Exercise 02:
Single-compartment model

Theoretical Neuroscience I

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Question:
Compute and plot the dependent variables of a neuron with the single-compartment model for a constant input current, an oscillating input current with low frequency (10Hz), an oscillating input current with medium frequency (100Hz) and a high frequency random input current. Use the following values for the independent variables: $r_m = 0.9\text{M}\Omega\,\text{mm}^2$, $c_m = 12\text{nF}\,\text{mm}^{-2}$, $V_0 = 0\text{mV}$ and $i_0 = 25\text{nA}\,\text{mm}^{-2}$.

Answer:

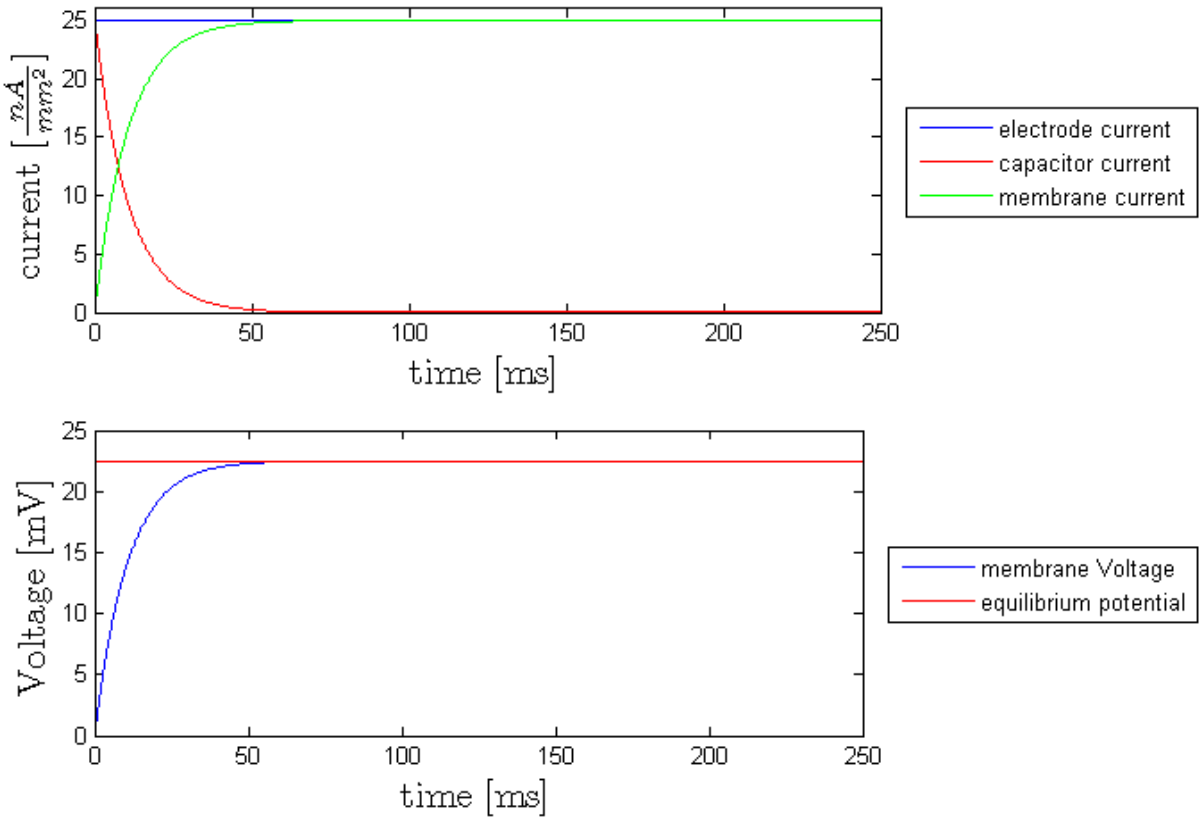

Figure 1: Constant input current: $i_e(t) = i_0$. Top: The electrode current(i_e, blue), the capacitor current(i_c, red) and the membrane current (i_r, green) over time. Bottom: The membrane voltage (V_m, blue) and the equilibrium potential (V_∞, red) over time.

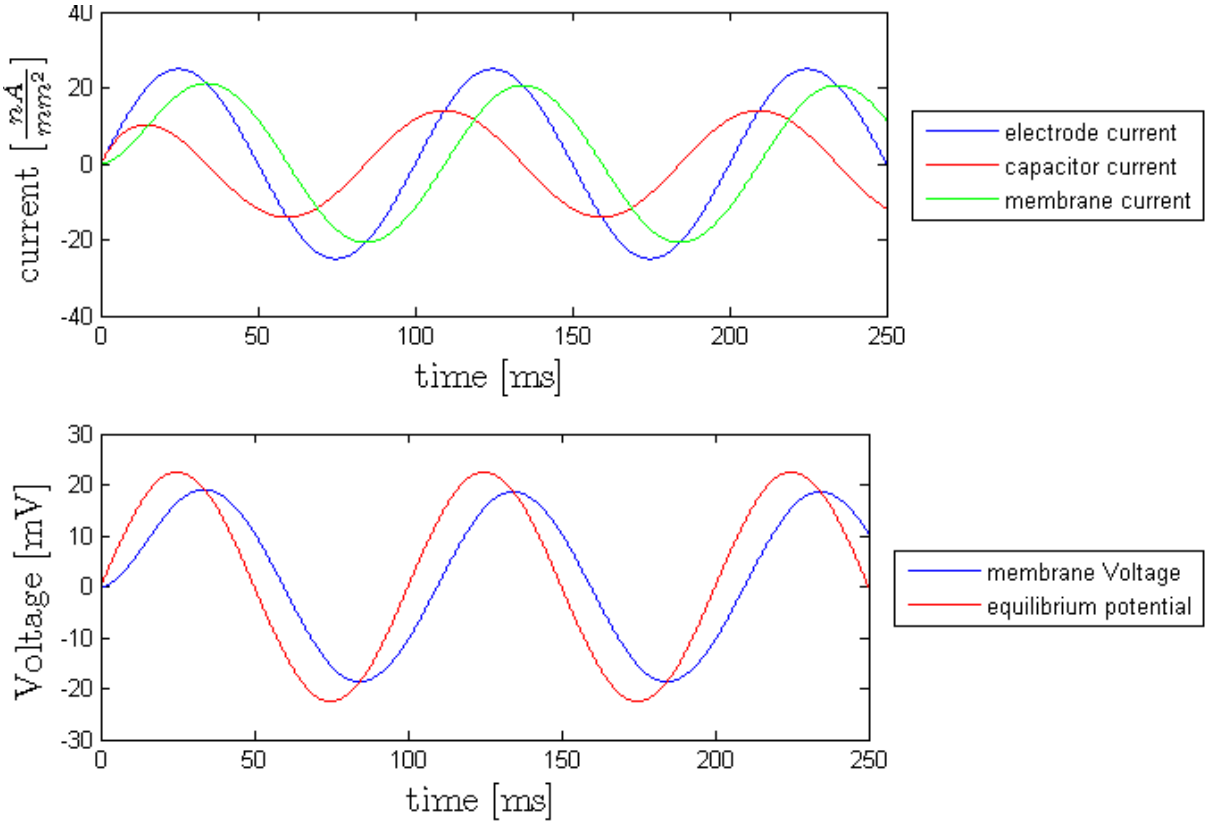

Figure 2: Low frequency input current: $i_e(t) = i_0 \cdot \sin 2\pi f t$, $f = 10\text{Hz}$. Same variables shown as in Figure 1.

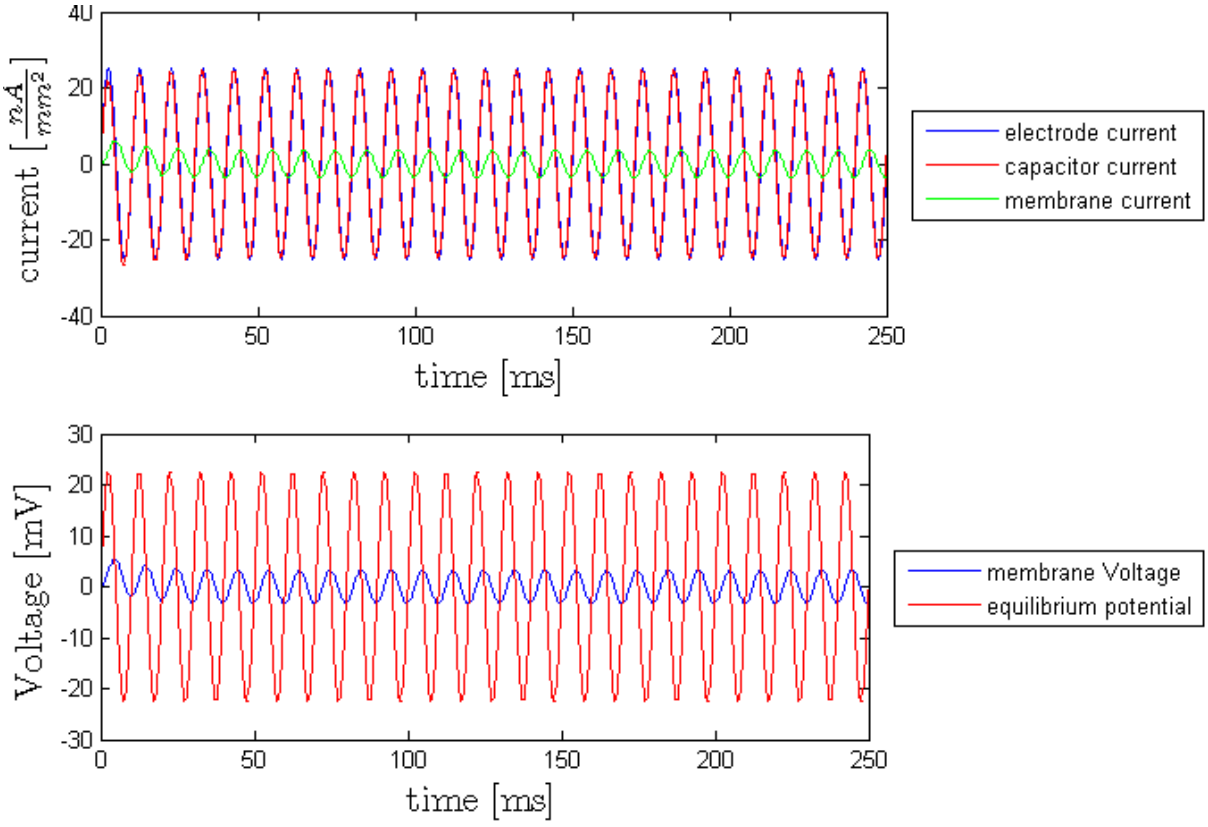

Figure 3: Medium frequency input current: $i_e(t) = i_0 \cdot \sin 2\pi f t$, $f = 100$Hz. Same variables shown as in Figure 1.

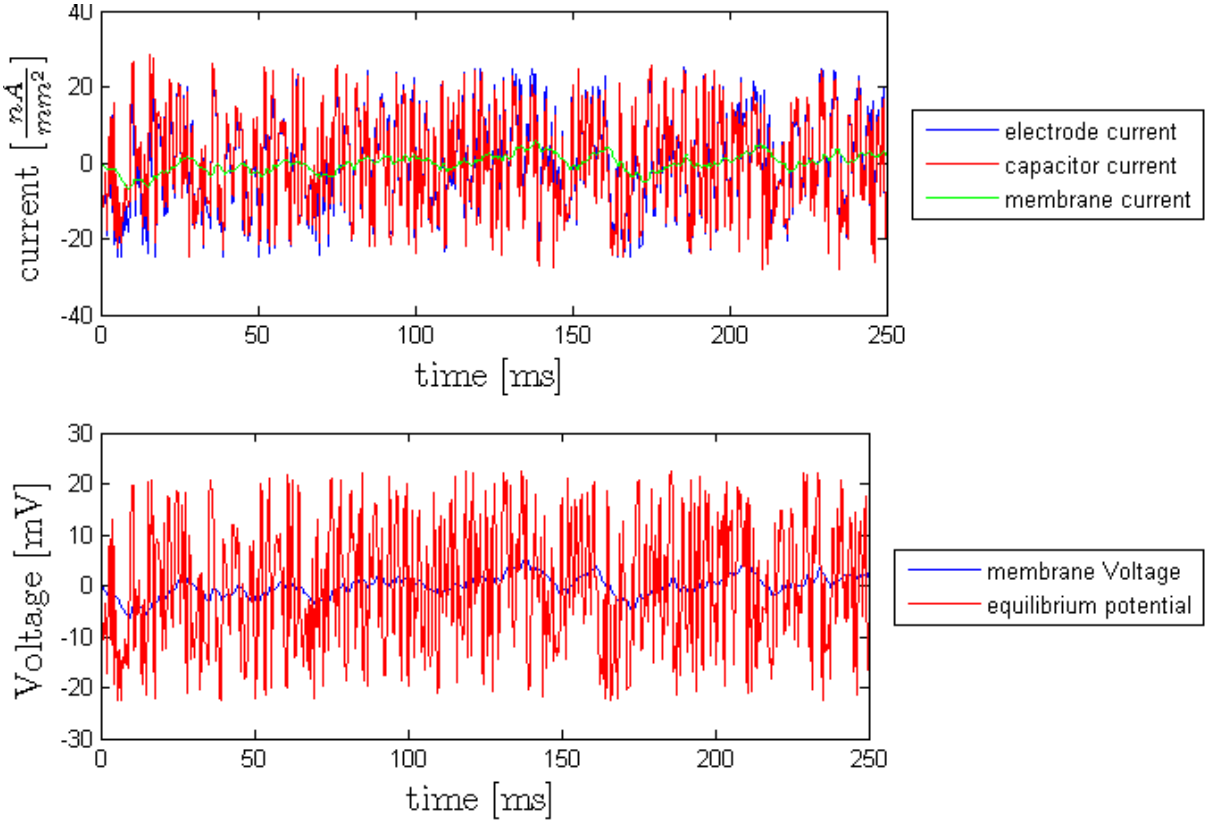

Figure 4: High frequency random input current. Same variables shown as in Figure 1.