Project 2

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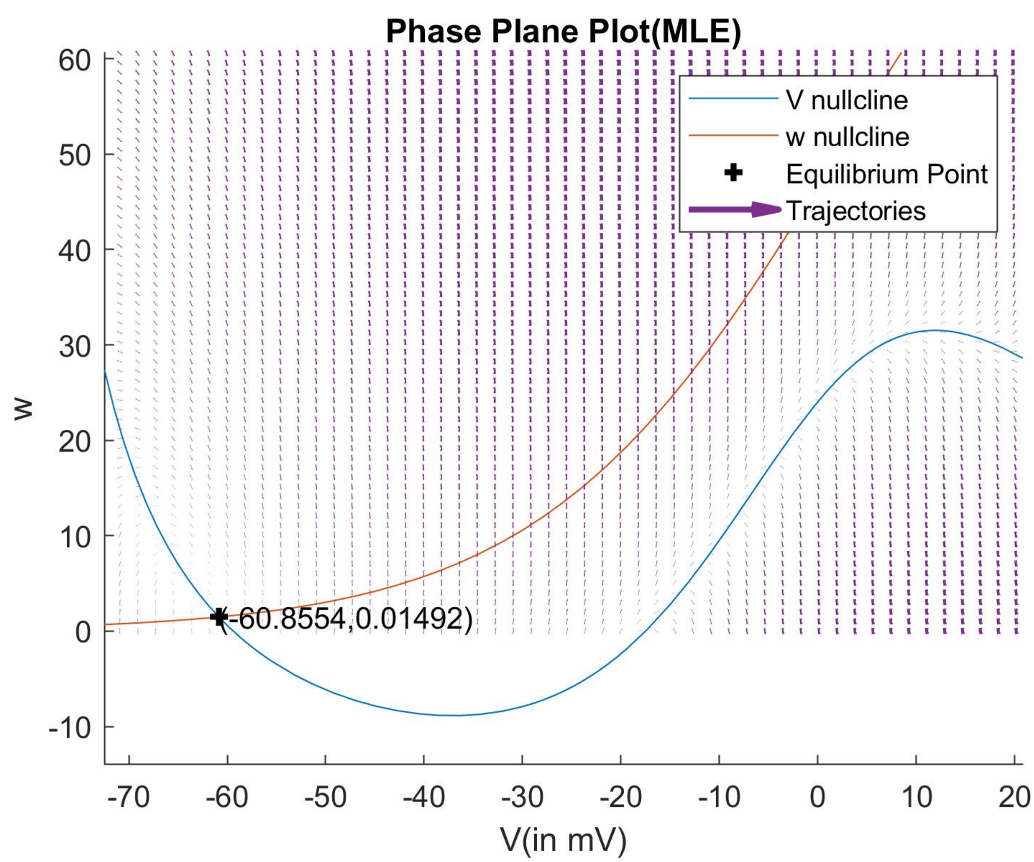
1

From question, microamps/cm^2 = millivolts $\times$ millisiemens/cm^2 as micro $= 10^{-6}$ and milli $= 10^{-3}$
Because charge = capacitance $\times$ voltage, and charge = current $\times$ time,
amp $\times$ second = farad $\times$ volt.
Therefore microamps/cm^2 $\times$ milliseconds = microfarads/cm^2 $\times$ millivolts

Set of units: microsiemens/cm^2, volts, microamps/cm^2, seconds, microfarads/cm^2
No - solution is NOT unique

2

The equilibrium point is located at (-60.855,0.0149)



3

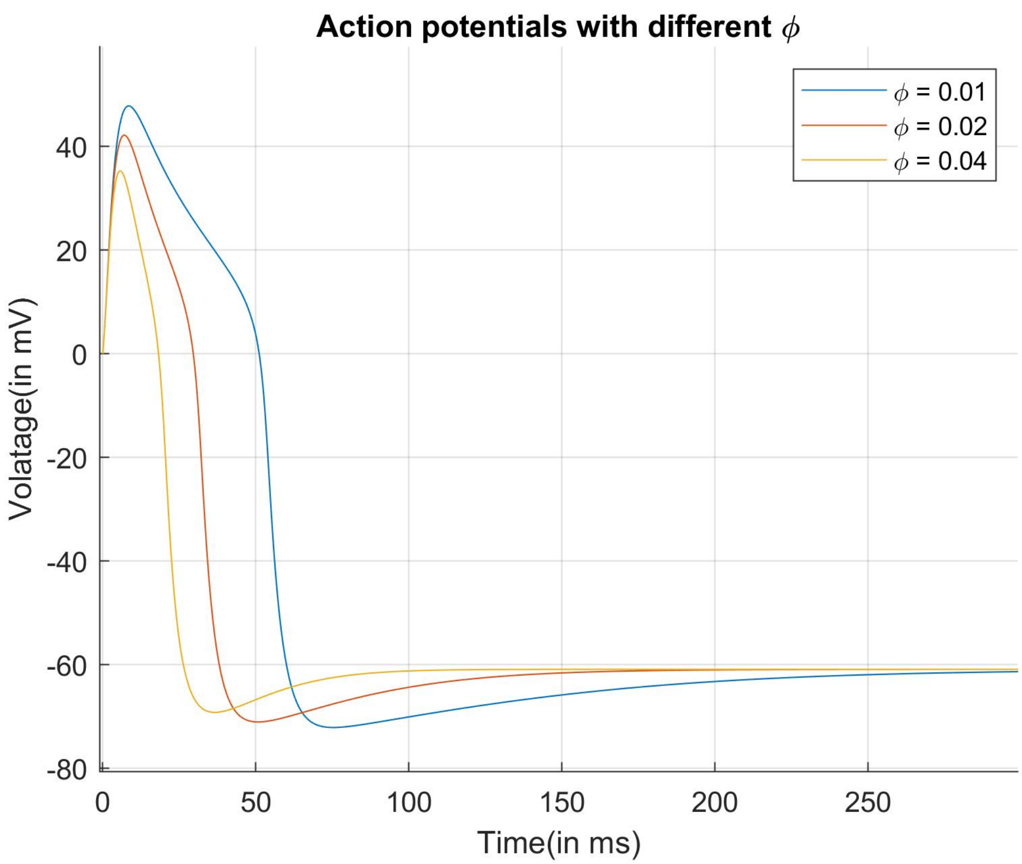
Stable - eigen values are -9.588030e-02 and -3.656140e-02 (real and negative albeit slow decay as small magnitude)

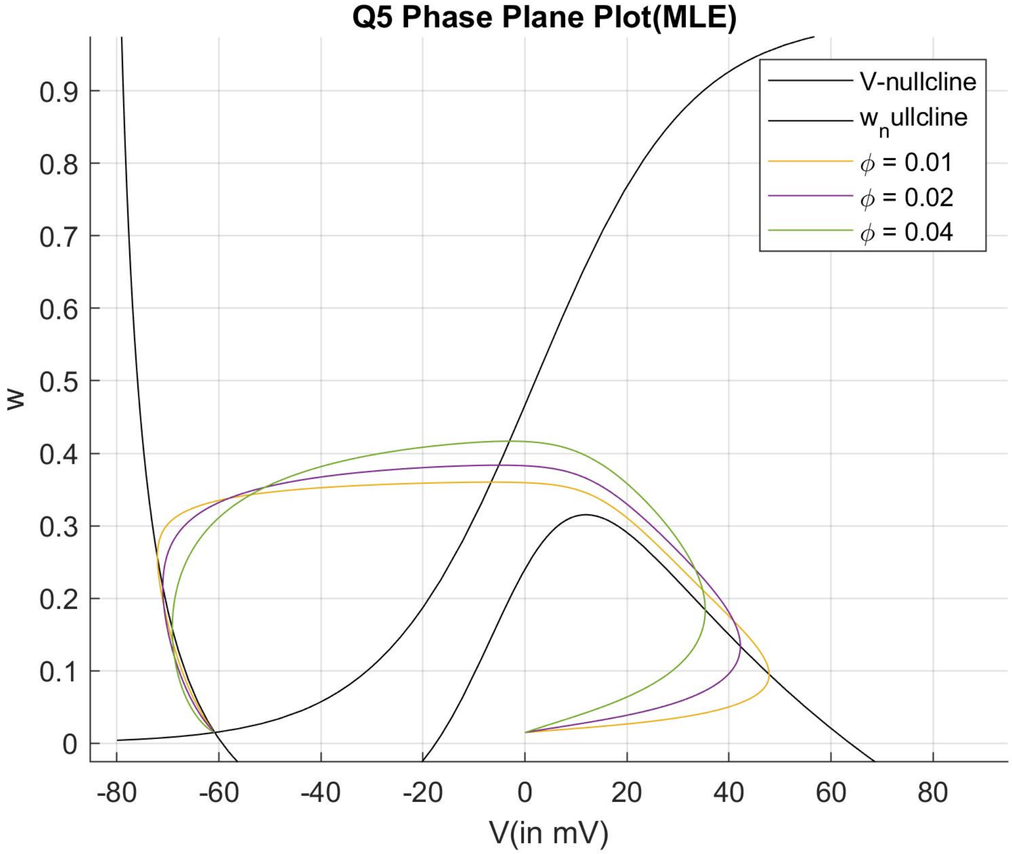
4

1 milli = 10^{-6} kilo
hence both tolerances would have to be multiplied by the same as voltage would now be 0.000060 kV and other values change accordingly

5

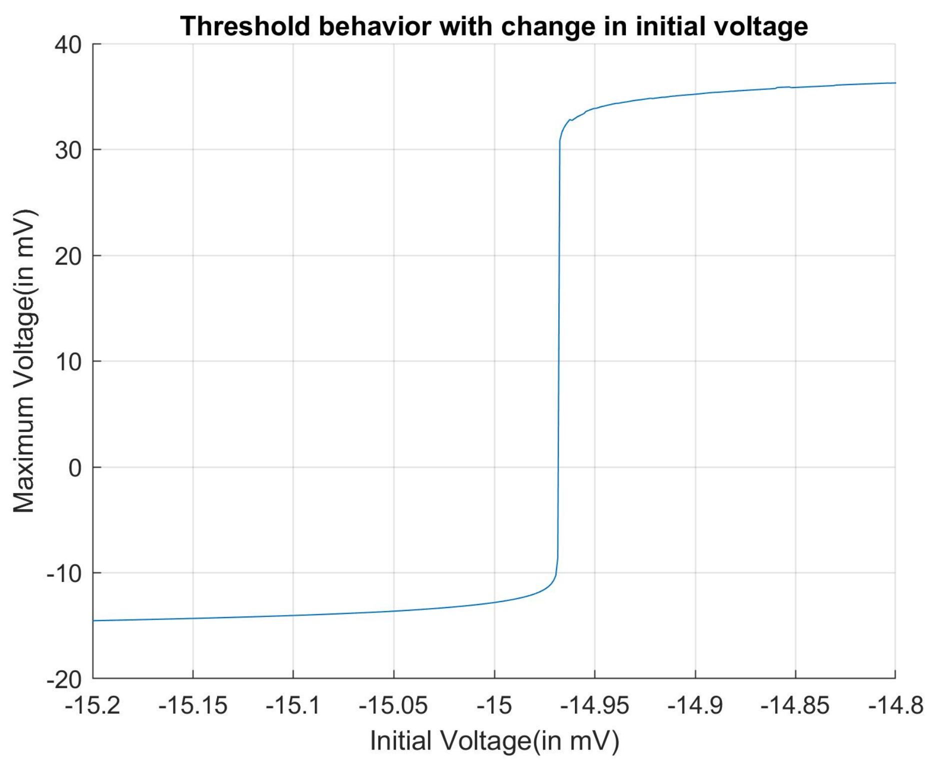
Decreasing ϕ leads to a taller and wider action potential. For the same w, the magnitude of the voltage near the spike and depression is higher

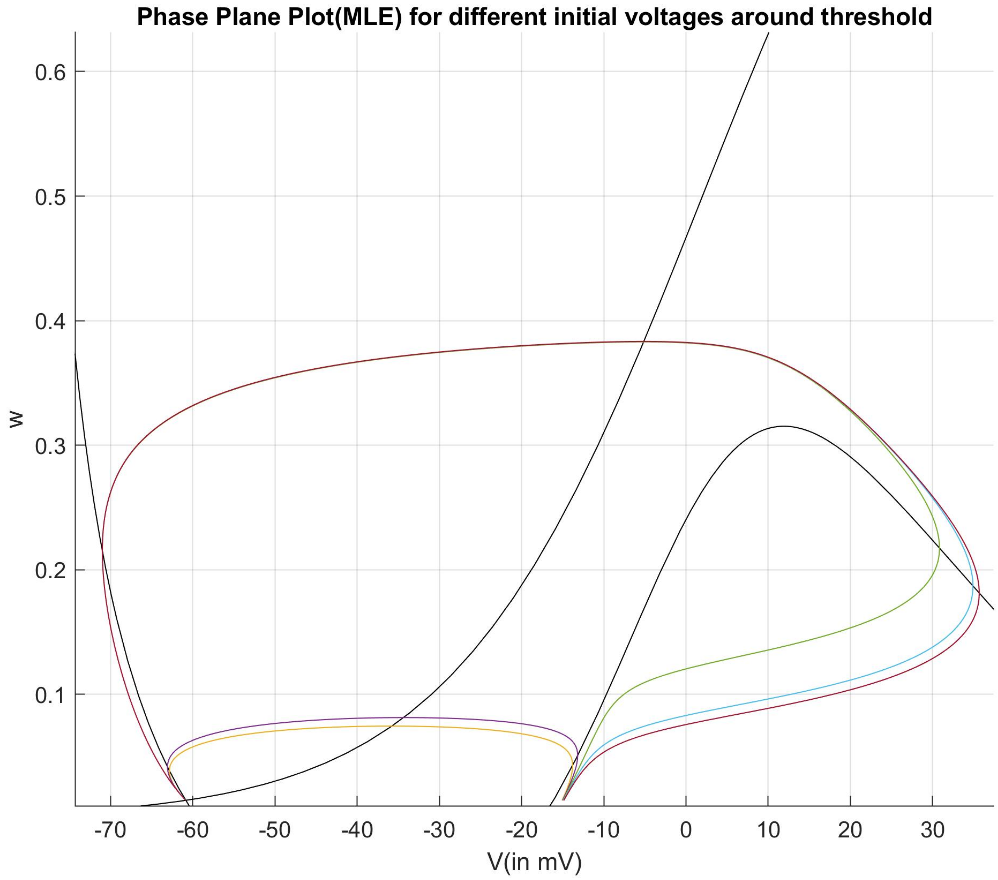




6

The current should depolarize the membrane potential to atleast -14.967419 mV for action potential to occur. No AP if this threshold is not crossed. Phase plane plot shows behavior of membrane potential for just above and below threshold value.





Green - threshold
blue, red - above threshold
yellow, purple - below threshold

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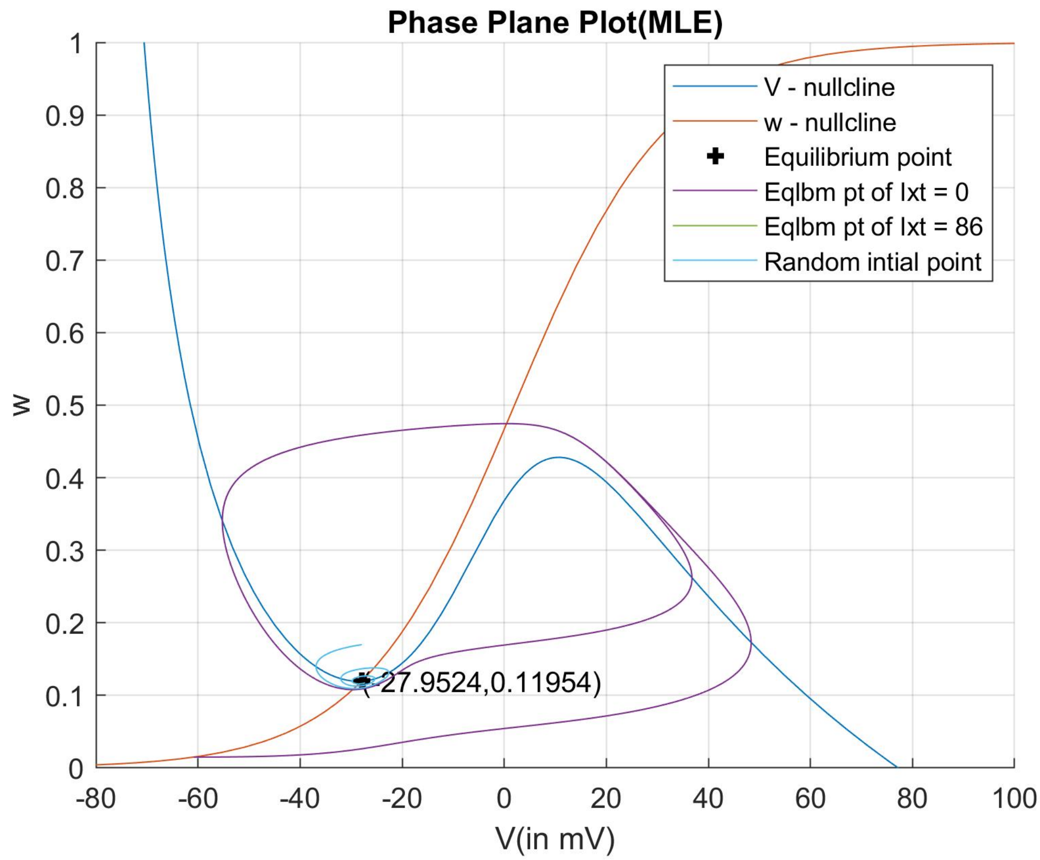
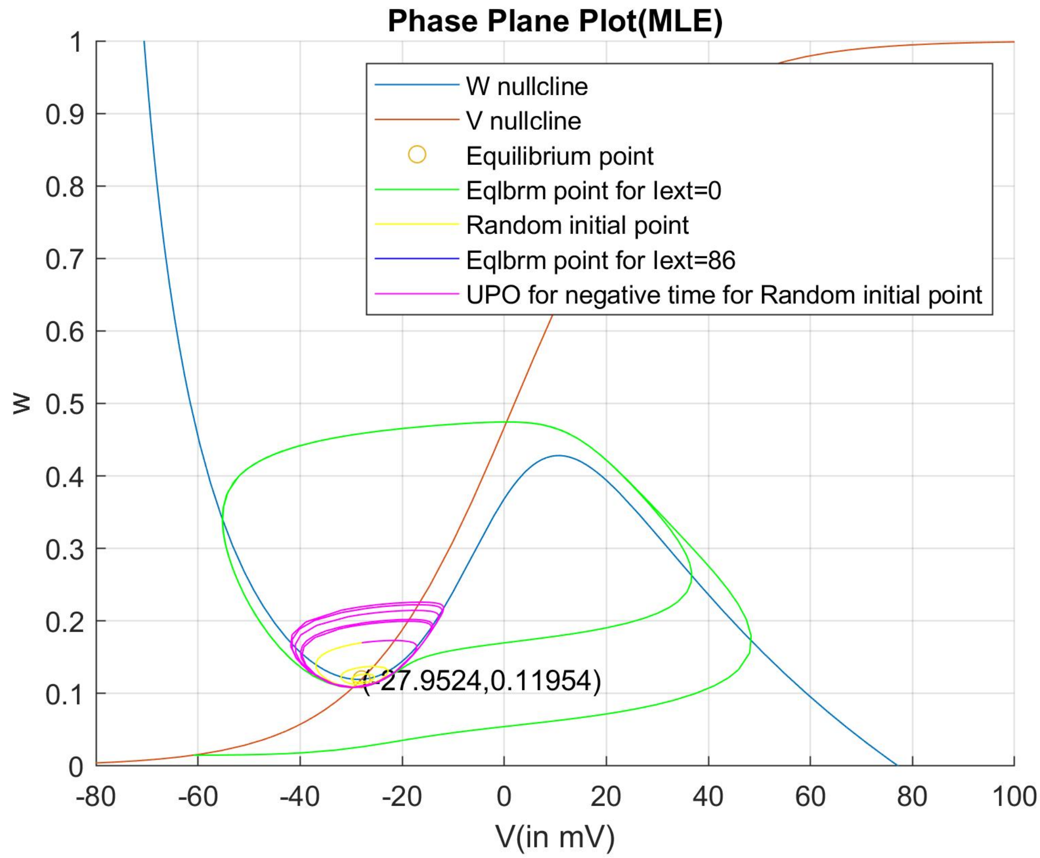
The new equilibrium point is -27.95, 0.11954



Since the external current is not 0, starting at the previous equilibrium point is like a perturbation and it decays to the new equilibrium. Starting at the new equilibrium causes no change in any values hence no green plot is observed. The (-27.9, 0.17) point decays in a spiral towards the new equilibrium. A current clamp experiment can be done to get such results.

8



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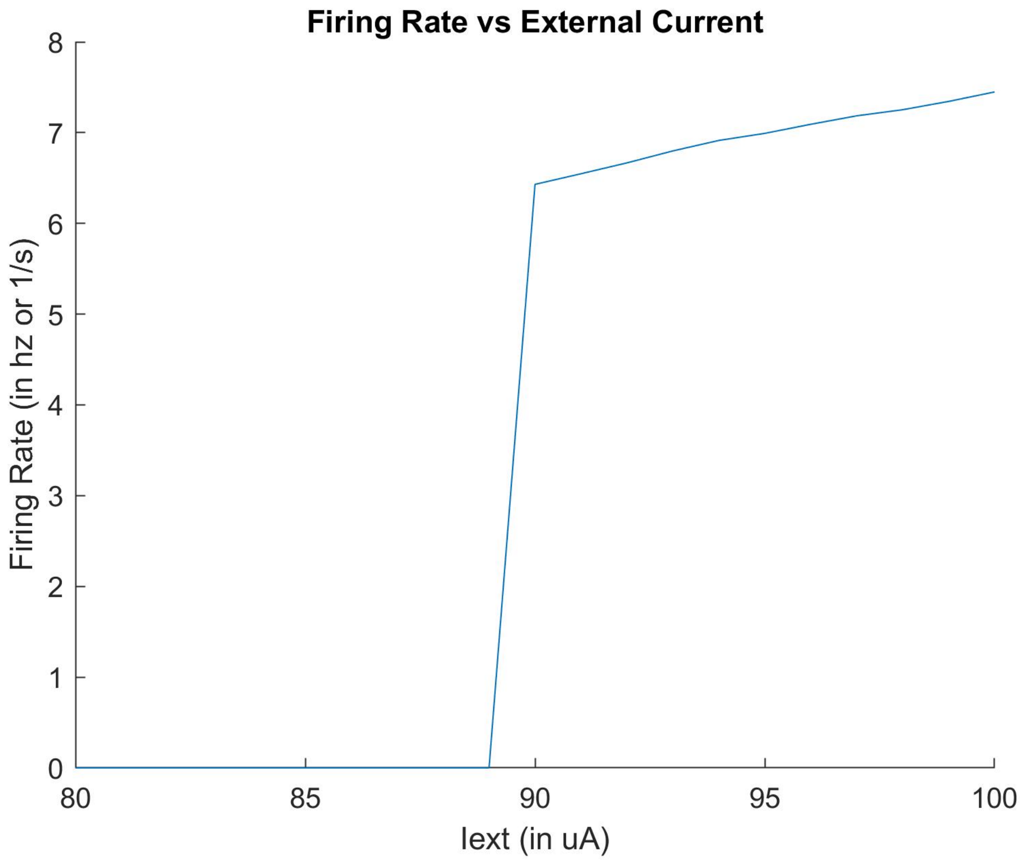
Iext = 80
The equilibrium point is located at (-2.996618e+01,1.061127e-01)
The eigen values are -0.017784+0.055717i , -0.017784-0.055717i

Iext = 86
The equilibrium point is located at (-2.795241e+01,1.195364e-01)
The eigen values are -0.006785+0.057427i , -0.006785-0.057427i

Iext = 90
The equilibrium point is located at (-2.659687e+01,1.293793e-01)
The eigen values are 0.001753+0.057170i , 0.001753-0.057170i



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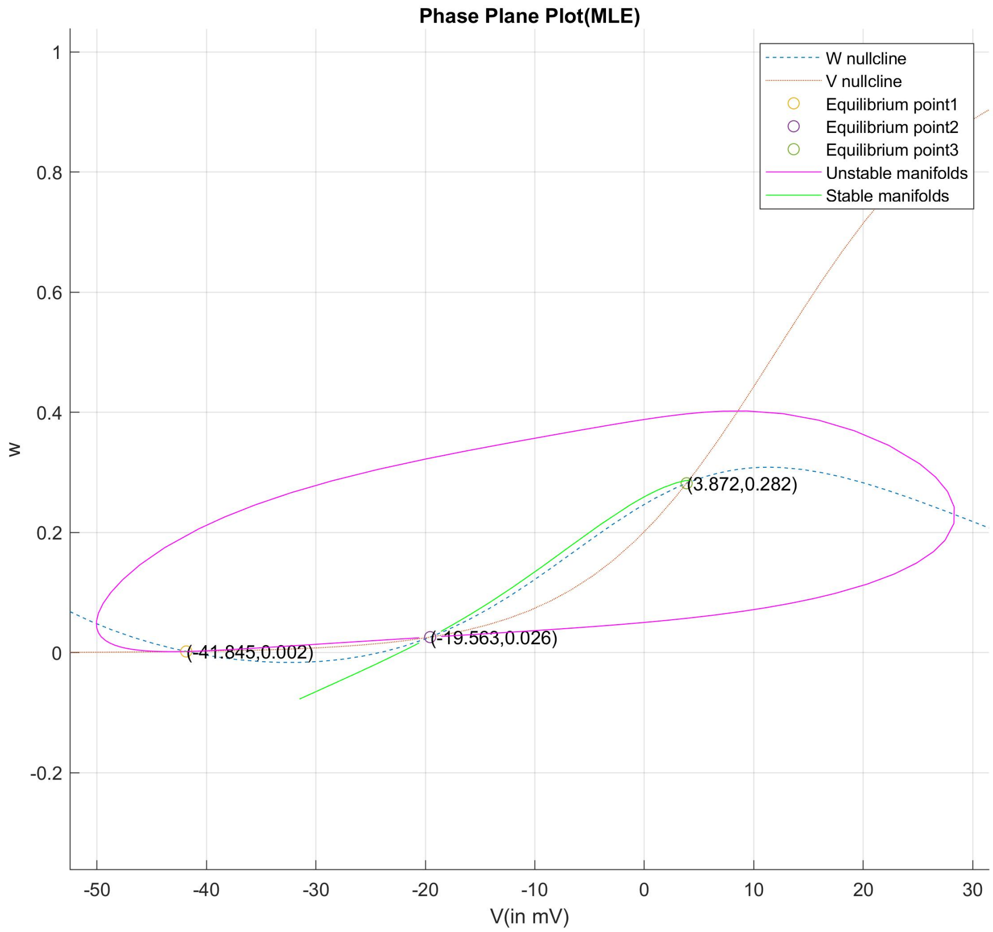
Equilibrium points are :

1. (-41.845162, 0.002047) - stable - eigen values are -0.071544+0.000000i , -0.156766+0.000000i
2. (-19.563243, 0.025883) - - eigen values are 0.153619+0.000000i , -0.067328+0.000000i
3. (3.871510, 0.282051) - unstable - eigen values are 0.093868+0.172310i , 0.093868-0.172310i



Phase Plane Plot(MLE)
W nullcline
V nullcline
Equilibrium point1
Equilibrium point2
Equilibrium point3
Unstable manifolds
Stable manifolds
(3.872,0.282)
(-19.563,0.026)
(-41.845,0.002)
w
V(in mV)
1
0.8
0.6
0.4
0.2
0
-0.2
-50
-40
-30
-20
-10
0
10
20
30

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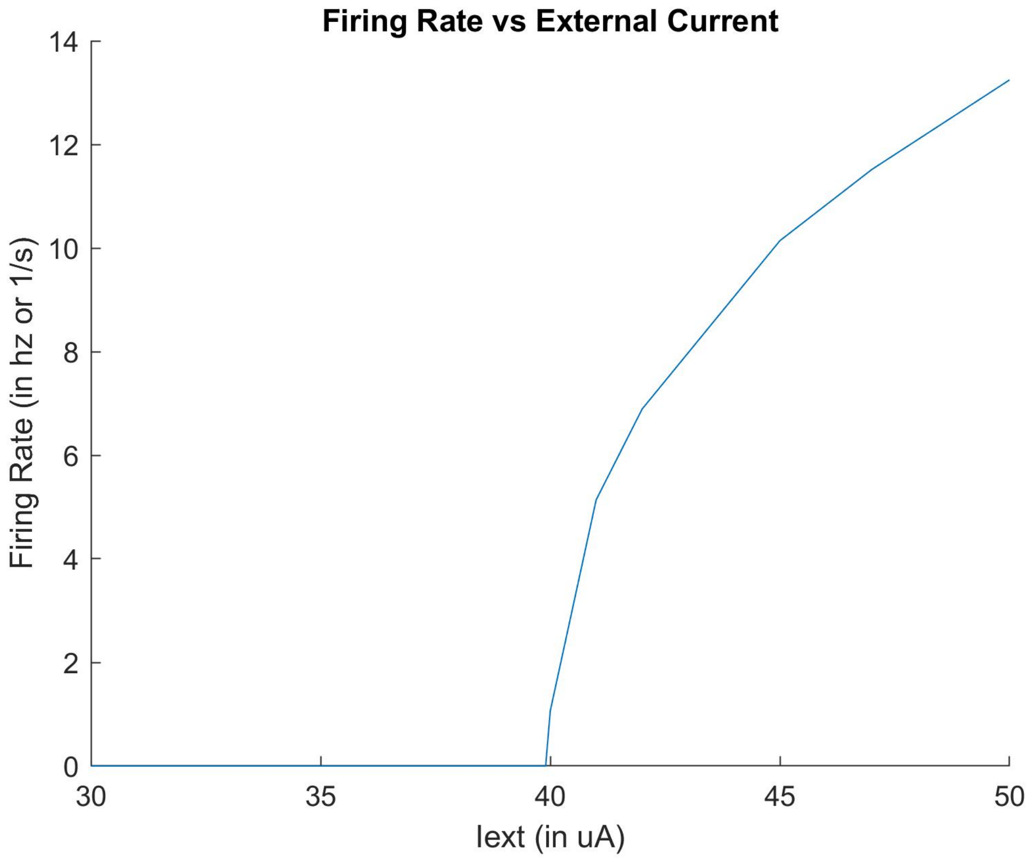
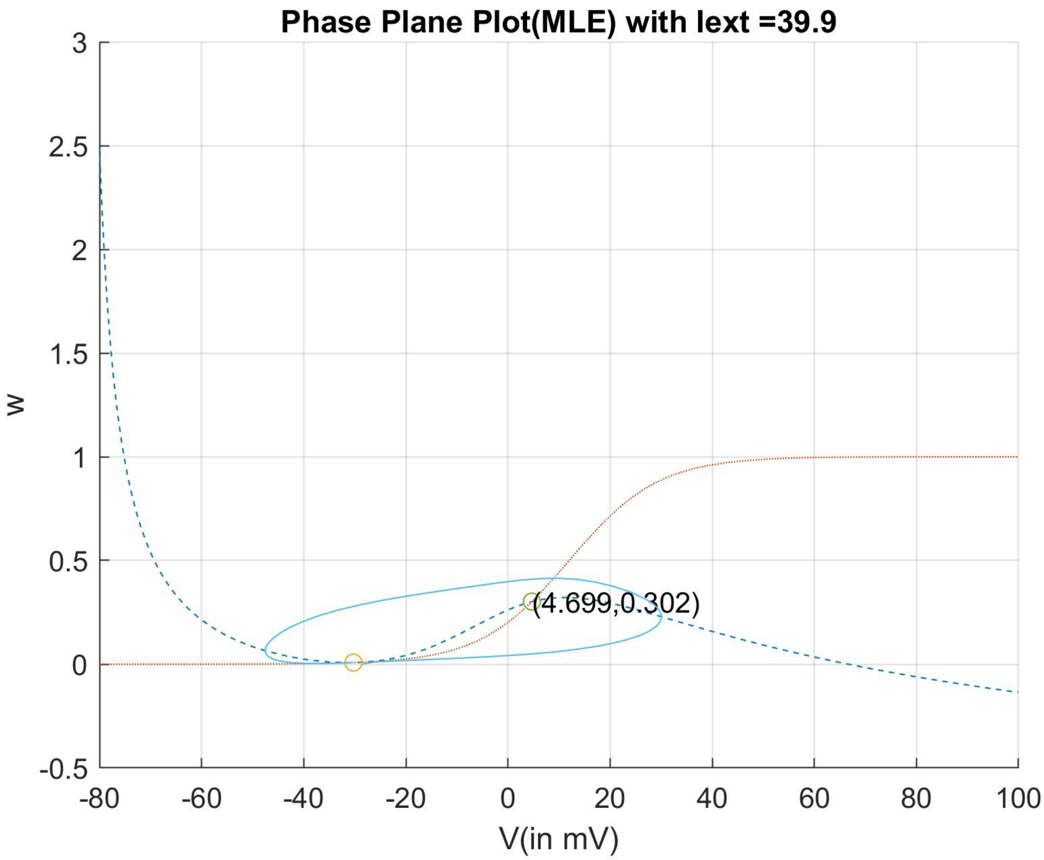
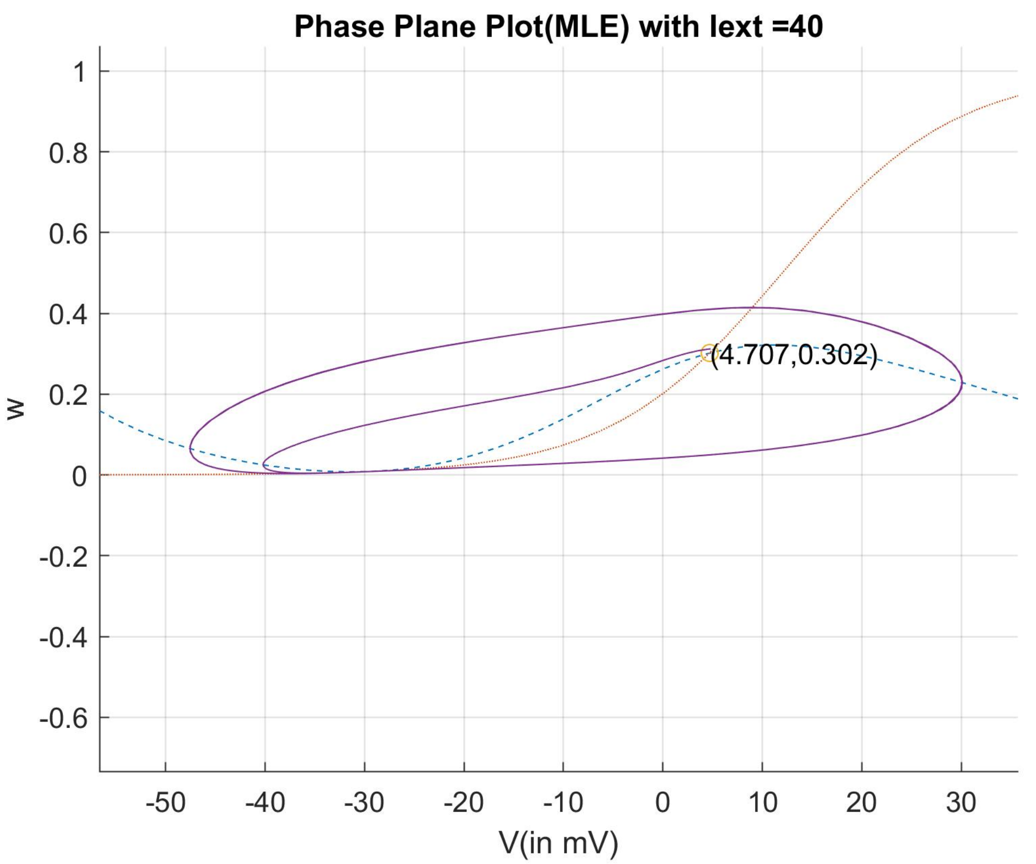


Firing rate increases (appears log in plots due to nature of Morris Lecar, in real neuron it is almost linear) after a threshold Iext current

Iext	No. of distinct equilibirium
30.0	3
35.0	3
39.0	3
...	3
39.9	3
40.0	1
40.1	1
...	1
50.0	1


Phase Plane Plot(MLE) with Iext =39.9
(4.699,0.302)
w
V(in mV)
3
2.5
2
1.5
1
0.5
0
-0.5
-80
-60
-40
-20
0
20
40
60
80
100


Phase Plane Plot(MLE) with Iext =40
(4.707,0.302)
w
V(in mV)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-50
-40
-30
-20
-10
0
10
20
30

12 CODE

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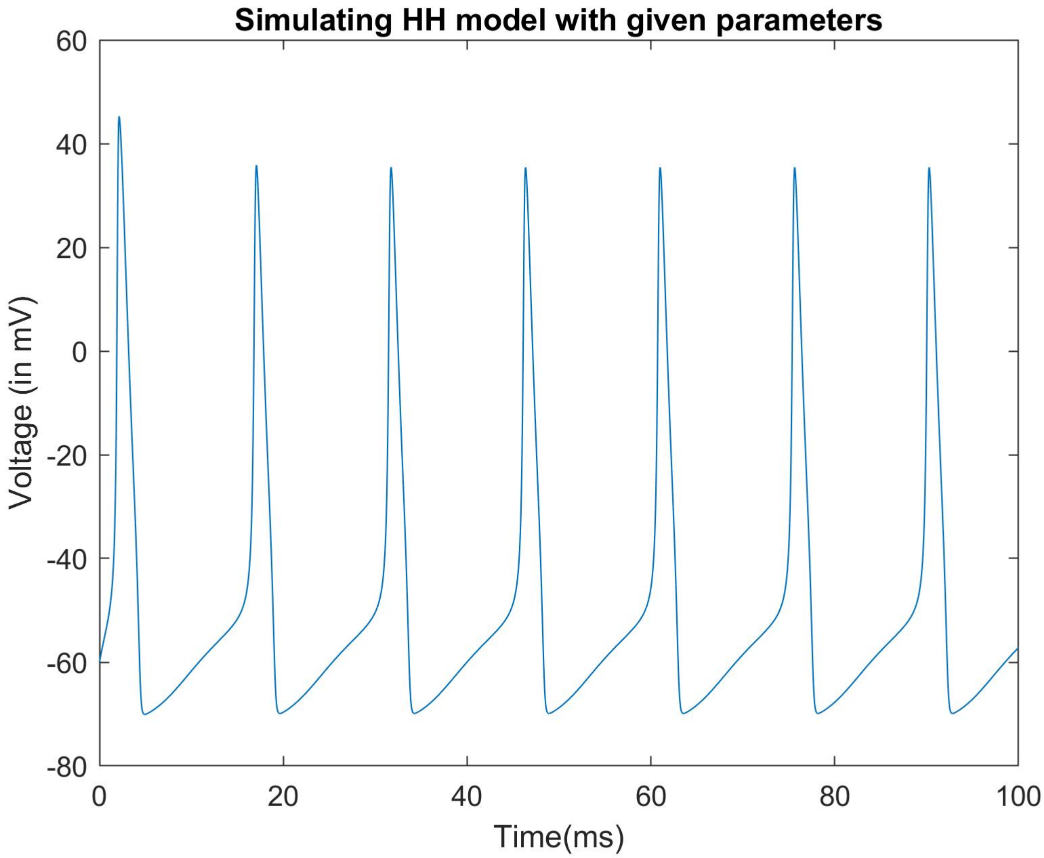
$E_L = -4.940108e + 01$



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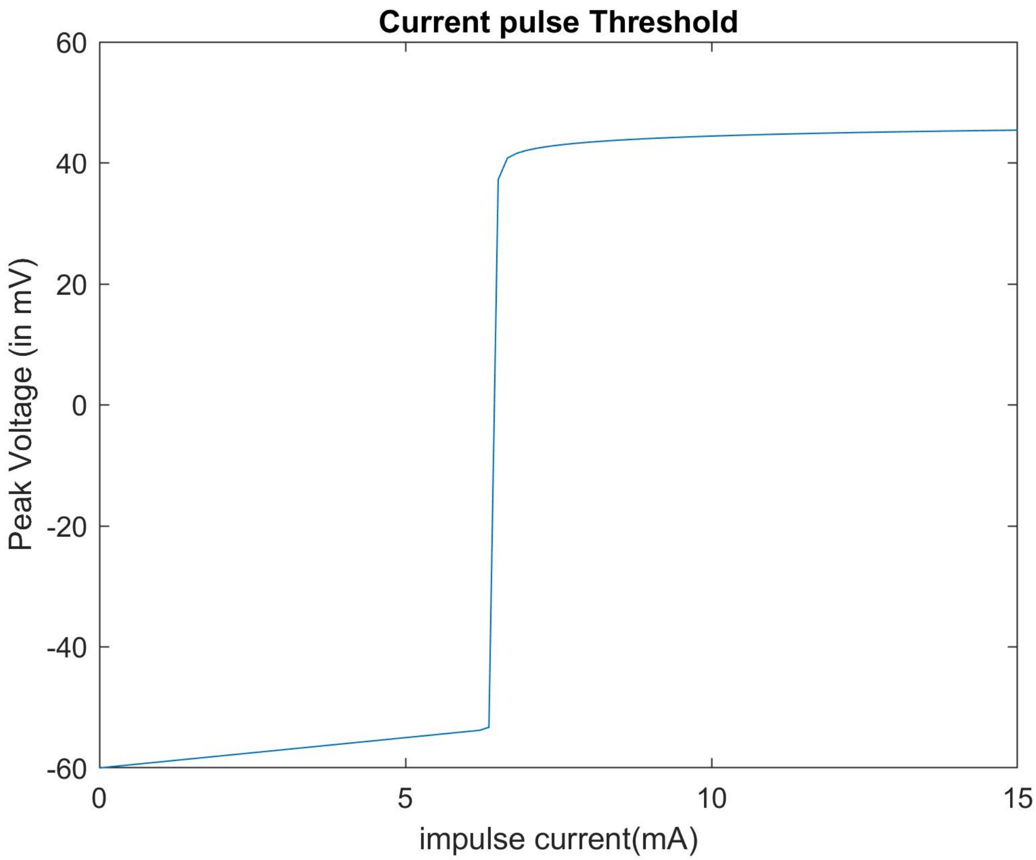
Threshold: 6.515152 mA
Iext =0
Equilibrium Point V=-60.000000 n=0.317677 m=0.052932 h=0.596121
The eigen values are -4.675345+0.000000i , -0.202718+0.383061i , -0.202718-0.383061i , -0.120659+0.000000i
Stable



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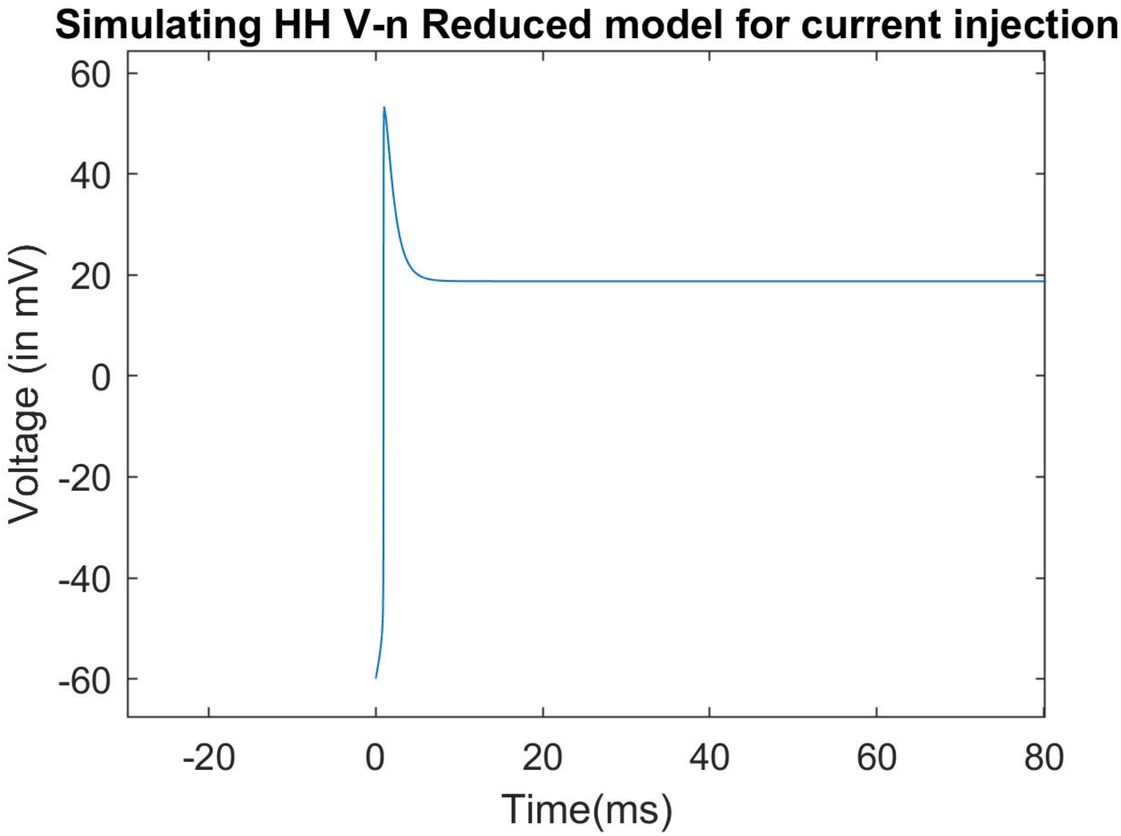
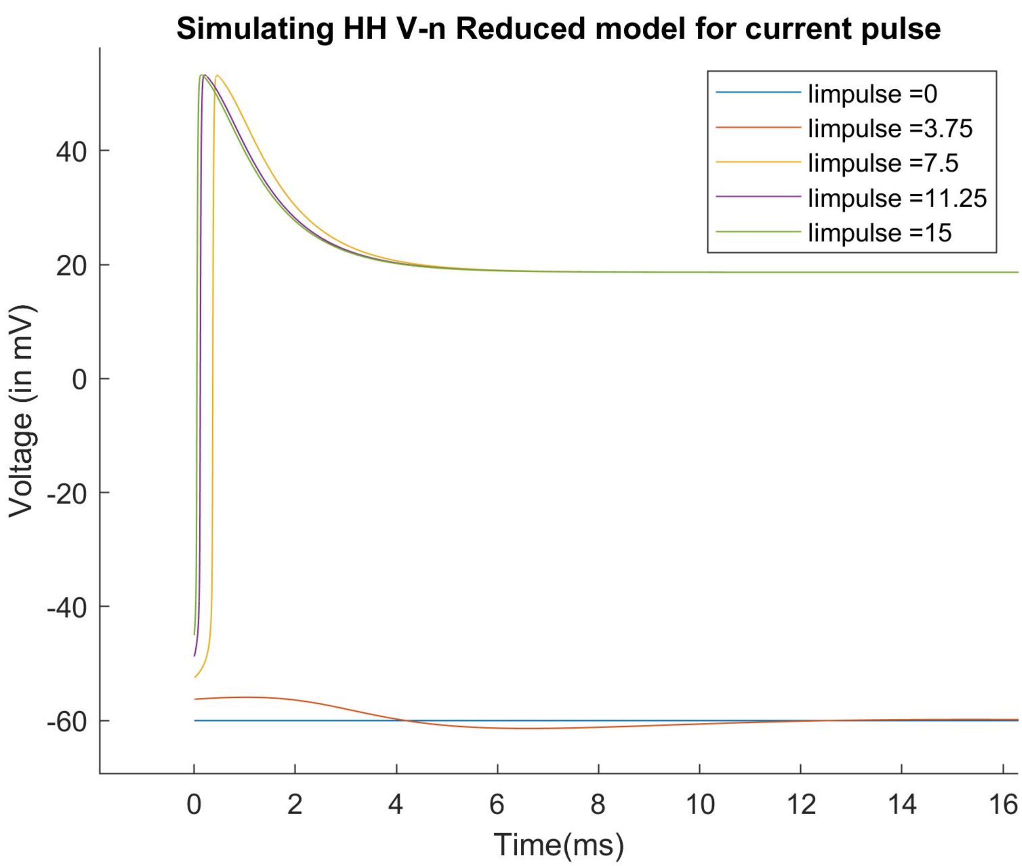
Iext	Equilibrium Point	Eigenvalues
8	V=-55.355128 n=0.390607 m=0.090048 h=0.430515	-4.690140+0.000000i , -0.034549+0.566792i
9	V=-54.952404 n=0.397027 m=0.094133 h=0.416502	-4.730588+0.000000i , -0.014865+0.578298i
10	V=-54.572150 n=0.403092 m=0.098131 h=0.403419	-4.774093+0.000000i , 0.004122+0.588328i ,
11	V=-54.211777 n=0.408841 m=0.102052 h=0.391169	-4.819956+0.000000i , 0.022390+0.597090i
12	V=-53.869127 n=0.414306 m=0.105899 h=0.379667	-4.867630+0.000000i , 0.039926+0.604761i

Eigenvalues continued	Stability
-0.034549-0.566792i , -0.135013+0.000000i	stable
-0.014865-0.578298i , -0.136960+0.000000i	Stable
0.004122-0.588328i , -0.138902+0.000000i	Cannot say (Need to plot in 4 dimensions)
0.022390-0.597090i , -0.140836+0.000000i	Cannot say (Need to plot in 4 dimensions)
0.039926-0.604761i , -0.142760+0.000000i	Cannot say (Need to plot in 4 dimensions)

current injection (Iext $= 10\mu$A)





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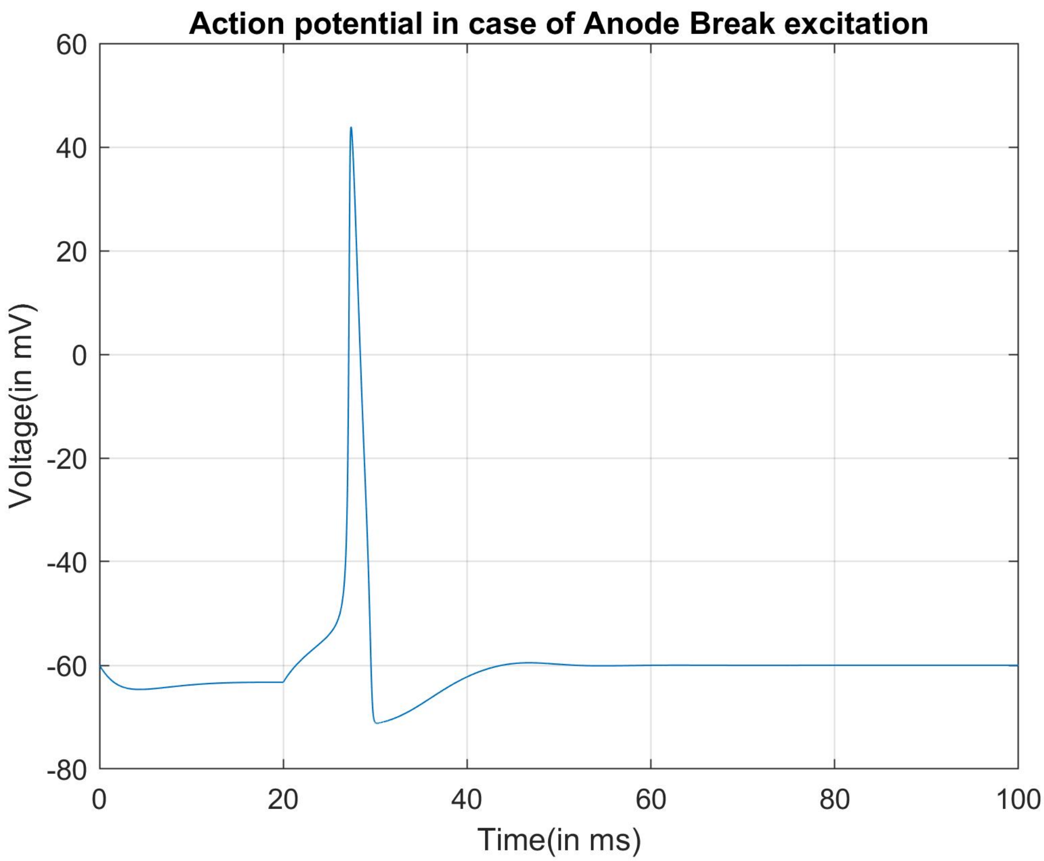
The electrical potential across a membrane decreases (becomes negative of the resting potential) when a hyperpolarizing current is placed across it. This decrease is followed by a reduction in the threshold necessary for an action potential (since the threshold is directly linked to the potential across the membrane.

After the hyperpolarizing current stops, ABE develops. Although the potential across the cell rises quickly in the absence of a hyperpolarizing stimulus, the action potential threshold remains at its lower value. As a result, the potential is high enough to activate the cell's action potential.



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Equilibrium Point for case 1 V=-54.329239 m=0.100760
Equilibrium Point for case 2 V=54.348821 m=0.999221