SBML Model Report

Model name: "Wang1996_Synaptic_Inhibition_Two_Neuron"

May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by Lukas Endler[1] at January 24th 2011 at 0:42 a. m. and last time modified at April eighth 2016 at 4:57 p. m. Table 1 gives an overview of the quantities of all components of this model.

Table 1: Number of components in this model, which are described in the following sections.

Element	Quantity	Element	Quantity
compartment types	0	compartments	2
species types	0	species	0
events	0	constraints	0
reactions	0	function definitions	0
global parameters	45	unit definitions	6
rules	31	initial assignments	5

Model Notes

This is a model of one presynaptic and one postsynaptic cell, as described in the article:
Gamma oscillation by synaptic inhibition in a hippocampal interneuronal network model.
Wang XJ, Buzski G. J Neurosci. 1996 Oct 15;16(20):6402-13. PMID:8815919;

Abstract:
Fast neuronal oscillations (gamma, 20-80 Hz) have been observed in the neocortex and hippocampus during behavioral arousal. Using computer simulations, we investigated the hypoth-

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esis that such rhythmic activity can emerge in a random network of interconnected GABAergic fast-spiking interneurons. Specific conditions for the population synchronization, on properties of single cells and the circuit, were identified. These include the following: (1) that the amplitude of spike afterhyperpolarization be above the GABAA synaptic reversal potential; (2) that the ratio between the synaptic decay time constant and the oscillation period be sufficiently large; (3) that the effects of heterogeneities be modest because of a steep frequency-current relationship of fast-spiking neurons. Furthermore, using a population coherence measure, based on coincident firings of neural pairs, it is demonstrated that large-scale network synchronization requires a critical (minimal) average number of synaptic contacts per cell, which is not sensitive to the network size. By changing the GABAA synaptic maximal conductance, synaptic decay time constant, or the mean external excitatory drive to the network, the neuronal firing frequencies were gradually and monotonically varied. By contrast, the network synchronization was found to be high only within a frequency band coinciding with the gamma (20-80 Hz) range. We conclude that the GABAA synaptic transmission provides a suitable mechanism for synchronized gamma oscillations in a sparsely connected network of fast-spiking interneurons. In turn, the interneuronal network can presumably maintain subthreshold oscillations in principal cell populations and serve to synchronize discharges of spatially distributed neurons.

The presynaptic and postsynaptic cell have identical parameters and the variables in each cell are identified by using **_pre** or **_post** as a postfix to their names. The presynaptic cell influences the postsynaptic one via the synapse (variables and parameters: I_syn, E_syn, g_syn, F, theta_syn, alpha, beta). The applied current to the presynaptic cell, I_app_pre, is set to 2 microA/cm^2 for 10 ms as in figure 1C of the article. The dependence of the postsynaptic cell on directly applied current can be investigated in isolation by setting I_app_pre to 0 and altering I_app_post.

Originally created by libAntimony v1.4 (using libSBML 3.4.1)

2 Unit Definitions

This is an overview of ten unit definitions of which four are predefined by SBML and not mentioned in the model.

2.1 Unit `time`

Name ms

Definition ms

2.2 Unit `per_ms`

Name per_ms

Definition ms^{-1}

2.3 Unit `mV`

Name mV

Definition mV

2.4 Unit `uA_per_cm2`

Name microA_per_cm2

Definition $\mu A \cdot cm^{-2}$

2.5 Unit `uF_per_cm2`

Name uF_per_cm2

Definition $\mu F \cdot cm^{-2}$

2.6 Unit `mS_per_cm2`

Name mS_per_cm2

Definition $mS \cdot cm^{-2}$

2.7 Unit `substance`

Notes Mole is the predefined SBML unit for `substance`.

Definition mol

2.8 Unit `volume`

Notes Litre is the predefined SBML unit for `volume`.

Definition l

2.9 Unit `area`

Notes Square metre is the predefined SBML unit for `area` since SBML Level 2 Version 1.

Definition m^2

2.10 Unit `length`

Notes Metre is the predefined SBML unit for `length` since SBML Level 2 Version 1.

Definition m

3 Compartments

This model contains two compartments.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
pre_synaptic_cell		0000290	3	1	litre	☑	
post_synaptic_cell		0000290	3	1	litre	☑	

3.1 Compartment pre_synaptic_cell

This is a three dimensional compartment with a constant size of one litre.

SBO:0000290 physical compartment

3.2 Compartment post_synaptic_cell

This is a three dimensional compartment with a constant size of one litre.

SBO:0000290 physical compartment

4 Parameters

This model contains 45 global parameters.

Table 3: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Cm		0000258	1.0	$\mu F \cdot cm^{-2}$	☑
gL		0000257	0.1	$mS \cdot cm^{-2}$	☑
gK		0000257	9.0	$mS \cdot cm^{-2}$	☑
gNa		0000257	35.0	$mS \cdot cm^{-2}$	☑
E_K		0000259	-90.0	mV	☑
E_L		0000259	-65.0	mV	☑
E_Na		0000259	55.0	mV	☑
phi			5.0	dimensionless	☑
tau_0			0.0	ms	☐
I_app_post			0.0	$\mu A \cdot cm^{-2}$	☑
I_Na_post			0.0	$\mu A \cdot cm^{-2}$	☐
m_inf_post			0.0	dimensionless	☐
h_post			0.0	dimensionless	☐
V_post		0000259	-64.0	mV	☐

Id	Name	SBO	Value	Unit	Constant
alpha_m_post			0.0	ms^{-1}	☐
beta_m_post			0.0	ms^{-1}	☐
alpha_h_post			0.0	ms^{-1}	☐
beta_h_post			0.0	ms^{-1}	☐
I_K_post			0.0	$\mu A \cdot cm^{-2}$	☐
n_post			0.0	dimensionless	☐
alpha_n_post			0.0	ms^{-1}	☐
beta_n_post			0.0	ms^{-1}	☐
I_L_post			0.0	$\mu A \cdot cm^{-2}$	☐
I_syn			0.0	$\mu A \cdot cm^{-2}$	☐
g_syn		0000257	0.1	$mS \cdot cm^{-2}$	☑
s			0.0	dimensionless	☐
E_syn			-75.0	mV	☑
alpha			12.0	ms^{-1}	☑
F			0.0	dimensionless	☐
beta			0.1	ms^{-1}	☑
V_pre		0000259	-64.0	mV	☐
theta_syn			0.0	mV	☑
I_app_pre			0.0	$\mu A \cdot cm^{-2}$	☐
I_Na_pre			0.0	$\mu A \cdot cm^{-2}$	☐
m_inf_pre			0.0	dimensionless	☐
h_pre			0.0	dimensionless	☐
n_pre			0.0	dimensionless	☐
alpha_n_pre			0.0	ms^{-1}	☐
beta_n_pre			0.0	ms^{-1}	☐
alpha_h_pre			0.0	ms^{-1}	☐
beta_h_pre			0.0	ms^{-1}	☐
alpha_m_pre			0.0	ms^{-1}	☐
beta_m_pre			0.0	ms^{-1}	☐
I_K_pre			0.0	$\mu A \cdot cm^{-2}$	☐
I_L_pre			0.0	$\mu A \cdot cm^{-2}$	☐

5 Initialassignments

This is an overview of five initialassignments.

5.1 Initialassignment h_post

Derived unit dimensionless

Math $\frac{\text{alpha\_h\_post}}{\text{beta\_h\_post}+\text{alpha\_h\_post}}$

5.2 Initialassignment n_post

Derived unit dimensionless

Math $\frac{\text{alpha\_n\_post}}{\text{beta\_n\_post}+\text{alpha\_n\_post}}$

5.3 Initialassignment s

Derived unit dimensionless

Math $\frac{\text{alpha}\cdot\text{F}}{\text{beta}+\text{alpha}\cdot\text{F}}$

5.4 Initialassignment h_pre

Derived unit dimensionless

Math $\frac{\text{alpha\_h\_pre}}{\text{beta\_h\_pre}+\text{alpha\_h\_pre}}$

5.5 Initialassignment n_pre

Derived unit dimensionless

Math $\frac{\text{alpha\_n\_pre}}{\text{beta\_n\_pre}+\text{alpha\_n\_pre}}$

6 Rules

This is an overview of 31 rules.

6.1 Rule tau_0

Rule `tau_0` is an assignment rule for parameter `tau_0`:

$$\text{tau\_0} = \frac{\text{Cm}}{\text{gL}} \tag{1}$$

Derived unit $\mu\text{F} \cdot \text{mS}^{-1}$

6.2 Rule I_Na_post

Rule `I_Na_post` is an assignment rule for parameter `I_Na_post`:

$$\text{I\_Na\_post} = \text{gNa} \cdot \text{m\_inf\_post}^3 \cdot \text{h\_post} \cdot (\text{V\_post} - \text{E\_Na}) \tag{2}$$

Derived unit $\text{mS} \cdot \text{cm}^{-2} \cdot \text{mV}$

6.3 Rule m_inf_post

Rule m_inf_post is an assignment rule for parameter m_inf_post:

$$\text{m\_inf\_post} = \frac{\text{alpha\_m\_post}}{\text{alpha\_m\_post} + \text{beta\_m\_post}} \tag{3}$$

Derived unit dimensionless

6.4 Rule h_post

Rule h_post is a rate rule for parameter h_post:

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{h\_post} = \text{phi} \cdot (\text{alpha\_h\_post} \cdot (1 - \text{h\_post}) - \text{beta\_h\_post} \cdot \text{h\_post}) \tag{4}$$

6.5 Rule V_post

Rule V_post is a rate rule for parameter V_post:

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{V\_post} = \frac{\text{I\_app\_post} - (\text{I\_Na\_post} + \text{I\_K\_post} + \text{I\_L\_post} + \text{I\_syn})}{\text{Cm}} \tag{5}$$

Derived unit $\mu\text{A} \cdot \mu\text{F}^{-1}$

6.6 Rule alpha_m_post

Rule alpha_m_post is an assignment rule for parameter alpha_m_post:

$$\text{alpha\_m\_post} = \frac{-0.1 \cdot (\text{V\_post} + 35)}{\exp(-0.1 \cdot (\text{V\_post} + 35)) - 1} \tag{6}$$

6.7 Rule beta_m_post

Rule beta_m_post is an assignment rule for parameter beta_m_post:

$$\text{beta\_m\_post} = 4 \cdot \exp\left(\frac{(\text{V\_post} + 60)}{18}\right) \tag{7}$$

6.8 Rule alpha_h_post

Rule alpha_h_post is an assignment rule for parameter alpha_h_post:

$$\text{alpha\_h\_post} = 0.07 \cdot \exp\left(\frac{(\text{V\_post} + 58)}{20}\right) \tag{8}$$

6.9 Rule beta_h_post

Rule beta_h_post is an assignment rule for parameter beta_h_post:

$$\text{beta\_h\_post} = \frac{1}{\exp\left(-0.1 \cdot (\text{V\_post} + 28)\right) + 1} \tag{9}$$

6.10 Rule I_K_post

Rule I_K_post is an assignment rule for parameter I_K_post:

$$\text{I\_K\_post} = \text{gK} \cdot \text{n\_post}^{4} \cdot (\text{V\_post} - \text{E\_K}) \tag{10}$$

Derived unit $\text{mS} \cdot \text{cm}^{-2} \cdot \text{mV}$

6.11 Rule n_post

Rule n_post is a rate rule for parameter n_post:

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{n\_post} = \text{phi} \cdot (\text{alpha\_n\_post} \cdot (1 - \text{n\_post}) - \text{beta\_n\_post} \cdot \text{n\_post}) \tag{11}$$

6.12 Rule alpha_n_post

Rule alpha_n_post is an assignment rule for parameter alpha_n_post:

$$\text{alpha\_n\_post} = \frac{-0.01 \cdot (\text{V\_post} + 34)}{\exp\left(-0.1 \cdot (\text{V\_post} + 34)\right) - 1} \tag{12}$$

6.13 Rule beta_n_post

Rule beta_n_post is an assignment rule for parameter beta_n_post:

$$\text{beta\_n\_post} = 0.125 \cdot \exp\left(\frac{(\text{V\_post} + 44)}{80}\right) \tag{13}$$

6.14 Rule I_L_post

Rule I_L_post is an assignment rule for parameter I_L_post:

$$\text{I\_L\_post} = \text{gL} \cdot (\text{V\_post} - \text{E\_L}) \tag{14}$$

Derived unit $\text{mS} \cdot \text{cm}^{-2} \cdot \text{mV}$

6.15 Rule I_syn

Rule I_syn is an assignment rule for parameter I_syn:

$$\text{I\_syn} = \text{g\_syn} \cdot \text{s} \cdot (\text{V\_post} - \text{E\_syn}) \tag{15}$$

Derived unit $\text{mS} \cdot \text{cm}^{-2} \cdot \text{mV}$

6.16 Rule s

Rule s is a rate rule for parameter s:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s} = \mathrm{alpha} \cdot \mathrm{F} \cdot (1 - \mathrm{s}) - \mathrm{beta} \cdot \mathrm{s} \tag{16}$$

6.17 Rule F

Rule F is an assignment rule for parameter F:

$$\mathrm{F} = \frac{1}{1 + \exp\left(\frac{(\mathrm{V\_pre} - \mathrm{theta\_syn})}{2}\right)} \tag{17}$$

6.18 Rule V_pre

Rule V_pre is a rate rule for parameter V_pre:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{V\_pre} = \frac{\mathrm{I\_app\_pre} - (\mathrm{I\_Na\_pre} + \mathrm{I\_K\_pre} + \mathrm{I\_L\_pre})}{\mathrm{Cm}} \tag{18}$$

Derived unit $\mu\mathrm{A} \cdot \mu\mathrm{F}^{-1}$

6.19 Rule I_app_pre

Rule I_app_pre is an assignment rule for parameter I_app_pre:

$$\mathrm{I\_app\_pre} = \begin{cases} 2 & \text{if } (\mathrm{time} \geq 10) \land (\mathrm{time} \leq 20) \\ 0 & \text{otherwise} \end{cases} \tag{19}$$

6.20 Rule I_Na_pre

Rule I_Na_pre is an assignment rule for parameter I_Na_pre:

$$\mathrm{I\_Na\_pre} = \mathrm{gNa} \cdot \mathrm{m\_inf\_pre}^3 \cdot \mathrm{h\_pre} \cdot (\mathrm{V\_pre} - \mathrm{E\_Na}) \tag{20}$$

Derived unit $\mathrm{mS} \cdot \mathrm{cm}^{-2} \cdot \mathrm{mV}$

6.21 Rule m_inf_pre

Rule m_inf_pre is an assignment rule for parameter m_inf_pre:

$$\mathrm{m\_inf\_pre} = \frac{\mathrm{alpha\_m\_pre}}{\mathrm{alpha\_m\_pre} + \mathrm{beta\_m\_pre}} \tag{21}$$

Derived unit dimensionless

6.22 Rule h_pre

Rule h_pre is a rate rule for parameter h_pre:

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{h\_pre} = \text{phi} \cdot (\text{alpha\_h\_pre} \cdot (1 - \text{h\_pre}) - \text{beta\_h\_pre} \cdot \text{h\_pre}) \tag{22}$$

6.23 Rule n_pre

Rule n_pre is a rate rule for parameter n_pre:

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{n\_pre} = \text{phi} \cdot (\text{alpha\_n\_pre} \cdot (1 - \text{n\_pre}) - \text{beta\_n\_pre} \cdot \text{n\_pre}) \tag{23}$$

6.24 Rule alpha_n_pre

Rule alpha_n_pre is an assignment rule for parameter alpha_n_pre:

$$\text{alpha\_n\_pre} = \frac{-0.01 \cdot (\text{V\_pre} + 34)}{\exp(-0.1 \cdot (\text{V\_pre} + 34)) - 1} \tag{24}$$

6.25 Rule beta_n_pre

Rule beta_n_pre is an assignment rule for parameter beta_n_pre:

$$\text{beta\_n\_pre} = 0.125 \cdot \exp\left(\frac{(\text{V\_pre} + 44)}{80}\right) \tag{25}$$

6.26 Rule alpha_h_pre

Rule alpha_h_pre is an assignment rule for parameter alpha_h_pre:

$$\text{alpha\_h\_pre} = 0.07 \cdot \exp\left(\frac{(\text{V\_pre} + 58)}{20}\right) \tag{26}$$

6.27 Rule beta_h_pre

Rule beta_h_pre is an assignment rule for parameter beta_h_pre:

$$\text{beta\_h\_pre} = \frac{1}{\exp(-0.1 \cdot (\text{V\_pre} + 28)) + 1} \tag{27}$$

6.28 Rule alpha_m_pre

Rule alpha_m_pre is an assignment rule for parameter alpha_m_pre:

$$\text{alpha\_m\_pre} = \frac{-0.1 \cdot (\text{V\_pre} + 35)}{\exp(-0.1 \cdot (\text{V\_pre} + 35)) - 1} \tag{28}$$

6.29 Rule beta_m_pre

Rule beta_m_pre is an assignment rule for parameter beta_m_pre:

$$\text{beta\_m\_pre} = 4 \cdot \exp\left(\frac{(\text{V\_pre} + 60)}{18}\right) \tag{29}$$

6.30 Rule I_K_pre

Rule I_K_pre is an assignment rule for parameter I_K_pre:

$$\text{I\_K\_pre} = \text{gK} \cdot \text{n\_pre}^4 \cdot (\text{V\_pre} - \text{E\_K}) \tag{30}$$

Derived unit $\mathrm{mS} \cdot \mathrm{cm}^{-2} \cdot \mathrm{mV}$

6.31 Rule I_L_pre

Rule I_L_pre is an assignment rule for parameter I_L_pre:

$$\text{I\_L\_pre} = \text{gL} \cdot (\text{V\_pre} - \text{E\_L}) \tag{31}$$

Derived unit $\mathrm{mS} \cdot \mathrm{cm}^{-2} \cdot \mathrm{mV}$

A Glossary of Systems Biology Ontology Terms

SBO:0000257 conductance: Measure of how easily electricity flows along a certain path through an electrical element. The SI derived unit of conductance is the Siemens

SBO:0000258 capacitance: Measure of the amount of electric charge stored (or separated) for a given electric potential. The unit of capacitance id the Farad

SBO:0000259 voltage: Difference of electrical potential between two points of an electrical network, expressed in volts

SBO:0000290 physical compartment: Specific location of space, that can be bounded or not. A physical compartment can have 1, 2 or 3 dimensions

SBML2LaTeX was developed by Andreas Dräger[a], Hannes Planatscher[a], Dieudonné M Wouamba[a], Adrian Schröder[a], Michael Hucka[b], Lukas Endler[c], Martin Golebiewski[d] and Andreas Zell[a]. Please see http://www.ra.cs.uni-tuebingen.de/software/SBML2LaTeX for more information.

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