# Brain Inspired Computing - Problem Set 1

Sven Bordukat, Paul Meehan

April 23, 2019

## Exercise 1

a) As there are approximately $10^{11}$ neurons in the brain, each firing at around 1 Hz, and the total energy use is 20 W, we calculate the energy use per neuron:

$$\begin{aligned} E_{spike} &= \frac{20J/s}{10^{11} * 1/s} \\ &= 2 * 10^{-10}J \end{aligned}$$

$10^{15}$ synapses means $10^4$ synapses per neuron. This results in

$$\begin{aligned} E_{event} &= \frac{2 * 10^{-10}J}{10^4} \\ &= 2 * 10^{-14}J \end{aligned}$$

b) As the time is 1 second and the neurons fire at 1 Hz, we have $1.23 * 10^9$ action potentials and $6 * 10^3 * 1.23 * 10^9 = 7.38 * 10^{12}$ synaptic events. This gives us

$$\begin{aligned} E_{spike} &= \frac{12.6 * 40 * 60 * 10^6 J}{1.23 * 10^9} \\ &= 24.6J \\ E_{event} &= \frac{12.6 * 40 * 60 * 10^6 J}{7.38 * 10^{12}} \\ &= 4.1 * 10^{-3}J \end{aligned}$$

c) In order to scale the system to the human brain, the number of neurons as well as the number of synapses would need to be scaled by approximately 2 orders of magnitude. This is equivalent to a number of computers $K \approx 100$. This would result in about 1.26GW of power usage.

d) As the system performs the equivalent of 1 second in 40 minutes, the power consumption is $40 * 60 * 1.26GW = 3.024TW$. This system requires $3.024TW/1.78GW \approx 1700$ nuclear power plants to power it.

## Exercise 2

Values for $I_0, g_L, C_m$ were selected in order to produce a nice result. The timescale is not in any specific unit.

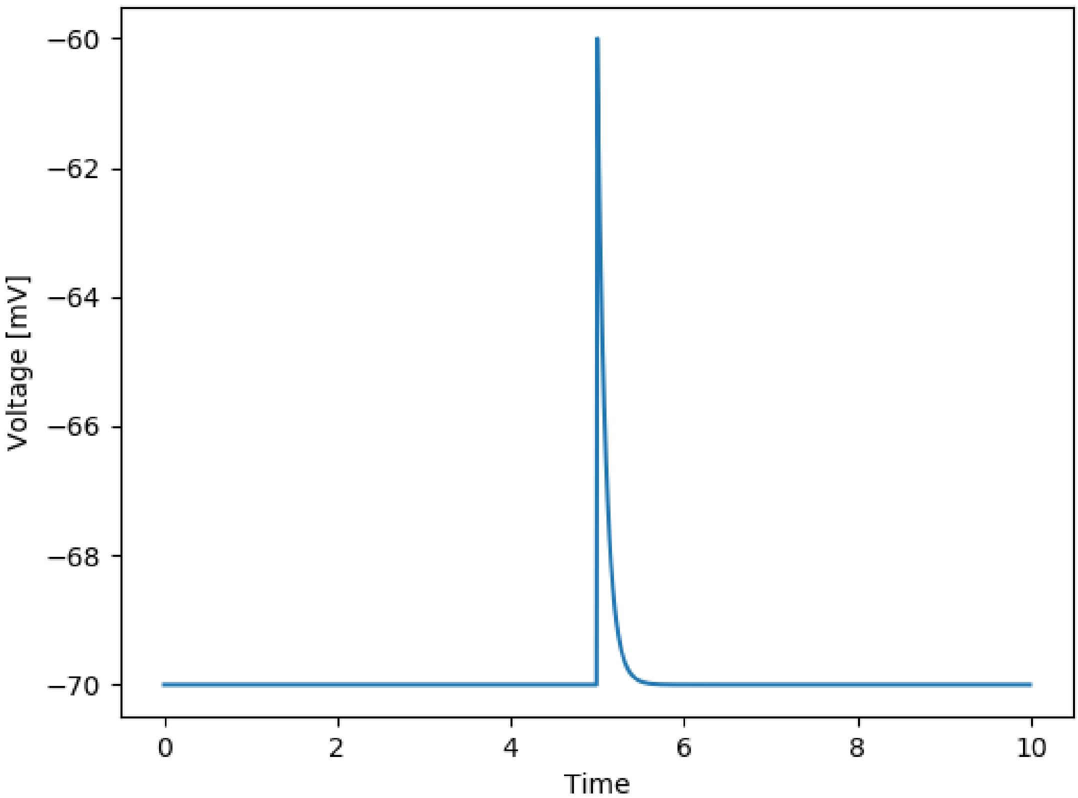


Figure 1: a)

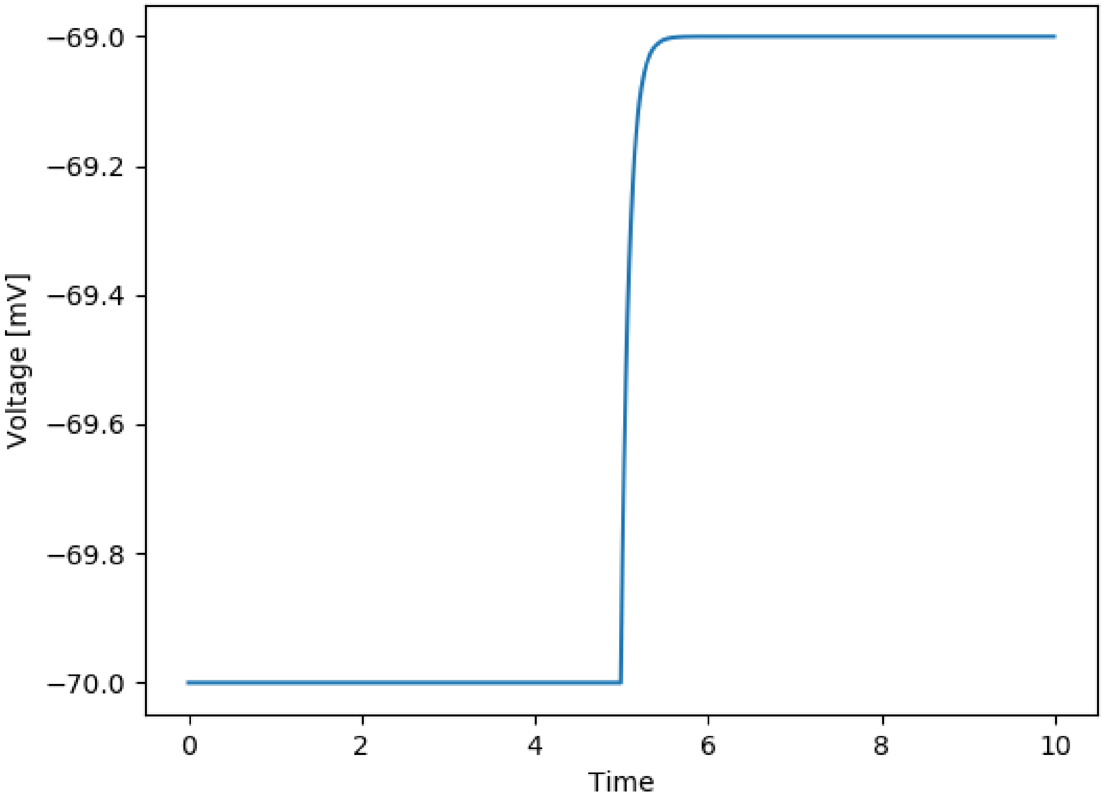


Figure 2: b)

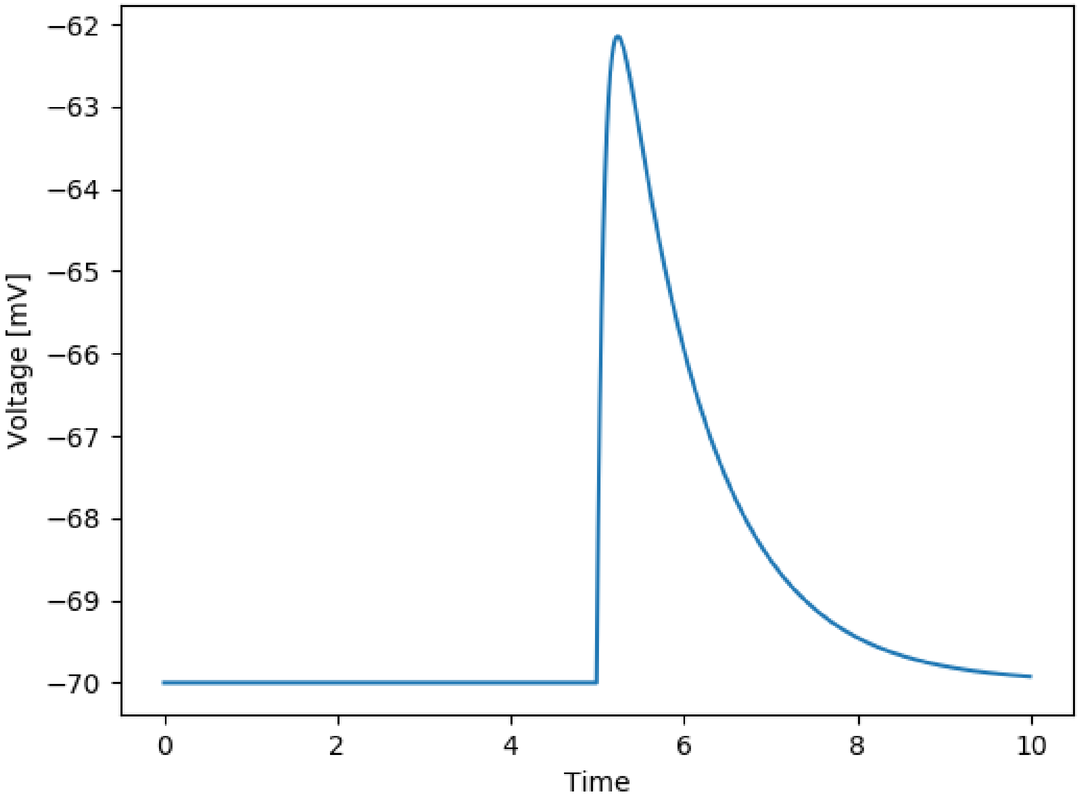


Figure 3: c)