Characterize Sodium Channel, Potassium Channel

Following are the model specifications used:

Model Parameters:

soma

- diameter = 18.8
- L=18.8
- Ra=123.0
- ena=71.5
- ek=-89.1

The Na.mod file is used to model the sodium channel, and the K.mod file is used to model the potassium channel.

Both files are present in the zip folder.

To create the soma model, the model.hoc file is used. Using this, we can simulate the model and find the different characteristics of both channels. This model contains sodium and potassium channels from the respective mod files.

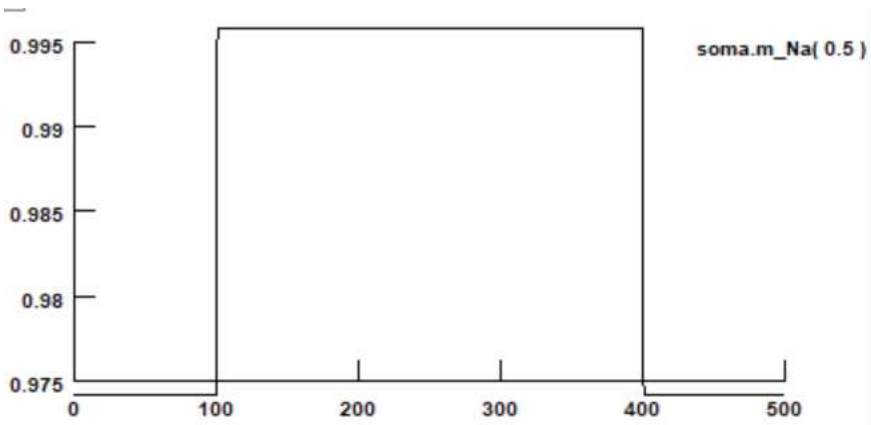
Only Sodium channel

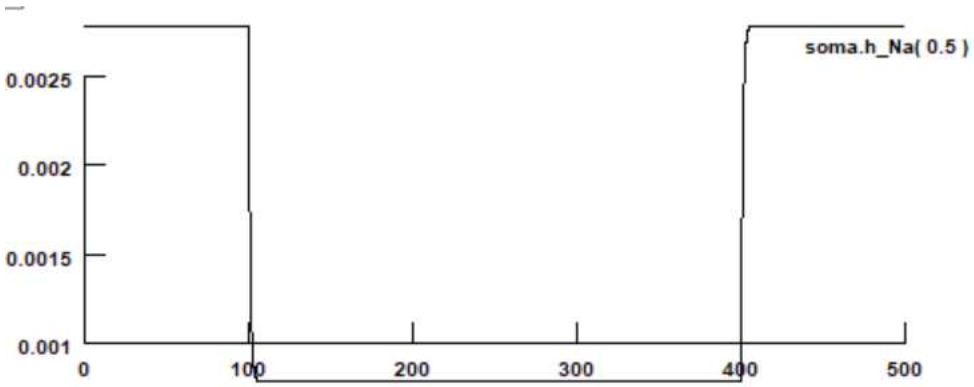
Use the soma_na.hoc file for this.

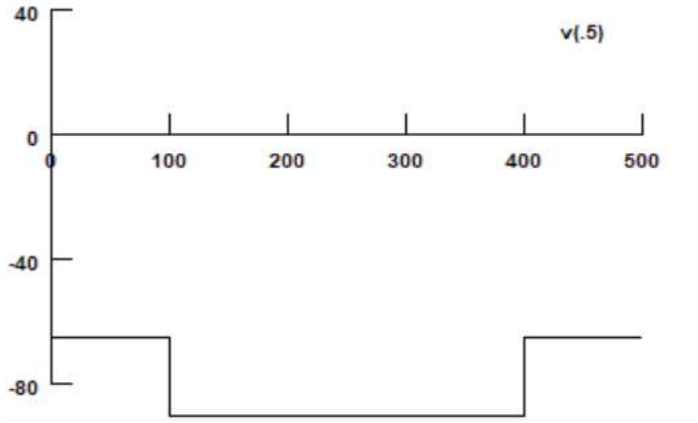
When voltage clamped at:

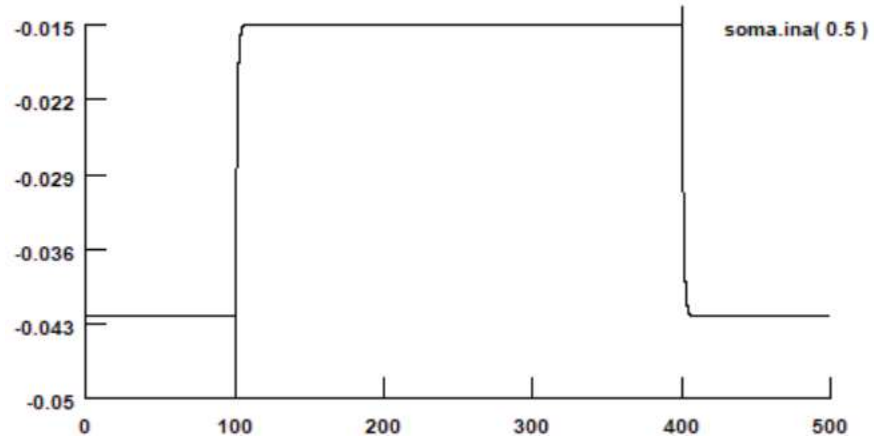
condition level : 100ms,-65 mv
Test level: 300 ms,-90mv
Return Level : 100ms ,-65mv

plotting sodium current and gating variables m and h.

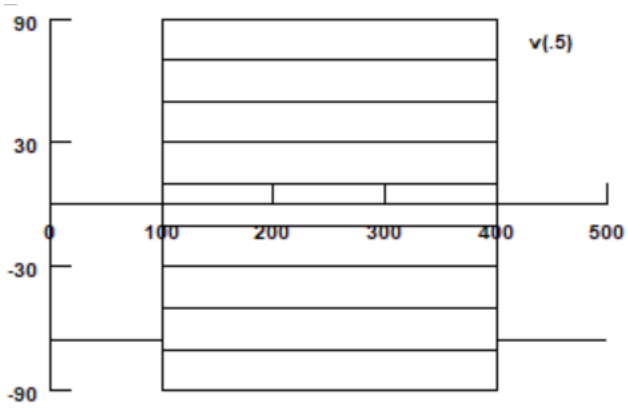


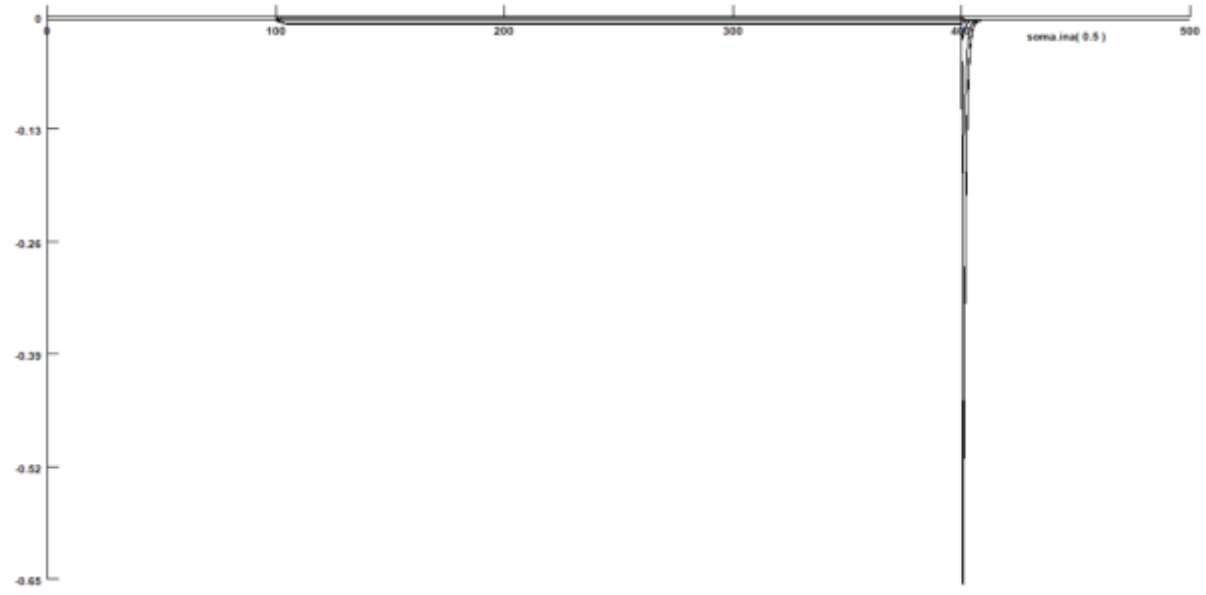


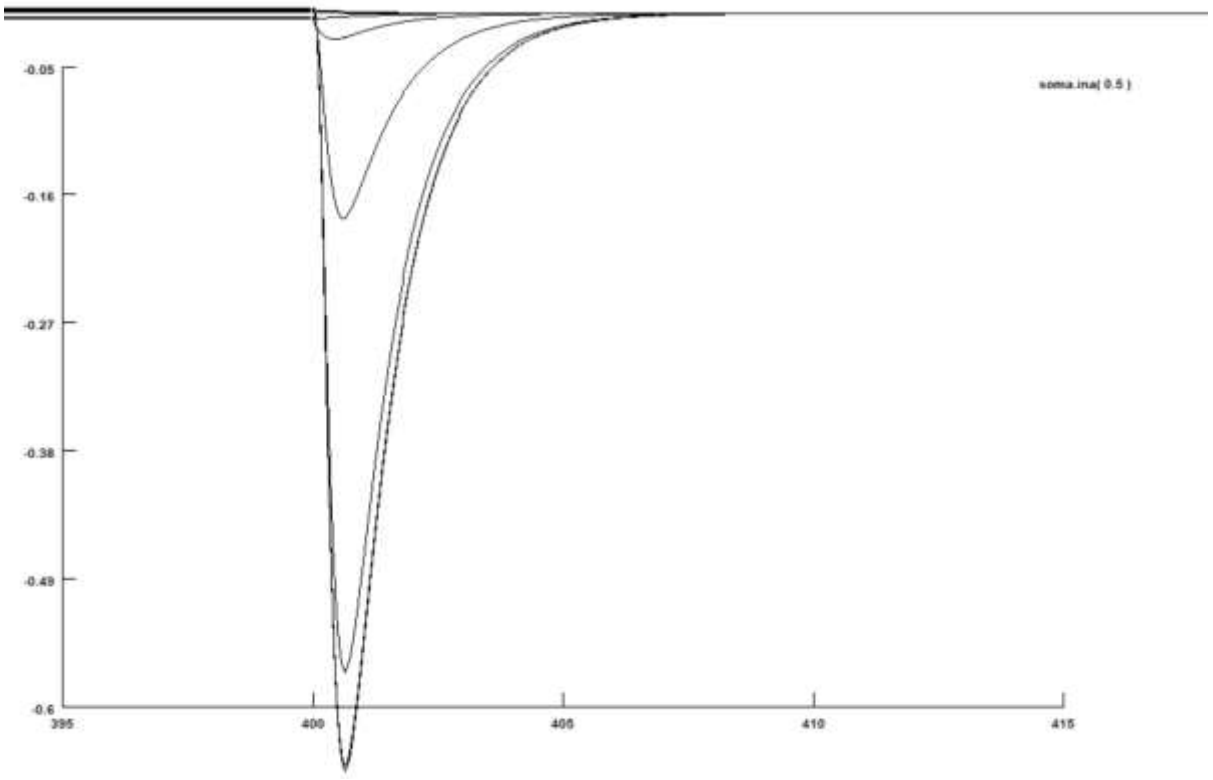


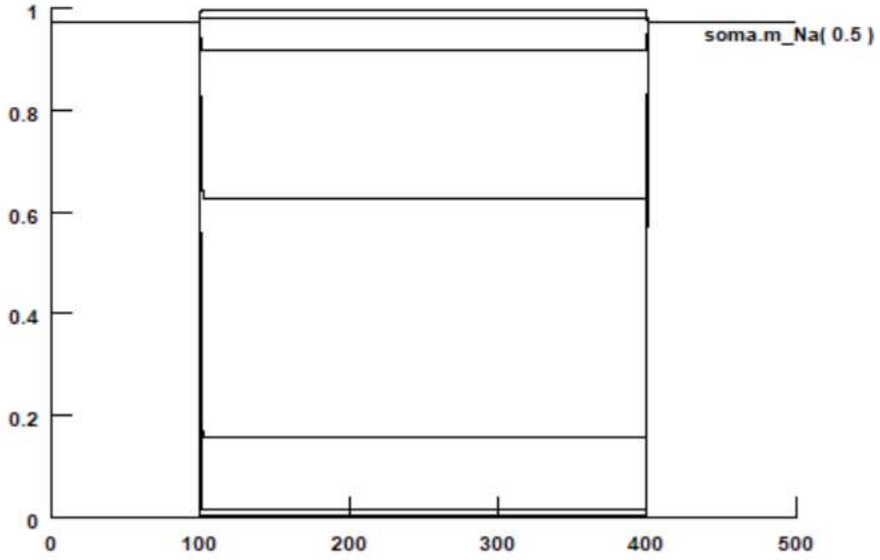


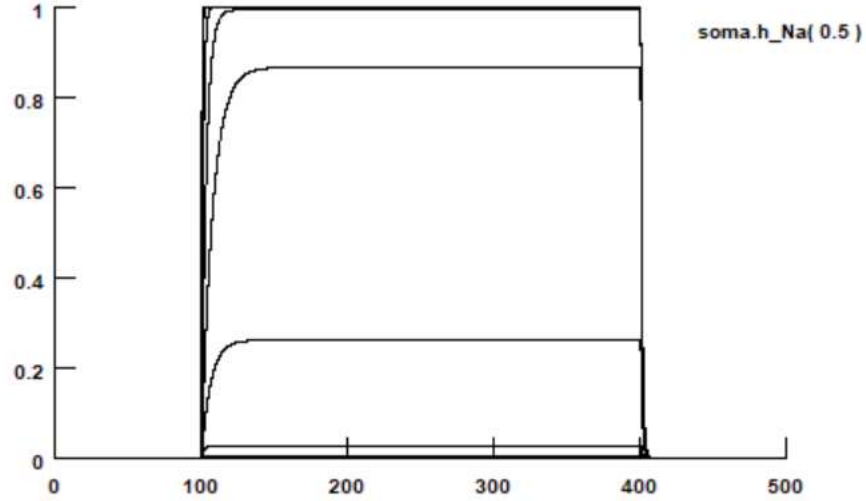
Here we are clamping voltage at different voltages ranging from -90mV to 90mV at an interval of 20mV. At each clamp we are plotting the sodium current and gating variables m and h.


90
30
-30
-90
0
100
200
300
400
500
v(.5)

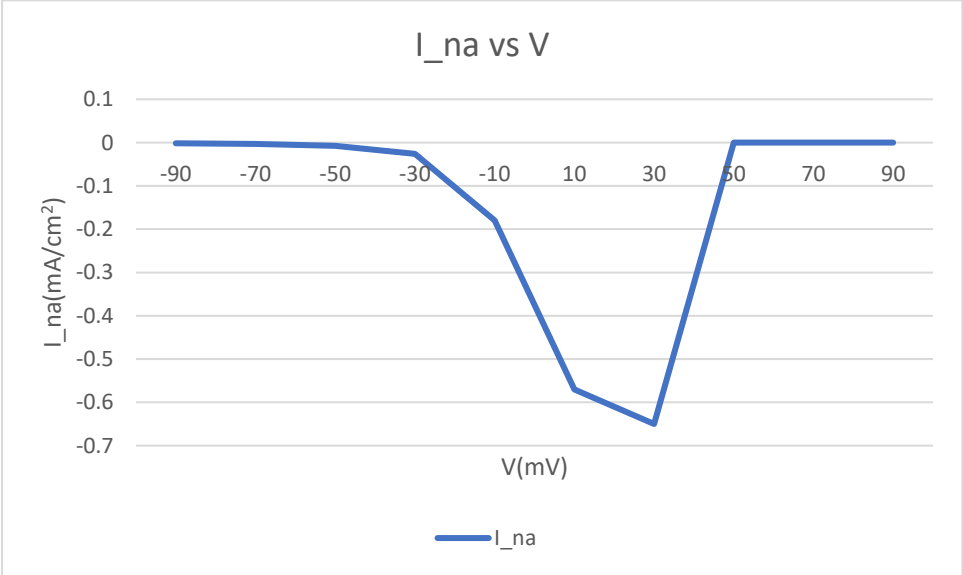

0
-0.13
-0.26
-0.39
-0.52
-0.65
0
100
200
300
400
500
soma.ina(0.5)


-0.05
-0.16
-0.27
-0.38
-0.49
-0.6
395
400
405
410
415
soma.ina(0.5)





I-V curve for sodium channel



From the plot we can observe that the sodium current is inward and also it goes to zero when it reaches E_na value. We can clearly observe the HH sodium current along with the gating variable m and h which are also same as HH model.

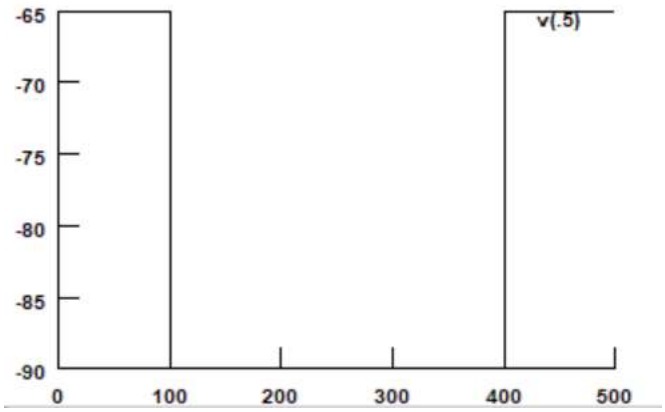
Only Potassium channel

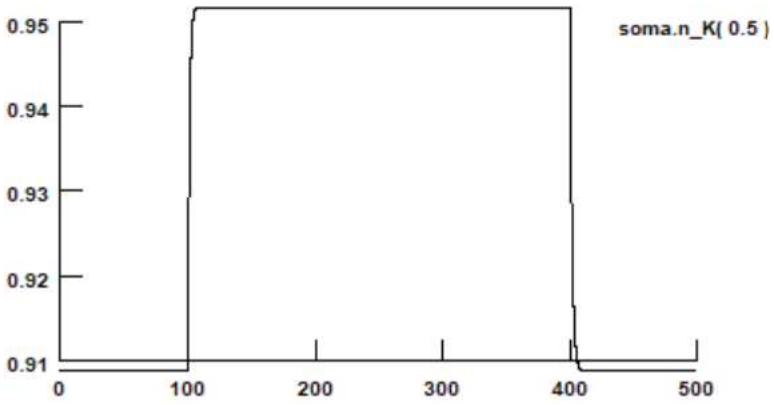
Use the soma_k.hoc file for this.

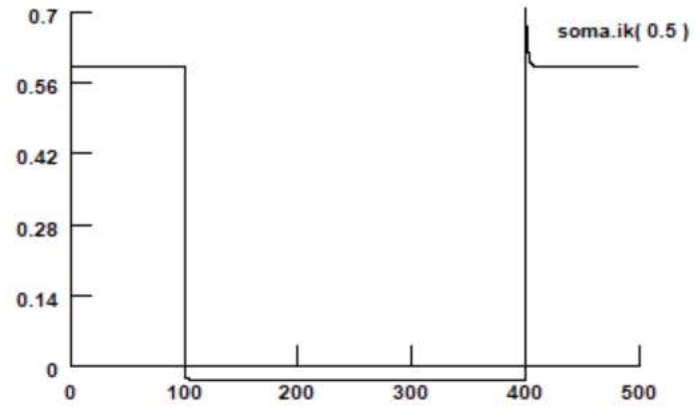
When voltage clamped at:

condition level: 100ms,-65 mv
Test level: 300 ms,-90mv
Return Level : 100ms ,-65mv

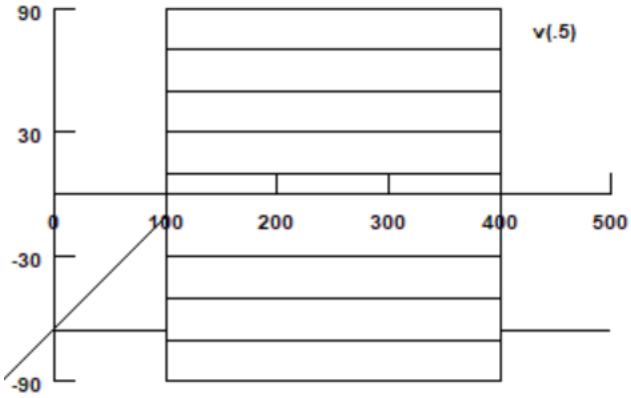
Plotting potassium current and gating variable n.

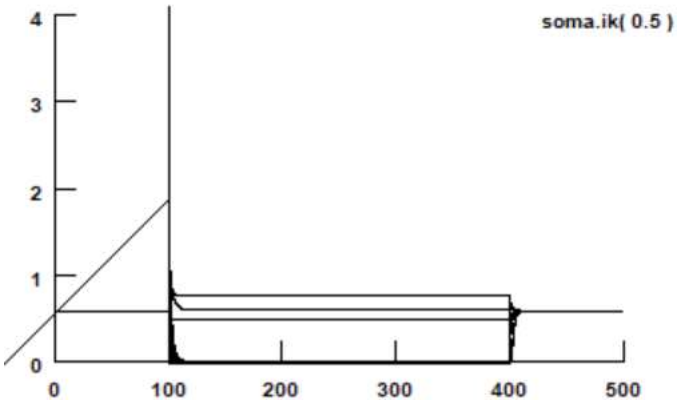


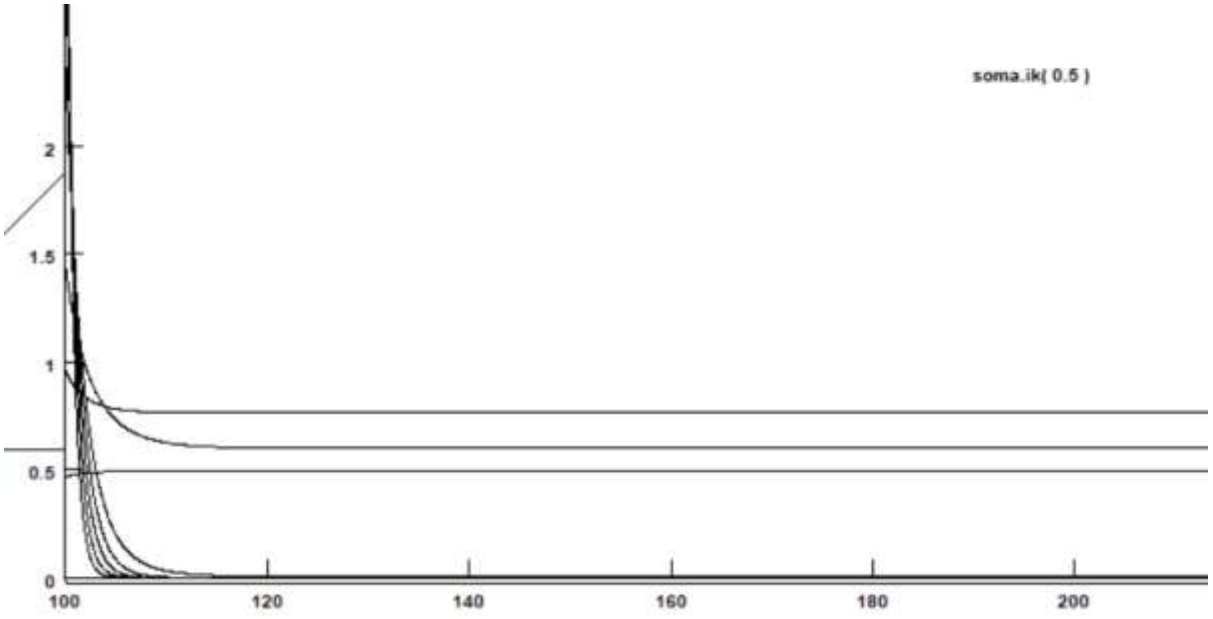


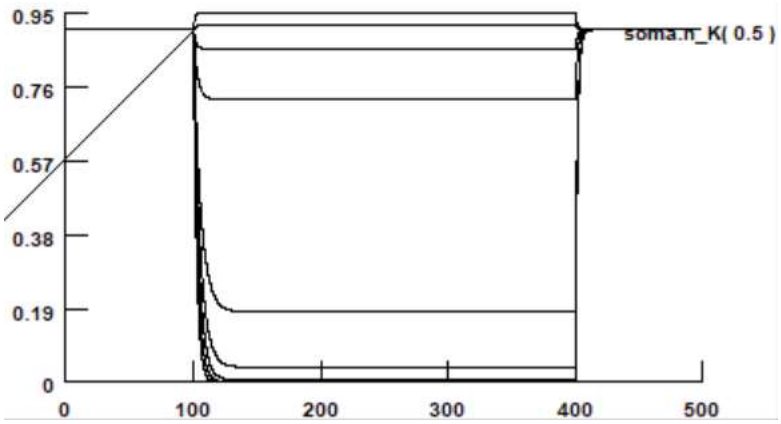


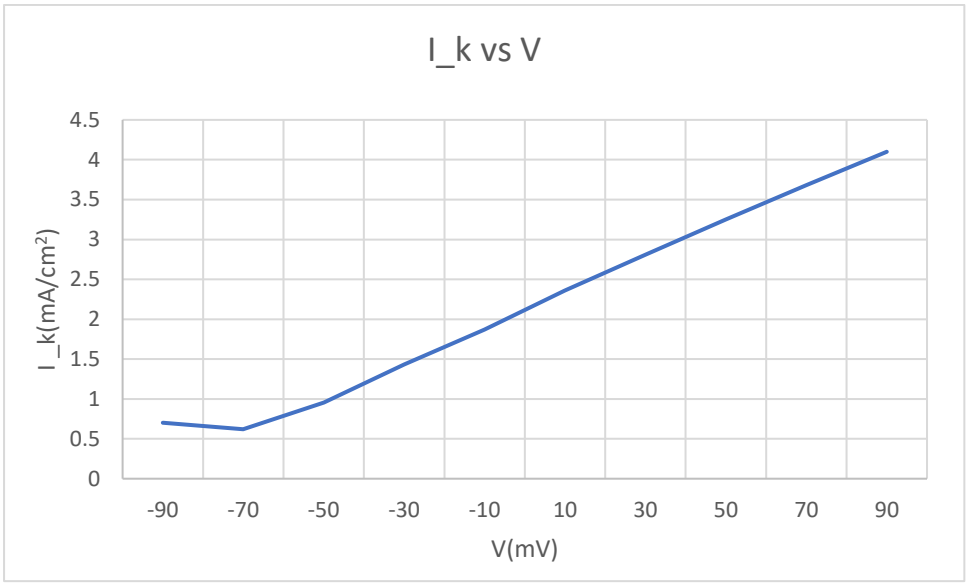
Here we are clamping voltage at different voltages ranging from -90mV to 90mV at an interval of 20mV. At each clamp we are plotting the potassium current and gating variable n.









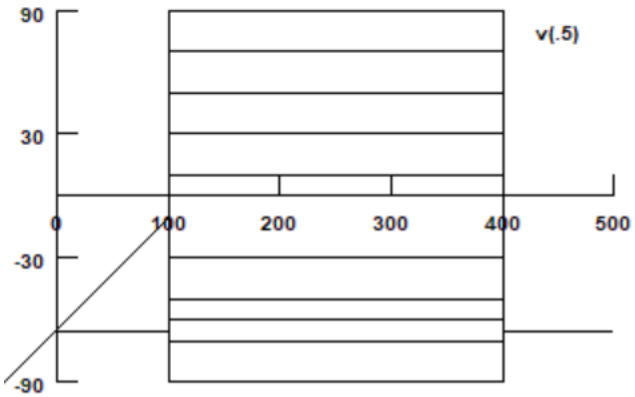


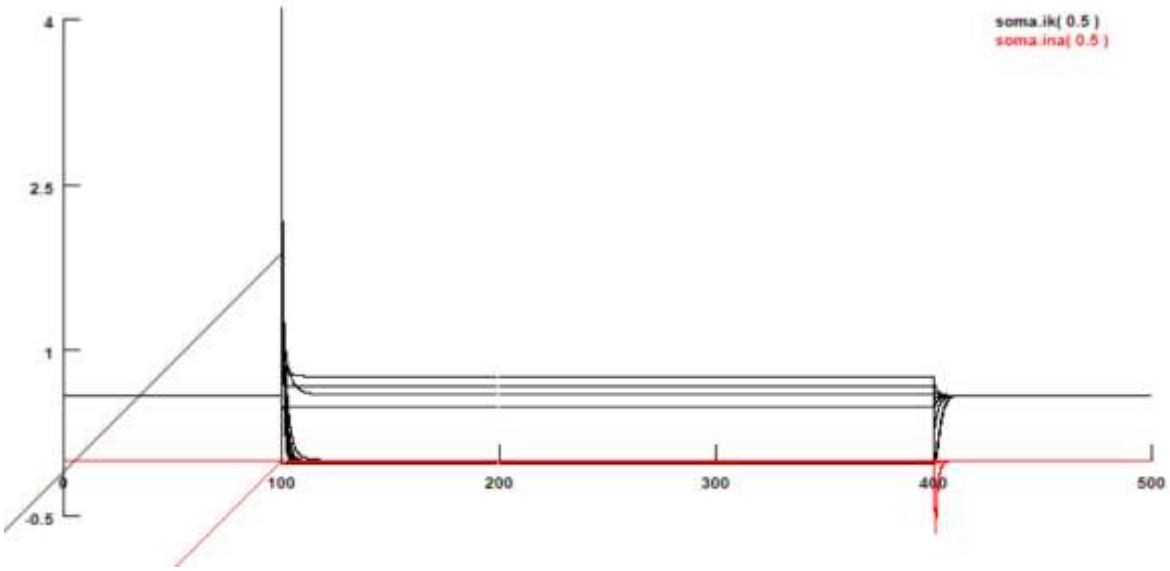
From the plot we can observe that the potassium current is outward. Also, we can see that potassium current is never zero but close to zero around E_k, this nature is same as HH model. The gating variable n is also same as HH model.

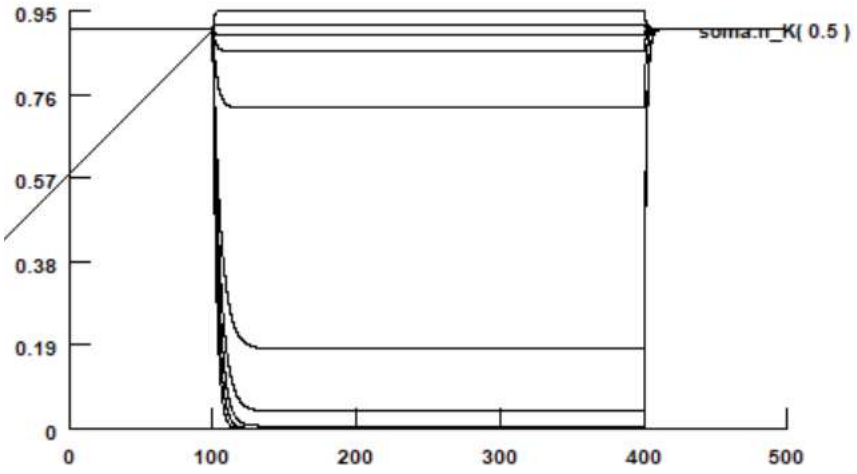
Both Sodium and potassium channel

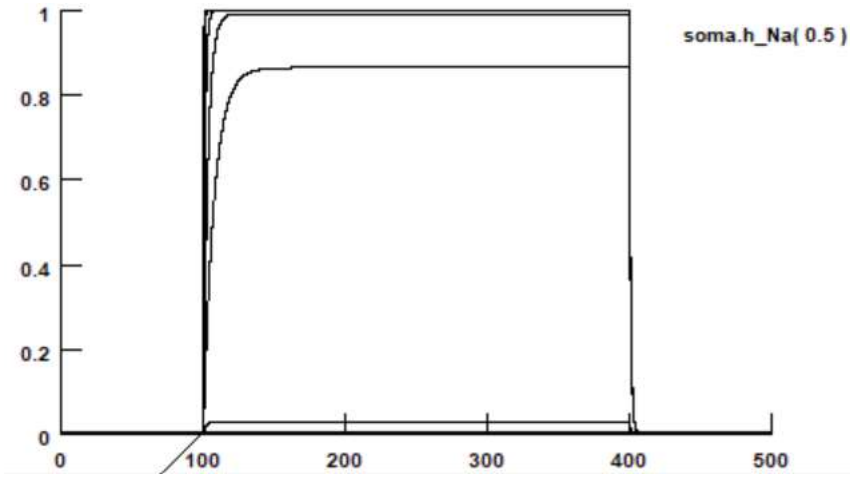
Use the model.hoc file for this.

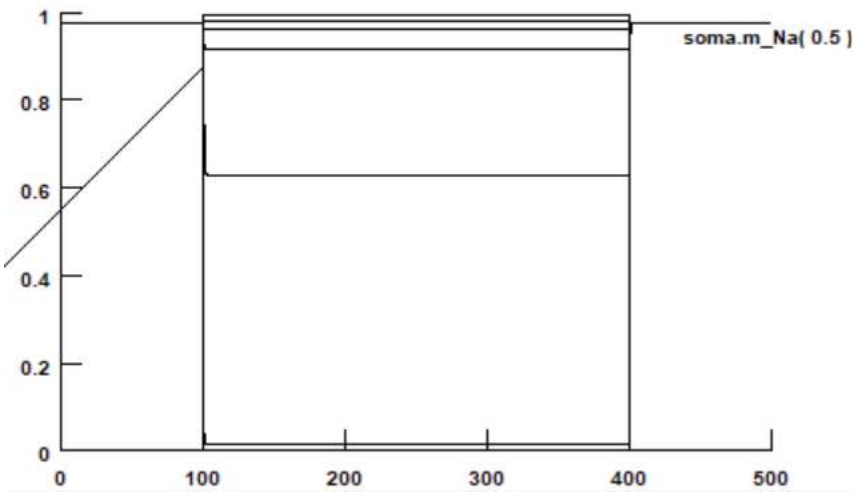
Here we are clamping voltage at different voltages ranging from -90mV to 90mV at an interval of 20mV. At each clamp we are plotting the sodium current, potassium current and gating variables m, n and h.



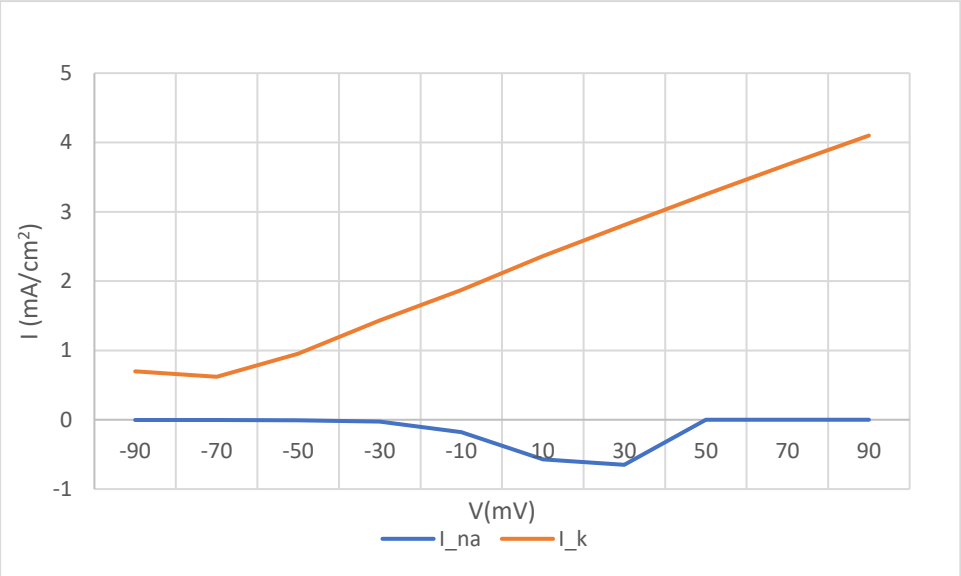

soma.ik(0.5)
soma.ina(0.5)
4
2.5
1
-0.5
0
100
200
300
400
500


soma.n_K(0.5)
0.95
0.76
0.57
0.38
0.19
0
0
100
200
300
400
500


soma.h_Na(0.5)
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500



I-V curve for both sodium and potassium channel combined



Looking at the plots we can infer the formation of action potential and understand the HH model. As both the channels together are exactly showing the HH model where the sodium inward current increases and then achieves a peak and comes back to zero at reversal potential of sodium. On the other hand potassium current increases and there is sudden increase once sodium current slow down and repolarization is happening.