Model Mathematics

Component: environment

Component: membrane

$$\frac{\mathrm{d}}{\mathrm{dtime}}(V) = \frac{\left(-\left(\text{i\_Na}+\text{i\_Ca}+\text{i\_to}+\text{i\_K}+\text{i\_K1}+\text{i\_b\_Na}+\text{i\_b\_Ca}+\text{i\_NaCa}+\text{i\_NaK}\right)\right)+\left(\text{rho\_x}S\right)^{-1.0}\text{V\_x2}+\left(\text{rho\_y}S\right)^{-1.0}\text{V\_y2}}{\text{Cm}}$$
$$\frac{\partial^{2.0}}{\partial x^{2.0}}(V) = \text{V\_x2}$$
$$\frac{\partial^{2.0}}{\partial y^{2.0}}(V) = \text{V\_y2}$$

Component: sodium_current

$$\text{i\_Na} = \text{g\_Na}m^{3.0}v^{2.0}(V - \text{E\_Na})$$
$$\text{E\_Na} = \frac{RT}{F}\ln\left(\frac{\text{Na\_e}}{\text{Na\_i}}\right)$$

Component: sodium_current_m_gate

$$\frac{\mathrm{d}}{\mathrm{dtime}}(m) = \text{alpha\_m}(1.0 - m) - \left(\text{beta\_m}m\right)$$
$$\text{alpha\_m} = \frac{0.32\left(V+47.13\right)}{1.0-\left(e^{(-0.1)\left(V+47.13\right)}\right)}$$
$$\text{beta\_m} = 0.08e^{\frac{-V}{11.0}}$$

Component: sodium_current_v_gate

$$\frac{\mathrm{d}}{\mathrm{dtime}}(v) = \frac{\text{v\_infinity}-v}{\text{tau\_v}}$$
$$\text{v\_infinity} = 0.5\left(1.0 - \left(\tanh(7.74 + V0.12)\right)\right)$$
$$\text{tau\_v} = 0.25 + 2.24\frac{1.0-\left(\tanh\left(7.74+V0.12\right)\right)}{1.0-\left(\tanh\left(0.07\left(V+92.4\right)\right)\right)}$$

Component: calcium_current

$$\text{i\_Ca} = \text{g\_Cad\_infinity}f\text{f\_Ca}(V - \text{E\_Ca})$$
$$\text{E\_Ca} = \frac{RT}{2.0F}\ln\left(\frac{\text{Ca\_e}}{\text{Ca\_i}}\right)$$

Component: calcium_current_d_gate

$$\text{d\_infinity} = \frac{\text{alpha\_d}}{\text{alpha\_d}+\text{beta\_d}}$$
$$\text{alpha\_d} = \frac{14.98e^{(-0.5)\left(\frac{V-22.36}{16.68}\right)^{2.0}}}{16.68\sqrt{2.0\pi}}$$
$$\text{beta\_d} = 0.1471 - \left(\frac{5.3e^{(-0.5)\left(\frac{V-6.27}{14.93}\right)^{2.0}}}{14.93\sqrt{2.0\pi}}\right)$$

Component: calcium_current_f_gate

$$\frac{\mathrm{d}}{\mathrm{dtime}}(f) = \text{alpha\_f}\left(1.0 - f\right) - \left(\text{beta\_f}f\right)$$
$$\text{alpha\_f} = \frac{6.87\text{e-3}}{1.0+e^{\frac{-\left(6.1546-V\right)}{6.12}}}$$
$$\text{beta\_f} = \frac{0.069e^{(-11.0)\left(V+9.825\right)}+0.011}{1.0+e^{(-0.278)\left(V+9.825\right)}} + 5.75\text{ e -4}$$

Component: calcium_current_f_Ca_gate

$$\text{f\_Ca} = \frac{1.0}{1.0+\frac{\text{Ca\_i}}{0.0006}}$$

Component: transient_outward_current

$$\text{i\_to} = \text{g\_tor\_infinityto}(V - \text{E\_to})$$
$$\text{E\_to} = \frac{RT}{F}\ln\left(\frac{0.043\text{Na\_e}+\text{K\_e}}{0.043\text{Na\_i}+\text{K\_i}}\right)$$

Component: transient_outward_current_r_gate

$$\text{r\_infinity} = \frac{\text{alpha\_r}}{\text{alpha\_r}+\text{beta\_r}}$$
$$\text{alpha\_r} = \frac{0.5266e^{(-0.0166)\left(V-42.2912\right)}}{1.0+e^{(-0.0943)\left(V-42.2912\right)}}$$
$$\text{beta\_r} = \frac{5.186\text{e-5}V+0.5149e^{(-0.1344)\left(V-5.0027\right)}}{1.0+e^{(-0.1348)\left(V-5.186\text{e-5}\right)}}$$

Component: transient_outward_current_to_gate

$$\frac{\mathrm{d}}{\mathrm{dtime}}(\text{to}) = \text{alpha\_to}(1.0 - \text{to}) - \left(\text{beta\_toto}\right)$$
$$\text{alpha\_to} = \frac{5.612\text{e-5}V+0.0721e^{(-0.173)\left(V+34.2531\right)}}{1.0+e^{(-0.1732)\left(V+34.2531\right)}}$$
$$\text{beta\_to} = \frac{1.215\text{e-4}V+0.0767e^{1.66\text{e-9}\left(V+34.0235\right)}}{1.0+e^{(-0.1604)\left(V+34.0235\right)}}$$
$$\text{tau\_to} = \frac{1.0}{p\text{alpha\_to}V+p\text{beta\_to}V}$$
$$\text{to\_infinity} = \frac{\text{alpha\_to}\left(V-\text{V\_shift}\right)}{\text{alpha\_to}\left(V-\text{V\_shift}\right)+\text{beta\_to}\left(V-\text{V\_shift}\right)}$$

Component: delayed_rectifier_potassium_current

Model Curation

- Curation Status
- JSim
- COR
- OpenCell

Source

Derived from workspace Bernus, Wilders, Zemlin, Verschelde, Panfilov, 2002 (https://models.cellml.org/workspace/bernus_wilders_ze at changeset 13cbb6e57dfe (https://models.cellml.org/workspace/bernus_wilders_ze

Collaboration

To begin collaborating on this work, please use your mercurial client and issue this command:

```
hg clone https://models.cellml.org/w
```

Downloads

(https://models.cellml.org/workspace/bernus_wild

(https://models.cellml.org/workspace/bernus_wild

Views Available (https://models.cellml.org/e/5/bernus_

Documentation (https://models.cellml.org/e/5/bernus_wilders_zemlin_ve

Model Metadata (https://models.cellml.org/e/5/bernus_wilders_zemlin_ve

Model Curation (https://models.cellml.org/e/5/bernus_wilders_zemlin_ve

Mathematics (https://models.cellml.org/e/5/bernus_wilders_zemlin_ve

Generated Code (https://models.cellml.org/e/5/bernus_wilders_zemlin_ve

Cite this model (https://models.cellml.org/e/5/bernus_wilders_zemlin_ve

Source View (https://models.cellml.org/e/5/bernus_wilders_zemlin_ve

Simulate using OpenCell (https://models.cellml.org/e/5/bernus_wilders_zemlin_ve

Navigation (https://models.cellml.org/sitemap)

A computationally efficient electrophysiological model of human ventricular cells (https://models.cellml.org/e/5/bernus_wilders_z

$$\mathrm{i\_K} = \mathrm{g\_K}X^{2.0}(V - \mathrm{E\_K})$$
$$\mathrm{E\_K} = \frac{RT}{F}\ln\left(\frac{\mathrm{K\_e}}{\mathrm{K\_i}}\right)$$

Component: delayed_rectifier_potassium_current_X_gate

$$\frac{\mathrm{d}}{\mathrm{dtime}}(X) = \frac{\mathrm{X\_infinity} - X}{\mathrm{tau\_X}}$$
$$\mathrm{X\_infinity} = \frac{0.988}{1.0 + e^{-0.861 - (V0.0620)}}$$
$$\mathrm{tau\_X} = 240.0e^{\frac{-\left((25.5+V)^{2.0}\right)}{156.0}} + 182.0\left(1.0 + \tanh\left(0.154 + 0.0116V\right)\right) + \mathrm{tau\_X\_a}$$
$$\mathrm{tau\_X\_a} = 40.0\left(1.0 - \left(\tanh\left(160.0 + 2.0V\right)\right)\right)$$

Component: inward_rectifier_potassium_current

$$\mathrm{i\_K1} = \mathrm{g\_K1K1\_infinity}(V - \mathrm{E\_K})$$

Component: inward_rectifier_potassium_current_K1_gate

$$\mathrm{K1\_infinity} = \frac{\mathrm{alpha\_K1}}{\mathrm{alpha\_K1} + \mathrm{beta\_K1}}$$
$$\mathrm{alpha\_K1} = \frac{0.1}{1.0 + e^{0.06\left(V - \left(\mathrm{E\_K} + 200.0\right)\right)}}$$
$$\mathrm{beta\_K1} = \frac{3.0e^{2.0\mathrm{e}\text{-}4\left(V + 100.0 + \left(-\mathrm{E\_K}\right)\right)} + e^{0.1\left(V - \left(10.0 + \mathrm{E\_K}\right)\right)}}{1.0 + e^{(-0.5)(V - \mathrm{E\_K})}}$$

Component: calcium_background_current

$$\mathrm{i\_b\_Ca} = \mathrm{g\_b\_Ca}(V - \mathrm{E\_Ca})$$

Component: sodium_background_current

$$\mathrm{i\_b\_Na} = \mathrm{g\_b\_Na}(V - \mathrm{E\_Na})$$

Component: sodium_potassium_pump

$$\mathrm{i\_NaK} = \mathrm{g\_NaKf\_NaKf\_NaK\_a}$$
$$\mathrm{f\_NaK} = \frac{1.0}{1.0 + 0.1245e^{(-0.0037)V} + 0.0365\mathrm{sigma}e^{(-0.037)V}}$$
$$\mathrm{f\_NaK\_a} = \frac{1.0}{1.0 + \left(\frac{10.0}{\mathrm{Na\_i}}\right)^{1.5}}\frac{\mathrm{K\_e}}{\mathrm{K\_e} + 1.5}$$
$$\mathrm{sigma} = 0.1428\left(e^{\frac{\mathrm{Na\_e}}{67.3}} - 1.0\right)$$

Component: sodium_calcium_pump

$$\mathrm{i\_NaCa} = \mathrm{g\_NaCaf\_NaCa}$$
$$\mathrm{f\_NaCa} = \left(87.5^{3.0} + \mathrm{Na\_e}^{3.0}\right)^{-1.0}(1.38 + \mathrm{Ca\_e})^{-1.0}\left(1.0 + 0.1e^{(-0.024)V}\right)^{-1.0}\left(\mathrm{Na\_i}^{3.0}\mathrm{Ca\_e}e^{0.013V} - \left(\mathrm{Na\_e}^{3.0}\mathrm{Ca\_i}e^{(-0.024)V}\right)\right)$$

Component: ionic_concentrations