Homework 1 Report

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All the codes run without error in Matlab R2014b.

The source files are included as part of the submission, and all of them are heavily commented.

The LaTeX source code of this report and all the matlab png images are also included.

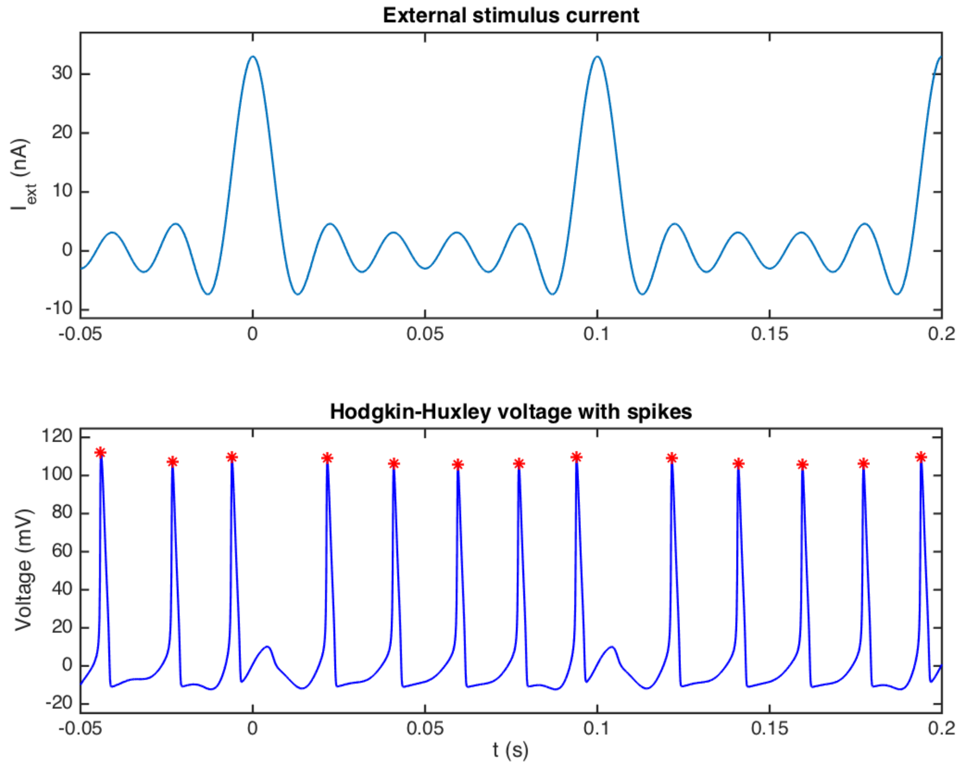
Problem 1

Problem 1 related codes are in `problem1.m`. By running `problem1` in Matlab console, the plots shown below can be reproduced.

Part 1

Empirically, the range of reasonable a_m values is approximately $[0.3, 15.0]$.

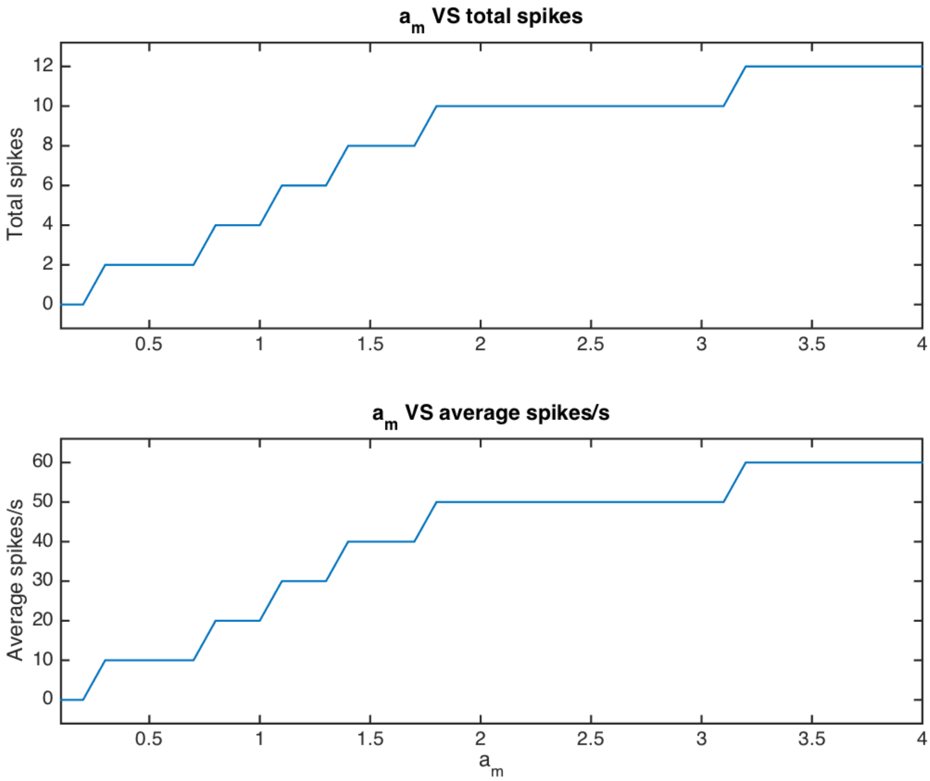
The code plots the Hodgkin-Huxley voltage with $a_m = 3.0$.



Part 2

The a_m values I tried are $0.1 \leq a_m \leq 4.0$ with a 0.1 increment. The first plot shows the total number of spikes VS a_m. The second plot shows the average number of spikes per second VS a_m.

As we can see from the graph, the number of spikes increases as a_m increases.

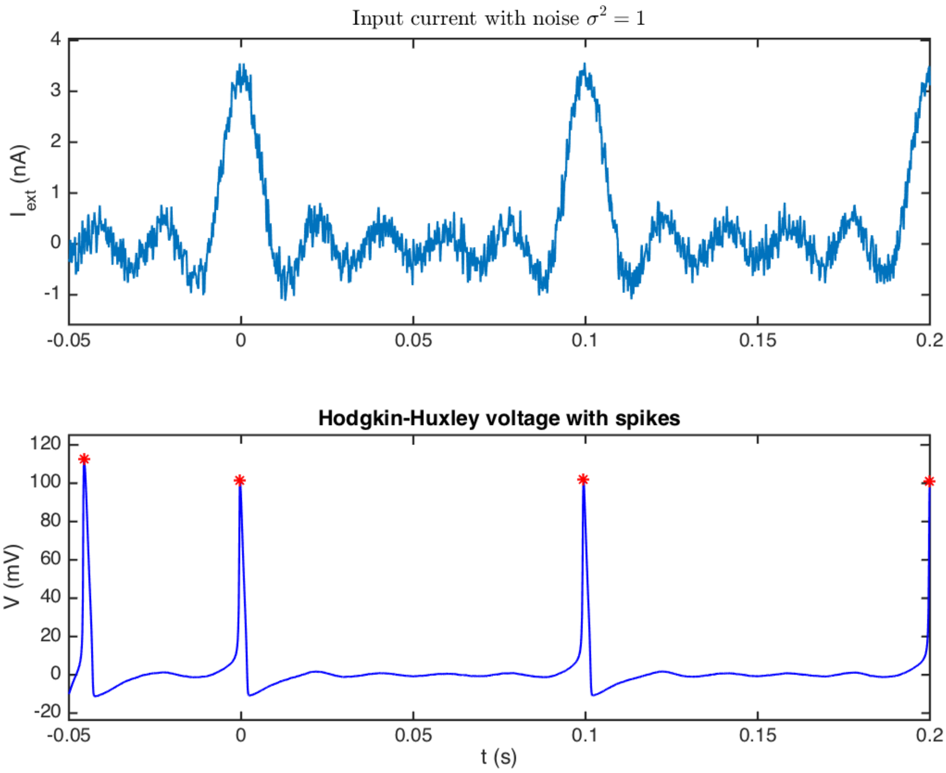


Part 3

Bandlimited white noise is calculated by `wgn.m` function. The function arguments are:

$wgn(t, \sigma^2)$ where σ^2 is the power level.

The first plot repeats the experiment in part 1: it shows the external stimulus current with noise added, and its effect on the voltage.



The second plot repeats the experiments in part 2 and represents a 3D function of amplitude a_m, noise power σ^2 and firing frequency (spikes/s). (Because it takes very long to compute, the actual code included in my submission plots only a subset of the experiments I tried.)

I use a_m as the measure for characterizing external current because it represents the amplitude of the current, which is one of the key signatures of the signal.

X-axis is a_m: $\begin{cases} 0.1 \leq a_m \leq 4.0 \\ \Delta a_m = 0.1 \end{cases}$

Y-axis is σ^2: $\begin{cases} 0.0 \leq \sigma^2 \leq 20.0 \\ \Delta \sigma^2 = 1.5 \end{cases}$

Z-axis is the corresponding firing frequency (spikes/s) for each pair (a_m, σ^2).

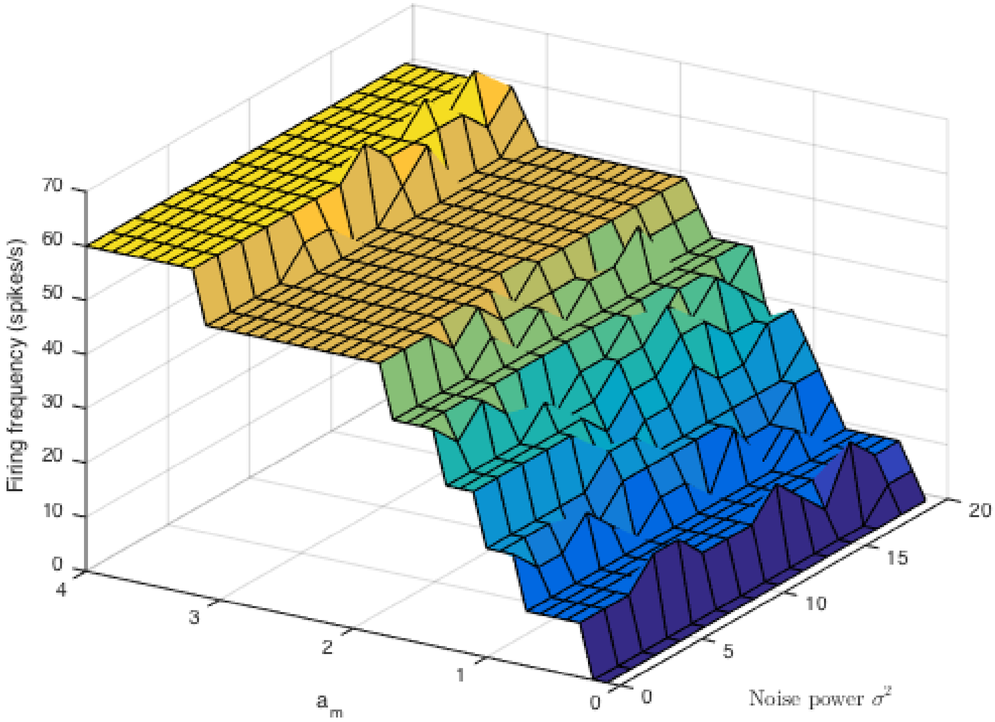


Figure 1: 3D perspective 1

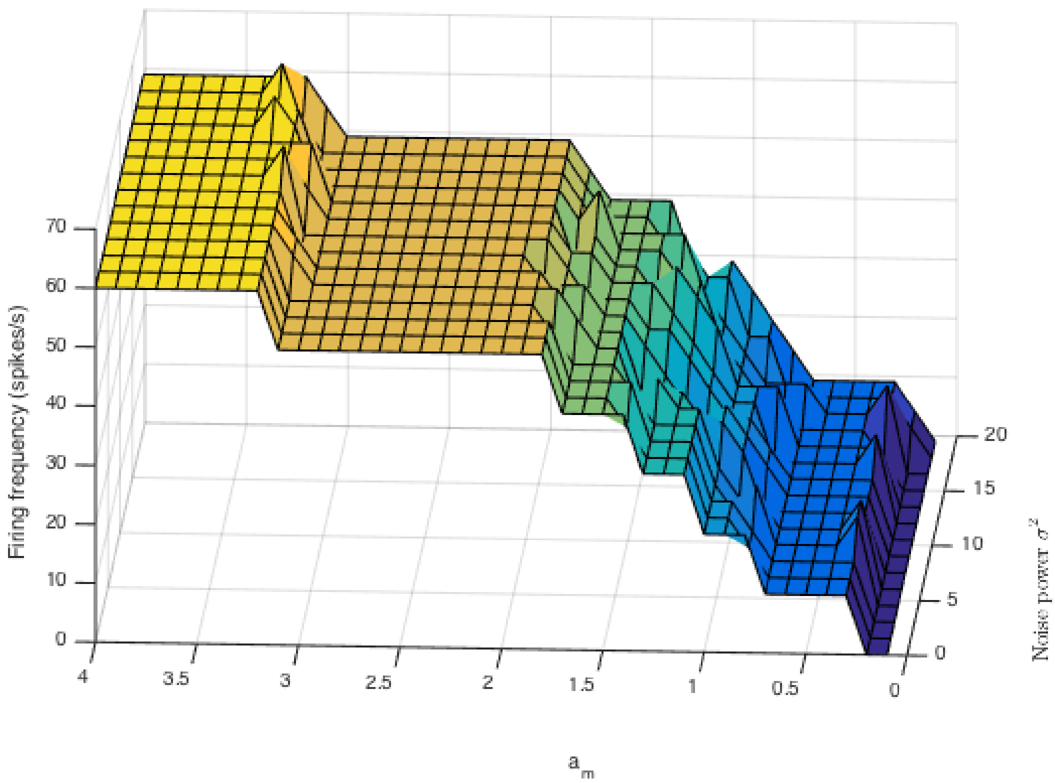


Figure 2: 3D perspective 2

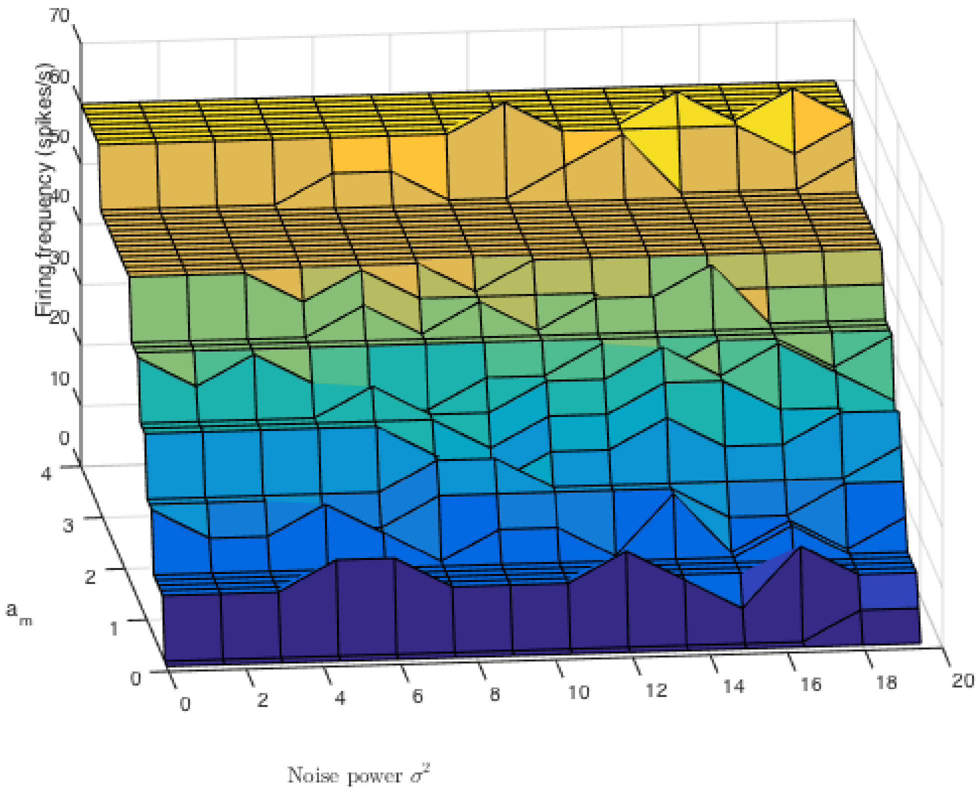


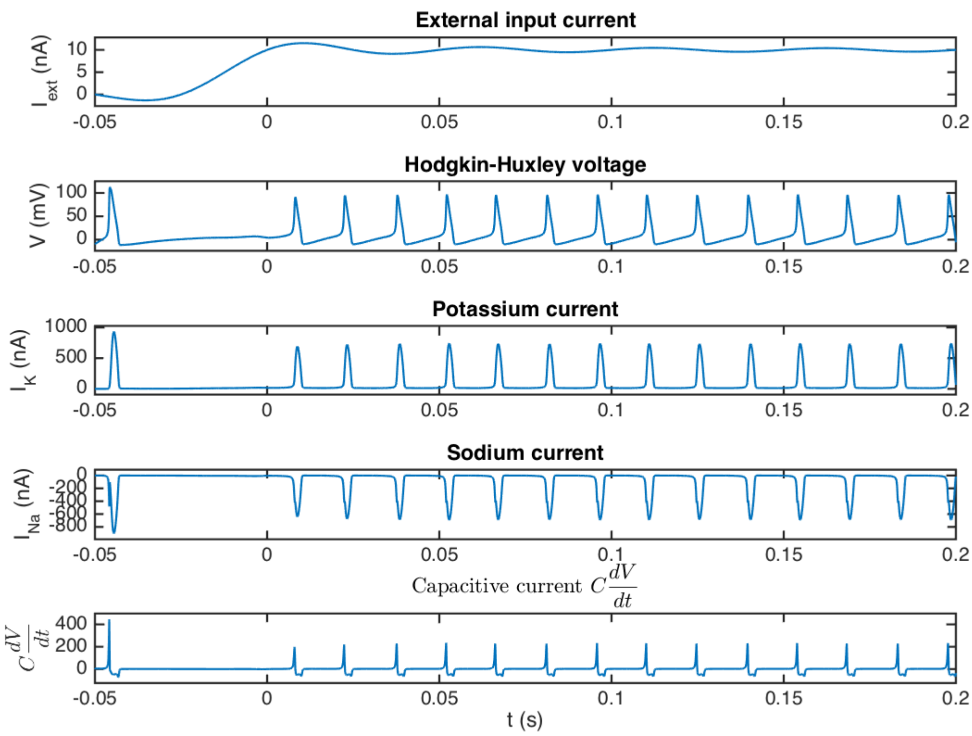
Figure 3: 3D perspective 3

Problem 2

Problem 2 related codes are in `problem2.m`. By running `problem2` in Matlab console, the plots shown below can be reproduced.

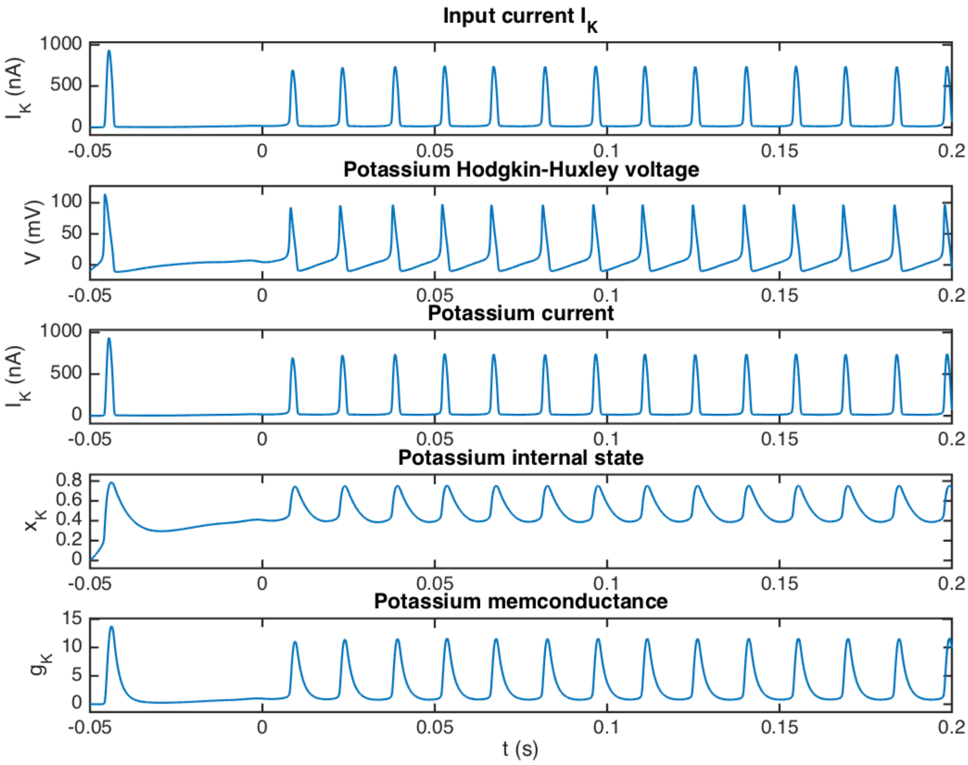
Part 0

Plot I_{ext}, V, I_K, I_{Na}, and $C\frac{dV}{dt}$ as functions of time t.



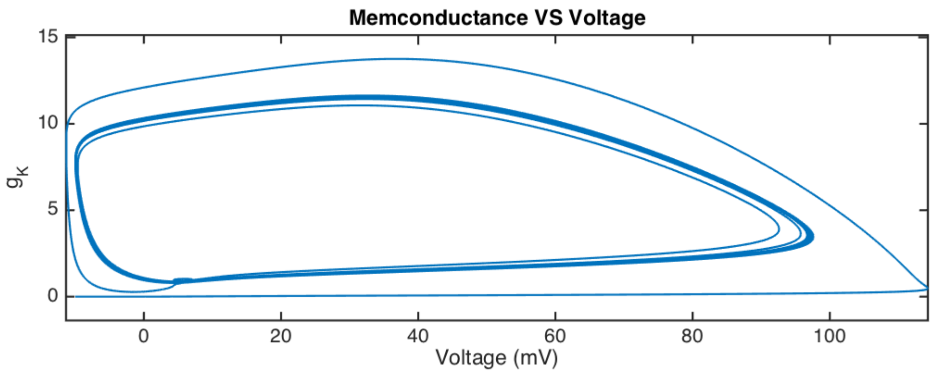
Part 1

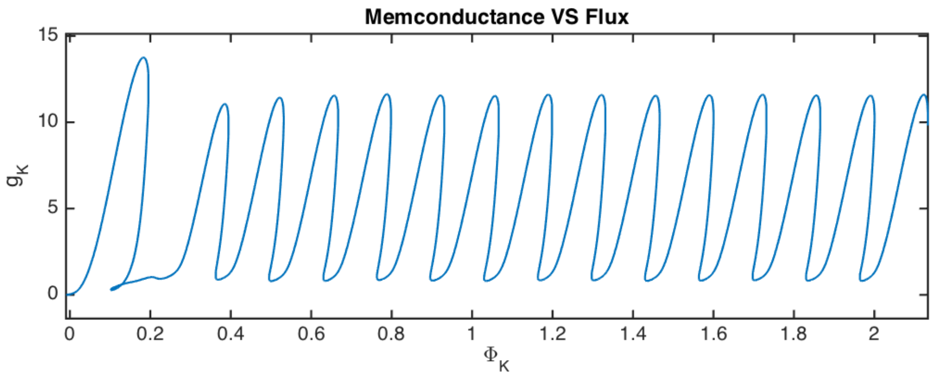
Plot I_K, V_K, internal state x_K, and memconductance g_K as functions of time t.



Part 2

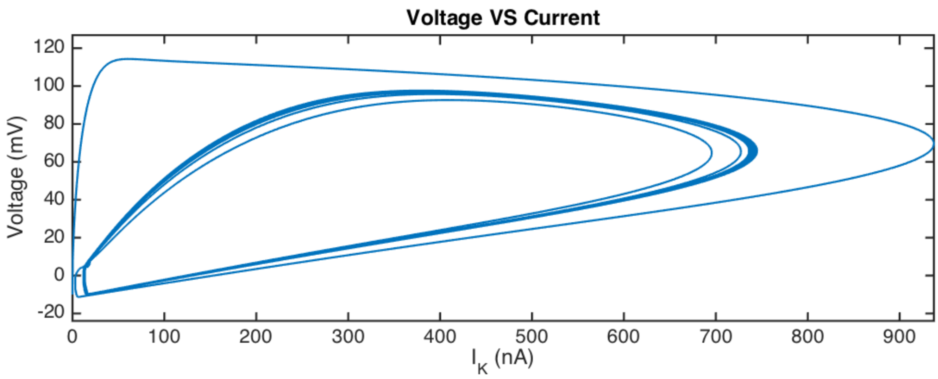
Plot memconductance g_K vs V_K, and g_K vs flux $\Phi_K = \int V_K$.

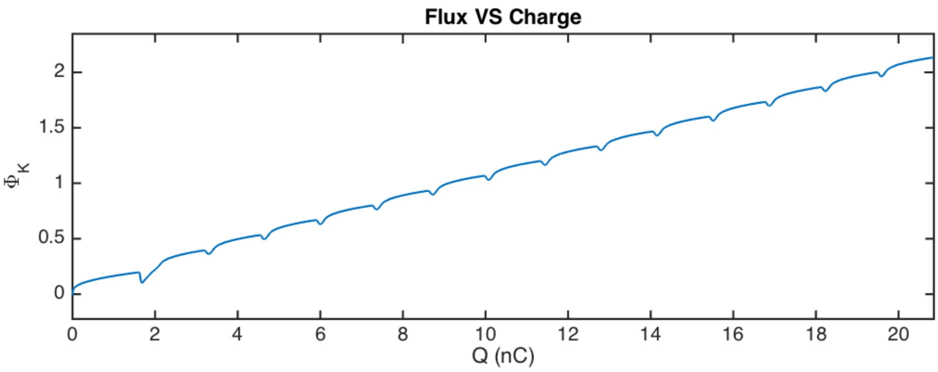




Part 3

Plot I_K vs V_K, and $Q_K = \int I_K$ vs flux $\Phi_K = \int V_K$.





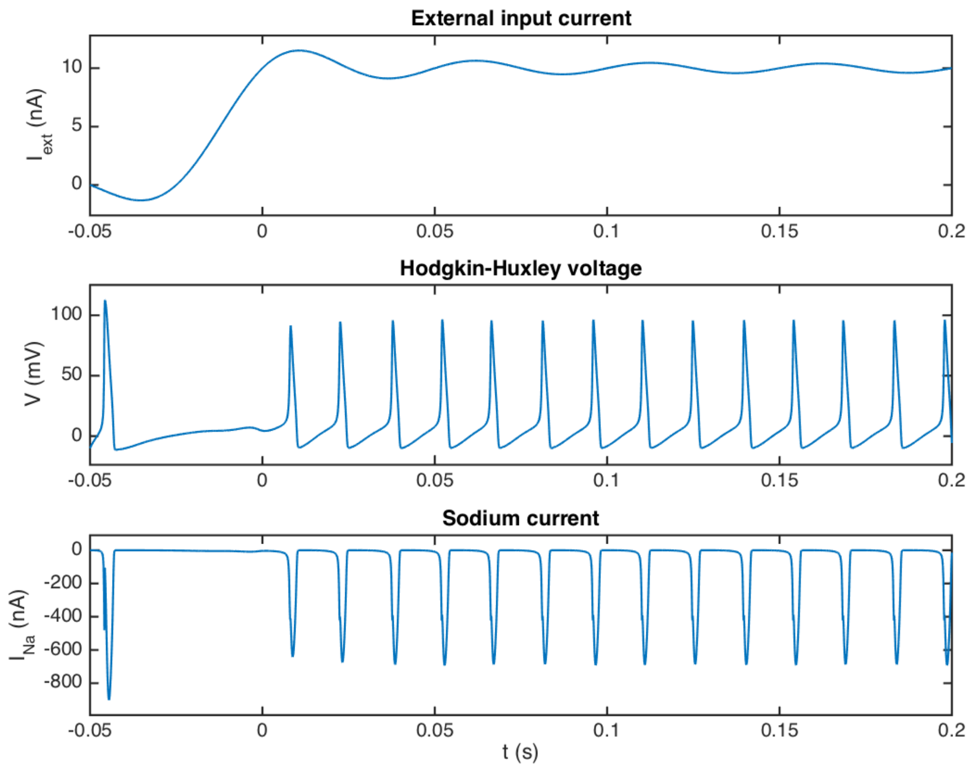
Bonus

Bonus related codes are in `bonus.m`. By running `bonus` in Matlab console, the plots shown below can be reproduced.

I have spent almost an entire day trying to debug the numerical instability problem. It doesn't seem to be fully solved.

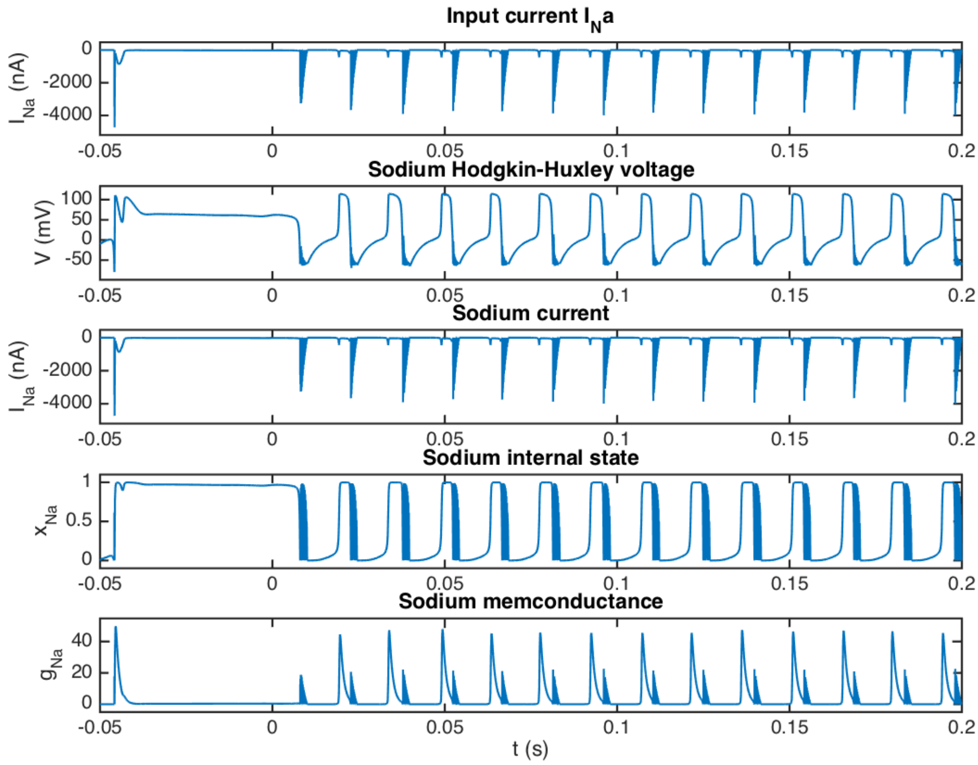
Part 0

Plot I_{ext}, V, and I_{Na} as functions of time t.



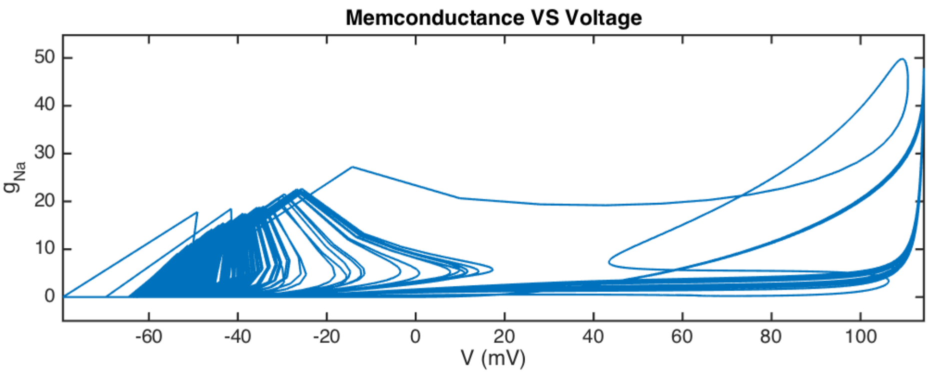
Part 1

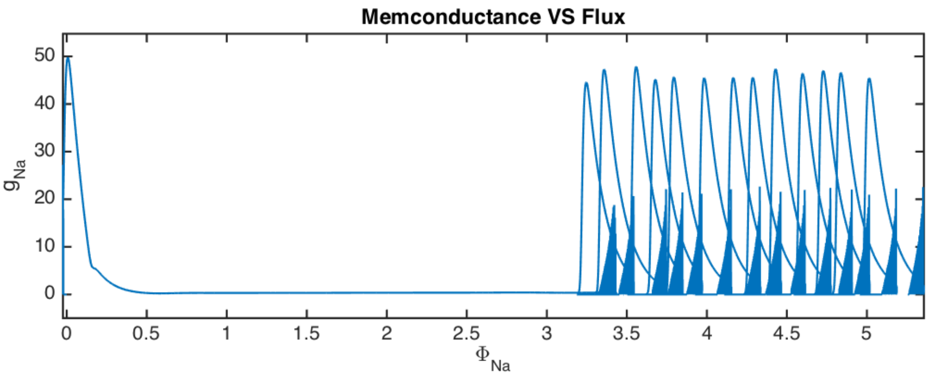
Plot I_{Na}, V_{Na}, internal state x_{Na}, and memconductance g_{Na} as functions of time t.



Part 2

Plot memconductance g_{Na} vs V_{Na}, and g_{Na} vs flux $\Phi_{Na} = \int V_{Na}$.





Part 3

Plot I_{Na} vs V_{Na}, and $Q_{Na} = \int I_{Na}$ vs flux $\Phi_{Na} = \int V_{Na}$.