Current addition report

# Summary

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| v | Template | Dims. | z | Intervals | Timing | Cm | Current amplitude | Current duration | ED constants | Conductances | Max voltage | Length constant | Time constant | Comment |
| T1v2 | - | 20X1um | -0.85 all |  |  | 2 |  |  | 1e-7 | 1e-3 |  |  |  |  |
| T1v3 | - | 20X1um | -0.85 all |  |  | 2 |  |  | 1e-8 | 1e-3 |  |  |  |  |
| T1v4 |  | 20X1um | -0.85 all |  |  | 2 |  |  | 1e-7/2 | 1e-3 |  |  |  |  |
| T1v5 |  | 20X1um | -0.85 all |  |  | 2 |  |  | 1e-7/2 | 1.5e-3 |  |  |  |  |
| T2v2 | - | 20X1um | -0.45 all |  |  | 2 |  |  | 1e-7/2 | 1e-3 |  |  |  |  |
| T3v2 |  | 20X1um | -1.25 all |  |  | 2 |  |  | 1e-7/2 | 1e-3 |  |  |  |  |
| T2v3 | - | 20X1um | -0.45 (8) |  |  | 2 |  |  | 1e-7/2 | 1e-3 |  |  |  |  |
| T3v3 | - | 20X1um | -1.25 (8) |  |  | 2 |  |  | 1e-7/2 | 1e-3 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| H-A | T1v4 | 20X1um | -0.85 all | 50000 | 0.12s total t  0.01 start t | 2 | +0.1 nA | 1ms | 1e-7/2 | 1e-3 |  |  |  |  |
| H-B | T2v2 | 20X1um | -0.45 | 50000 | 0.12s total t  0.01 start t | 2 | +0.1 nA | 1ms | 1e-7/2 | 1e-3 |  |  |  |  |
| H-C | T3v2 | 20X1um | -1.25 | 50000 | 0.12s total t  0.01 start t | 2 | +0.1 nA | 1ms | 1e-7/2 | 1e-3 |  |  |  |  |
| H-D | T2v3 | 20X1um | -0.45(8) | 50000 | 0.12s total t  0.01 start t | 2 | +0.1 nA | 1ms | 1e-7/2 | 1e-3 |  |  |  |  |
| H-E | T3v3 | 20X1um | -1.25(8) | 50000 | 0.12s total t  0.01 start t | 2 | +0.1 nA | 1ms | 1e-7/2 | 1e-3 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| H43 | T1v2 | 20X1um | -0.85 | 50000 | 0.1s | 2 | 0.1nA | 1ms | 1e-7 | 1e-3 | -57.57mv | 76.88um | 7.95ms |  |
| H44 | T1v3 | 20X1um | -0.85 | 50000 | 0.1s | 2 | 0.1nA | 1ms | 1e-8 | 1e-3 | -34mv | 37.72um | 1.98 |  |
| H47 | T1v5 | 20X1um | -0.85 | 50000 | 0.1s | 2 | 0.1nA | 1ms | 1e-7 /2 | 1.5e-3 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| H46 | T1v4 | 20X1um | -0.85 | 50000 | 0.1s | 2 | +0.1nA | 1ms | 1e-7 /2 | 1e-3 | -52.47mv | 48.03um | 2.79ms | **BASELINE** |
| H45 | T2v2 | 20X1um | -0.45 | 50000 | 0.1s | 2 | +0.1nA | 1ms | 1e-7 /2 | 1e-3 | -29.42mV | 46.88um | 2.55ms | **4c** |
| H48 | T3v2 | 20X1um | -1.25 | 50000 | 0.1s | 2 | +0.1nA | 1ms | 1e-7 /2 | 1e-3 | -68.14 | 45.95um | 0.7ms | **4c** |
| H51 | T1v4 | 20X1um | -0.85 | 50000 | 0.1s | 2 | -0.1nA | 1ms | 1e-7 /2 | 1e-3 | Min:-92.69 | 47.97um | 2.65ms | **4b/4c** |
| H54 | T2v2 | 20X1um | -0.45 | 50000 | 0.1s | 2 | -0.1nA | 1ms | 1e-7 /2 | 1e-3 | Min: -83.93 | 44.18um | 1.21ms | **4c** |
| H55 | T3v2 | 20X1um | -1.25 | 50000 | 0.1s | 2 | -0.1nA | 1ms | 1e-7 /2 | 1e-3 | Min:-100.69 | 51.6um | 8.41ms | **4c** |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| H49 | T2v3 | 20X1um | -0.45 (8) | 50000 | 0.1s | 2 | +0.1nA | 1ms | 1e-7 /2 | 1e-3 | -49.51 | 65.66um | 2.11ms | **4b** |
| H50 | T3v3 | 20X1um | -1.25 (8) | 50000 | 0.1s | 2 | +0.1nA | 1ms | 1e-7 /2 | 1e-3 | -54.79 | 35.40um | 3.34ms | **4b** |
| H52 | T2v3 | 20X1um | -0.45 (8) | 50000 | 0.1s | 2 | -0.1nA | 1ms | 1e-7 /2 | 1e-3 |  |  |  | **4b** |
| H53 | T3v3 | 20X1um | -1.25 (8) | 50000 | 0.1s | 2 | -0.1nA | 1ms | 1e-7 /2 | 1e-3 |  |  |  | **4b** |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| H27 | T1 | 20X5um |  | 50000 | 0.05s | 2 | 0.1nA | 1ms | 1e-9 | 1e-3 | -71.81 | 20.6um | 15.4ms |  |
| H28 | T1 | 20X5um |  | 50000 | 0.05s | 2 | 0.1nA | 1ms | 1e-8 | 1e-3 | -71.89 | 21.9um | 5.72ms |  |
| H29 | T1 | 20X5um |  | 50000 | 0.05s | 2 | 0.1nA | 1ms | 1e-7 | 1e-3 | -72.19 | 37.74um | 2.56ms |  |
| H30 | T1 | 20x5um |  | 50000 | 0.1s | 2 | 10nA | 1ms | 1e-7 | 1e-3 | -33.99 | 37.74um | 2ms |  |
| H31 | T1 | 20x5um |  | 50000 | 0.1s | 2 | 10nA | 1ms | 1e-8 | 1e-3 | -4.81 | 21.99um | 4.87ms |  |
| H32 | T1 | 20x5um |  | 50000 | 0.1s | 2 | 0.1nA | 1ms | ED OFF | 1e-3 | -71.8 | 20um | 17ms |  |
| H33 | T1 | 20x5um |  | 50000 | 0.1s | 2 | 10nA | 1ms | ED OFF | 1e-3 | 4.92 | 20.43um | 17.93ms |  |
| H34 | T1 | 20x5um |  | 50000 | 0.1s | 2 | 0.1nA (fixed dt issue) | 1ms | 1e-8 | 1e-3 | -4.81 | 21.99um | 4.87ms |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| H4v2 |  | 20x1um |  | 10000 | 0.01s | 2 | 1uA | 1ms | 1e-7 | 1e-3 | 3787mv | 37.77um | 1.96ms |  |
| H5v2 |  | 20x1um |  | 10000 | 0.01s | 2 | 1uA | 1ms | 1e-5 | 1e-3 | 854mv | 77.94um | Does not get to steady state |  |
| H21 |  | 20x1um |  | 10000 | 0.01s | 2 | 1nA | 1ms | 1e-6 | 1e-3 | -71.07mv | 76.92um | Does not get to steady state |  |
| H20 |  | 20x1um |  | 10000 | 0.01s | 2 | 1nA | 1ms | 1e-7 | 1e-3 | -68.71mv | 37.74um | 1.97ms |  |
| H25 |  | 20x1um |  | 10000 | 0.01s | 2 | 1nA | 1ms | 1e-8 | 1e-3 | -65.8mv | 22um | Needs longer sim |  |
| H24 |  | 20x1um |  | 10000 | 0.01s | 2 | 1nA | 1ms | 1e-9 | 1e-3 | -64.94mv | 37.75um | Needs longer sim |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| H22 |  | 20x1um |  | 10000 | 0.01s | 2 | 1nA | 1ms | 1e-7 | 1e-2 | Unable to calculate because a new steady state is required beforehand. | | |  |
| H23 |  | 20x1um |  | 10000 | 0.01s | 2 | 10nA | 1ms | 1e-7 | 1e-3 | -33.96mV | 37.75 | 1.18ms |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| H4 |  | 20x1um |  | 3000 | 0.4s | 2 | 1uA | 1ms | 1e-7 | 1e-3 | -66.9mv | 27.37um | 1.37ms |  |
| H5 |  | 20x1um |  | 3000 | 0.4s | 2 | 1uA | 1ms | 1e-5 | 1e-3 | -71.68mv | 110.6um | 24.68ms |  |
| H11 |  | 20x1um |  | 5000 | 0.5s | 0.5 | 1nA | 1ms | 1e-7 | 1e-3 | -64.23mv | 67.13um | 1ms |  |
| H13 |  | 20x1um |  | 5000 | 0.5s | 2 | 1nA | 1ms | 1e-5 | 1e-3 | -71.65mv | 77.95um | 17.76ms |  |
| H15 |  | 20x1um |  | 5000 | 0.5s | 2 | 1nA | 1ms | 1e-9 | 1e-3 | -64.95 | 20.56um | 12.4ms |  |

# Neuron model

|  |  |
| --- | --- |
| Dims | 20x1um |
| Cm | 2uF/cm2 |
| Pas | G= 0.0001 S/cm2 Vm=-72.6 |
| Iclamp | 1ms delay. 0.1nA. 1ms duration. Graphed for 30ms |
| Max v | -61.7mV |
| Tau | 13ms (est. on graph) |
| Lambda | Approx. 20-40um (est. by calculation) |
|  |  |
|  |  |

# Baseline trial

## Setup

|  |  |
| --- | --- |
| Experiment | **Experiment H4.** Using template T1 |
| Dimensions | 9 compartments – length 20um, diam 0.5 um. Total length 180um |
| IAs | Z = -0.85 in all compartments |
| Cm | 2 uF/Cm2 |
| Membrane  Conductances | gna = 2e-3/F  gk = 7e-3/F  gcl = 2e-3/F  gx = 1e-8 # gna,gk,gcl: conductances in mS/cm^2 conv to S/dm^2 (10^-3/10^-2)  g\_kcc2 = 2e-3/F  g\_na\_k\_atpase=(10 \*\* -1) / F |
| Diffusion constants | diff\_constants = {"na" : 1.33e-7, "k": 1.96e-7, "cl":2.03e-7, "x":0} |
| Current addition | 1uA current onto comp 9. 1 ms duration. Start at 0.1s and sim ends at 0.4s. |
| Timing | 0.5s total. Current start as 0.1 s. 3000 intervals for graphing clarity |

## Results

Chart

Description automatically generatedA picture containing background pattern

Description automatically generated Graphical user interface

Description automatically generated

Chart, line chart

Description automatically generated

Text, letter

Description automatically generated

## Conclusions

* Length constant is too short, it should be in the region of 150 um – 500 um.
  + This is clear from the axial resistance which needs to be 200 ohm-cm
  + To make this more accurate we need ions to increase the electrodiffusion constants
* Time constant is too short should be in the region of 12 – 20 ms.
  + This is clear from the Rm which needs to be between 3000- 30 000
  + To make this more accurate we need to increase the Rm by decreasing the conductances

## Plan

* Repeat the above experiment with diffusion constants increased by a factor of 100 so ions will move easier along the axial plane.
* Don’t want to change the membrane conductances just yet.
* Don’t actually see the membrane acting as a capacitor to calculate the length constant
  + Perhaps there aren’t enough intervals.. increasing from 3000 to 10000
  + Increase duration of current to 0.2s

# Trial 1 – attempt to reduce Ri

## Setup

|  |  |
| --- | --- |
| Experiment | **Experiment H5.** Using template T1 |
| Dimensions | 9 compartments – length 20um, diam 0.5 um. Total length 180um |
| IAs | Z = -0.85 in all compartments |
| Cm | 2 uF/Cm2 |
| Membrane  Conductances | gna = 2e-3/F  gk = 7e-3/F  gcl = 2e-3/F  gx = 1e-8 # gna,gk,gcl: conductances in mS/cm^2 conv to S/dm^2 (10^-3/10^-2)  g\_kcc2 = 2e-3/F  g\_na\_k\_atpase=(10 \*\* -1) / F |
| Diffusion constants | **diff\_constants = {"na" : 1.33e-5, "k": 1.96e-5, "cl":2.03e-5, "x":0}** |
| Current addition | 1uA current onto comp 9. 1 ms duration. Start at 0.1s and sim ends at 0.4s. |
| Timing | 0.5s total. Current start as 0.1 s. 3000 intervals for graphing clarity |

## Results

A picture containing background pattern

Description automatically generatedGraphical user interface

Description automatically generated

Chart, scatter chart

Description automatically generatedChart

Description automatically generated

## Conclusion

## Plan

# Trial 2 – decreasing the capacitance

## Setup

|  |  |
| --- | --- |
| Experiment | **Experiment H11.** Using template T4 (capacitance in template already 0.5) |
| Dimensions | 9 compartments – length 20um, diam 0.5 um. Total length 180um |
| IAs | Z = -0.85 in all compartments |
| Cm | 0.5 uF/Cm2 |
| Membrane  Conductances | gna = 2e-3/F  gk = 7e-3/F  gcl = 2e-3/F  gx = 1e-8 # gna,gk,gcl: conductances in mS/cm^2 conv to S/dm^2 (10^-3/10^-2)  g\_kcc2 = 2e-3/F  g\_na\_k\_atpase=(10 \*\* -1) / F |
| Diffusion constants | diff\_constants = {"na" : 1.33e-7, "k": 1.96e-7, "cl":2.03e-7, "x":0} |
| Current addition | 1nA current onto comp 9. 1 ms duration. Start at 0.1s and sim ends at 0.4s. |
| Timing | 0.5s total. Current start as 0.1 s. 5000 intervals for graphing clarity |

## Results

Chart

Description automatically generatedGraphical user interface

Description automatically generated

Text, letter

Description automatically generatedChart

Description automatically generatedText, letter

Description automatically generated

Text, letter

Description automatically generatedChart, scatter chart

Description automatically generatedText, letter

Description automatically generated

# Trial 3 – trying to compare to neuron

## Setup

Experiment-H13

|  |  |
| --- | --- |
| PYTHON | NEURON |
| Capacitance = 2uF/Cm2 | Capacitance = 2uF/Cm2 |
| **diff\_constants = {"na" : 1.33e-5, "k": 1.96e-5, "cl":2.03e-5, "x":0}** | Ra = 200 ohm-cm (as per reviews) |
| gna = 2e-3/F  gk = 7e-3/F  gcl = 2e-3/F |  |
| Current:  1nA  1ms duration | Current:  1nA  1ms duration |
|  |  |
|  | Tau = 2 ms |
| Plan: Try to increase resistance by decreasing the diff. constants to e-7 |  |

# Trial 4 – increasing resistance

Experiment-H14

|  |  |
| --- | --- |
| PYTHON | NEURON |
| Capacitance = 2uF/Cm2 | Capacitance = 2uF/Cm2 |
| **diff\_constants = {"na" : 1.33e-7, "k": 1.96e-7, "cl":2.03e-7, "x":0}** | Ra = 200 ohm-cm (as per reviews) |
| gna = 2e-3/F  gk = 7e-3/F  gcl = 2e-3/F |  |
| Current:  1nA  1ms duration | Current:  1nA  1ms duration |
|  |  |
|  | Tau = +-2 ms |
|  |  |

# Trial 5 – further resistance increase

Experiment H15

|  |  |
| --- | --- |
| PYTHON | NEURON |
| Capacitance = 2uF/Cm2 | Capacitance = 2uF/Cm2 |
| **diff\_constants = {"na" : 1.33e-9, "k": 1.96e-9, "cl":2.03e-9, "x":0}** | Ra = 200 ohm-cm (as per reviews) |
| gna = 2e-3/F  gk = 7e-3/F  gcl = 2e-3/F |  |
| Current:  1nA  1ms duration | Current:  1nA  1ms duration |
| Too much axial resistance |  |
|  | Tau = +-2 ms |
|  |  |

# Trial 6 –Less leaky

Experiment H16

|  |  |
| --- | --- |
| PYTHON | NEURON |
| Capacitance = 2uF/Cm2 | Capacitance = 2uF/Cm2 |
| diff\_constants = {"na" : 1.33e-7, "k": 1.96e-7, "cl":2.03e-7, "x":0} | Ra = 200 ohm-cm (as per reviews) |
| gna = 2e-3/(F \***10)**  gk = 7e-3/(F \*10)  gcl = 2e-3/(F \*10) |  |
| Current:  1nA  1ms duration | Current:  1nA  1ms duration |
|  | Chart  Description automatically generated |
|  | Tau = +-2 ms |
| Stuff up experiment |  |