

Step current response of the HH Model

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HH Model Step Current Response

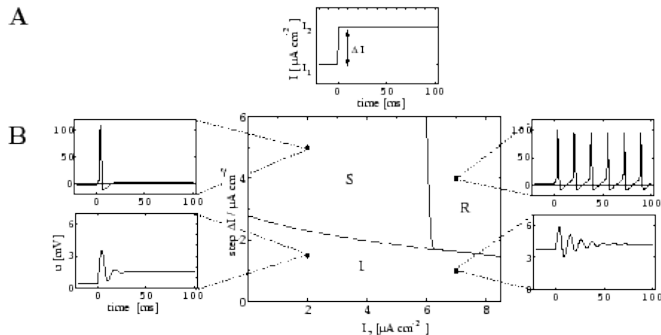


Figure: Step Current Stimulation Phase diagram

Applications: Refractory Period

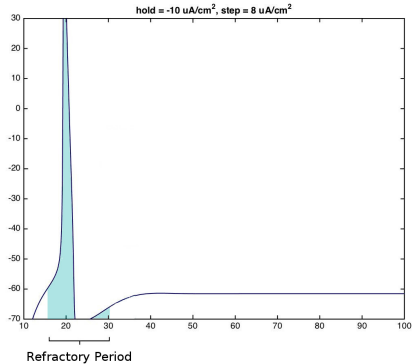


Figure: Reducing the Refractory Period can lead to faster reflexes.

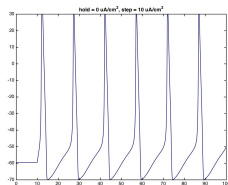
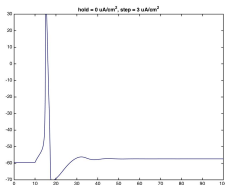
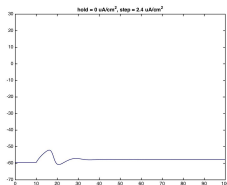


Figure: Response in the *Ring*ing, *Single AP* and *AP Train* regions

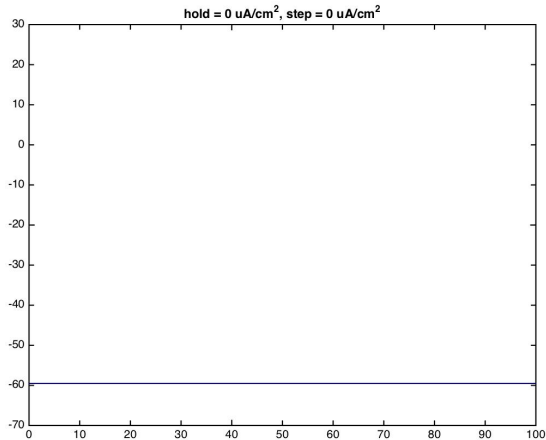


Figure: HH Model's step current response starting at 0 $\mu\text{A}/\text{cm}^2$

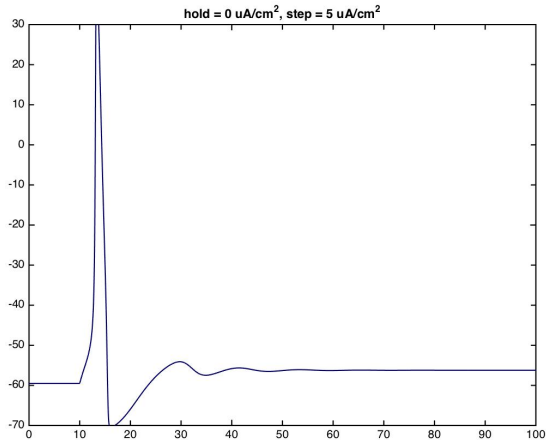


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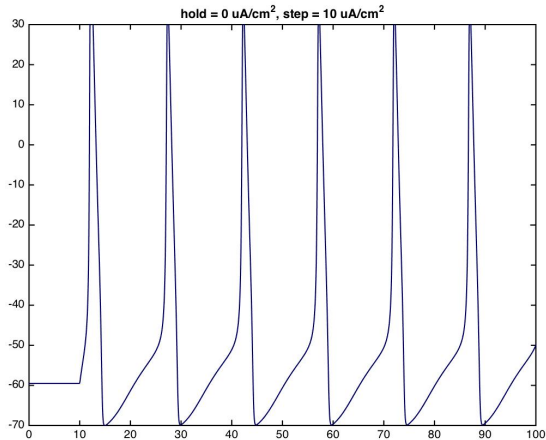


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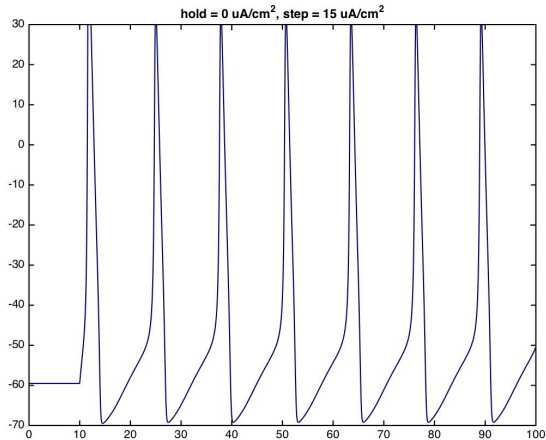


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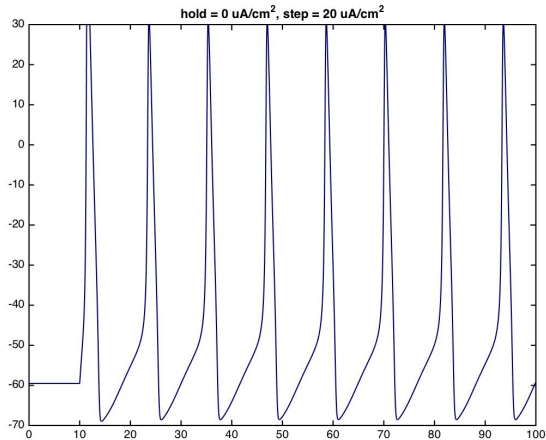


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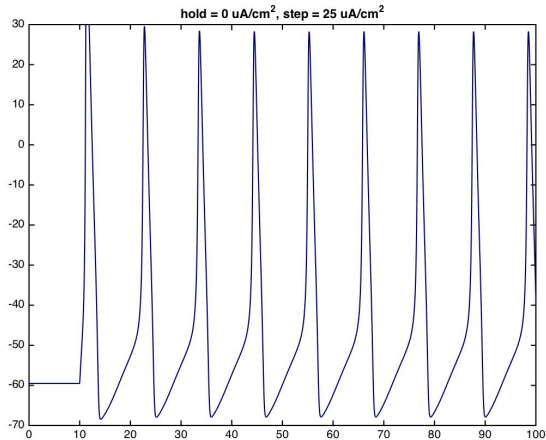


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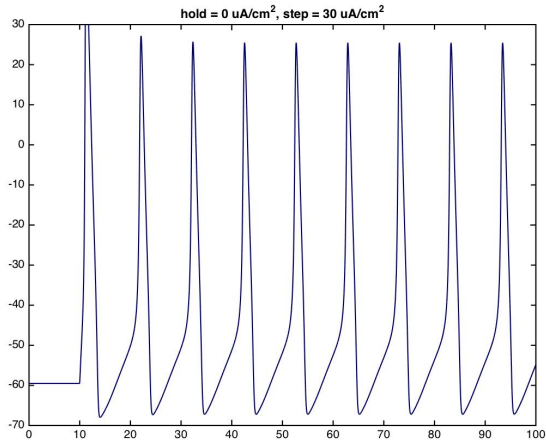


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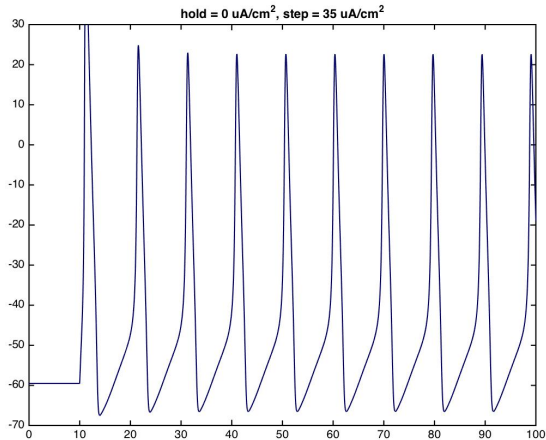


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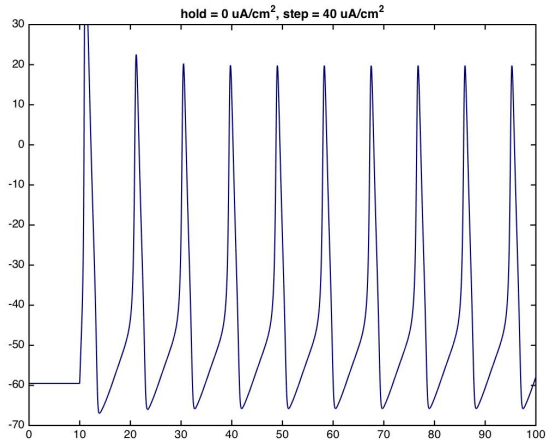


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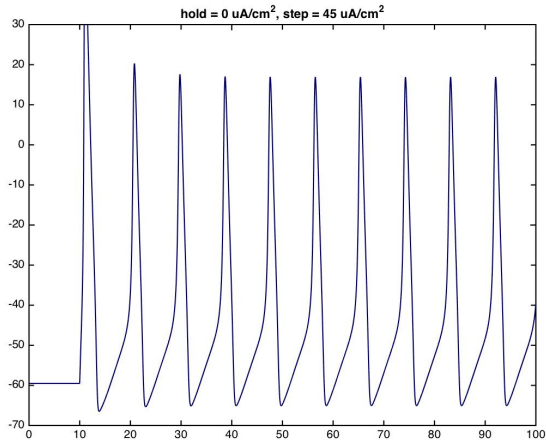


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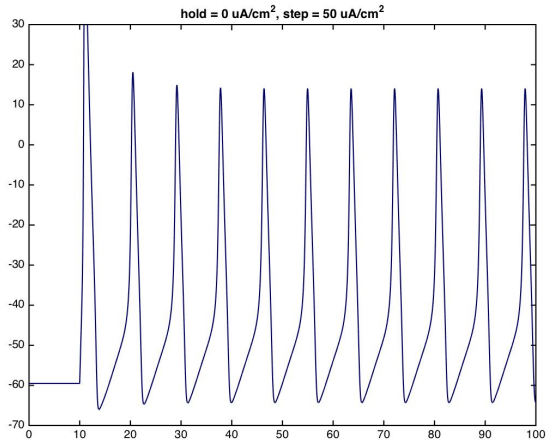


Figure: HH Model's step current response starting at 0 $\mu\text{A}/\text{cm}^2$

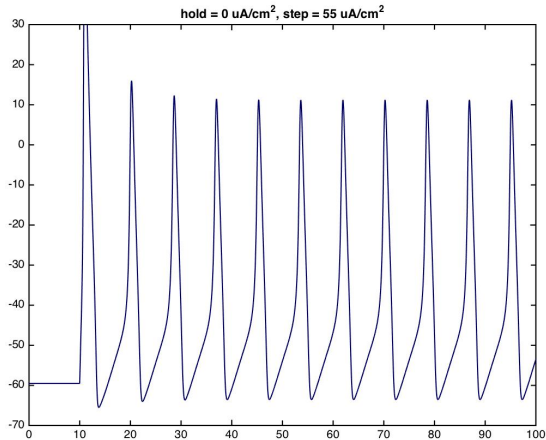


Figure: HH Model's step current response starting at 0 $\mu\text{A}/\text{cm}^2$

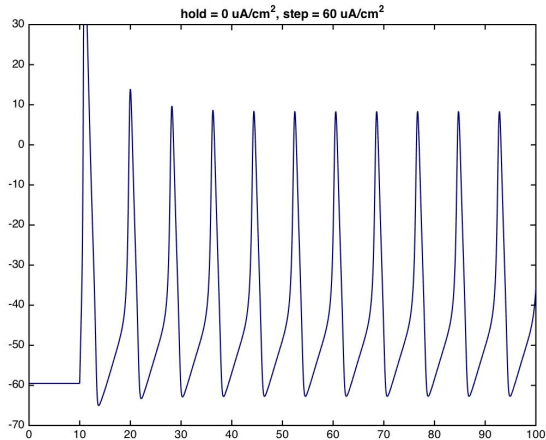


Figure: HH Model's step current response starting at 0 $\mu\text{A}/\text{cm}^2$

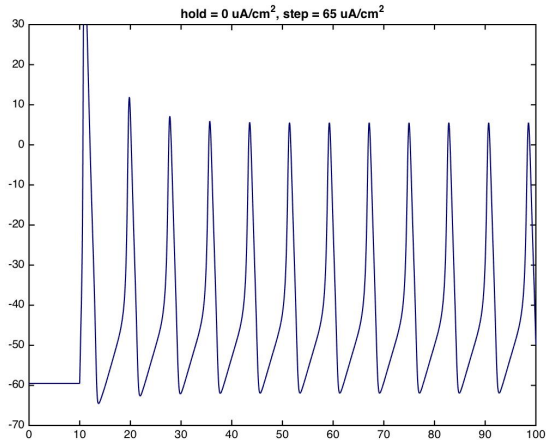


Figure: HH Model's step current response starting at 0 $\mu\text{A}/\text{cm}^2$

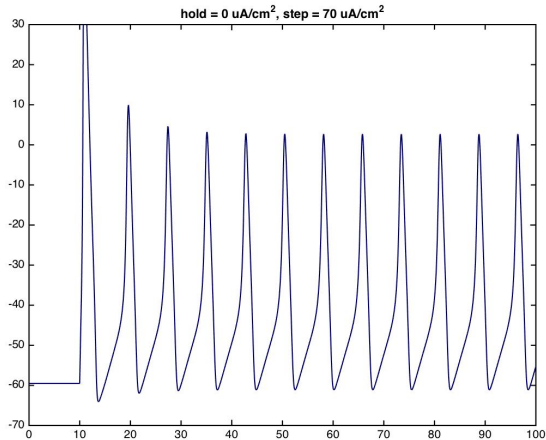


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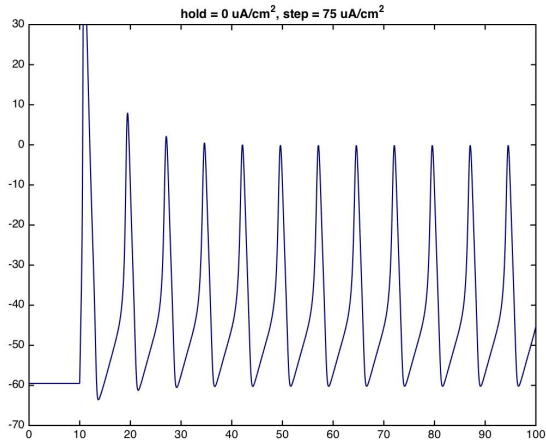


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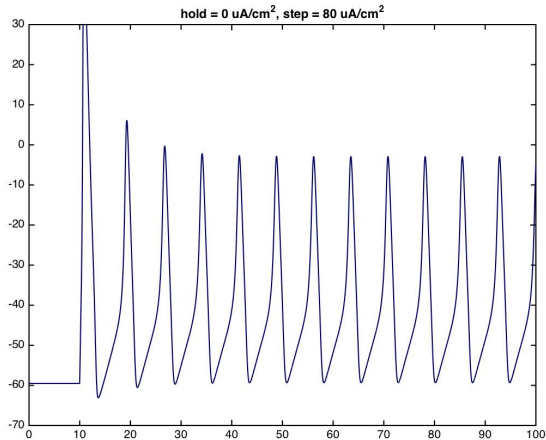


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Naive Mechanism

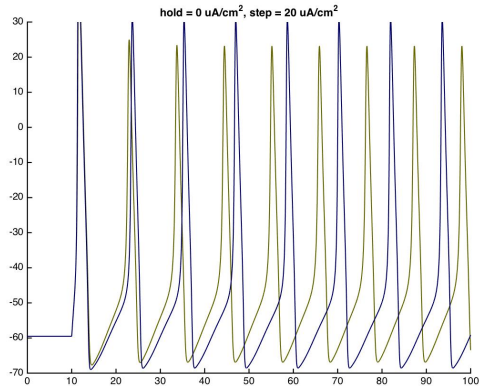


Figure: Equal ratio of current to capacitance

Mechanism

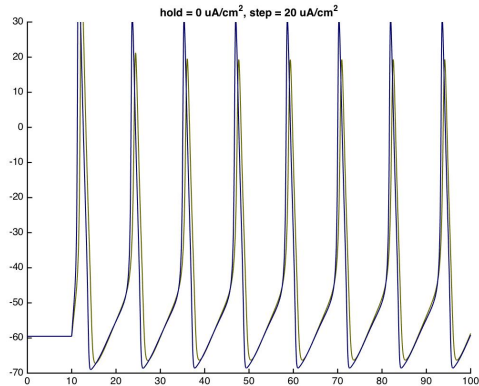


Figure: Unequal ratio of current to capacitance

DFT insufficient

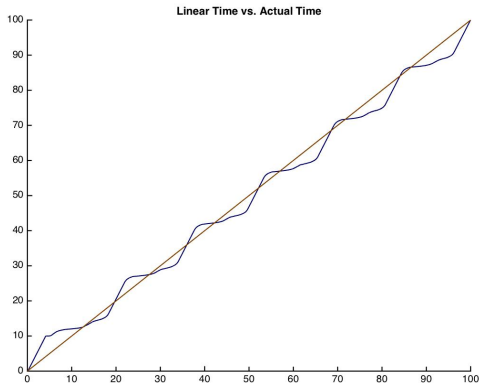


Figure: Discrete Fourier Transform insufficient due to variable time intervals.

Least-squares spectral analysis

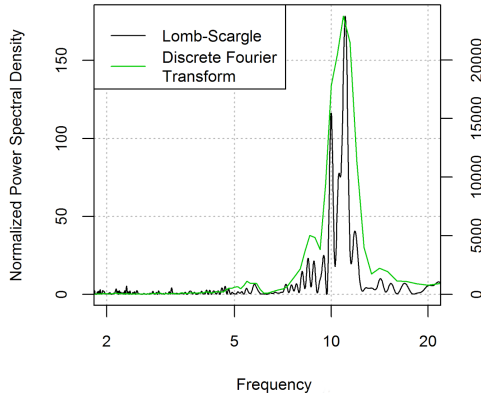
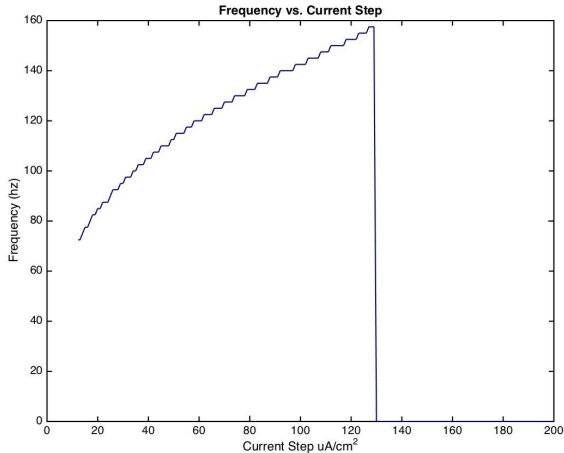


Figure: The LombScargle Periodogram works with variable intervals.

Train frequency over increasing input step



Issues with precision approximation

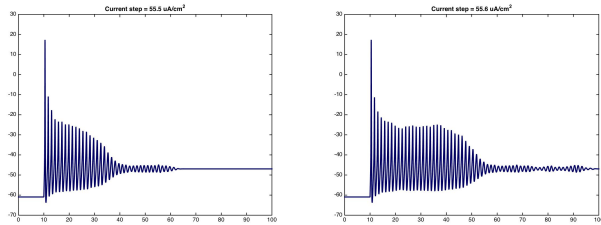


Figure: Incorrect behavior due to low precision

References

- 1 Weiss, T. F. (1995). Cellular Biophysics. Volume 1: Transport, MIT Press.
- 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.
- 4 Gerstner, Wulfram, and Werner M. Kistler. Spiking neuron models: Single neurons, populations, plasticity. Cambridge university press, 2002.
- 5 Press, William H., and George B. Rybicki. "Fast algorithm for spectral analysis of unevenly sampled data." The Astrophysical Journal 338 (1989): 277–280.