BT6270 Assignment 1

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1 Introduction

The Hodgkin-Huxley model clearly explains the dynamics of the ions involved in the generation of an action potential in a neuron. The ions involved in the generation of an action potential are Na^+, K^+, Cl^-. When the ions reach a particular concentration on the inside of neuron and outside of the neuron, thereby reaching a particular threshold voltage of +55mV. Once the voltage of the neuron crosses the threshold voltage, an action potential is generated.

2 Frequency Vs I_{ext} plot

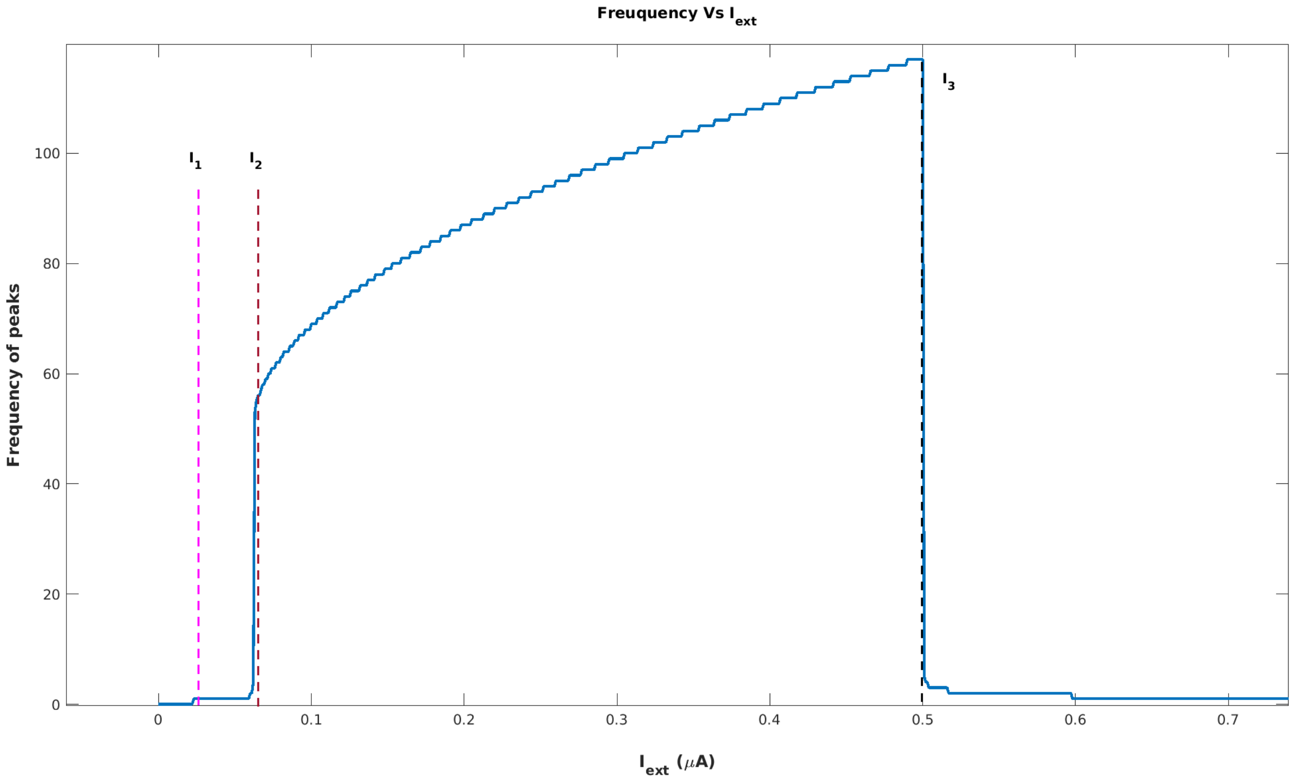

Figure 1: Firing rate Vs I_{ext}

First, in order to get a better understanding of what is happening, I modified the code such that I could visualize how the firing frequency varies with different I_{ext} ranging from 0 μA to 0.75 μA with a step size of 0.001 μA.

This was done by adding an external for loop wrapping the already present for loop. And then, `findpeaks()` function from the **signal processsing toolbox** in MATLAB was used to find the number of action potential peaks produced for a particular I_{ext} value. And only when a local maxima is above a **threshold** value of **+7.5mv**, it is considered a peak

Now the graph generated as a result of the previous modifications is shown in Figure 1. From this graph, we can approximately interpret the values of I_1, I_2, I_3. Current I_1 is the minimum value of external current at which an action potential is generated and this can be approximated as 0.02 μA and further accurate analysis is done in Section 3.

The **continous firing** of neuron starts at value of I_2 and ends at I_3. By interpreting the graphshown in Figure 1, the values of I_2 and I_3 can be approximated to 0.06 μA and 0.5 μA. Between the I_1 and I_2, there is **finite number** of action potentials generated. And after I_3, there are almost no action potential generated by the neuron.

3 Results with current I_1

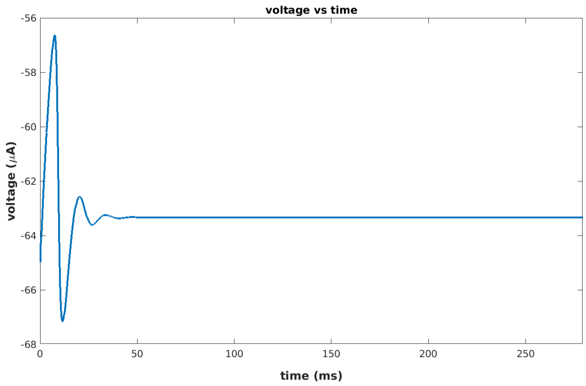

Figure 2: Voltage Vs time plot at I_{ext} value of 0.0223 μA

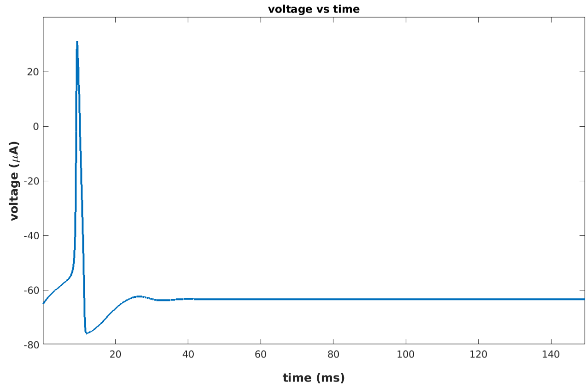

Figure 3: Voltage Vs time plot at I_{ext} value of 0.0224 μA

The I_{ext} values were slowly increased from 0.02 μA. As shown in Figure 2, the plot does not look like an action potential until a I_{ext} value of 0.0223 μA. But with an increase of 0.0001 μA, an action potential is generated as shown in Figure 3.

4 Results between current I_1 and I_2

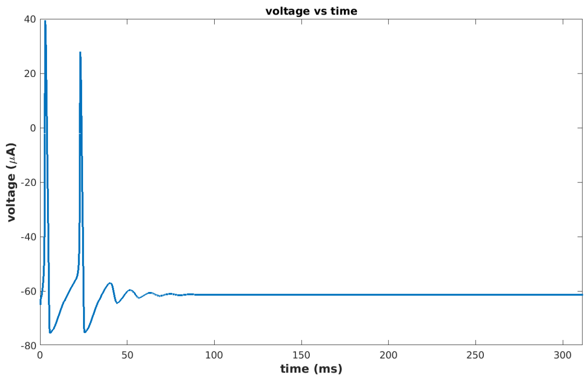

Figure 4: Voltage Vs time plot at I_{ext} value of 0.06 μA

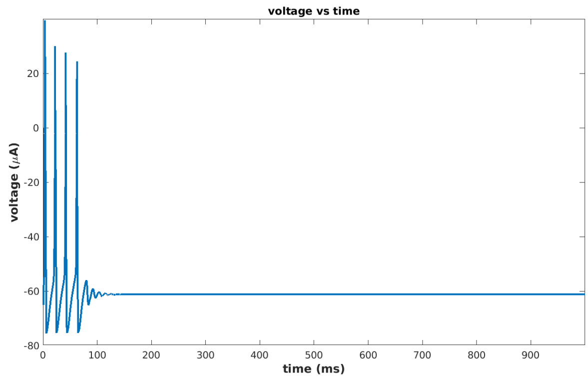

Figure 5: Voltage Vs time plot at I_{ext} value of 0.063 μA

The second action potential starts when a current value of 0.06 μA is applied as shown in Figure 4. The third action potential comes up at 0.063 μA which is shown in Figure 5. This is the region in the graph with finite number of action potentials.

5 Results between current I_2 and I_3

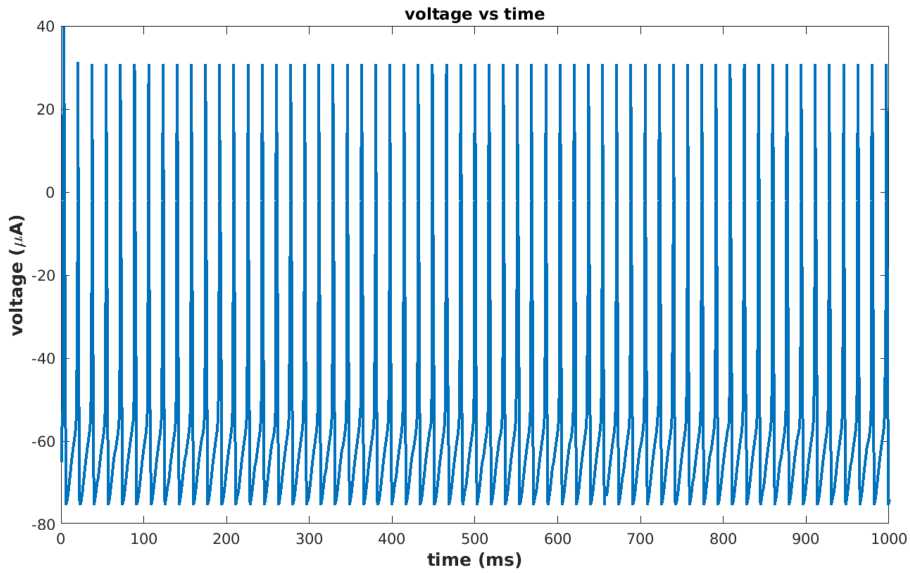

Figure 6: Continous firing of action potentials

This region between I_2 and I_3 is the region with continous firing as shown in the Figure 6.

6 Results after current I_3

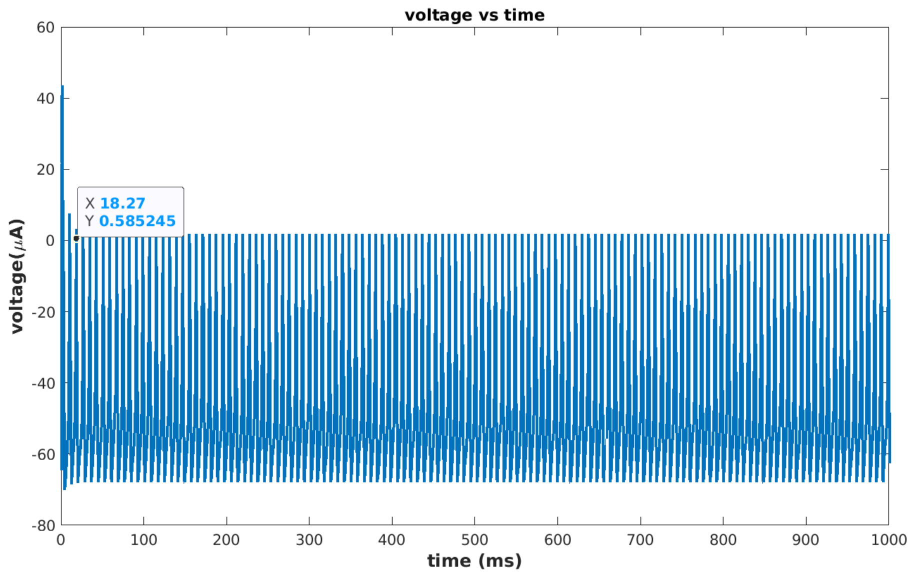

Figure 7: Action potential peaks below threshold value of 7.5 μA

This region after I_3 is the region with almost no action potentials as shown in Figure 1. As you can see in the Figure 7, there are a lot of firing happening and hence there are so many peaks, but as the data point in the figure shows, the peaks are below the **threshold** value of 7.5 μA.