

# Guide to Using HHsim

HHsim is a graphical simulation of a section of excitable neuronal membrane using the Hodgkin-Huxley equations. It provides full access to the Hodgkin-Huxley parameters, membrane parameters, stimulus parameters, and ion concentrations, and can be used for many sorts of [exercises](#).

## Starting HHsim

If you've downloaded and installed the executable version of HHsim for Windows, you can start HHsim via a shortcut on the desktop or an entry in the Start menu. Or you can go to the HHsim folder and click on the icon for hhsim.exe.

To run the Unix executable, cd to that directory and type `./hhsim` to begin.

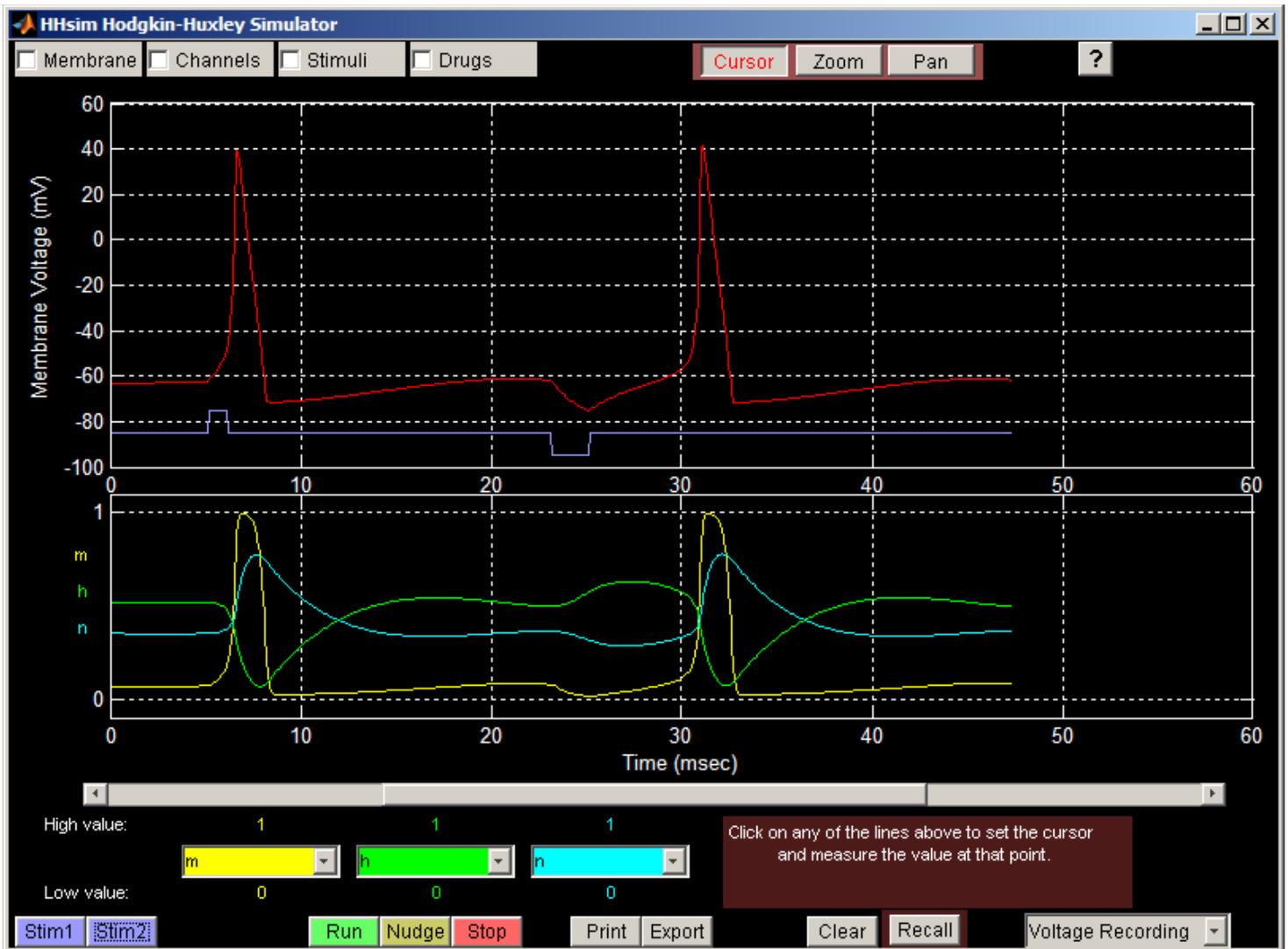
If you've downloaded just the Matlab source code, run Matlab, cd to the directory containing the source, and type "hhsim". Note: HHsim requires Matlab version 6 or higher.

## Main Window

The main window consists of two plots. The large plot displays membrane voltage in red and external stimuli (current pulses) in blue. The smaller plot displays three quantities as yellow, green, and cyan lines. By default these are the Hodgkin-Huxley variables  $m$ ,  $h$ , and  $n$ , but other information can be selected, such as currents or conductances. The yellow, green, and cyan pulldown menus select the variables to be plotted.

Click on the purple **Stim1** or **Stim2** buttons to inject a depolarizing or hyperpolarizing current stimulus. Click on the Membrane, Channels, or Stimuli buttons to view and modify the simulation parameters.

Radio buttons at the top of the display will allow you to use three different modes:  $\hat{A}$  cursor, zoom and pan. In cursor mode, clicking on any of the plot lines causes an elliptical cursor to appear, and the value of the selected variable is displayed in the cursor subpanel in the bottom right corner of the main window. Cursor control buttons move the cursor left or right, either by one timestep or to the next local maximum or minimum of the graph. In zoom mode, left-clicking on a plot will zoom in; right-clicking will bring up more options. Clicking and dragging your cursor in zoom mode will give a zoom box for a more controlled zoom. In pan mode, clicking and dragging on a plot will allow you to pan in any axis direction.



The simulation runs whenever a stimulus is applied or a parameter value is changed. It stops when the membrane voltage appears to have reached an asymptote. If it stops too soon, click the yellow **Nudge** button to nudge the simulation along for a few more time steps. Click **Run** (green button) to enter continuous run mode, and **Stop** (red button) to leave this mode.

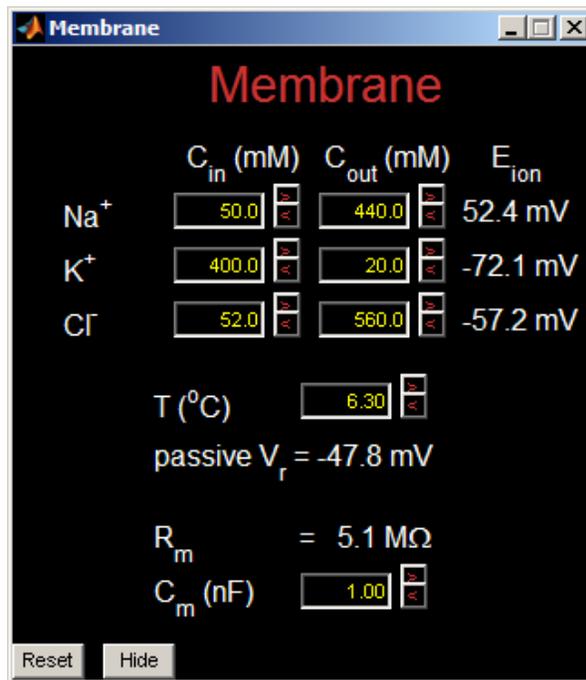
The **Clear** button clears the display and resets the time, but does not affect any other simulation parameters. The **Recall** button resets the Hodgkin-Huxley variables to a previously-stored state. Initially this is the resting state; see the [cursor control](#) page for information on saving state for later recall. **Zoom in** and **Zoom out** buttons are self-explanatory.

### [Click here for cursor controls](#)

The **Print** button outputs the plots in the main window as a Postscript file, suitable for printing or for inclusion in other documents. The **Export** button saves the plotted curves as a table in ASCII format, readable by Microsoft Excel, Matlab (using the `importdata` function), and many other programs. If the cursor is active, only that curve are exported; otherwise all the curves are exported.

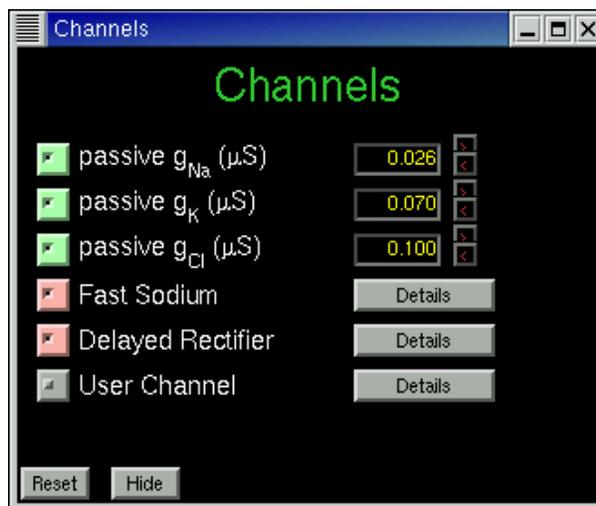
## Membrane Window

The Membrane window provides for manipulation of internal and external ion concentrations, and adjustment of a few membrane parameters.

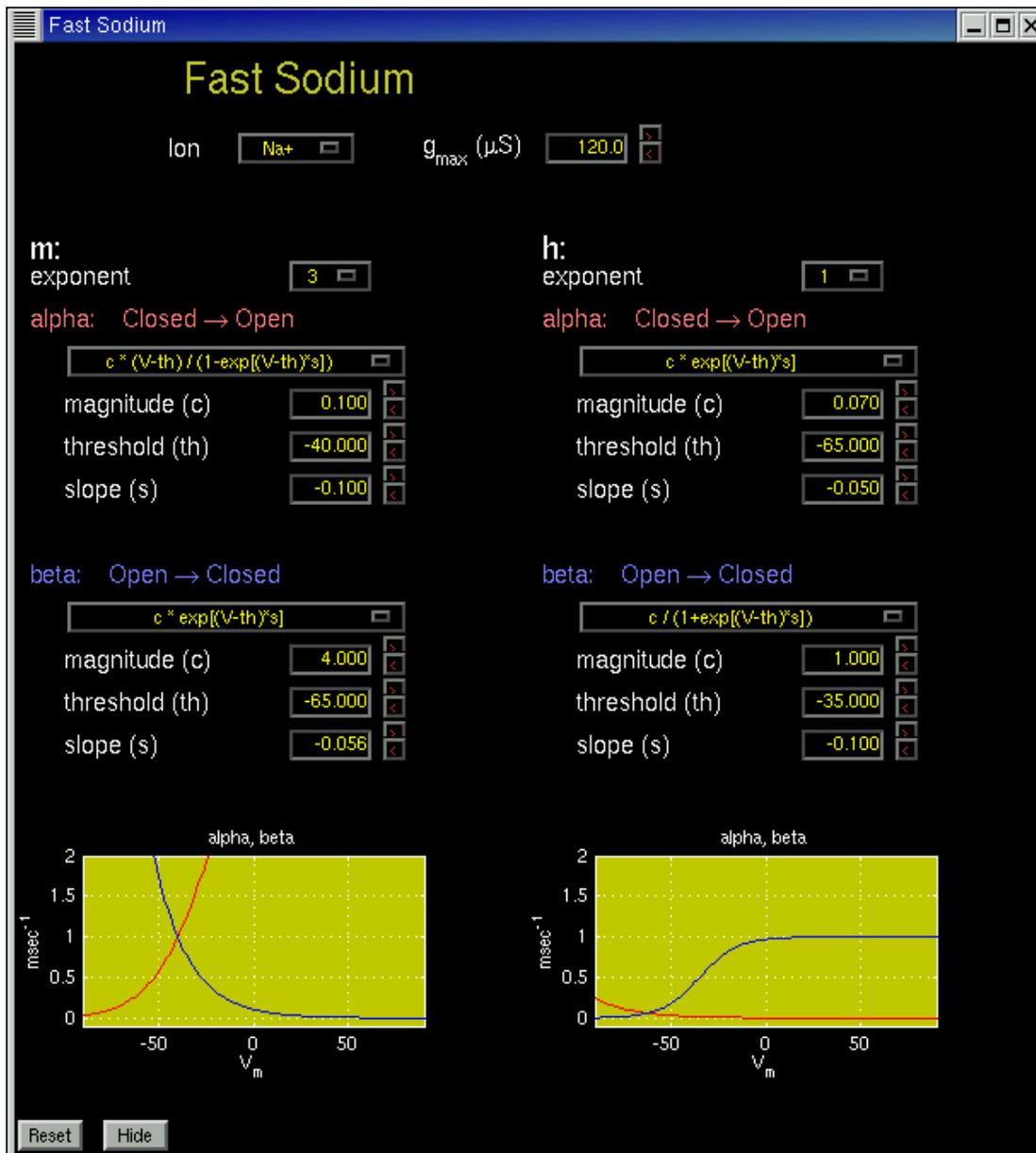


## Channels Window

The Channels window provides access to parameters for each of the active or passive channel types. Channels can be temporarily disabled by clicking the associated toggle to the left of the channel name.

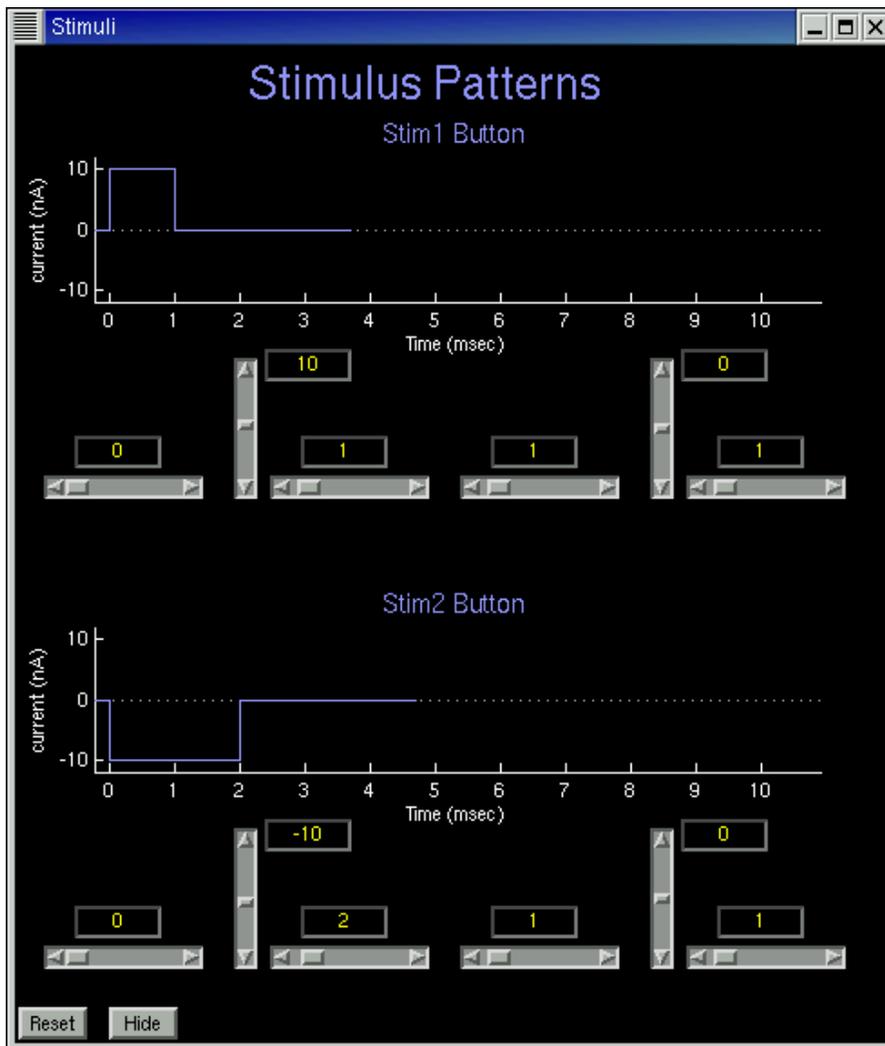


For passive channels the only parameter is the conductance, in micro-Siemens. For active channels, namely the fast sodium channel, the delayed rectifier, and a user-defined active channel, a Details button calls up another window for accessing the channel's Hodgkin-Huxley parameters. Shown below is the window for the fast sodium channel.



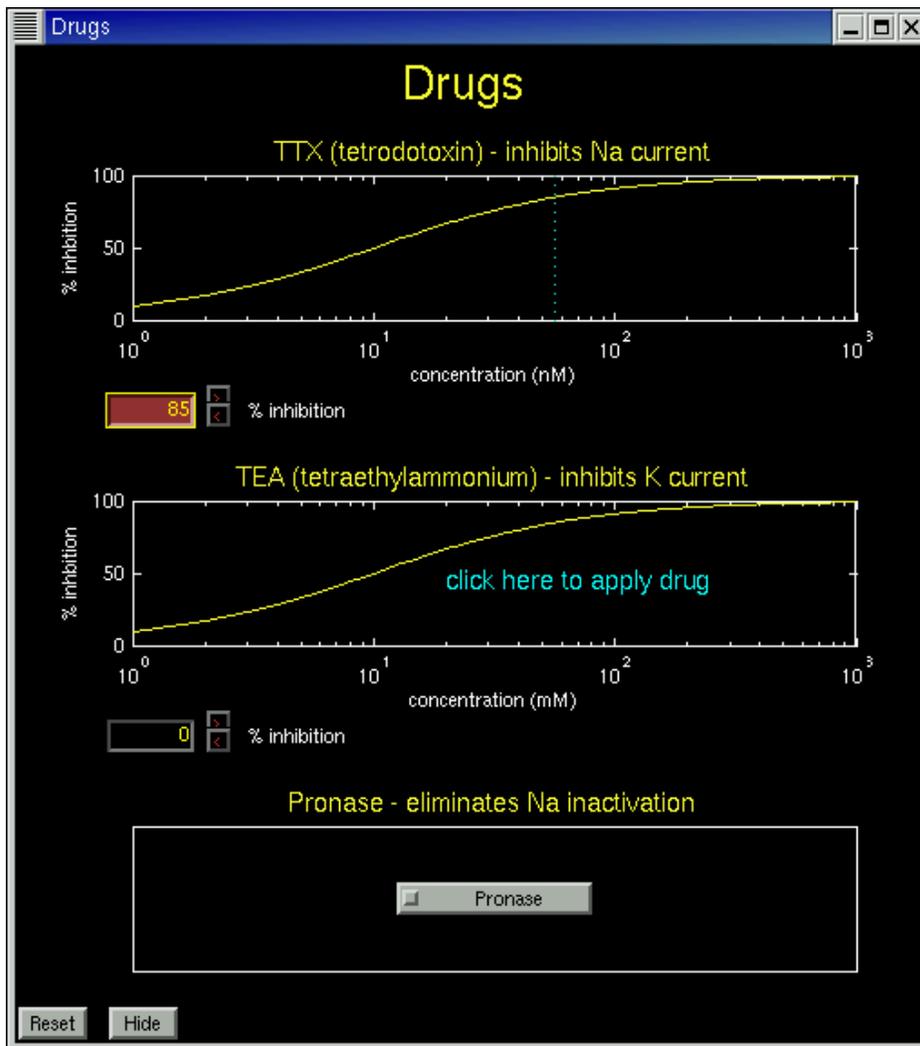
## Stimuli Window

The Stimuli window controls the parameters for two external stimuli, Stim1 and Stim2, each of which consists of either a single current pulse or a sequence of two independently-adjustable pulses.



## Drugs Window

The Drugs window allows application of any of three drugs: TTX, which inhibits the sodium current; TEA, which inhibits the potassium current; and pronase, which eliminates sodium channel inactivation. Any time a drug is being applied, the Drugs button in the main window will be yellow instead of the usual gray



## Voltage Clamp Mode

HHsim starts up in "Voltage Reporting" mode. To switch to "Voltage Clamp" mode, use the pulldown menu in the lower right portion of the main screen.

[Click here for voltage clamp controls](#)

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