Defining a Channel

Classical HH–like Kinetic scheme voltage and ligand gated

ohmic conductance GHK constant field

ion selective

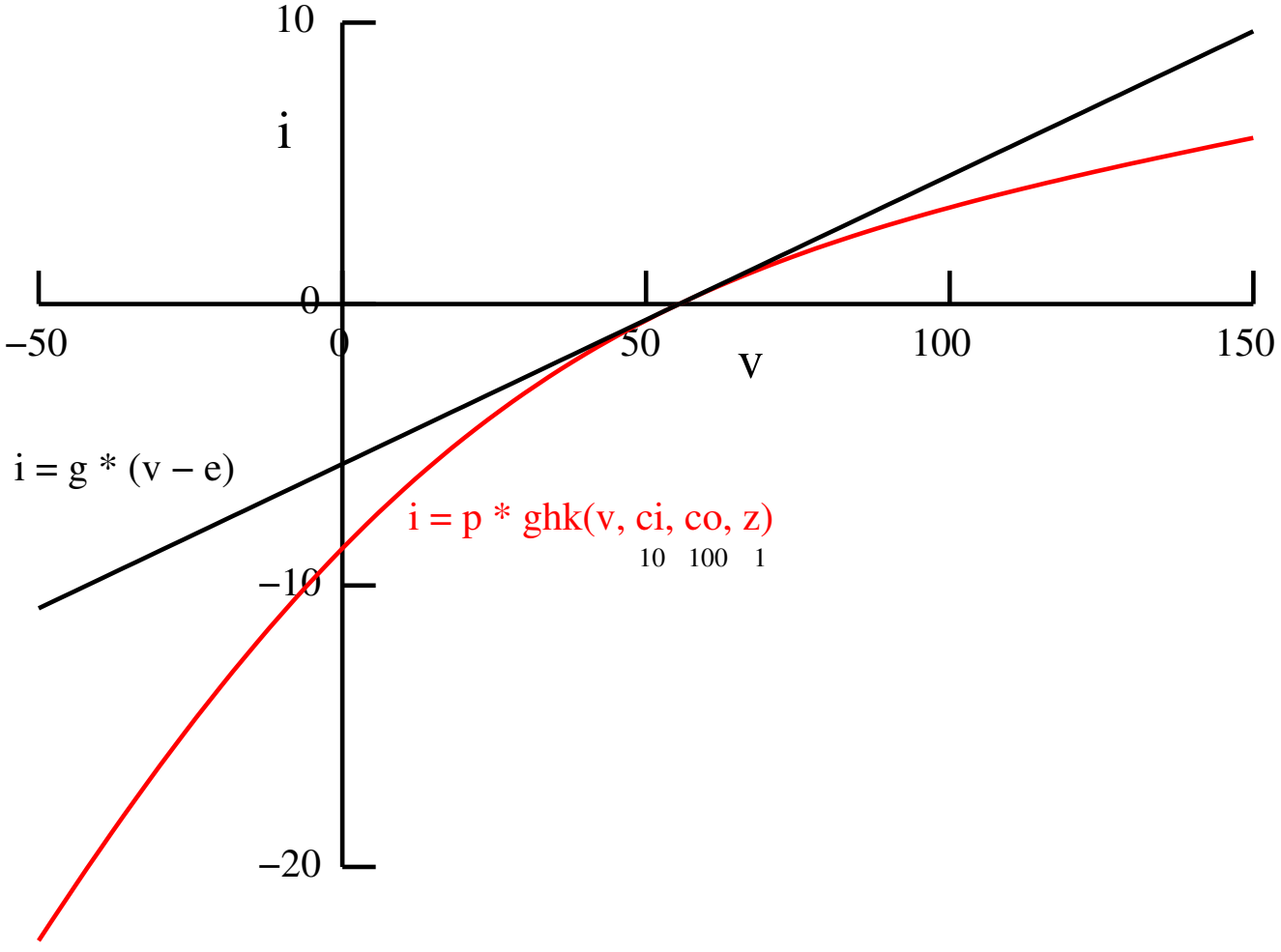
multiple gates fractional openness independent identical subunits

transition style (α, β) (∞, τ) functions tables

ligand sensitive voltage sensitive

leave out pumps ionic accumulation

Ohmic vs Constant Field



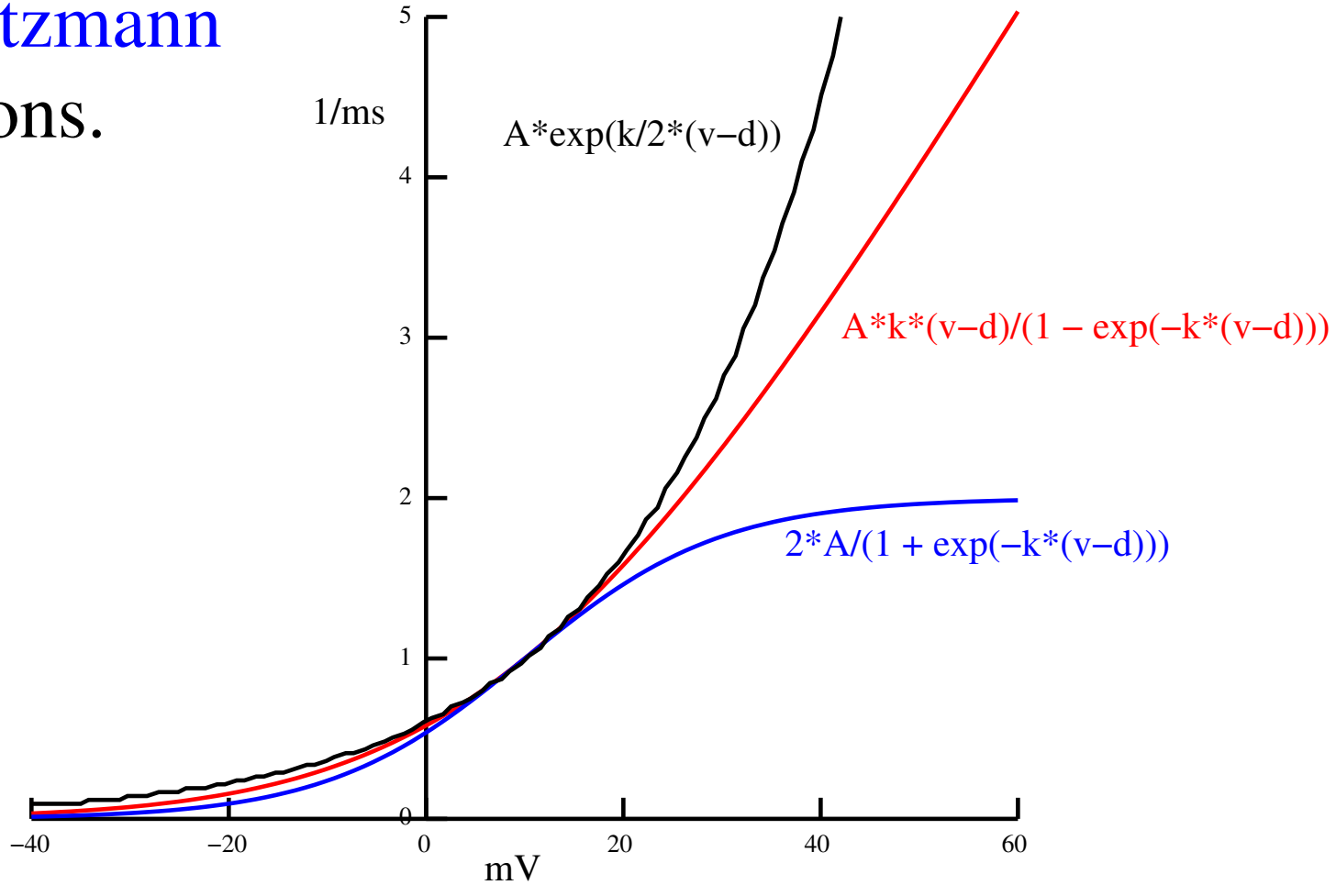
Voltage sensitive α and β rates generally have the form of

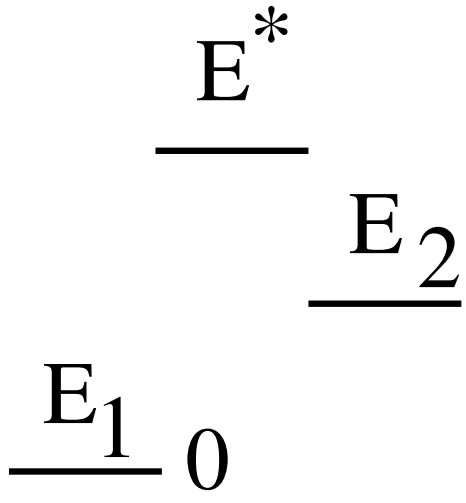
Exponential

Einstein

Boltzmann

functions.

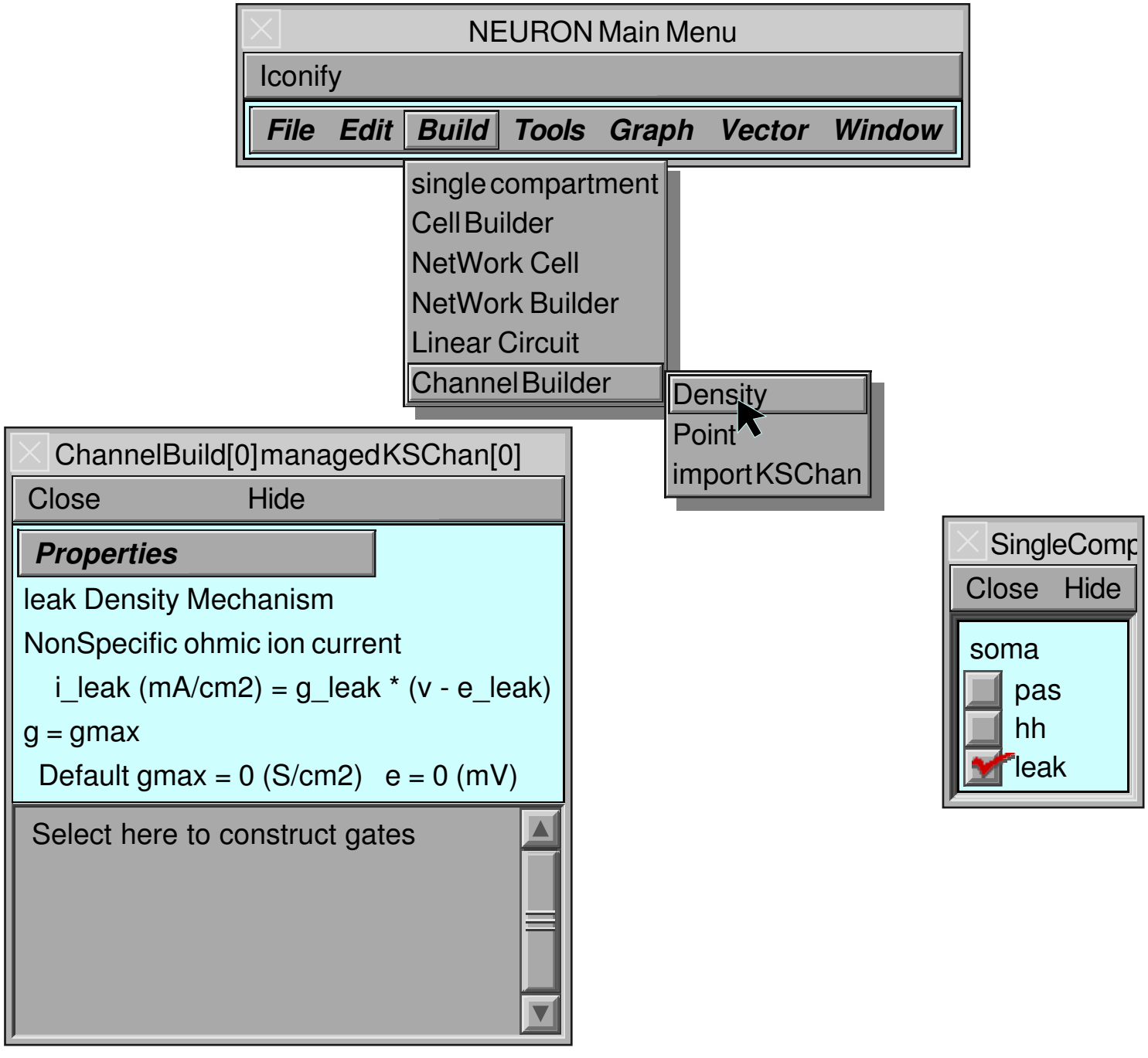


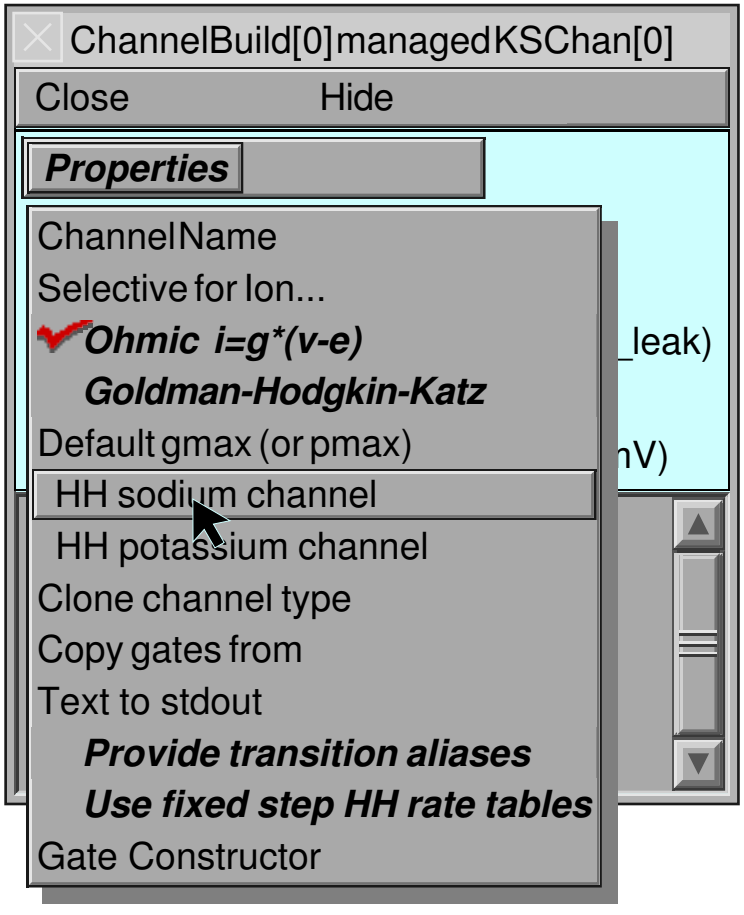


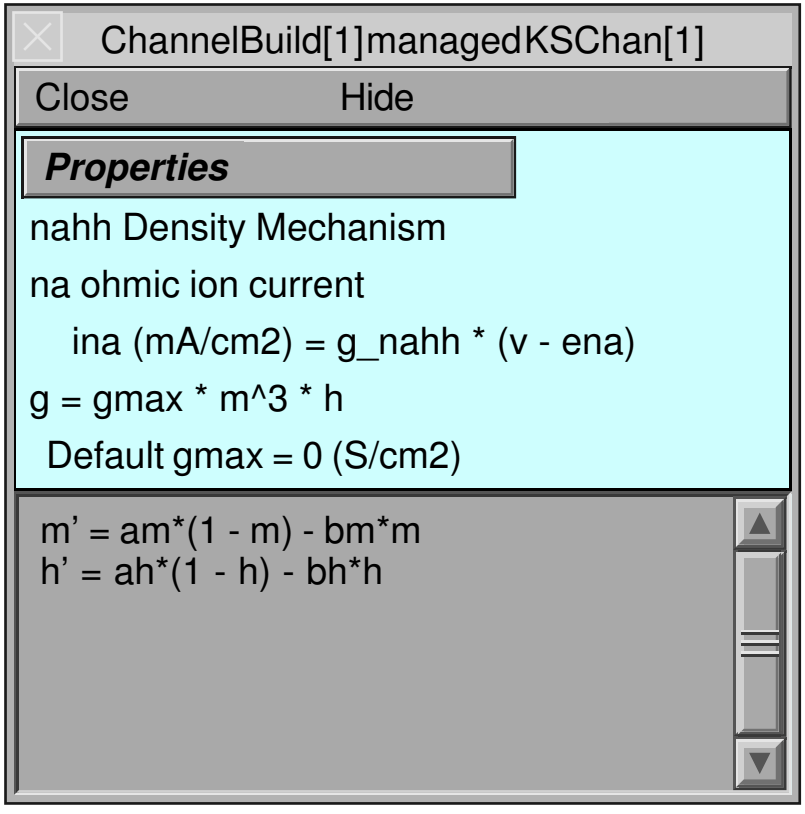
If the energy difference between states is linear with voltage, then the steady state is a Boltzmann distribution.

$$P_2 \sim e^{-\frac{E_2}{kT}}$$

$$= \frac{1}{1 + e^{\frac{E_2}{kT}}}$$


NEURON Main Menu
Iconify
File Edit Build Tools Graph Vector Window
single compartment
Cell Builder
NetWork Cell
NetWork Builder
Linear Circuit
Channel Builder
Density
Point
import KSChan
ChannelBuild[0] managed KSChan[0]
Close Hide
Properties
leak Density Mechanism
NonSpecific ohmic ion current
i_leak (mA/cm2) = g_leak * (v - e_leak)
g = gmax
Default gmax = 0 (S/cm2) e = 0 (mV)
Select here to construct gates
SingleComp
Close Hide
soma
pas
hh
leak


ChannelBuild[0]managedKSChan[0]
Close
Hide
Properties
ChannelName
Selective for Ion...
Ohmic i=g*(v-e)
Goldman-Hodgkin-Katz
Default gmax (or pmax)
HH sodium channel
HH potassium channel
Clone channel type
Copy gates from
Text to stdout
Provide transition aliases
Use fixed step HH rate tables
Gate Constructor
_leak)
nV)


ChannelBuild[1]managedKSChan[1]
Close
Hide
Properties
nahh Density Mechanism
na ohmic ion current
ina (mA/cm2) = g_nahh * (v - ena)
g = gmax * m^3 * h
Default gmax = 0 (S/cm2)
m' = am*(1 - m) - bm*m
h' = ah*(1 - h) - bh*h

Default gmax = 0 (S/cm2)

m' = am*(1 - m) - bm*m
h' = ah*(1 - h) - bh*h

ChannelBuildGateGUI[0]forChannelBuild[0]

Close Hide

States Transitions Properties

Select hh state or ks transition to change properties

m

h

m^3

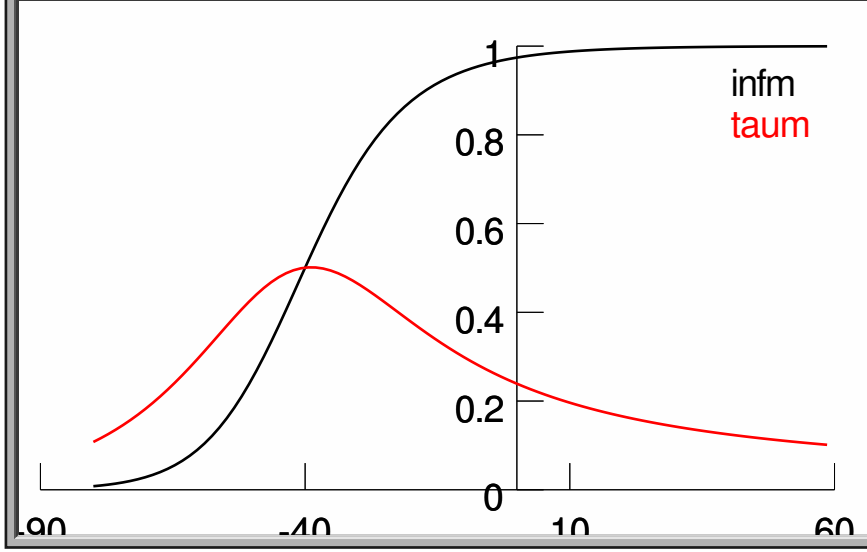
m' = am*(1 - m) - bm*m

Power 3

Fractional Conductance

m fraction 1

Adjust Run



m <-> m (a, b) (KSTrans[0])

Display inf, tau

am = A*x/(1 - exp(-x)) where x = k*(v - d)

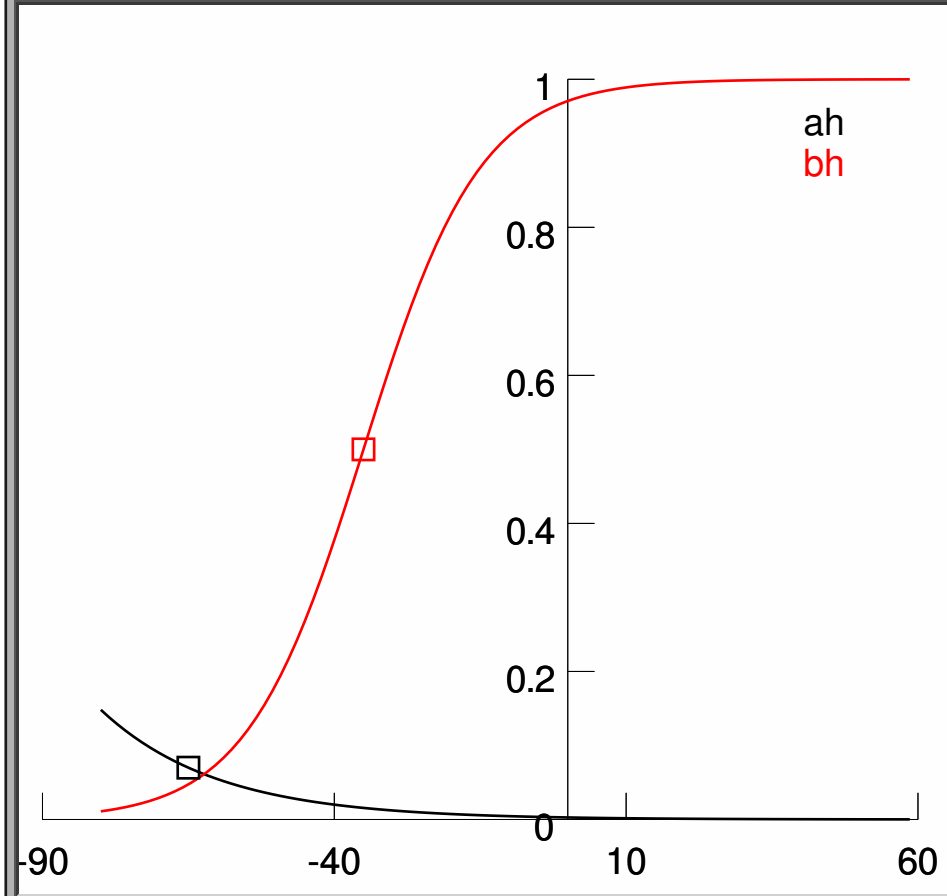
A 1

k 0.1

d -40

bm = A*exp(k*(v - d)))

Adjust Run



h <-> h (a, b) (KSTrans[1])

Display inf, tau

ah = A*exp(k*(v - d)))

A (/ms)	0.07
k (/mV)	-0.05
d (mV)	-65

bh = A/(1 + exp(-k*(d - v)))

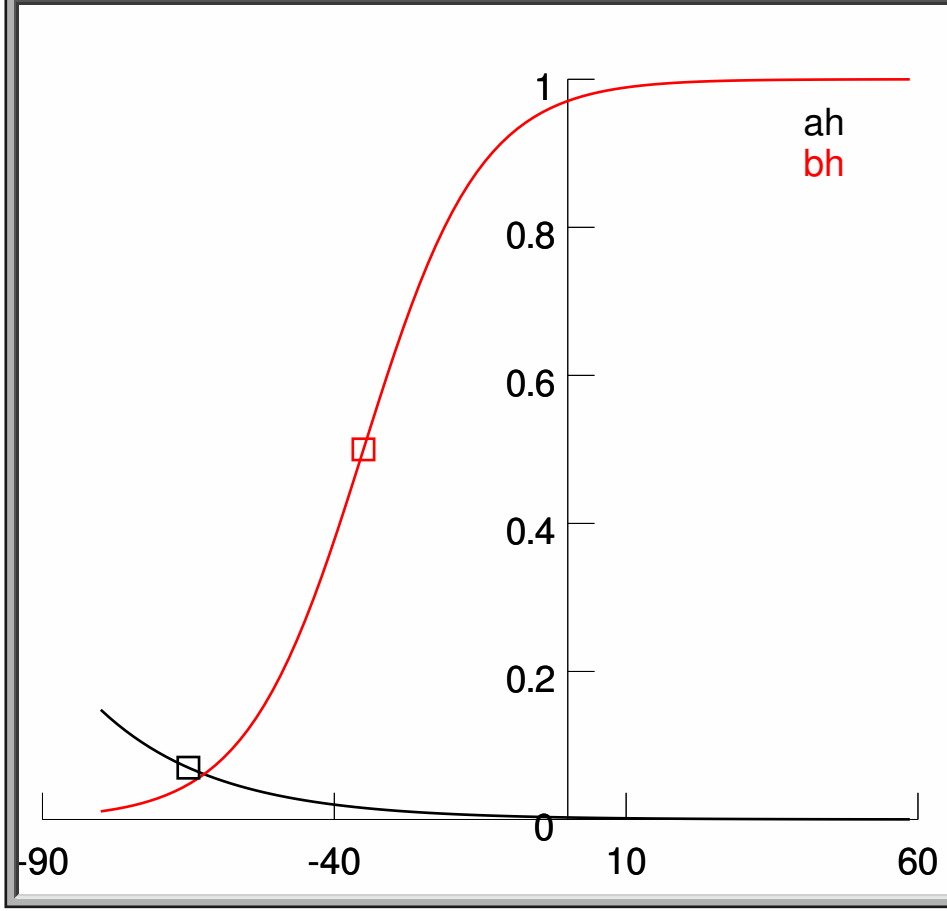
A (/ms)	1
k (/mV)	-0.1
d (mV)	-35

EquationType

alpha,beta
ah
bh

a,b
inf,tau
Copy

Adjust Run



h <-> h (a, b) (KSTrans[1])

Display inf, tau

ah = A*exp(k*(v - d)))

A (/ms)	0.07
k (/mV)	-0.05
d (mV)	-65

bh = A/(1 + exp(-k*(d - v)))

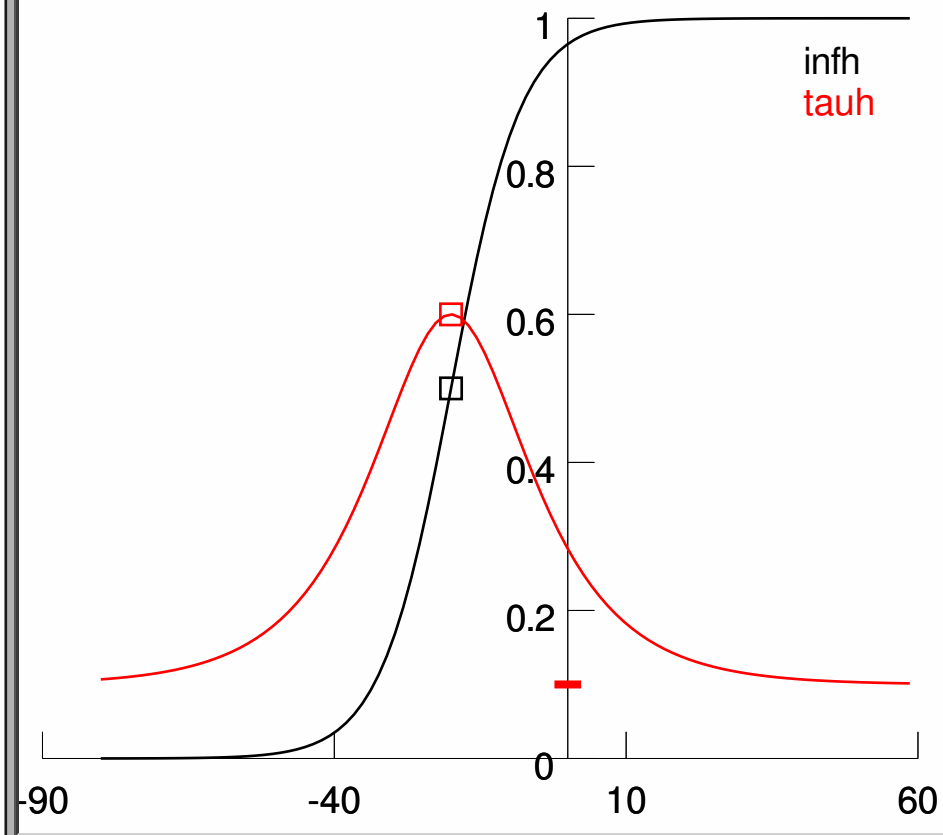
A (/ms)	1
k (/mV)	-0.1
d (mV)	-35

EquationType

alpha,beta
ah
bh

A
A*exp(k*(v - d)))
A*x/(1 - exp(-x)) where x = k*(v - d)
A/(1 + exp(-k*(d - v)))
KSChanTable

Adjust Run



h <-> h (inf, tau) (KSTrans[1])

Display inf, tau

infh = KSChanBGinf

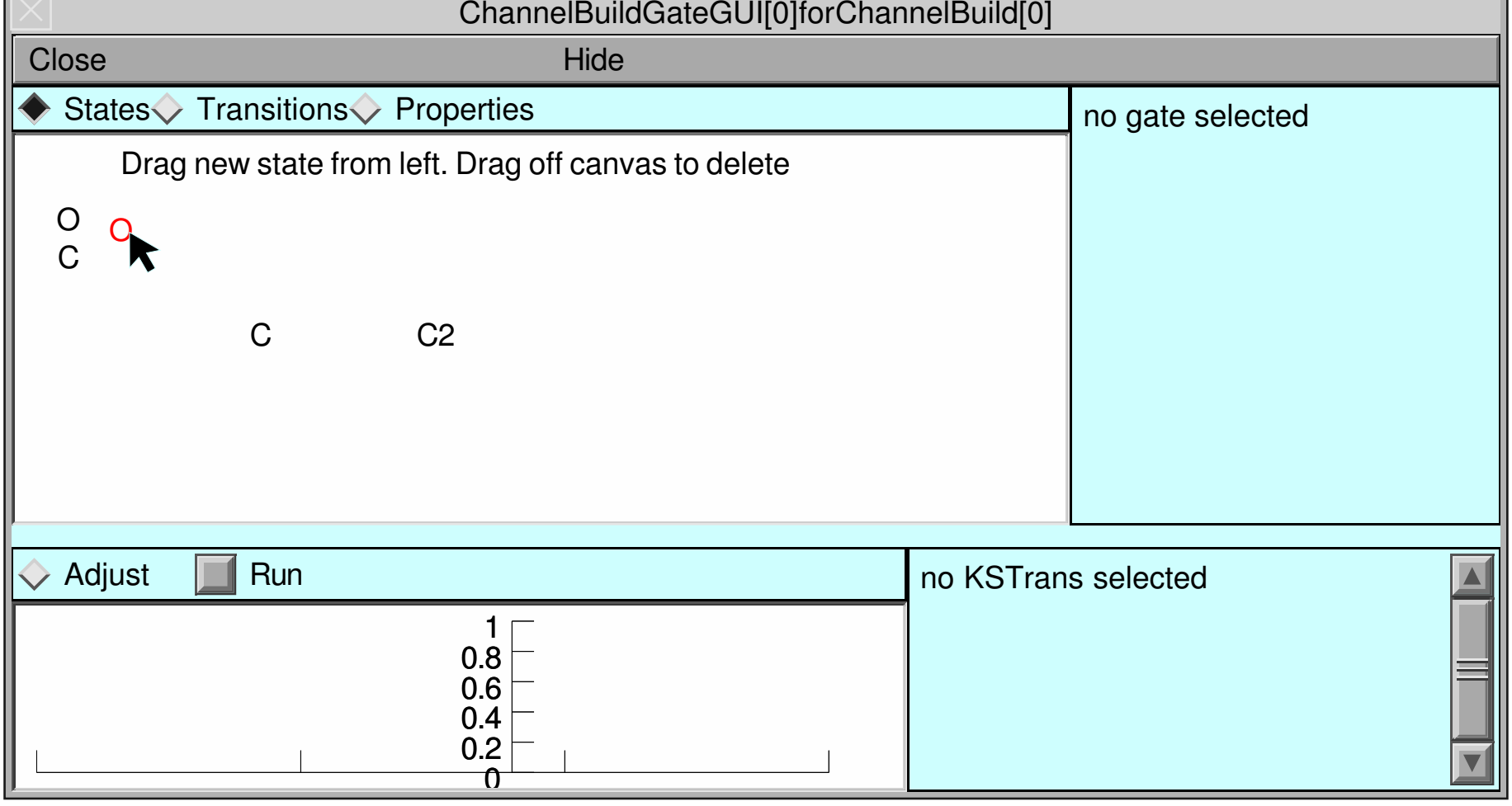
K (/ms)	1
vhalf (mV)	-20
z	4
gam	0.5
tau0 (ms)	0.1

tauh = KSChanBGtau

EquationType

inf,tau
infh
tauh

A
A/(1 + exp(-k*(d - v)))
KSChanBGinf
KSChanTable


ChannelBuildGateGUI[0]forChannelBuild[0]
Close
Hide
States
Transitions
Properties
Drag new state from left. Drag off canvas to delete
O
C
O
C
C2
no gate selected
Adjust
Run
1
0.8
0.6
0.4
0.2
0
no KSTrans selected

ChannelBuildGateGUI[0]forChannelBuild[0]

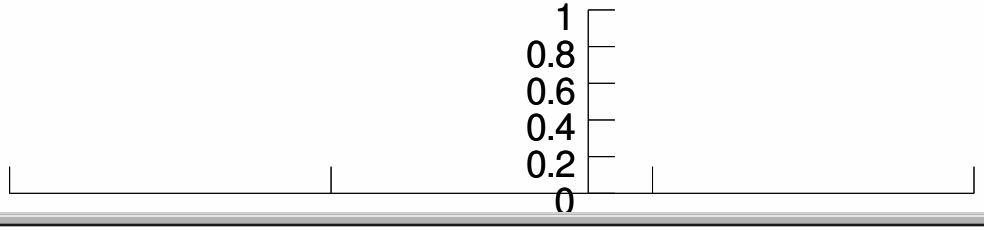
Close Hide

States Transitions Properties

New transition pair: select source and drag to target

no gate selected

Adjust Run



no KSTrans selected

ChannelBuildGateGUI[0]forChannelBuild[0]

Close Hide

States Transitions Properties

Select hh state or ks transition to change properties

C <-v-> C2 <-v-> O

O

O: 3 state, 2 transitions

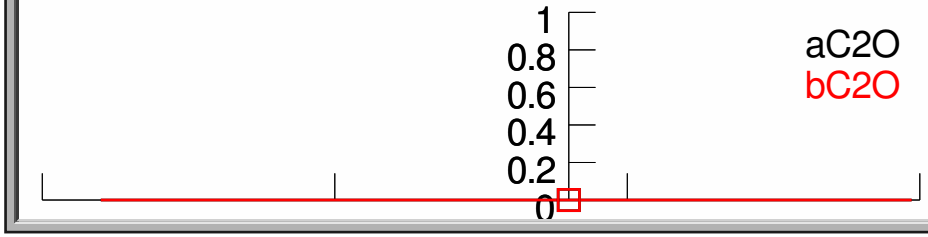
Power 1

Fractional Conductance

C2 fraction 0

O fraction 1

Adjust Run



bC2O = A

A (/ms) 0

EquationType

alpha,beta
aC2O
bC2O
a,b
inf,tau
Ligand
Copy
nai
nao
ki
ko
cai
cao
New Ligand

ChannelBuildGateGUI[0]forChannelBuild[0]

Close Hide

States Transitions Properties

Select hh state or ks transition to change properties

O

O: 3 state, 2 transitions

Power 1

Fractional Conductance

C2 fraction 0

O fraction 1

Adjust Run

aC2O

bC2O

C2 + cai <-> O (a, b) (KSTrans[9])

Display inf, tau

aC2O = A

ChannelBuild[0]managedKSChan[

Close Hide

Properties

kca Density Mechanism

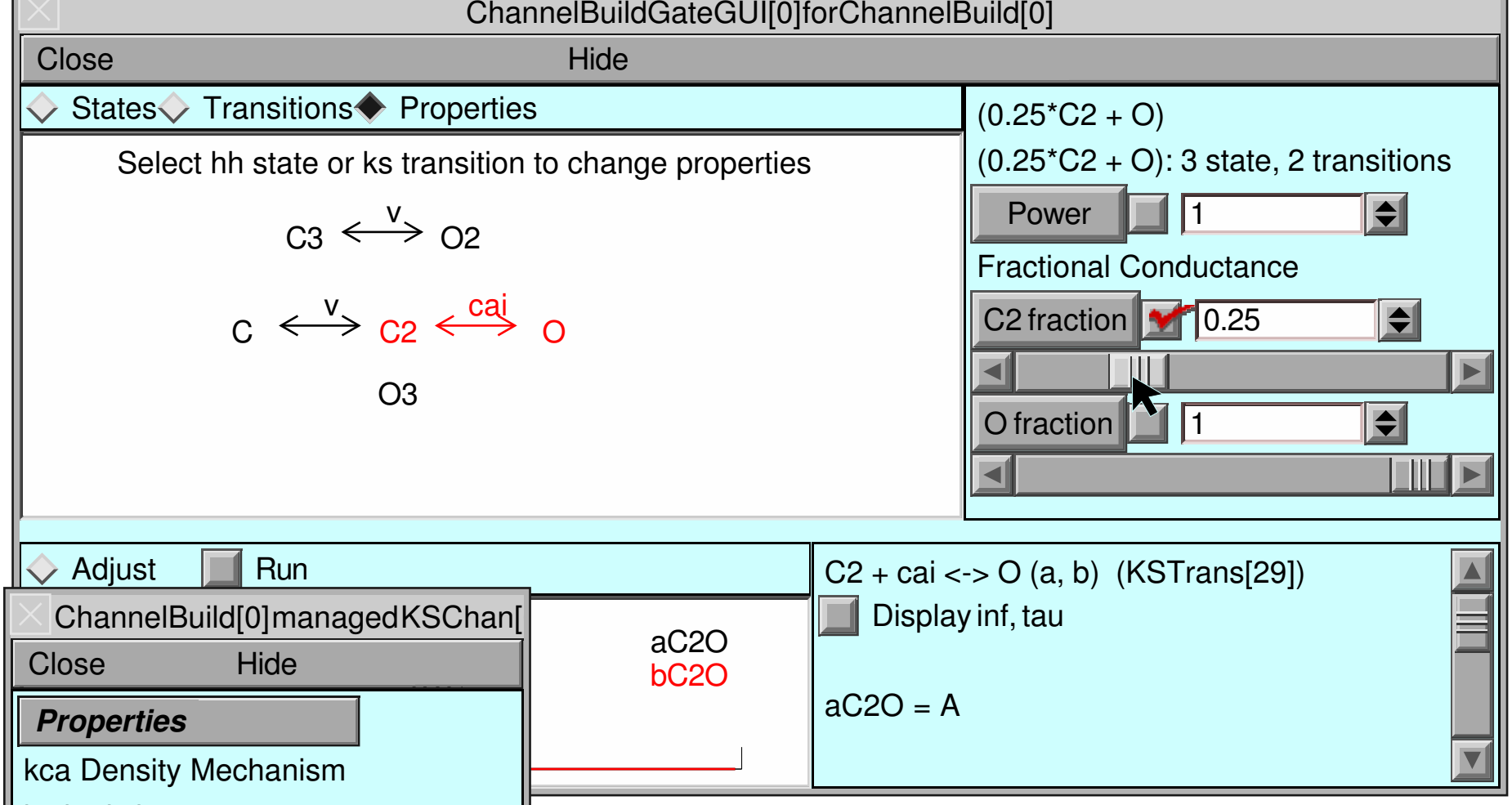
k ohmic ion current

ik (mA/cm2) = g_kca * (v - ek)

g = gmax * O

Default gmax = 0 (S/cm2)

O: 3 state, 2 transitions


ChannelBuildGateGUI[0]forChannelBuild[0]
Close
Hide
States
Transitions
Properties
Select hh state or ks transition to change properties
C3
v
O2
C
v
C2
cai
O
O3
(0.25*C2 + O)
(0.25*C2 + O): 3 state, 2 transitions
Power
1
Fractional Conductance
C2 fraction
0.25
O fraction
1
Adjust
Run
aC2O
bC2O
C2 + cai <-> O (a, b) (KSTrans[29])
Display inf, tau
aC2O = A
ChannelBuild[0]managedKSChan[
Close
Hide
Properties
kca Density Mechanism
k ohmic ion current
ik (mA/cm2) = g_kca * (v - ek)
g = gmax * (0.25*C2 + O) * O2 * O3
Default gmax = 0 (S/cm2)
(0.25*C2 + O): 3 state, 2 transiti
O2: 2 state, 1 transitions
O3' = aO3*(1 - O3) - bO3*O3

ChannelBuild[3]managedKSChan[3]

Close Hide

Properties

nahh0 Point Process (Allow Single Channels)

na ohmic ion current

ina (mA/cm2) = nahh0.g * (v - ena)*(0.01/area)

g = gmax * m3h1

Default gmax = 0.12 (uS)

m3h1: 8 state, 10 transitions

SingleComp

Close Hide

soma

pas

hh

nahh

khh

leak

PointProcessManager

Close Hide

SelectPointProcess

Show

nahh0[0]

at:soma(0.5)

nahh0[0]

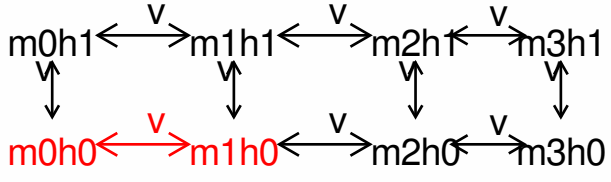
Nsingle 0

ChannelBuildGateGUI[0]forChannelBuild[3]

Close Hide

States Transitions Properties

Select hh state or ks transition to change properties



m3h1

m3h1: 8 state, 10 transitions

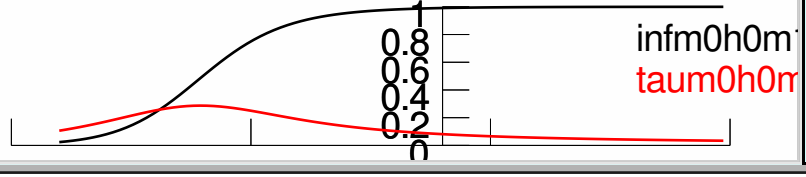
Power 1

Fractional Conductance

m0h0 fraction 0

m1h0 fraction 0

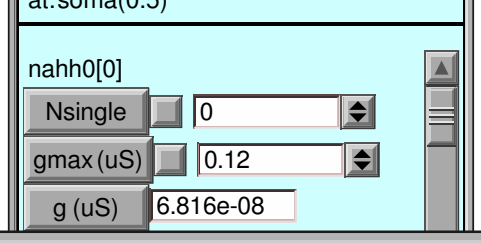
Adjust Run

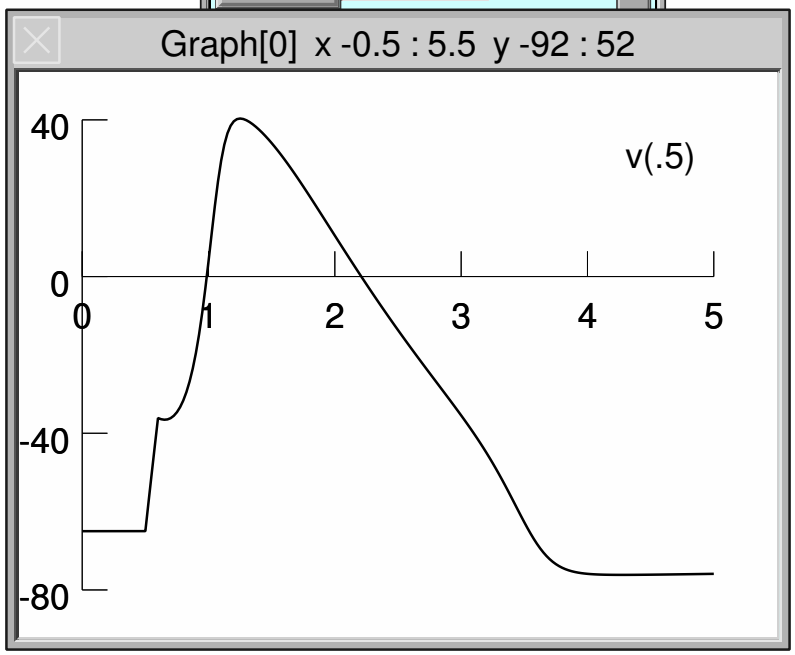


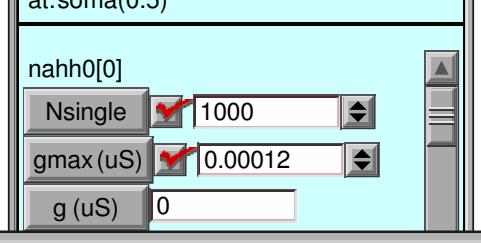
m0h0 <-> m1h0 (a, b) (KSTrans[14])

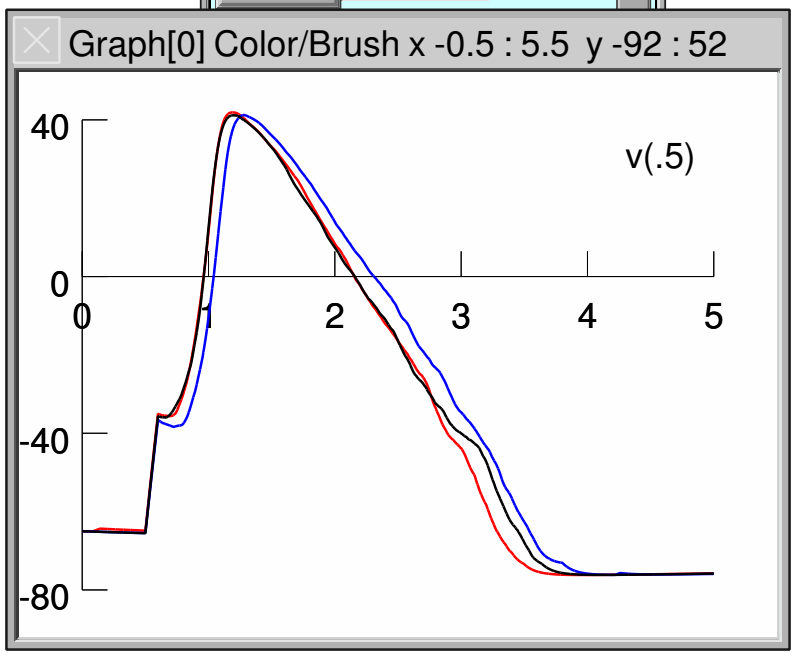
Display inf, tau

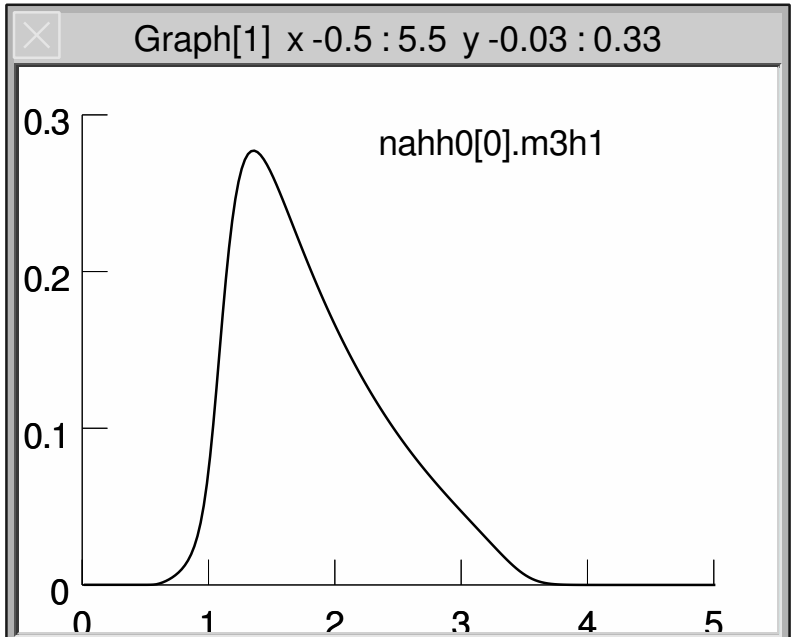
am0h0m1h0 = A*x/(1 - exp(-x)) where x = k*(v - d)

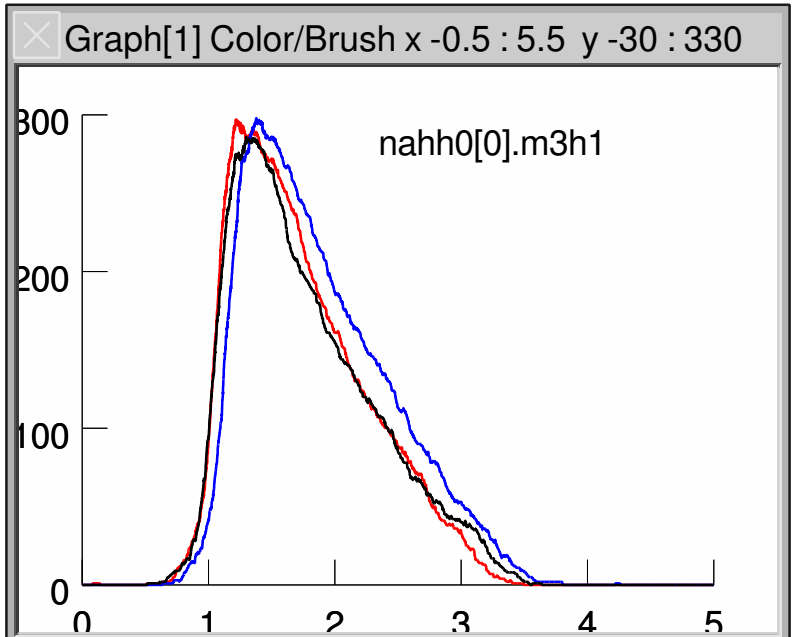

nahh0[0]
Nsingle
0
gmax (uS)
0.12
g (uS)
6.816e-08

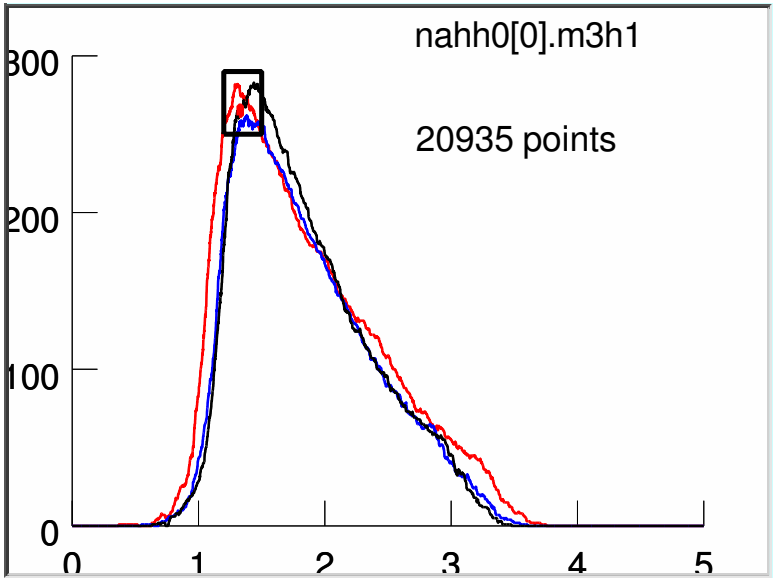

Graph[0] x -0.5 : 5.5 y -92 : 52
v(.5)
40
0
-40
-80
0
1
2
3
4
5


nahh0[0]
Nsingle
1000
gmax (uS)
0.00012
g (uS)
0

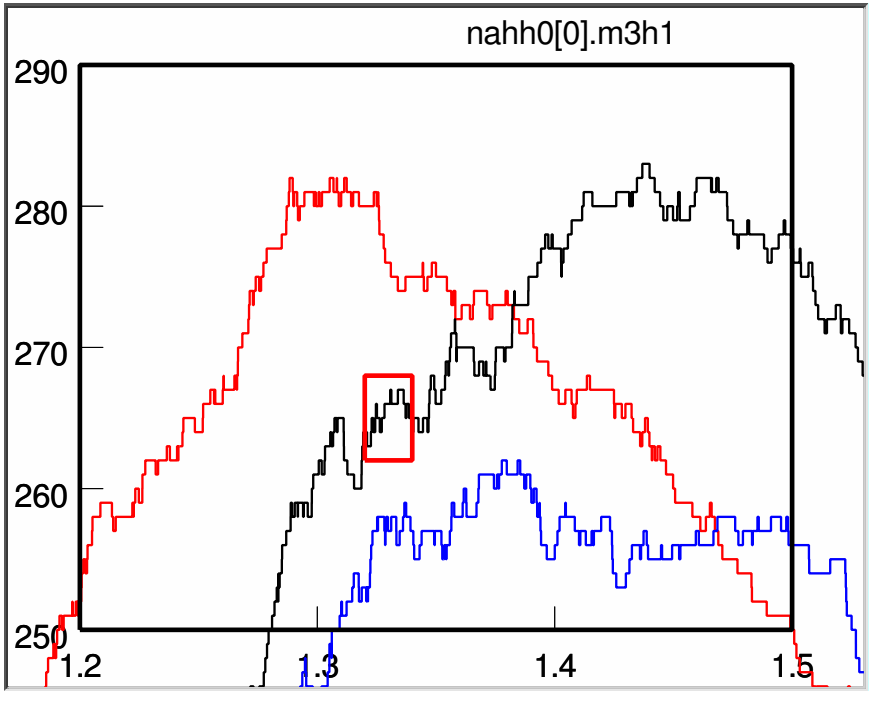

Graph[0] Color/Brush x -0.5 : 5.5 y -92 : 52
v(.5)
40
0
-40
-80
0
1
2
3
4
5

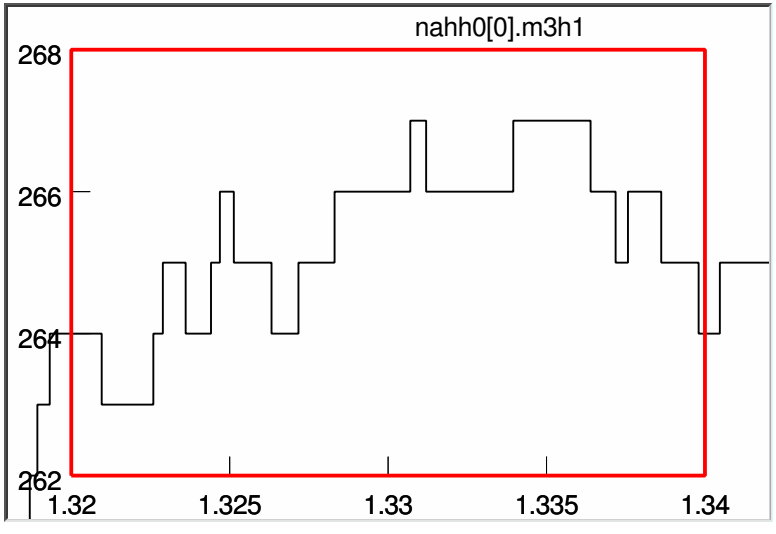

Graph[1] x -0.5 : 5.5 y -0.03 : 0.33
nahh0[0].m3h1
0.3
0.2
0.1
0
0
1
2
3
4
5


Graph[1] Color/Brush x -0.5 : 5.5 y -30 : 330
nahh0[0].m3h1
300
200
100
0
0
1
2
3
4
5


nahh0[0].m3h1
20935 points
300
200
100
0
0
1
2
3
4
5


Use variable dt
Absolute Tolerance
0.001
Atol Scale Tool
Details


nahh0[0].m3h1
290
280
270
260
250
1.2
1.3
1.4
1.5


nahh0[0].m3h1
268
266
264
262
1.32
1.325
1.33
1.335
1.34