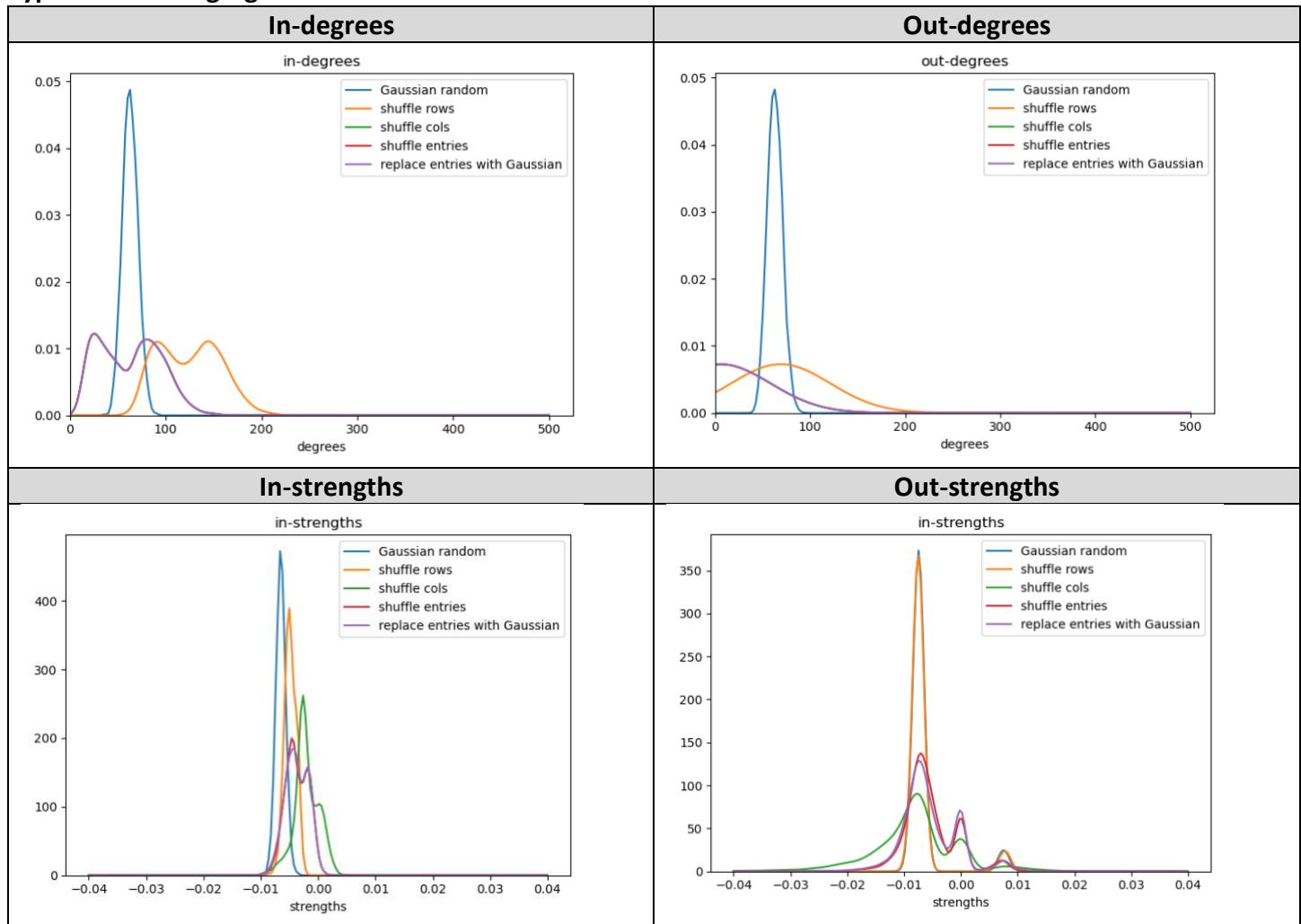
Params	Accuracy
p=0.4, std=0.5	{'sensitivity': 0.037021632232609666, 'specificity': 0.9785598517053431, 'error_FN': 0.9629783677673903, 'error_FP': 1.375782783619366}
p=0.5, std=0.5	{'sensitivity': 0.043645410196108916, 'specificity': 0.9667369874921816, 'error_FN': 0.9563545898038911, 'error_FP': 2.1344385920584634}
p=0.6, std=0.5	{'sensitivity': 0.05281141280052866, 'specificity': 0.952323691858484, 'error_FN': 0.9471885871994713, 'error_FP': 3.0593185749548115}
p=0.4, std=1.0	{'sensitivity': 0.00652271092884492, 'specificity': 0.9976720525452555, 'error_FN': 0.9934772890711551, 'error_FP': 0.14938096441274223}
p=0.5, std=1.0	{'sensitivity': 0.006693747449029173, 'specificity': 0.9974677233468674, 'error_FN': 0.9933062525509708, 'error_FP': 0.16249246856232144}
p=0.6, std=1.0	{'sensitivity': 0.006895881518337836, 'specificity': 0.9972298945793396, 'error_FN': 0.9931041184816621, 'error_FP': 0.17775359079512545}
p=0.4, std=1.5	{'sensitivity': 0.0003653962022118132, 'specificity': 0.9998885366958097, 'error_FN': 0.9996346037977882, 'error_FP': 0.007152436298614216}
p=0.5, std=1.5	{'sensitivity': 0.0003692833958523644, 'specificity': 0.9998797529028164, 'error_FN': 0.9996307166041476, 'error_FP': 0.00771607937649414}
p=0.6, std=1.5	{'sensitivity': 0.0003692833958523644, 'specificity': 0.9998686671502801, 'error_FN': 0.9996307166041476, 'error_FP': 0.00842743581271501}

Mij Data (Distribution)



Degree/Strength Distribution of Reference Networks

Type A: same orig sign



Type B: majority sign

