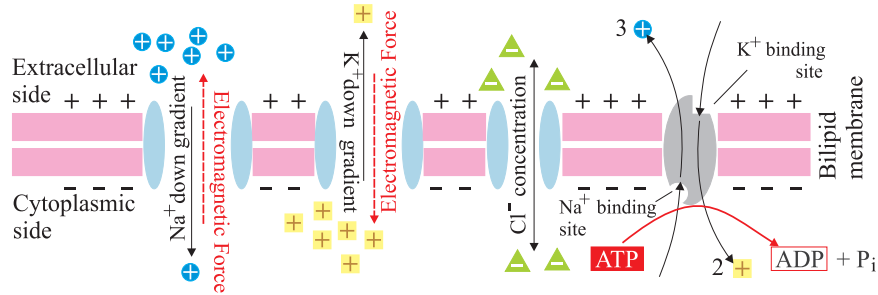


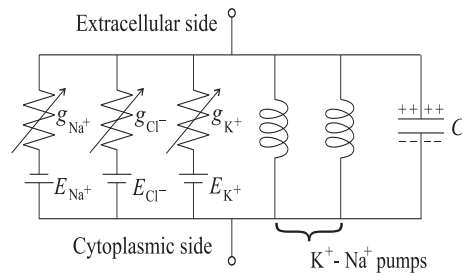
Bonus Project: Making Your Own Neuron Circuits

A square-burster circuit was constructed in the LectureNotes folder: `matlab/mfilechcircuits/SquareBursterCircuit/PiecewiseLinearIV`. It used piecewise IV -characteristics for two nonlinear resistors in parallel, one models a sodium Na^+ channel and the other models a potassium K^+ channel. The IV -characteristics for the Na^+ channel has the shape of a letter 'S' while that for the K^+ channel has the shape of a letter 'N'. Also the resting potential for the Na^+ channel E_{Na} is positive and that for the K^+ channel $-E_{\text{K}}$ is negative. The sodium-potassium pump is modeled by an inductor and the bilipid layer of the cell wall is modeled by a capacitor. All components are in parallel with each other. See illustration below.

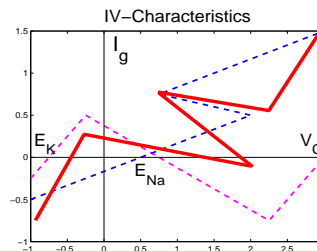
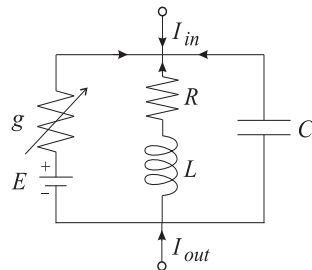
Neuron Cell Membrane



Circuit Model



Equivalent Circuit and its IV-Characteristics



The ion current due to the chloride, Cl^- , channel is assumed voltage independent, therefore treated as a current source and lumped together with the current term I_{in} . The solid IV -characteristic curve is the equivalence of the Na^+ and K^+ characteristics in parallel with resisting potential E_{Na} and $-E_K$ respectively as shown. Mfiles, K.m, Na.m, KNa.m, from the folder show how the characteristics are constructed using linear characteristics and nonlinear ramp characteristics, which are piecewise linear.

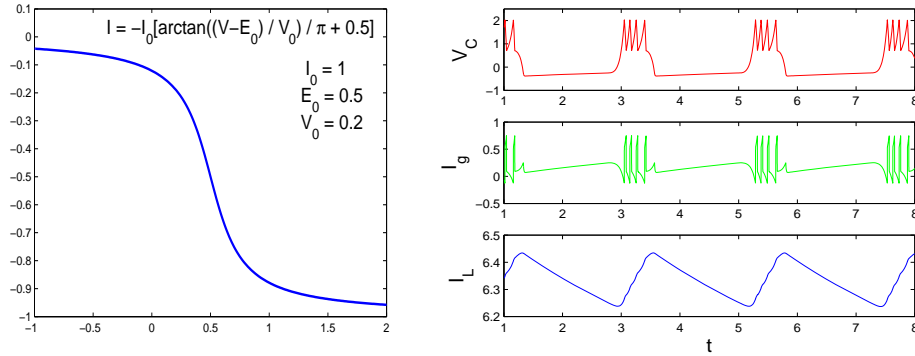
In this project, instead of piecewise linear ramp characteristics, use either the arctangent $\arctan x$ function or the tangent hyperbolic function $\tanh x$ as basic ingredients for the ramp characteristics. For example, the following curve

$$I = -I_0 \left[\frac{1}{\pi} \arctan\left(\frac{V - E_0}{V_0}\right) + \frac{1}{2} \right]$$

with parameter I_0, E_0, V_0 would produces a ramp-like function for which the following holds

$$\lim_{V \rightarrow \infty} I = -I_0, \quad \lim_{V \rightarrow -\infty} I = 0, \quad I(E_0) = -\frac{I_0}{2}.$$

The left graph below shows the shape of an arctangent ramp function.



The goal is to produce smooth characteristics with configurations similar to the one shown in the previous page, and to generate spike-bursts similar to the one shown on the right figure above.