

Step Current Response of the HH Model

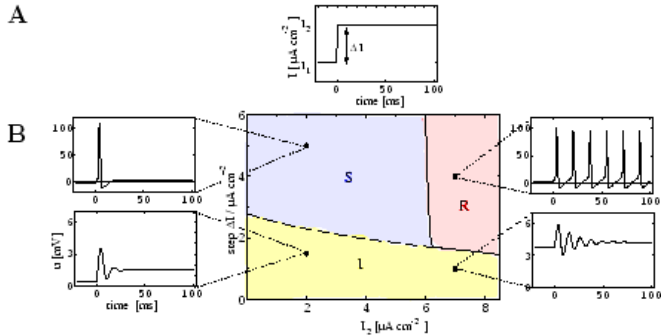
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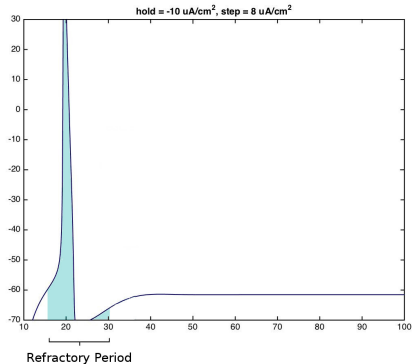
December 4, 2014

HH Model Step Current Response



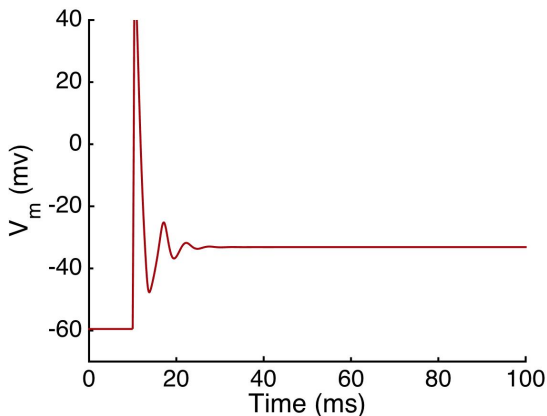
Step Current Stimulation Phase diagram

Applications: Refractory Period

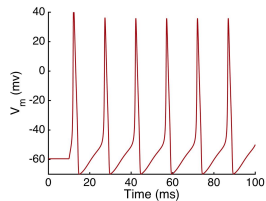
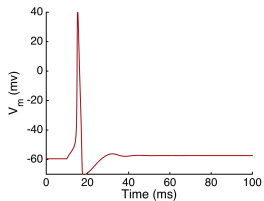
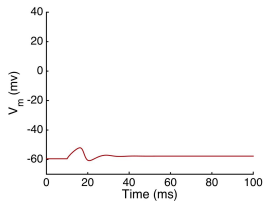


Reducing the Refractory Period can lead to faster reflexes.

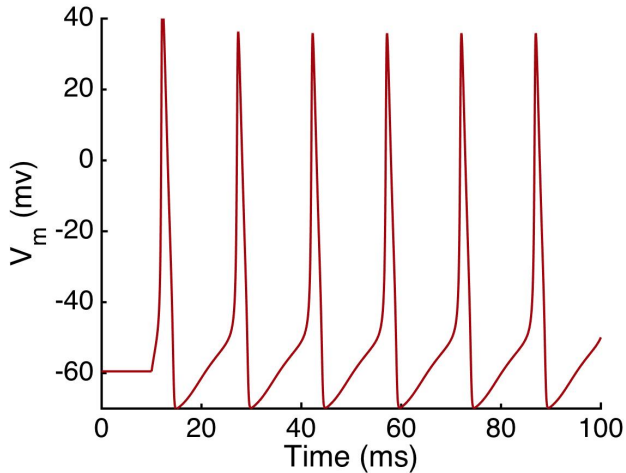
Applications: Neuron Inhibition



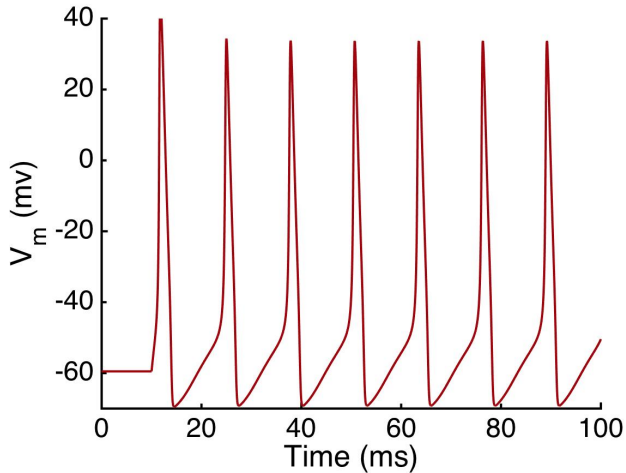
High current fully damps neuron response



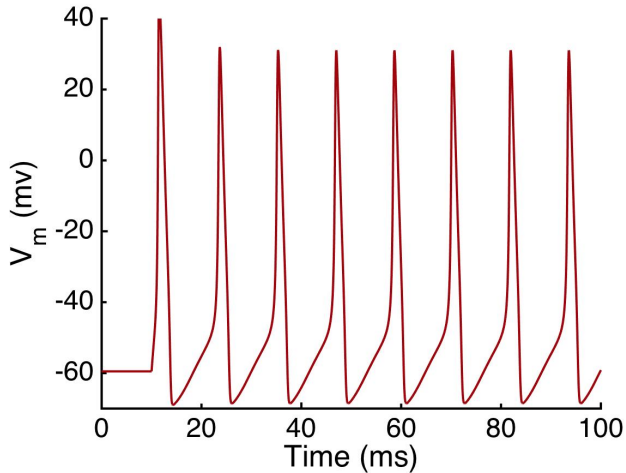
Response in the *Ringin*, *Single AP* and *AP Train* regions



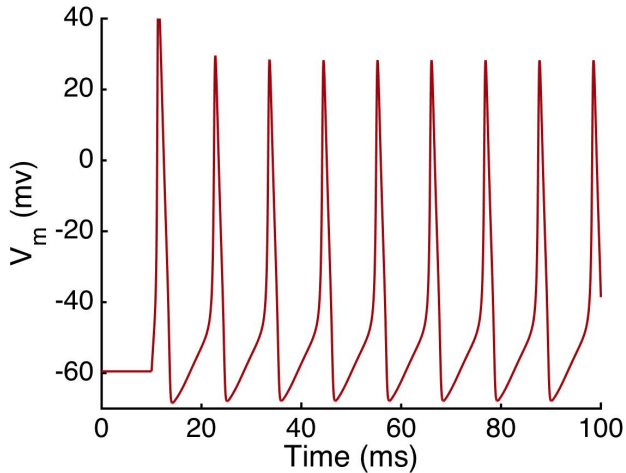
HH Model's step current response starting at $0 \mu A/cm^2$



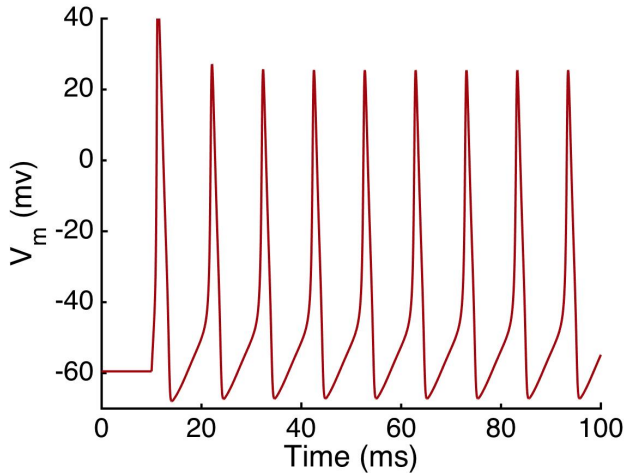
HH Model's step current response starting at $0 \mu A/cm^2$



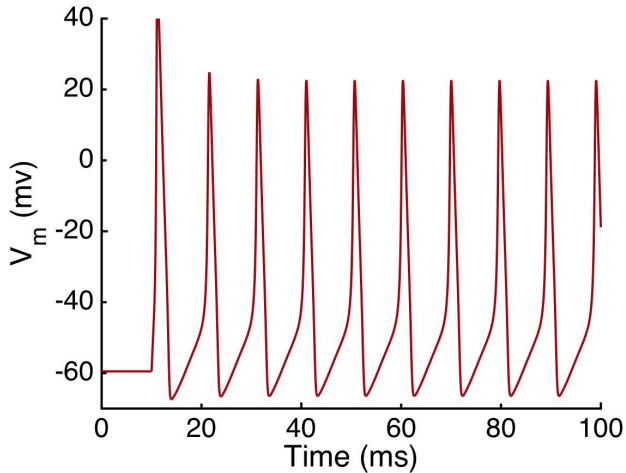
HH Model's step current response starting at $0 \mu\text{A}/\text{cm}^2$



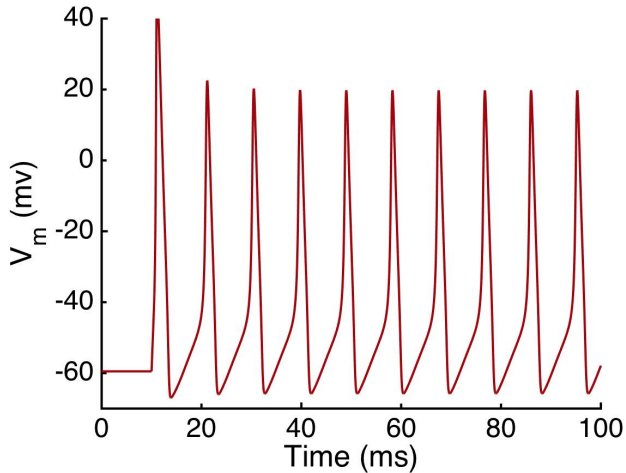
HH Model's step current response starting at $0 \mu\text{A}/\text{cm}^2$



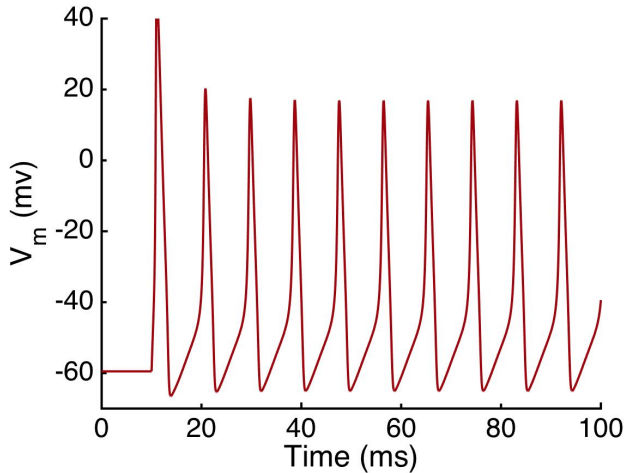
HH Model's step current response starting at $0 \mu A/cm^2$



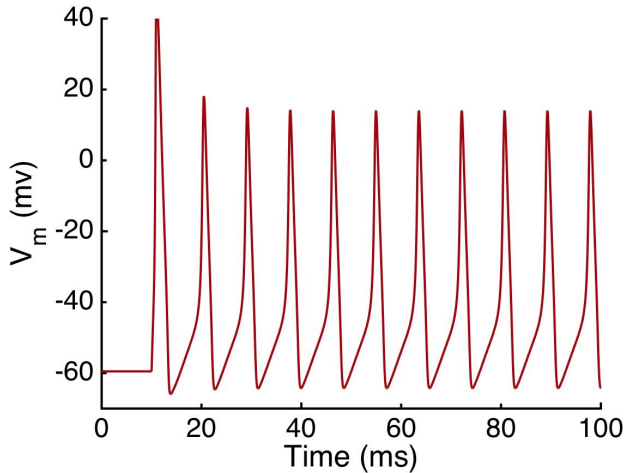
HH Model's step current response starting at $0 \mu A/cm^2$



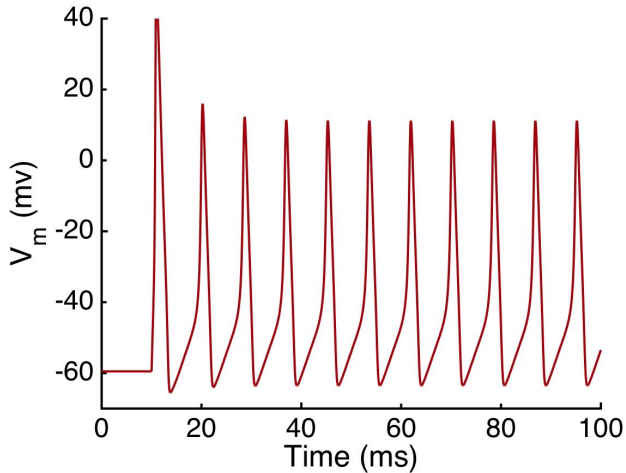
HH Model's step current response starting at $0 \mu A/cm^2$



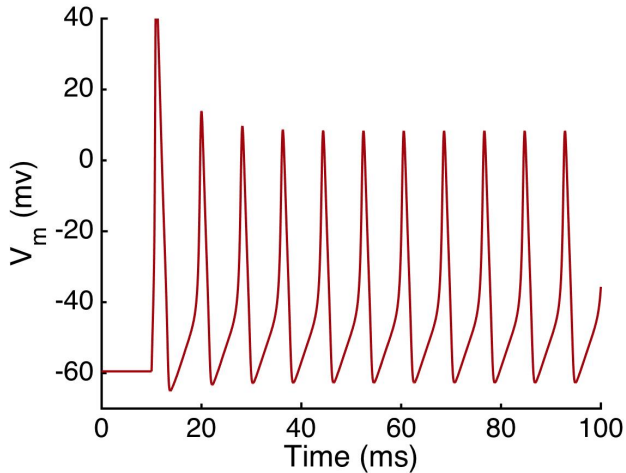
HH Model's step current response starting at $0 \mu A/cm^2$



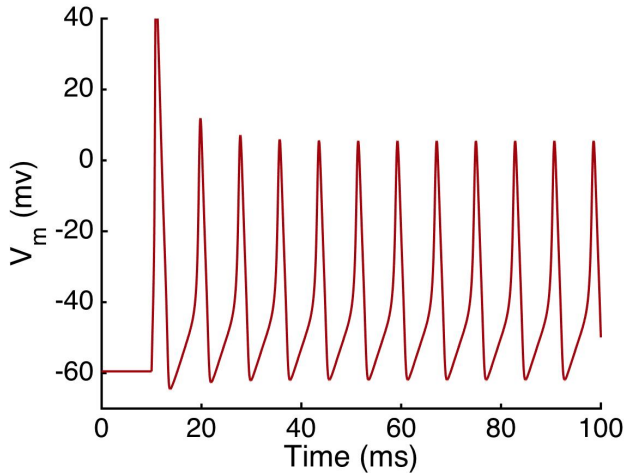
HH Model's step current response starting at $0 \mu A/cm^2$



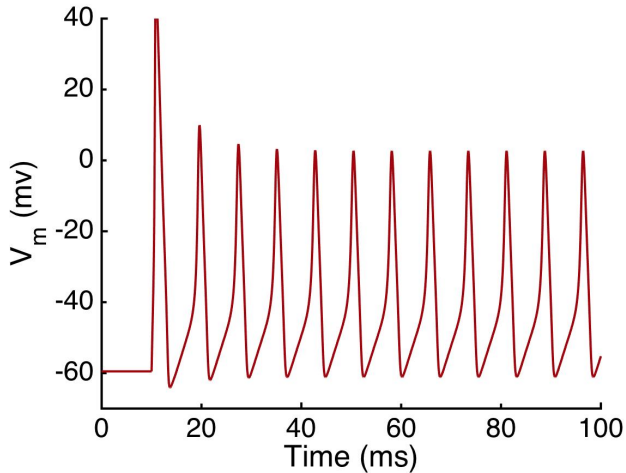
HH Model's step current response starting at $0 \mu A/cm^2$



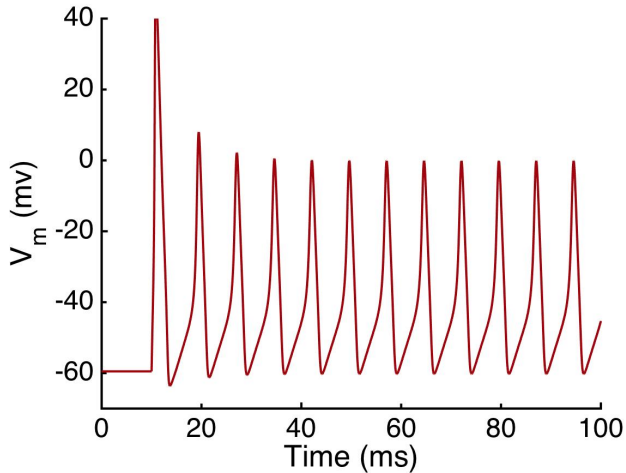
HH Model's step current response starting at $0 \mu\text{A}/\text{cm}^2$



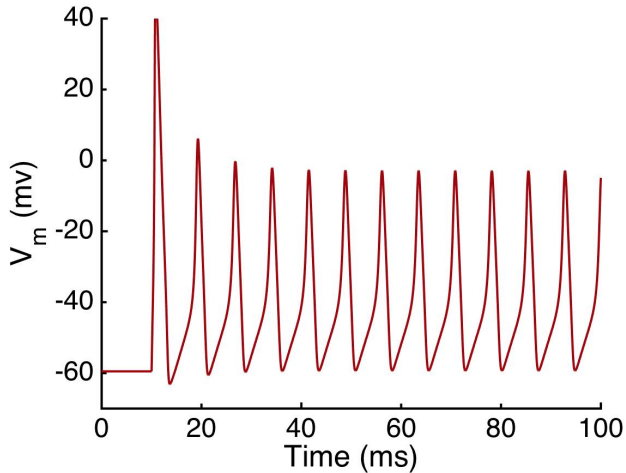
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HH Model's step current response starting at $0 \mu A/cm^2$

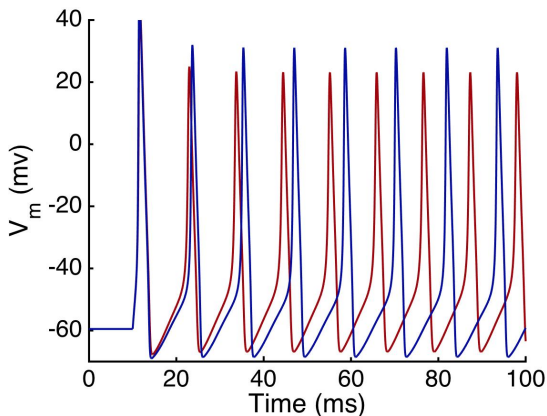


HH Model's step current response starting at $0 \mu A/cm^2$



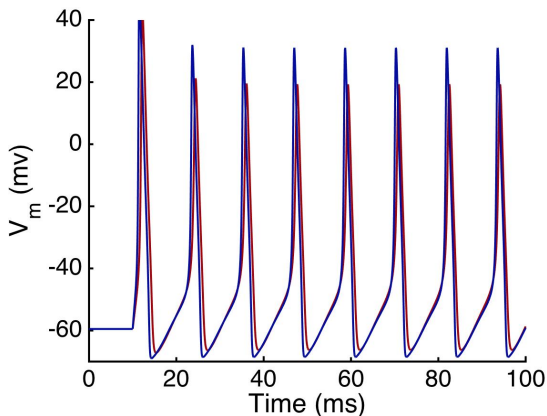
HH Model's step current response starting at $0 \mu\text{A}/\text{cm}^2$

Naive Mechanism



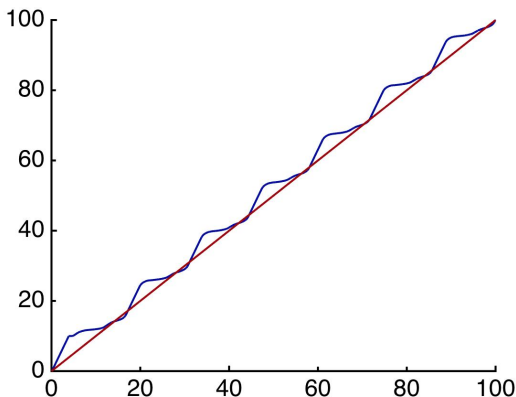
Equal ratio of current to capacitance

Mechanism



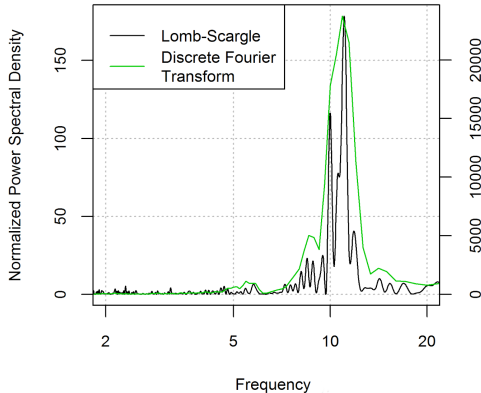
Unequal ratio of current to capacitance

Fourier Transform insufficient: Inconsistent Time Intervals



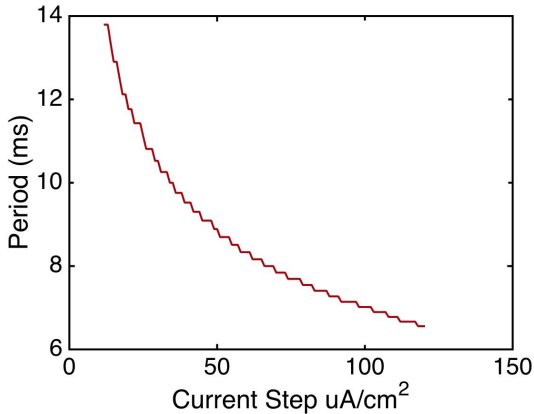
FFT insufficient,
need a better Spectral Analysis Method

Least-squares spectral analysis



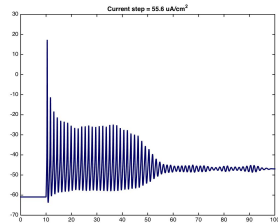
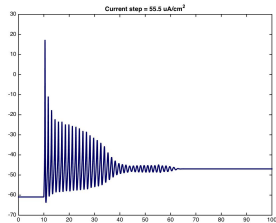
The Lomb-Scargle
Periodogram works with variable intervals.

Train period over increasing input step



Nonlinearity shows complexity of behavior

Anomalies with precision approximation



Incorrect behavior due to low precision

Conclusion

- 1 Clear definition of saturation threshold
- 2 High accuracy prediction of cell response
- 3 Refuted possible simplification
- 4 Innovative experimental method

References

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- 2 Weiss, T. F. (1995). Cellular Biophysics. Volume 2: Electrical Properties, MIT Press.
- 3 Blaustein, M.P., Kao, J.P.Y., Matteson, D.R. (2012). Cellular Physiology and Neurophysiology, 2nd edition, Elsevier-Mosby.
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- 5 Press, William H., and George B. Rybicki. "Fast algorithm for spectral analysis of unevenly sampled data." The Astrophysical Journal 338 (1989): 277–280.