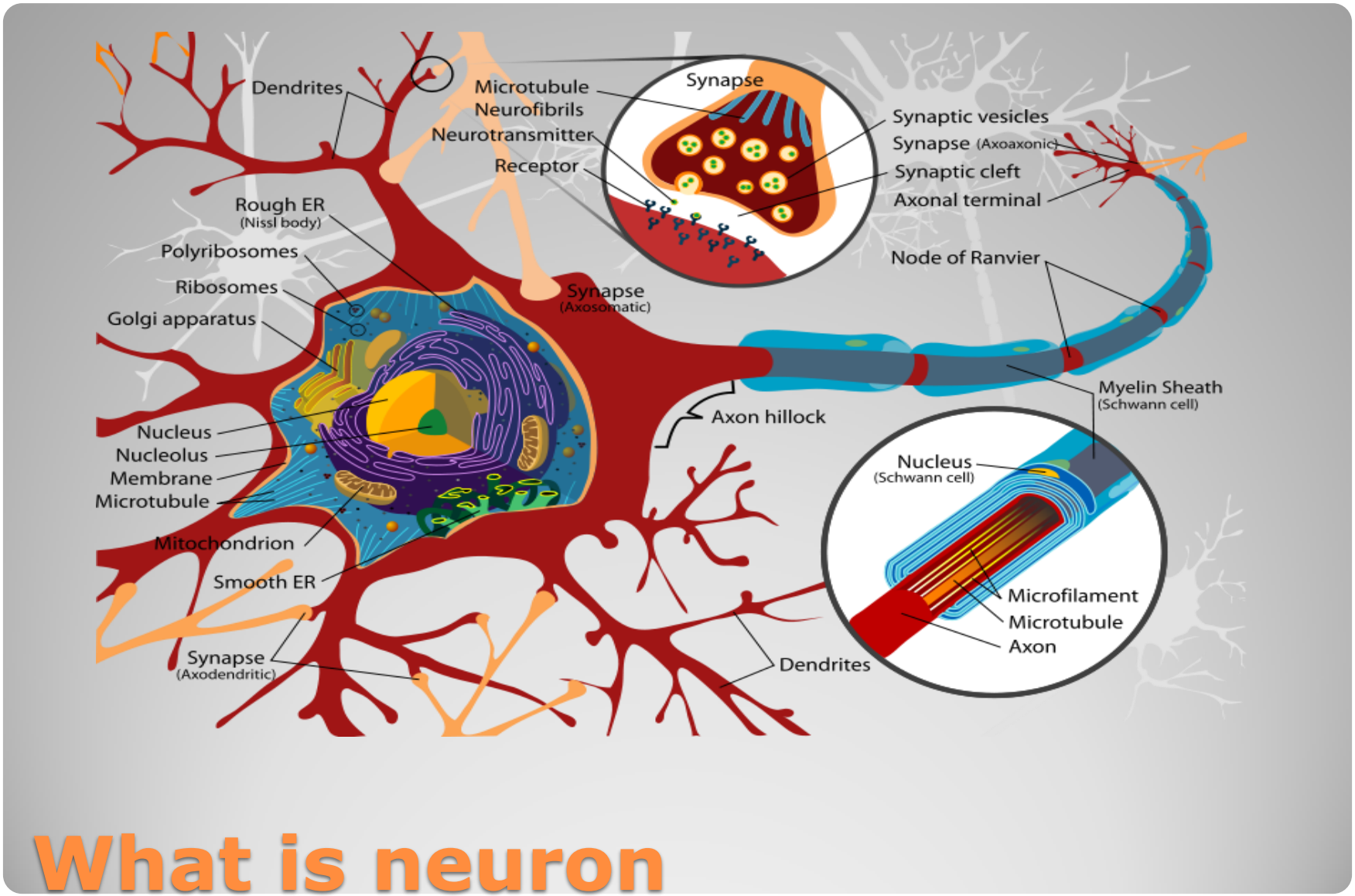
Neuron Implementation on FPGA

By Rui Yuan
310-097-94

ECE 641 lab project
Professor : Ali . Akansu

- Brief introduction about biological neuron
- The principle of neuron behavior
- The basic model of neuron
- My neuron

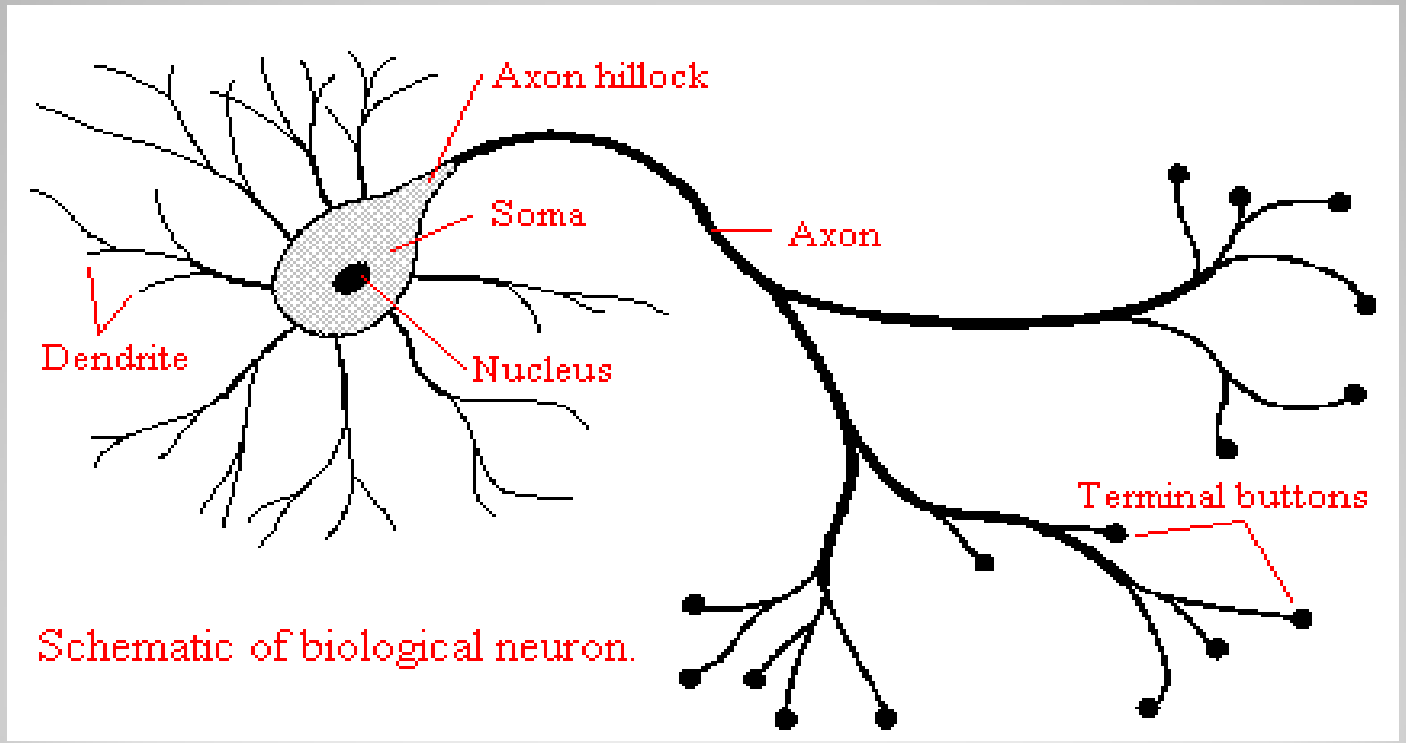
introduction



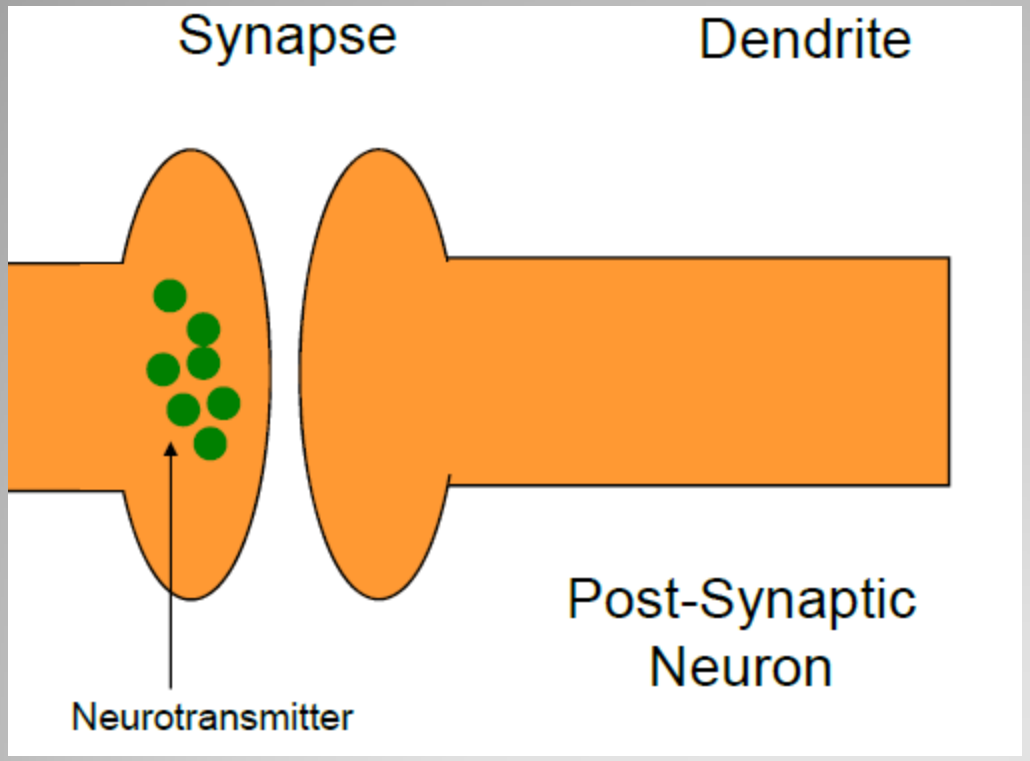
What is neuron

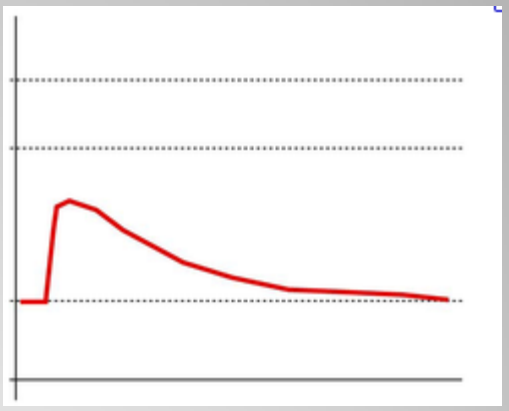
Simply it

- Make it simple not simpler.



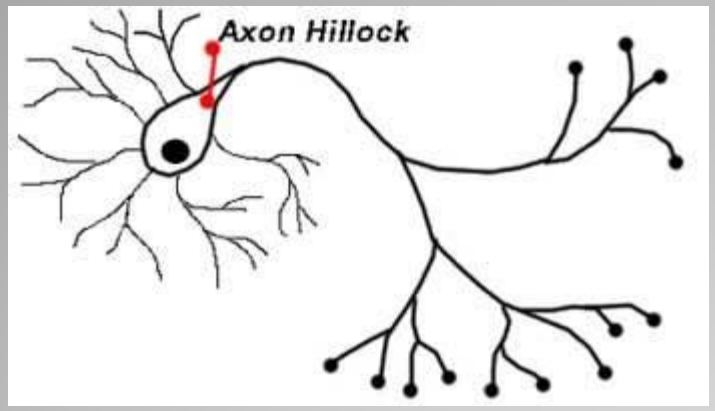
This image is from about.com

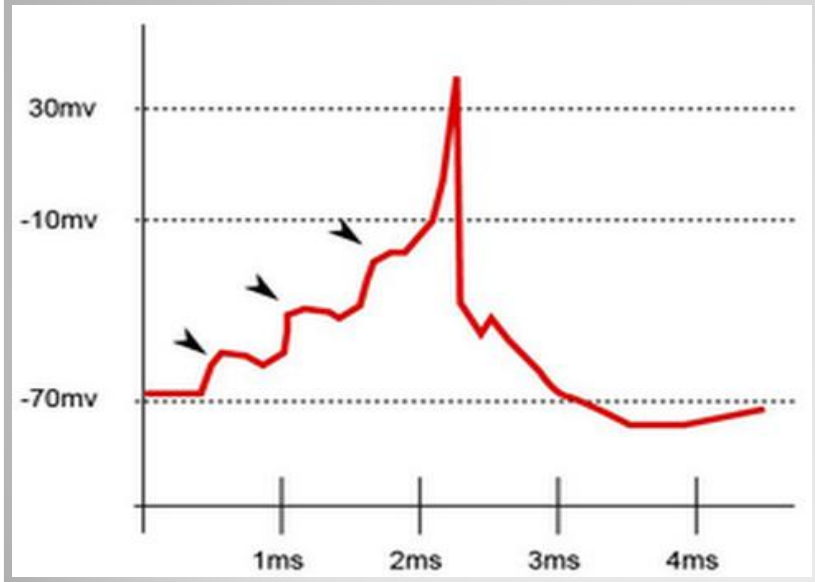


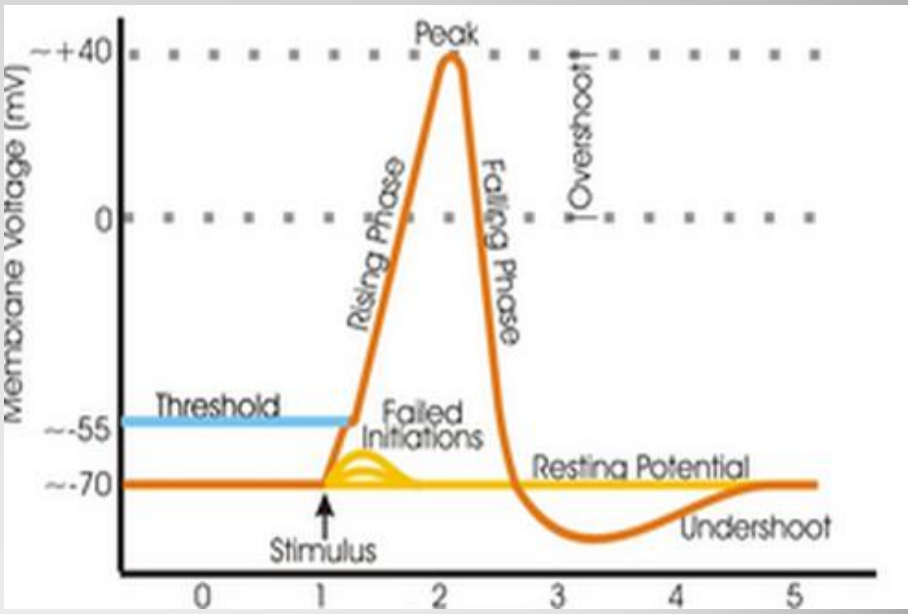


alpha function $f(x) = x * e^{-x}$

Excitatory postsynaptic potential

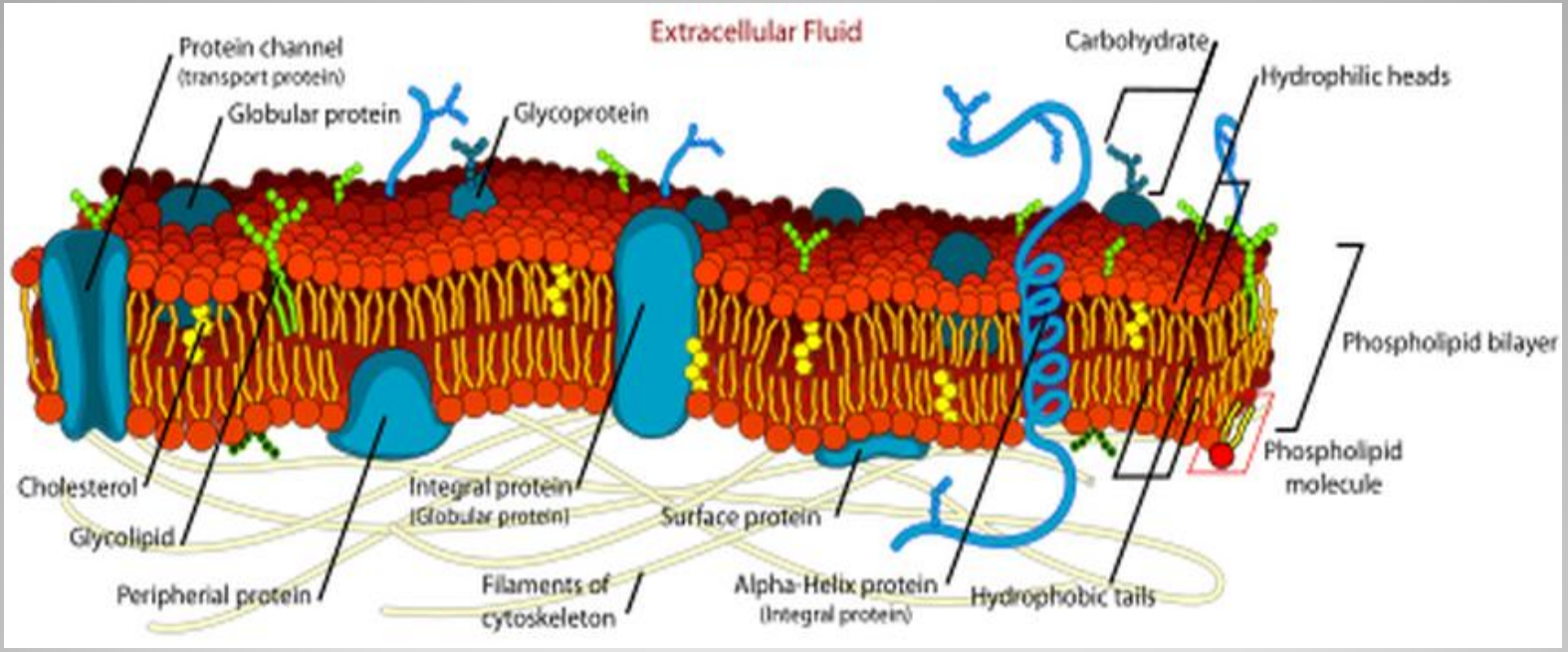






Action potential

About the membrane potential



The ion channels play the main part of the membrane potential.

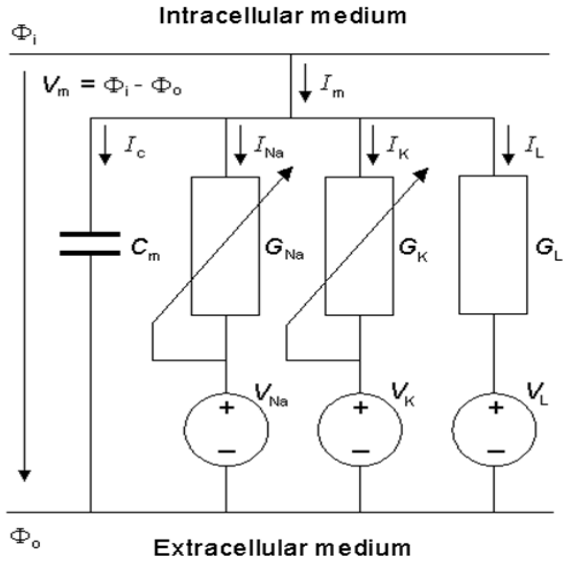
Hodgkin–Huxley model

$$I_{\mathrm{m}} = C_{\mathrm{m}} \frac{dV_{\mathrm{m}}}{dt} + (V_{\mathrm{m}} - V_{\mathrm{Na}})G_{\mathrm{Na}} + (V_{\mathrm{m}} - V_{\mathrm{K}})G_{\mathrm{K}} + (V_{\mathrm{m}} - V_{\mathrm{L}})G_{\mathrm{L}}$$

$$I(t,V) = g(t,V) \cdot (V - V_{\mathrm{eq}})$$

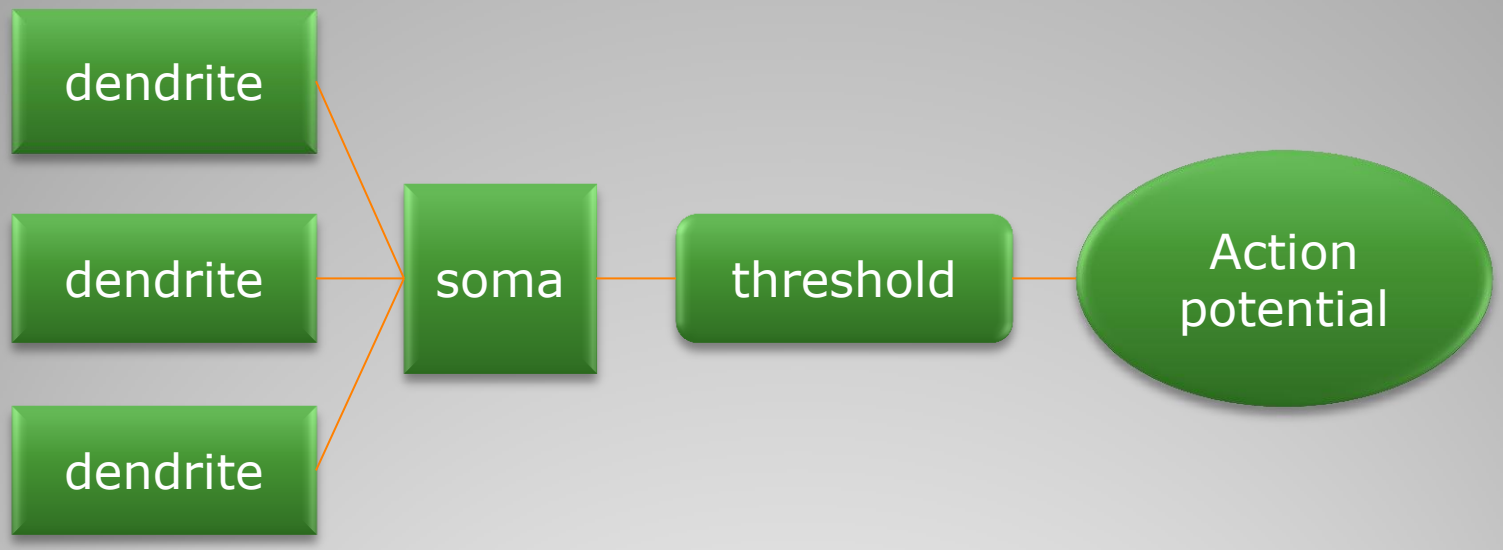
$$g(t,V) = \bar{g} \cdot m(t,V)^p \cdot h(t,V)^q$$

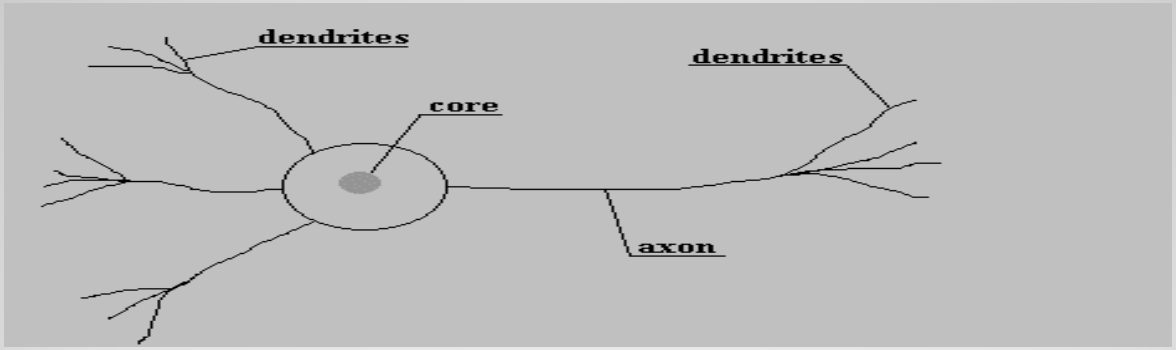
$$\frac{dm(t,V)}{dt} = \frac{m_\infty(V) - m(t,V)}{\tau_{\mathrm{m}}(V)} = \alpha_{\mathrm{m}}(V) \cdot (1-m) - \beta_{\mathrm{m}}(V) \cdot m$$



where

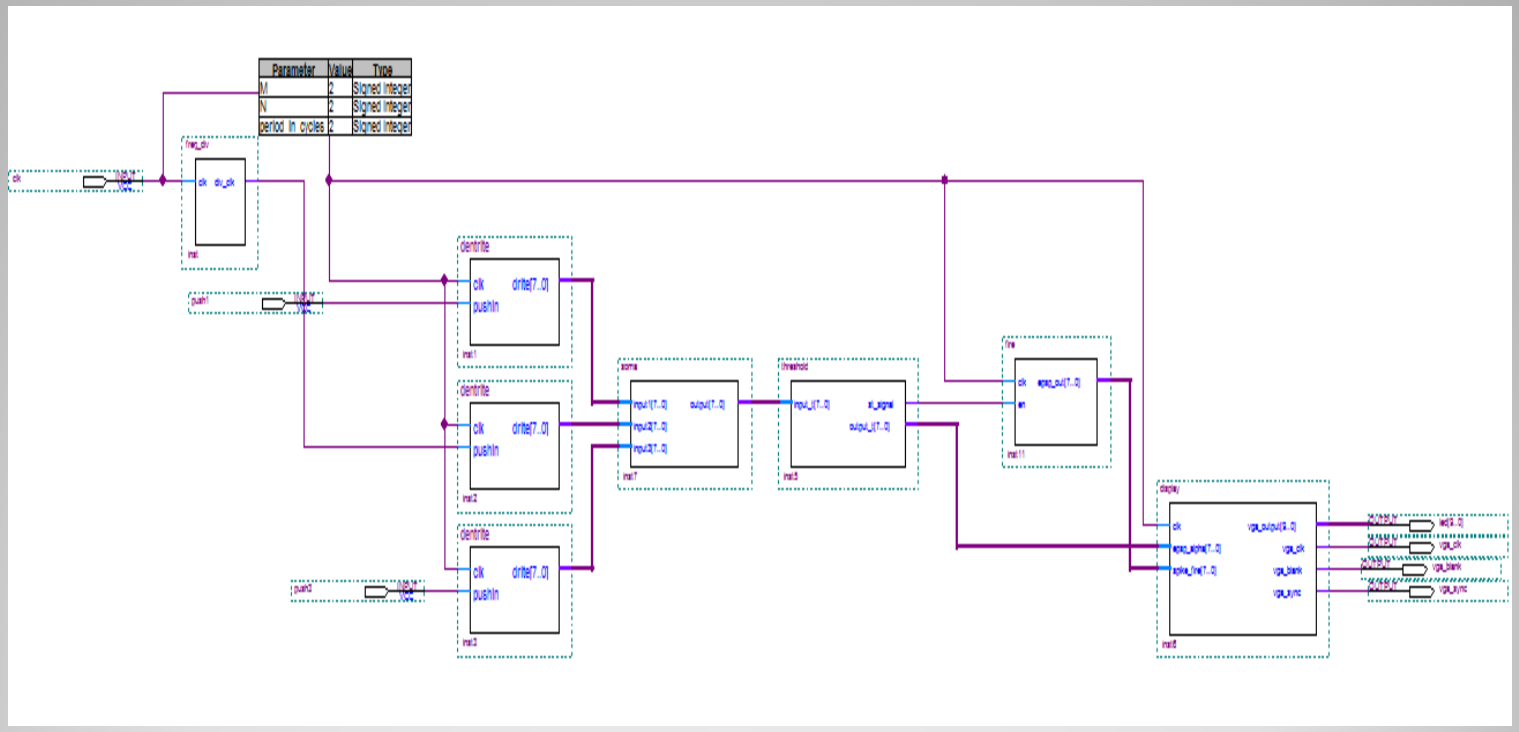
I_m	= membrane current per unit area [mA/cm²]
C_m	= membrane capacitance per unit area [F/cm²]
V_m	= membrane voltage [mV]
V_{Na}, V_K, V_L	= Nernst voltage for sodium, potassium and leakage ions [mV]
G_{Na}, G_K, G_L	= sodium, potassium, and leakage conductance per unit area [S/cm²]

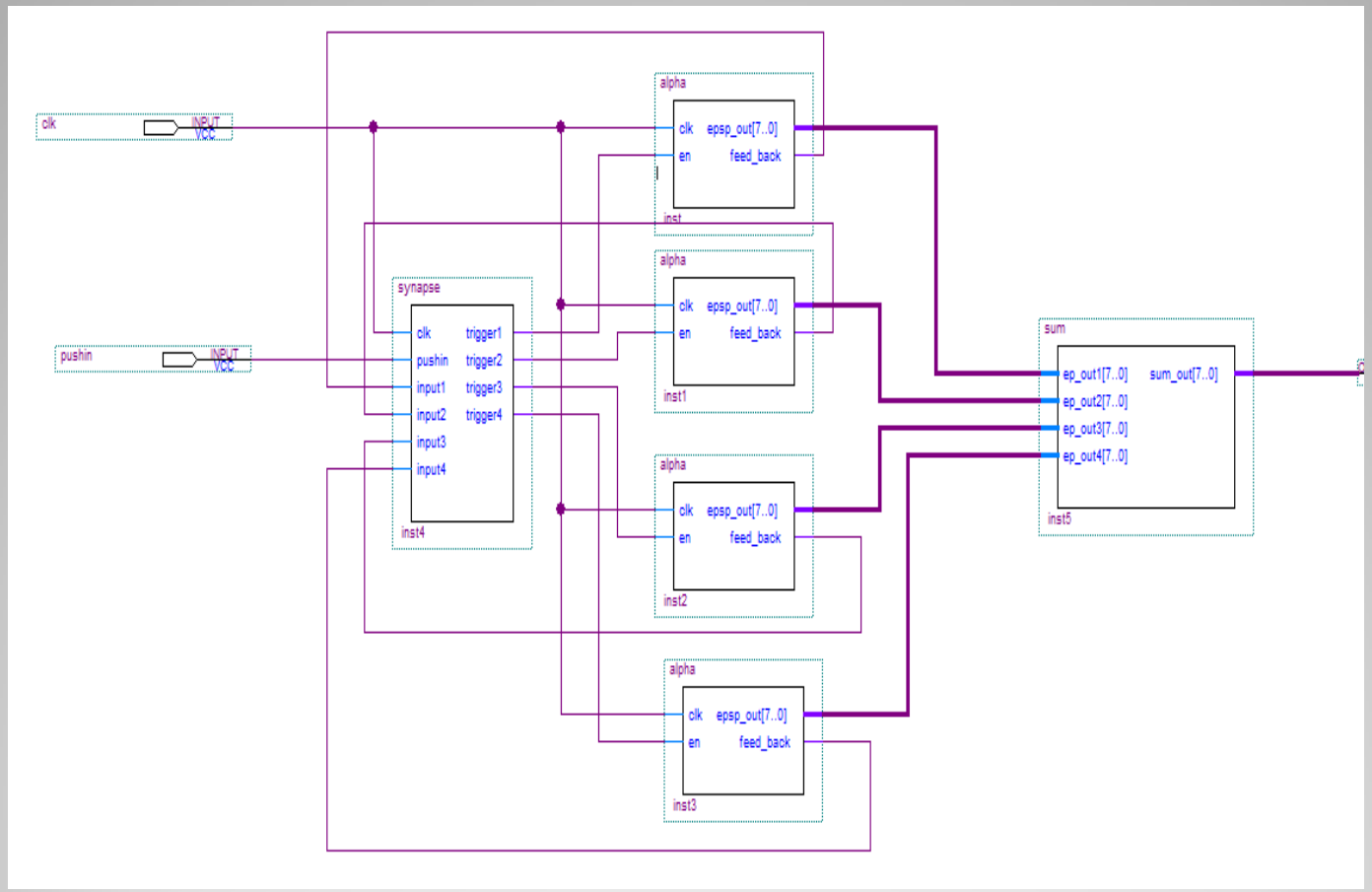




The basic model for neuron

My neuron


Parameter
Value
Type
M
2
Signed integer
N
2
Signed integer
period_in_cycles
2
Signed integer
clk
div_clk
clock_div
inst
push1
push2
dendrite
clk
push1n
drive[7..0]
inst1
inst2
inst3
soma
input1[7..0]
input2[7..0]
input3[7..0]
output[7..0]
inst7
threshold
input_i[7..0]
si_signal
output_i[7..0]
inst5
fire
clk
en
epsc_out[7..0]
inst11
display
vga_output[3..0]
vga_clk
vga_blank
vga_sync
epsc_alpha[7..0]
spike_line[7..0]
inst6



The complex dendrite

reference

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3. FPGA implementation of a multilayer perceptron neural network using VHDL

4. wiki.com

5. about.com

Thank you