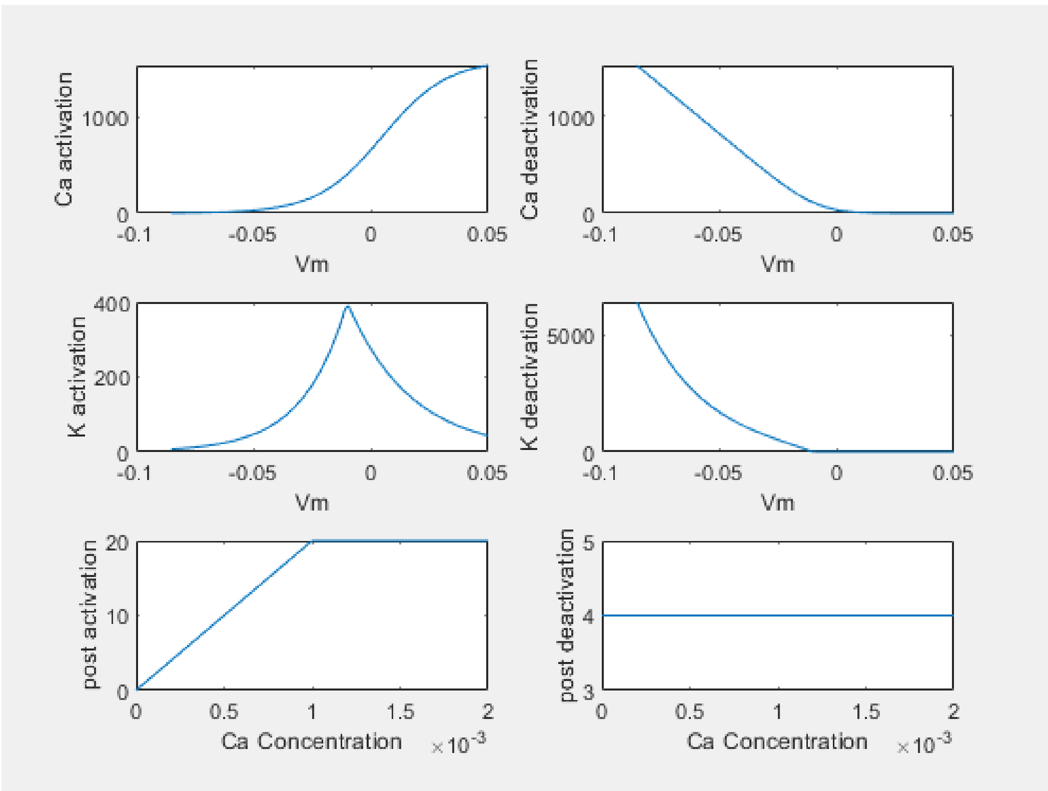
Connor Zawacki

Tutorial 4.3

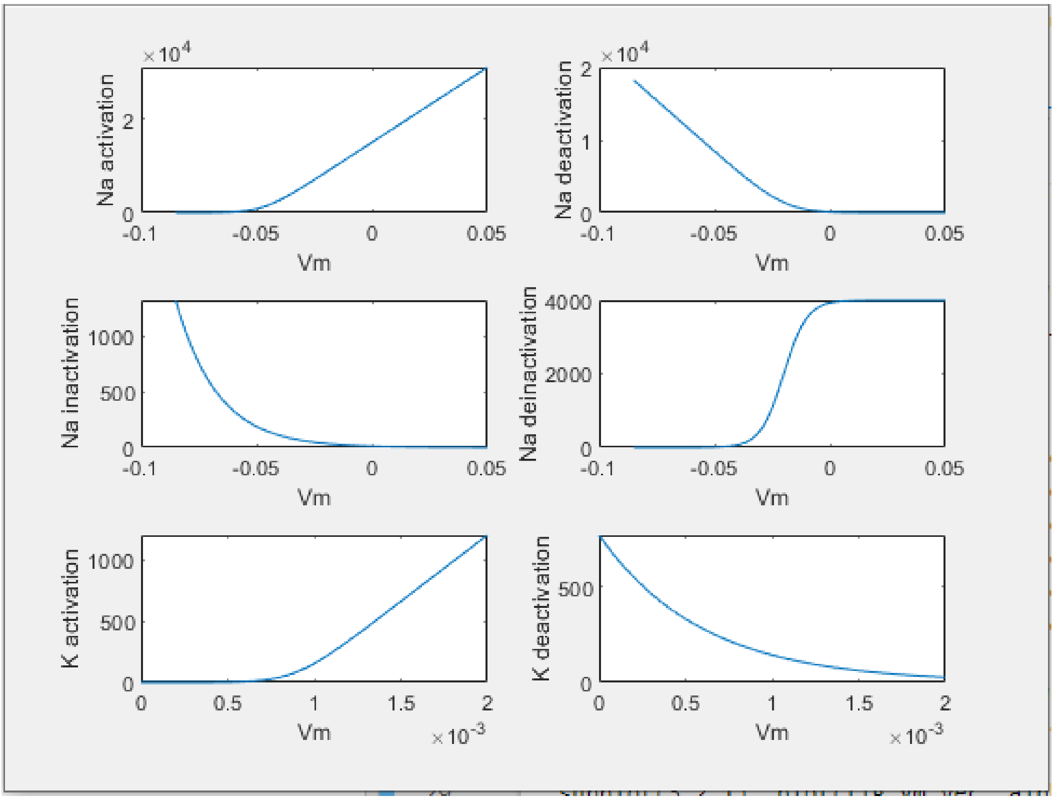
2.)

Dendrite gating variables:

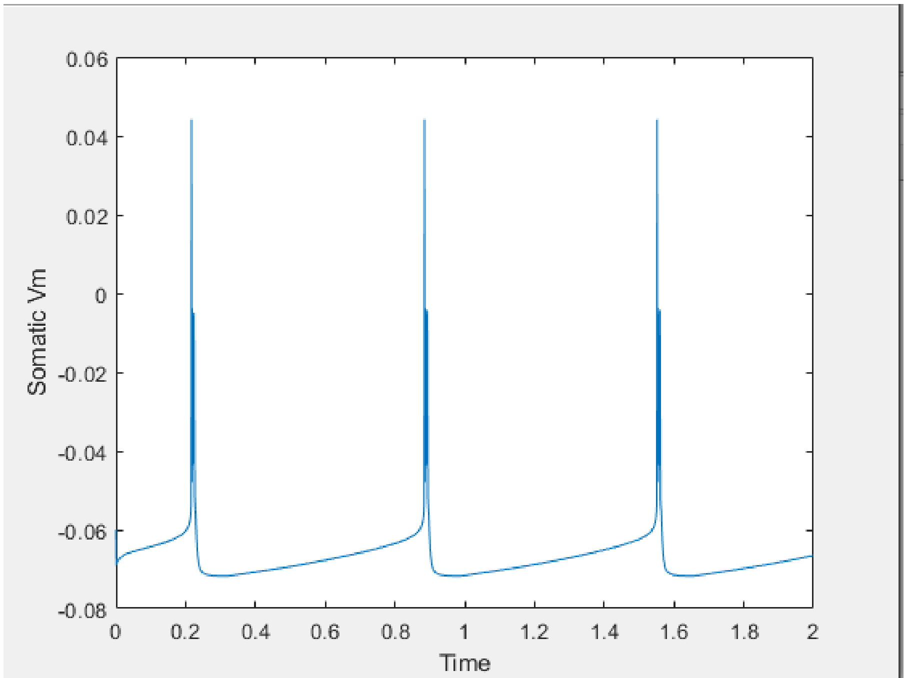


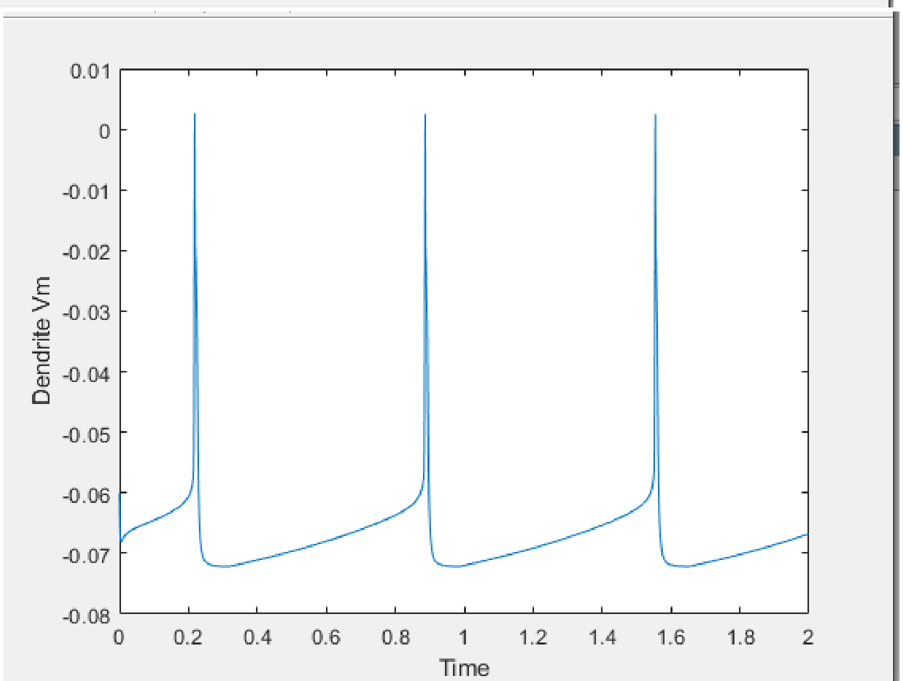
NOTE: “post activation” and “post deactivation” are stand ins for “after-hyperpolarization activation rate constant” and “after-hyperpolarization deactivation rate constant” respectively, the abbreviated names above are simply concessions towards space for axis titles. All y axis titles should theoretically end with “rate constant”. Additionally, all gating variables were plotted with respect to the variable they depend on, that being membrane potential for all except after-hyperpolarization activation and after-hyperpolarization deactivation, where it was calcium concentration.

Somatic gating variables:



3.) First simulation of the Pinsky-Rinzel model

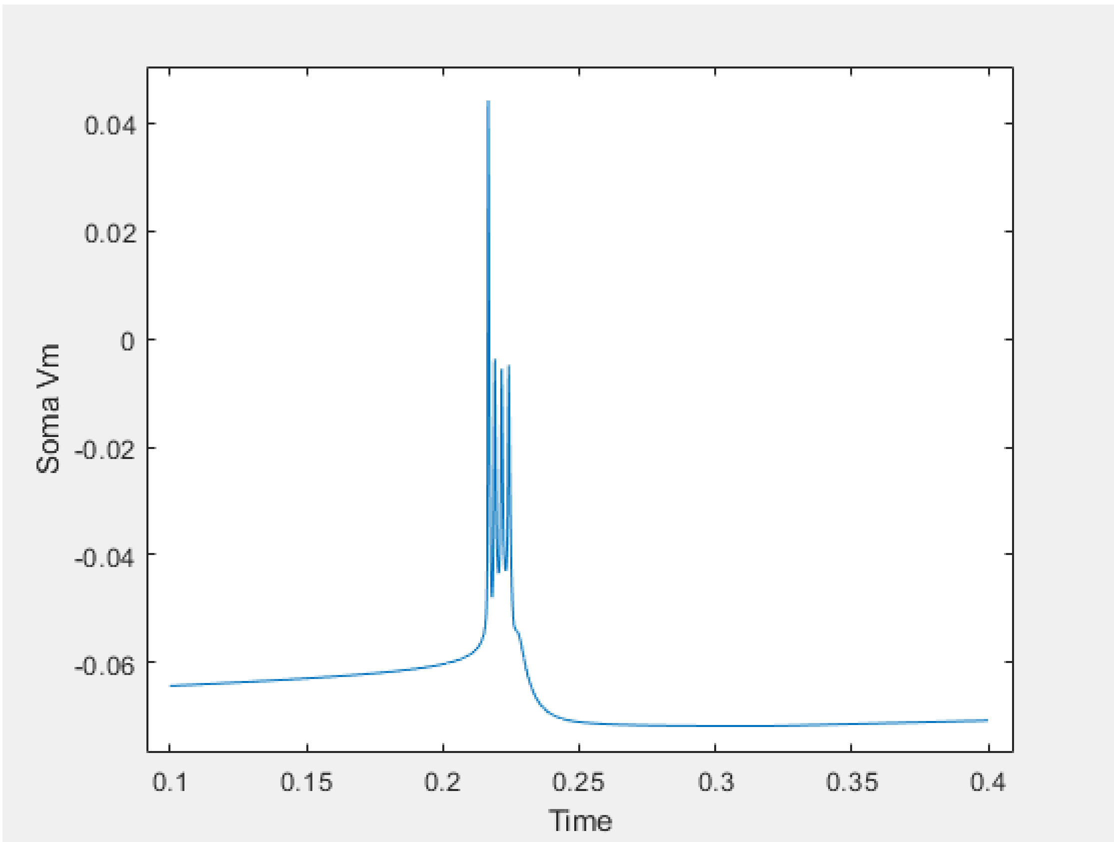




Despite a lack of applied current, the 2 compartment Pinsky-Rinzel model is capable of bursts of spikes.

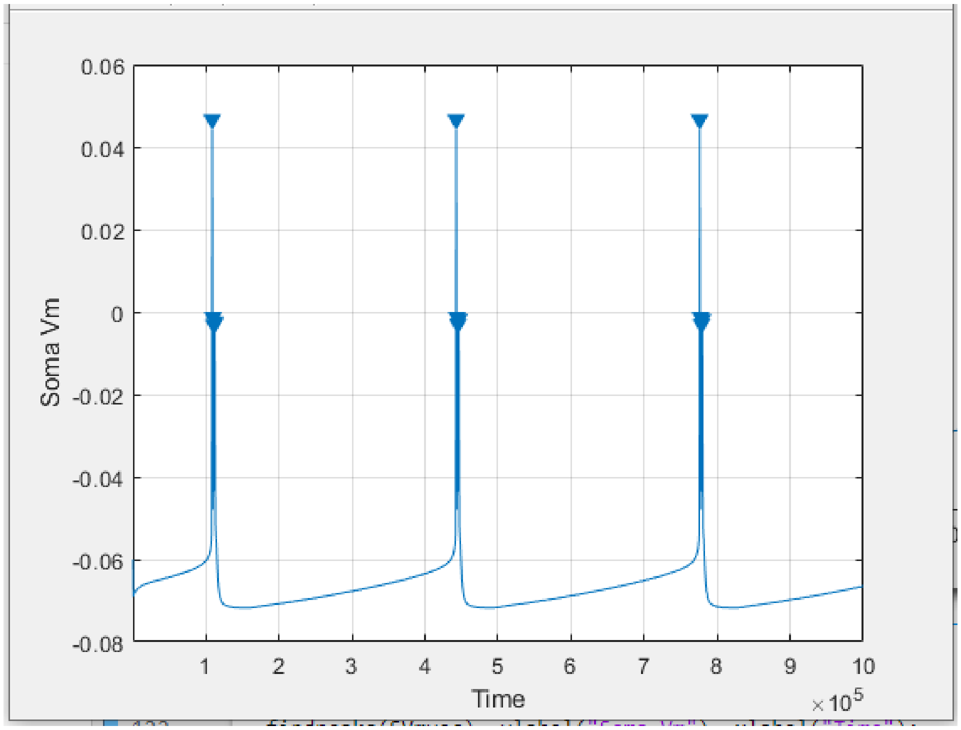
The first two graphs on the left show somatic and dendritic membrane potentials according to time. The third (next page) is a “zoomed in” view on one of the Somatic spiking events. As can clearly be seen, each of these events is a burst of spikes.

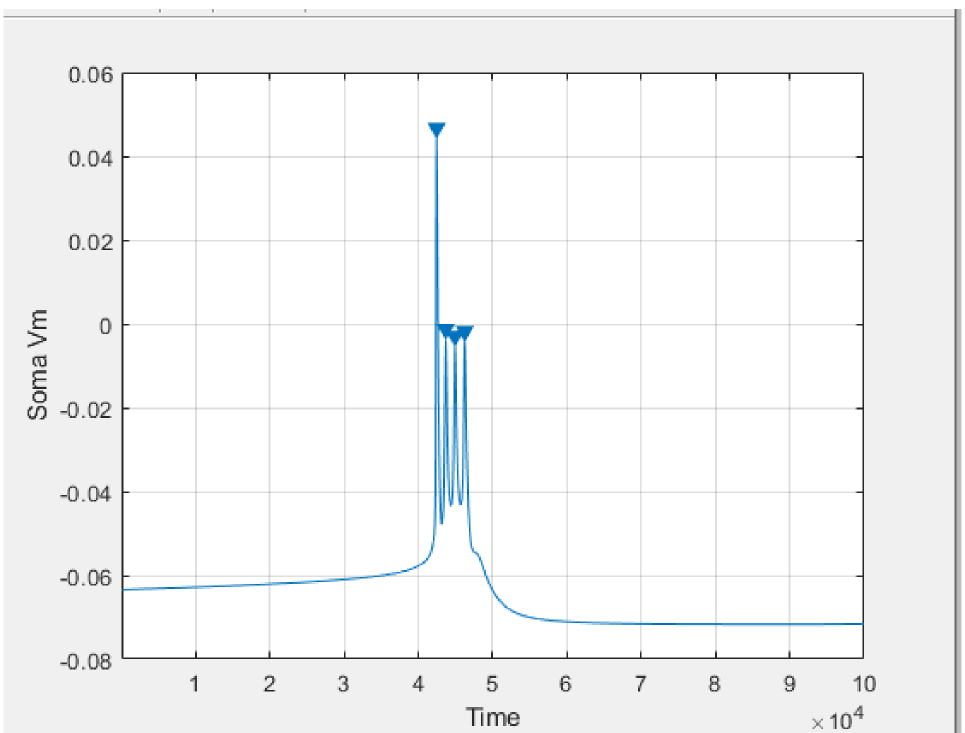
Regular broad calcium spikes in the dendrite contribute to shorter, more rapid sodium spikes in the soma, followed by a several hundread millisecond interval.



(a zoomed in view of the somatic Vm as a function of time for question 2.)

4.)Visualization of somatic spikes

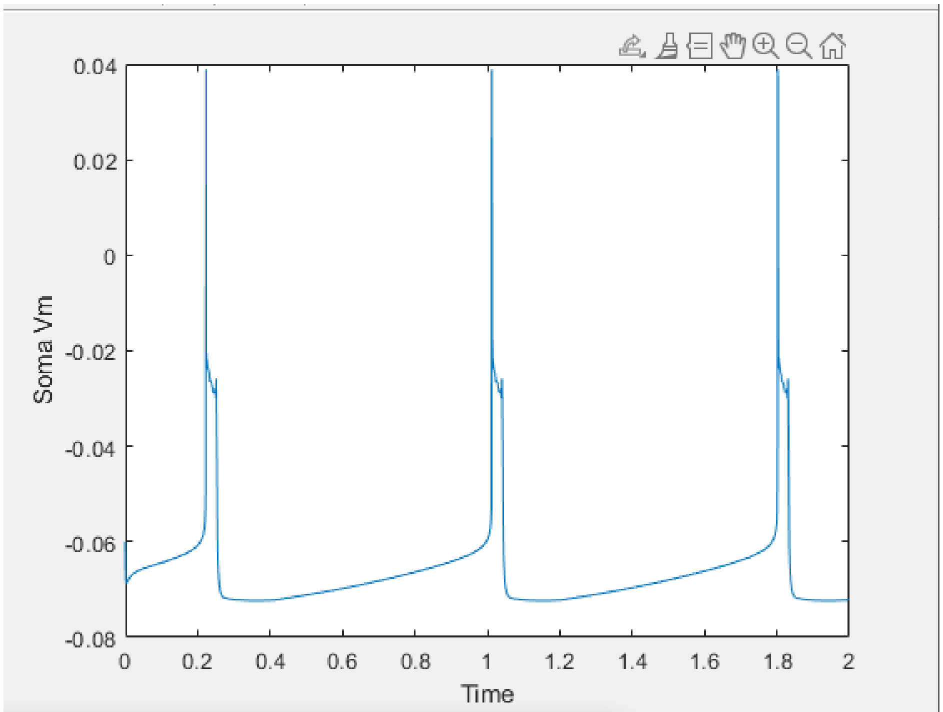


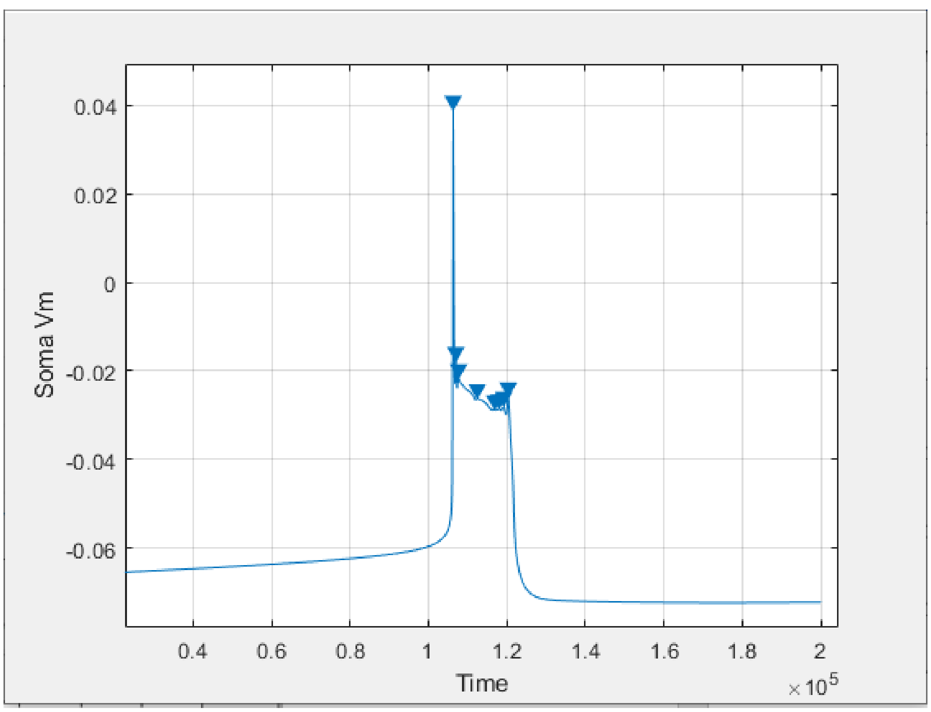


Using findpeaks, we are able to much bettter visualize the bursting activity of the 2 compartimental model. In the absence of input and a Glink of 50ns, each burst of sodium spikes In the soma produces 4 distinct spikes before hyperpolarizing again.

5.)Variation of link conductance

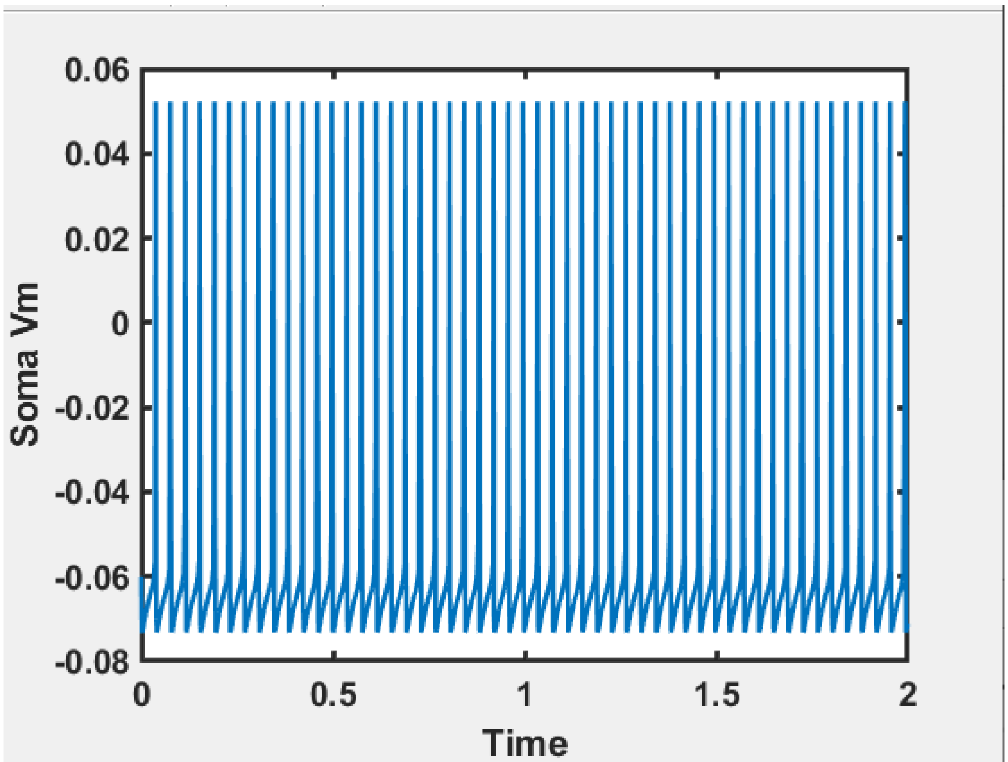
Graph set 1. Glink = 100nS





When link conductance is doubled, the broad calcium spikes provided by the dendrite have a more consistent impact on the soma throughout its duration. While at first this may seem like it should increase the number of spikes in any one burst, the opposite is true, because the extra depolarizing current prevents the somatic gating variables from oscilating propery to produce several distinct action potentials. While the findpeaks matlab function may detect half a dozen or so "spikes" in a single one of these events, only one or two of these peaks could actually be considered spikes. The rest are still oscillations, but they are much less dramatic in size than that of a typical action potential. Dendratic Vm as a function of time not provided as it appears similar to previous resutls.

Graph 2. Glink=0

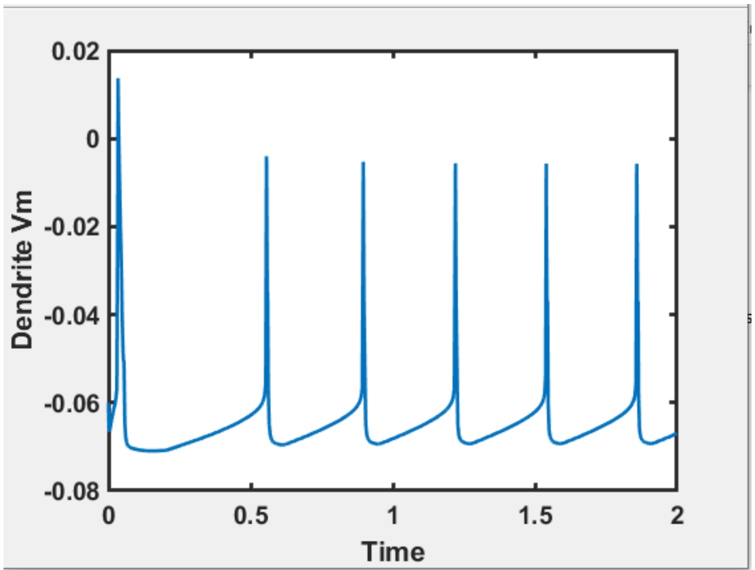


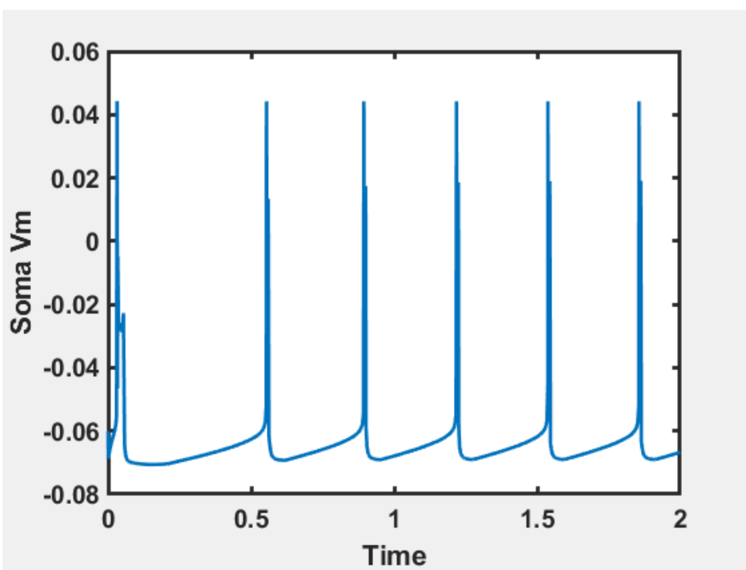
When glink= 0, the soma and dendrite can essentially be considered different "neurons". They have no conductance between one another and will fail to influence eachother's membrane potential. That being said, I'm unsure if there is something wrong with my model or I'm just not fully understanind the dynamics at play here, but I'm not sure why we would see the above activity, I'll do my best below to work it out though.

Given that there is no conductance between soma and dendrite, and no applied current to the soma, the soma will still maintain a relatively high regular firing rate. I believe this is because the starting values of the gating variables and how they are updated in this model. Many computer models have an initial "spike" that's purpose is to essentailly "prime" the model for further computation. In the case of the soma of this particular model, given that there is no outflow or inflow of current to another compartment, a spike will be followed with another spike. Sodium spikes will never cease because of how gating variables and rate constants for the soma are calculated in the P-R model. After a spike, m increases to a large enough value to cause another spike, and because current has nowhere to flow, there is no “burst” of activity, just a rapid depolarization followed by another spike because gating variables have not been given enough time to update to the new membrane potential.

6.)Variation of applied currents

Graph set 1. 50 pA applied to the dendrite

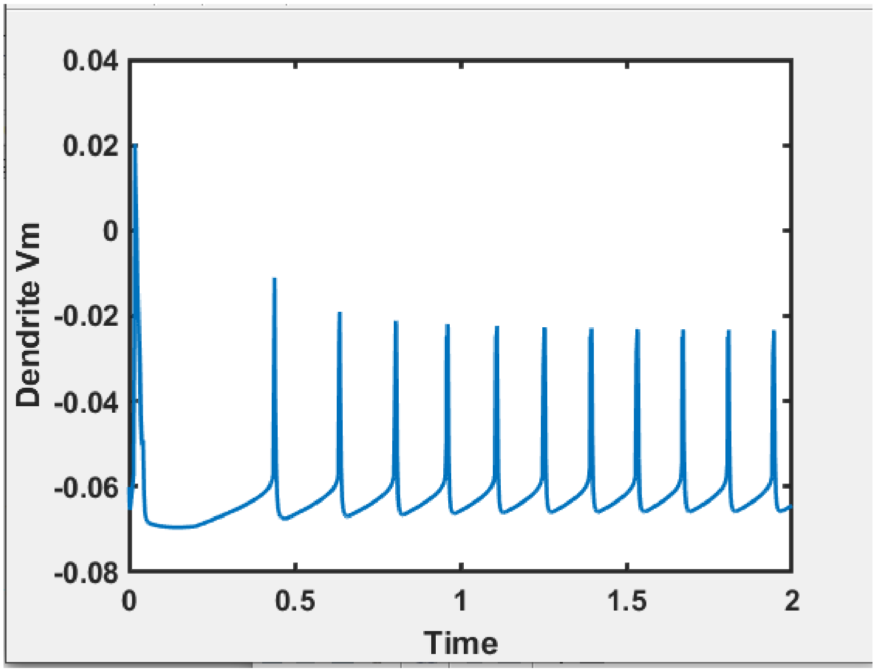


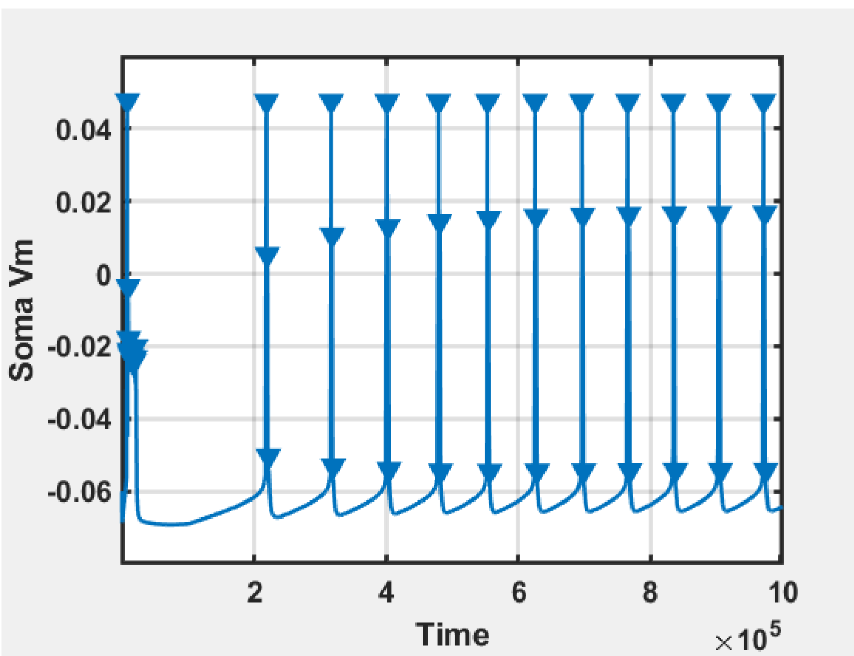


The difference here between a small applied current to the dendrite and a 0 applied current trial is fairly easy to understand. When current is applied to the soma, its firing rate increases, making, causing the dendrite's pause between bursts to shorten. Not super well visualized above, but the bursting activity discussed previously is conserved.

Graph set 2. 200 pA applied to dendrite

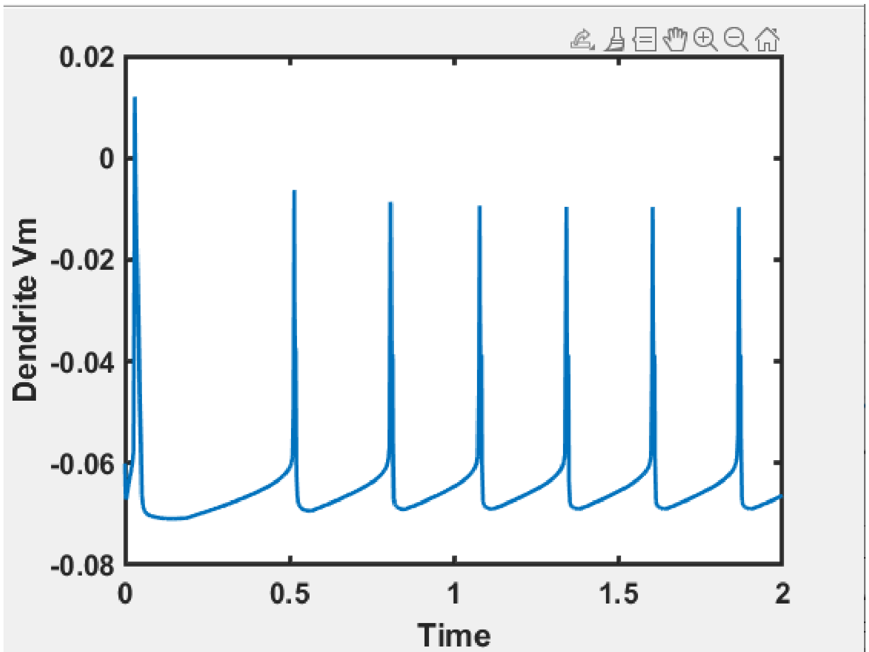
Graph set 2. 100pA applied to dendrite

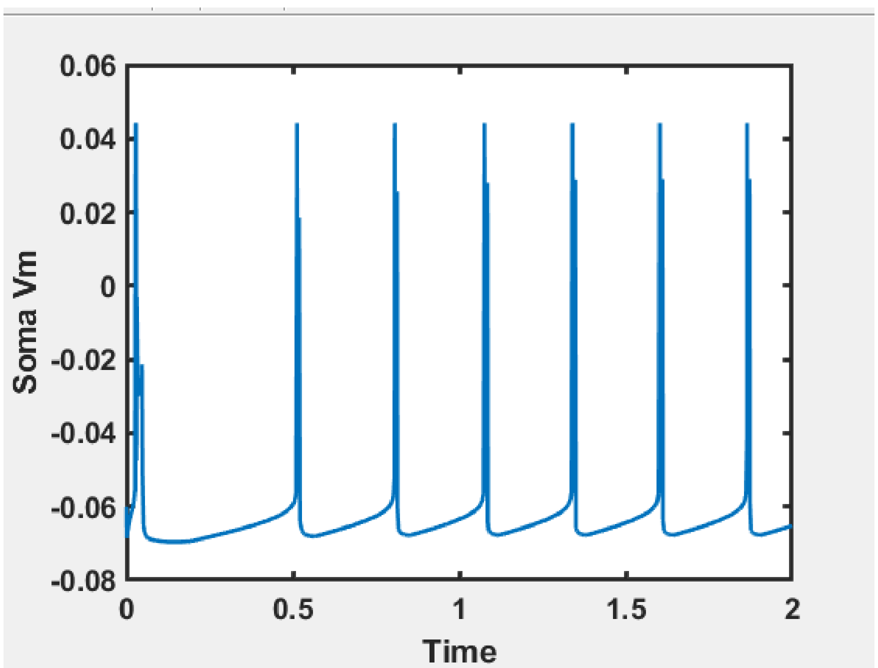




As applied current to dendrite gets larger, the bursting activity in the soma is less and less pronounced. This has to do with the reduction in time/size of calcium spikes in the dendrite. The increase applied current to the dendrite is increasing the rate at which the calcium current deactivates, making spikes shorter in leangth and amplitude. An applied current of 200pA (see "supplemental")takes this to an extreme and produces non biological activity, causing very rapid Vm oscillations in the dendrite that cause rapid spikes in the soma.

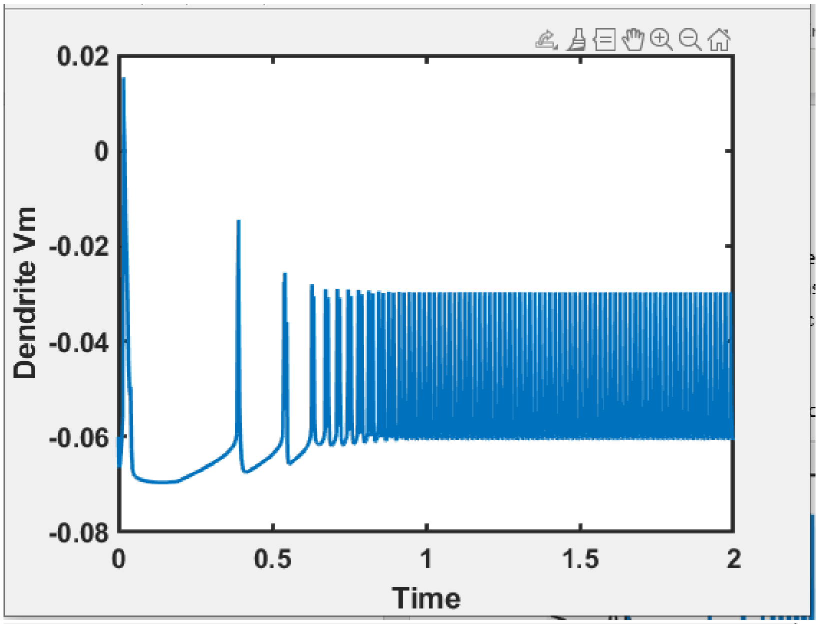
Graph set 3. 50pA applied to Soma

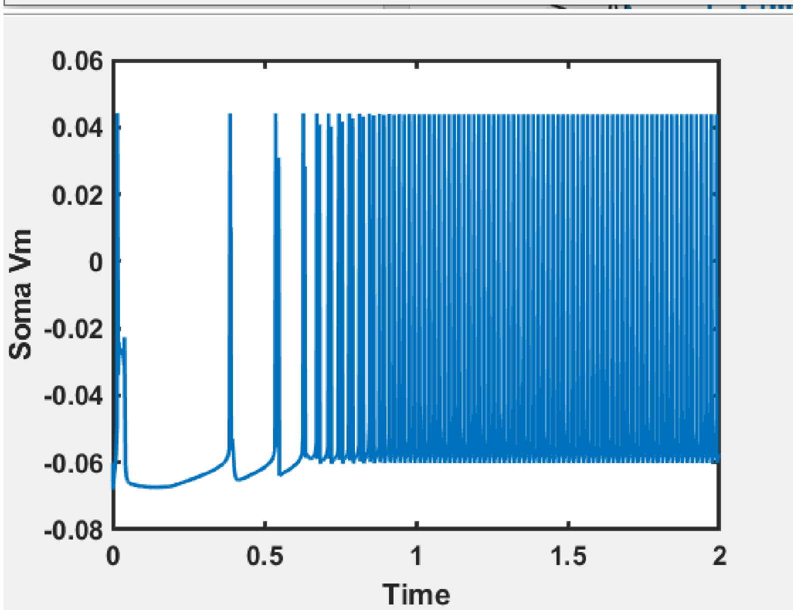




For small applied current, activity when current is applied to soma looks very similar to activity when it is applied to the dendrite. Inter-burst interval is decreased, as is the interspike interval for the dendrite. This mirrored activity makes a certain amount of sense, as differences are likely to be more dramatic when there is a bigger difference between how much the applied current is “doing” for the area its being applied to vs the area that it is incidentally connected to. This difference is dependent on the difference in applied current between the two areas and glink, so natually, as we scale the difference between applied current, a larger difference in activity dependent on where we apply the current will be present. (this was worded a little poorly, essentially what I was trying to say is that it makes sense that for small applied current values it doesn't matter much where it is applied as much as for larger applied current values).

Graph set 4 100pA applied to Soma





For a larger applied current to soma, activity that is fairly similar to the non biological activity dissused previously occurs (see above and supplemental). Logically, it makes sense that a lower applied current value to the soma produces activity similar to a higher applied current value to the dendrite considering how they both contriburte to the structure of a neuron. Because of the relative size of the dendrite compartment (twice the size of the soma) current will flow more readily from the soma to dendrite than vicce versa because it is significantly smaller.

Supplemental (200pA applied current to dendrite)