Equations for 3 neuron Circuit

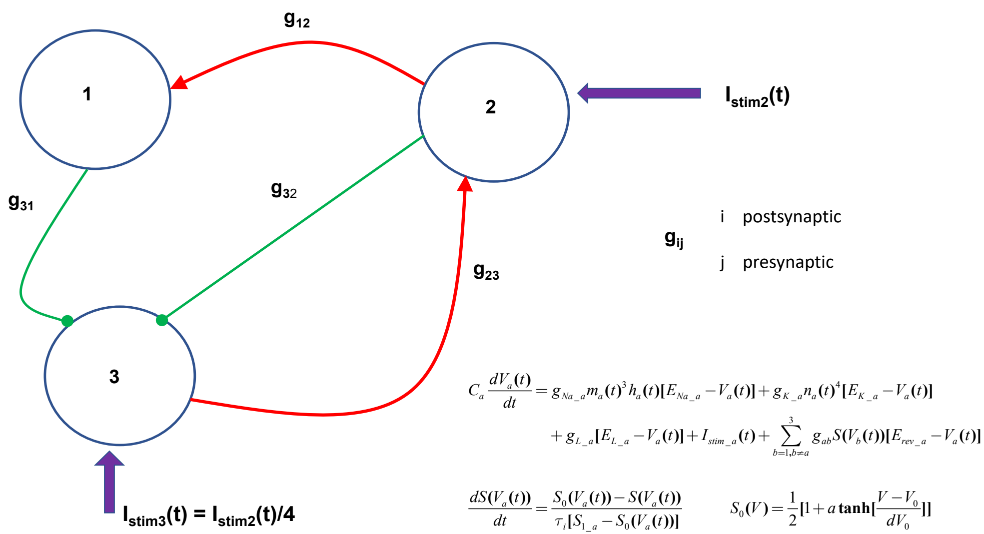

Figure 1:

1 Equations

$$C\frac{dV_1(t)}{dt} = F(V_1(t), m_1(t), h_1(t), n_1(t)) + g_{12}Se(V_2(t))[E_{reve} - V_1(t)] \quad (1)$$

$$C\frac{dV_2(t)}{dt} = F(V_2(t), m_2(t), h_2(t), n_1(t)) + g_{23}Se(V_3(t))[E_{reve} - V_2(t)]$$
$$+I_{stim2}(t) \quad (2)$$

$$C\frac{dV_3(t)}{dt} = F(V_3(t), m_3(t), h_3(t), n_3(t)) + g_{32}Si(V_2(t))[E_{revi} - V_3(t)]$$
$$+g_{31}Si(V_1(t))[E_{revi} - V_3(t)] + I_{stim3}(t) \quad (3)$$

The intrinsic HH model neuron is this:

$$F(V, m, h, n) = g_n m^3 h[E_{Na} - V] + g_K n^4[E_K - V] + g_L[E_L - V], \quad (4)$$

and the ion channel gating variables satisfy, $a = 1, 2, 3,$

$$\frac{dm_a(t)}{dt} = \frac{g(V_a(t), vm, dvm) - m_a(t)}{\tau(V_a(t), tm0, tm1, vm, dvm)}$$
$$\frac{dh_a(t)}{dt} = \frac{g(V_a(t), vh, dvh) - h_a(t)}{\tau(V_a(t), th0, th1, vh, dvh)}$$
$$\frac{dn_a(t)}{dt} = \frac{g(V_a(t), vn, dvn) - n_a(t)}{\tau(V_a(t), tn0, tn1, vn, dvn)} \tag{5}$$

with

$$g(V, A, B) = \frac{1}{2}[1.0 + \tanh(\frac{V - A}{B})]$$
$$\tau(V, t0, t1, A, B) = t0 + t1[1.0 - \tanh^2(\frac{V - A}{B})] \tag{6}$$

The excitatory synaptic gating variables $Se(V)$ satisfy

$$\frac{dSe(t)}{dt} = \frac{S0(V_{pre}(t)) - Se(t)}{\tau_1(S_1 - S0(V_{pre}(t))}, \tag{7}$$

and the inhibitory synaptic gating variables satisfy

$$\frac{dSi(t)}{dt} = \frac{S0(V_{pre}(t)) - Si(t)}{\tau_2(S_2 - S0(V_{pre}(t))}. \tag{8}$$

$$S0(V) = \frac{1}{2}[1.0 + \tanh(\frac{V - V0}{dV0}] \tag{9}$$

2 Parameters

units of C are nF
units of V are mV
units of current are nA
units of g are muS

C = 1.0
gn = 120.
vna = 50.
gk = 20.0
vk = -77.
gl = 0.3
vl = -54.4
vn = -55.0
dvn = 30.0
tn0 = 1.0
tn1 = 5.0
vm = -40.0
dvm = 15.0
tm0 = 0.1
tm1 = 0.4
vh = -60.0
dvh = -15.0
th0 = 1.0
th1 = 7.0
g12 = 0.35
g23 = 0.27
g32 = 0.215
g31 = 0.203
E_{reve} = 0.0
E_{revi} = -80.0
tau1 = 1.0
tau2 = 3.0
S1 = 3.0/2.0
S2 = 5.0/3.0