Modelling K(A) Channel

K(A) channel is voltage-gated(depolarization) and calcium-independent. These are transient and fast inactivating. This channel is similar to the potassium-delayed rectifier channel but comparatively faster than that. It is called K(A) since it is blocked by 4-Aminopyridine, and the current $I_{K(A)}$ is a 4-Aminopyridine-sensitive current.

$I_{K(A)}$ currents are voltage-gated, calcium-independent potassium currents that undergo rapid activation and inactivation—commonly associated with neuronal and cardiac cell types.

$I_{K(A)}$ is an outward current given by

$$I_{K(A)} = g_{K(A)}bar *m*h*(V-E_k)$$

where m is the activating gating variable and h is the inactivating gating variable; both depend on voltage.

For this channel the
Active voltage ~ -60mV
Activation time (tau_m) ~ 5-10ms
Inactivation time (tau_h) ~ 20-30ms

This channel is responsible for spike repolarization because it activates fast (almost in order of AP) and controls bursting because it's active immediately after an Action potential, leading to hyperpolarization.

Model Parameters specification:

soma

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

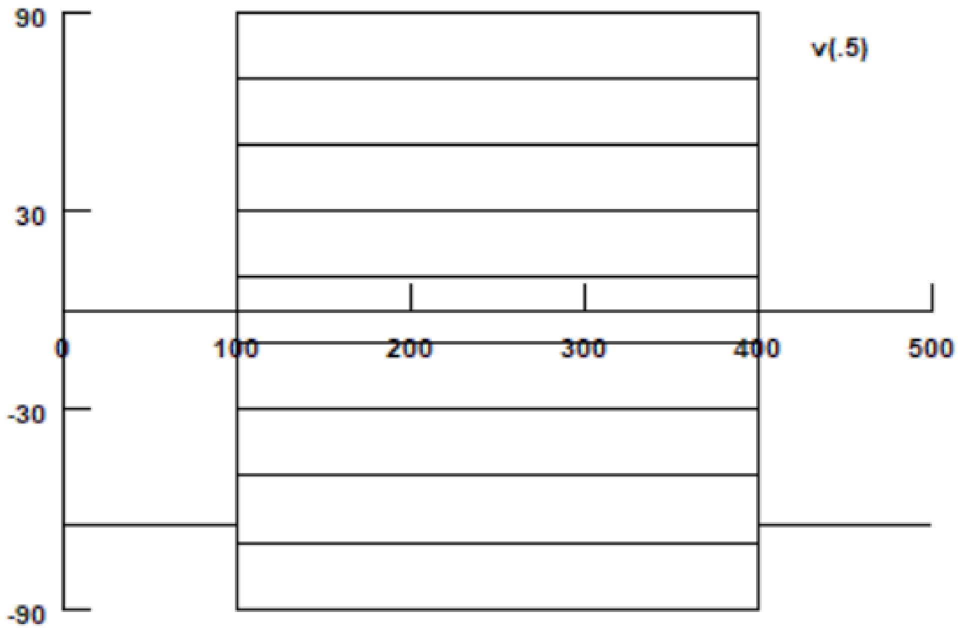
The ka.mod file models the voltage-gated transient potassium channel. It is responsible for transient and fast inactivating potassium current $I_{K(A)}$.

To create the soma model, the model.hoc file is used. Using this, we can simulate the model and find the behavior of this channel and the current produced.

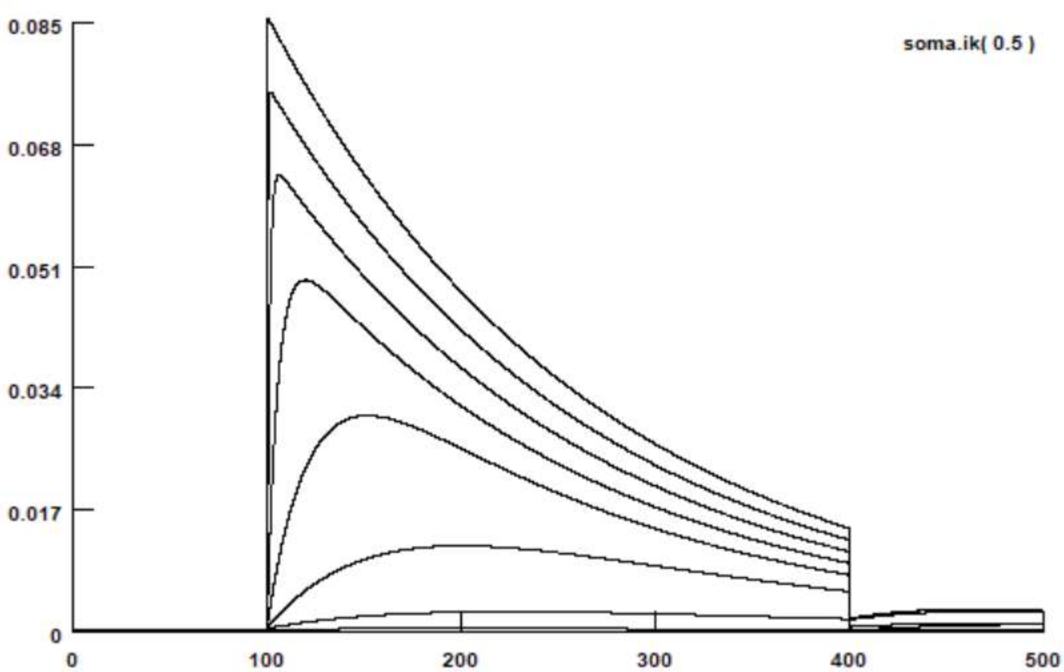
Voltage clamped at:

condition level: 100ms, -65 mv
Test level: 300 ms,(-90mV to +90mV) (varied with the steps of 20mV)
Return Level: 100ms, -65mv

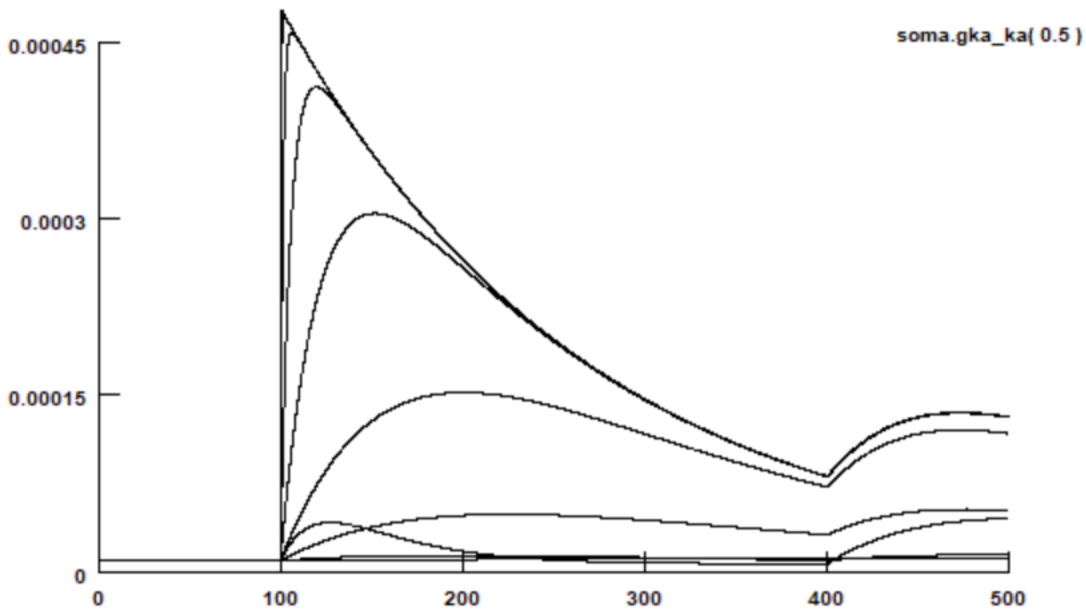
Voltage vs time graph



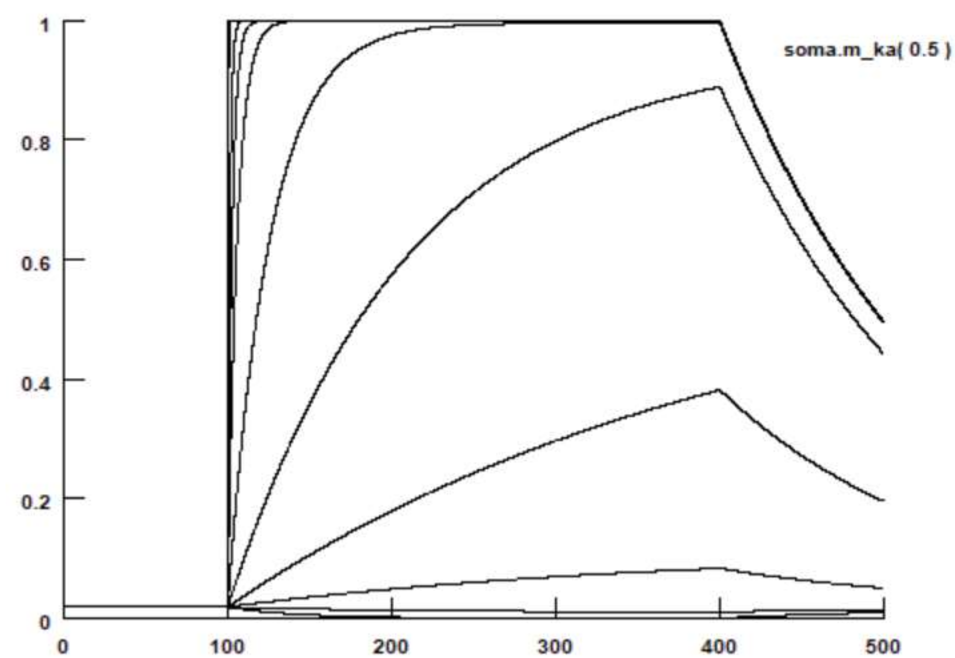
$I_{K(A)}$ vs time Graph



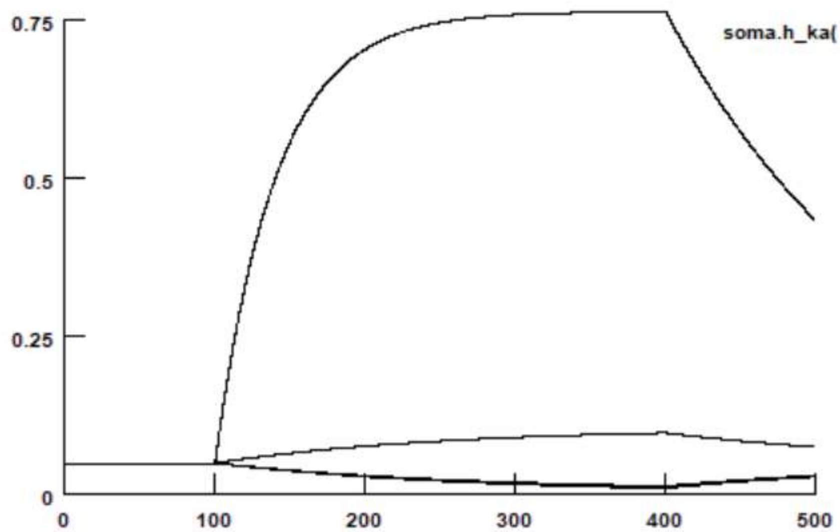
g$_{K(A)}$ vs time graph



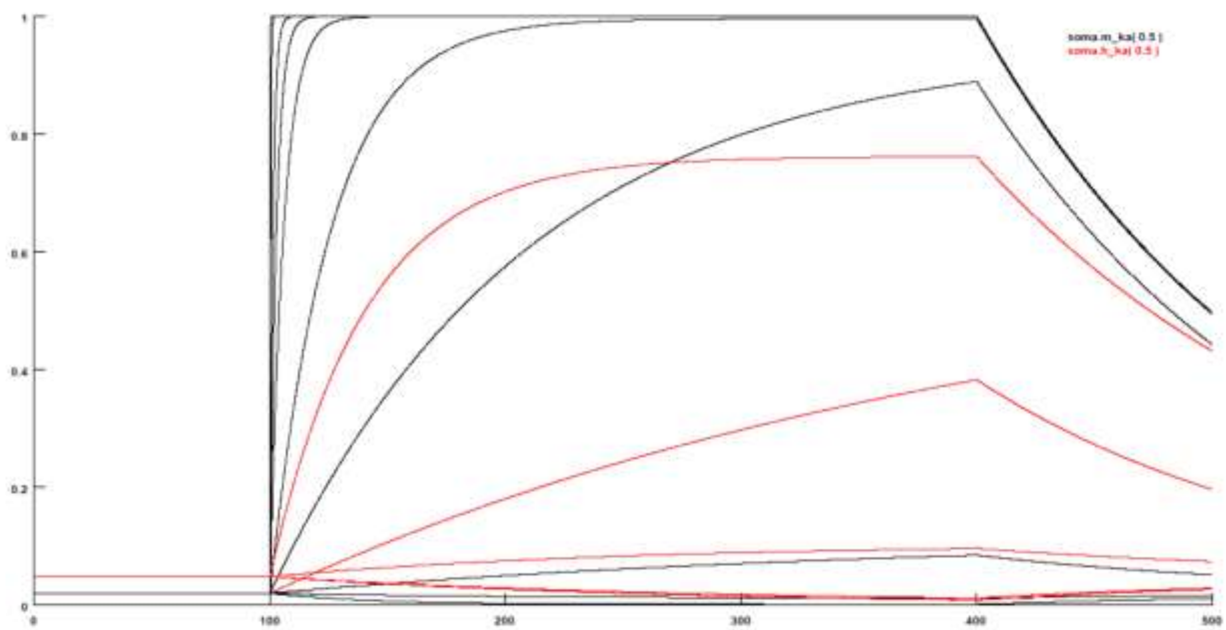
m vs time graph



h vs time graph



m and h vs time graph



In the above graphs, we can observe that as the stimulus is given at 100ms, the channel activates rapidly, and we get the current peak in 10ms since the time constant for activation is 5-10ms. However, since the inactivation is also fast, the current decays almost after 15 ms since the time constant for inactivation is 10-20 ms.

Also, we can see that for higher voltages, the value of the gating variable m is close to 1, and h is close to 0. Showing fast activation as well as inactivation.