Step current response of the HH Model

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A constant current applied to the HH model produces a train of action potentials.

HH Model Step Current Response

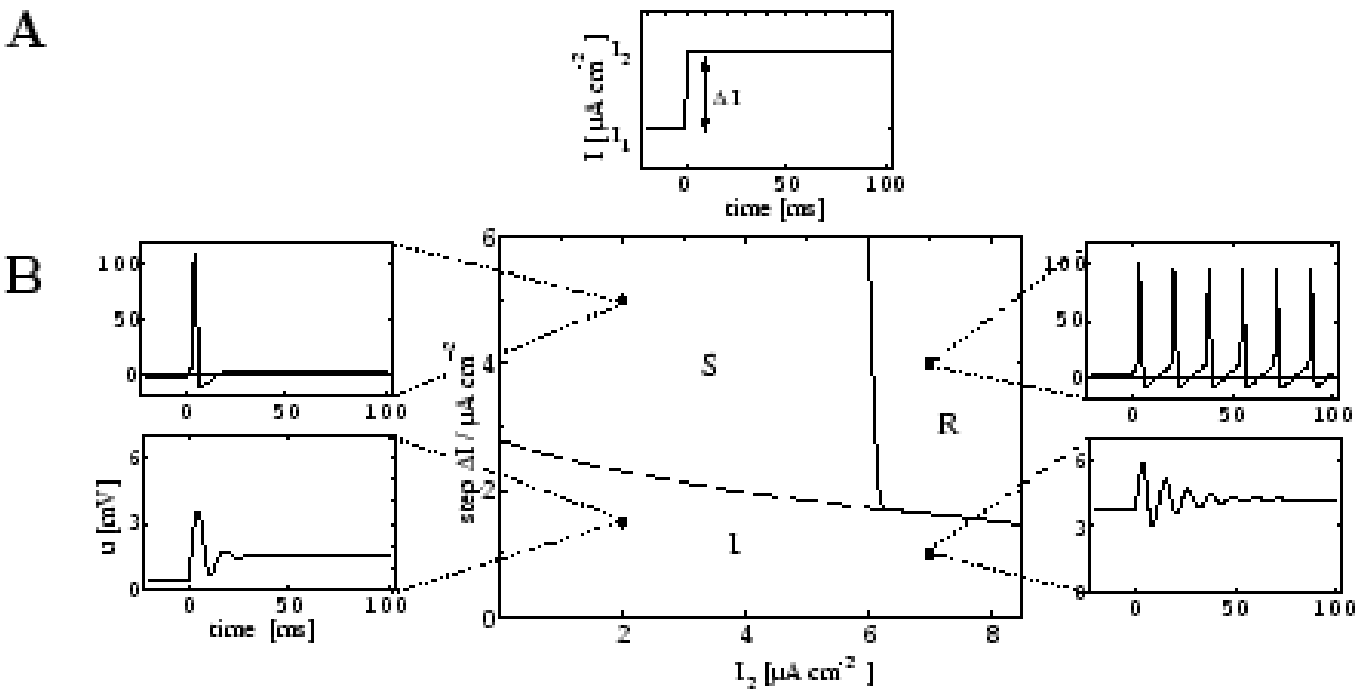

Figure : Step Current Stimulation Phase diagram

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Applications: Refractory Period

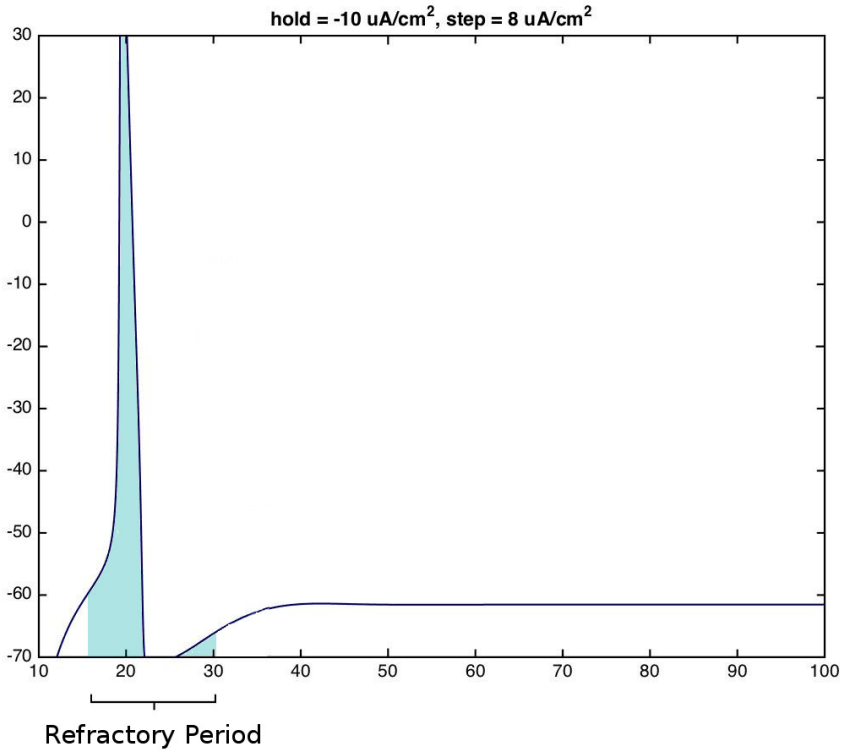


Figure : Reducing the Refractory Period can lead to faster reflexes.

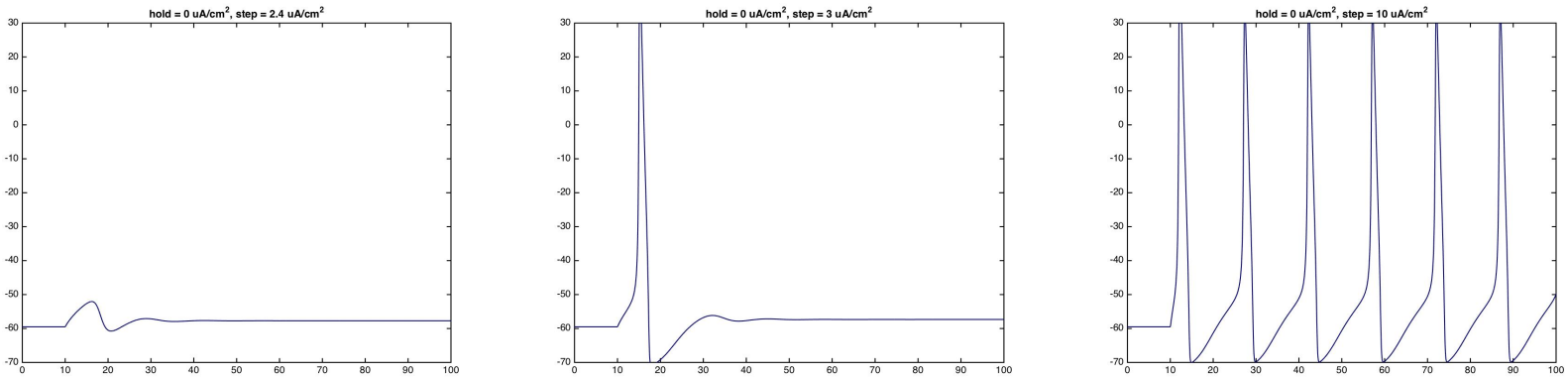


Figure : Response in the *Ringing*, *Single AP* and *AP Train* regions

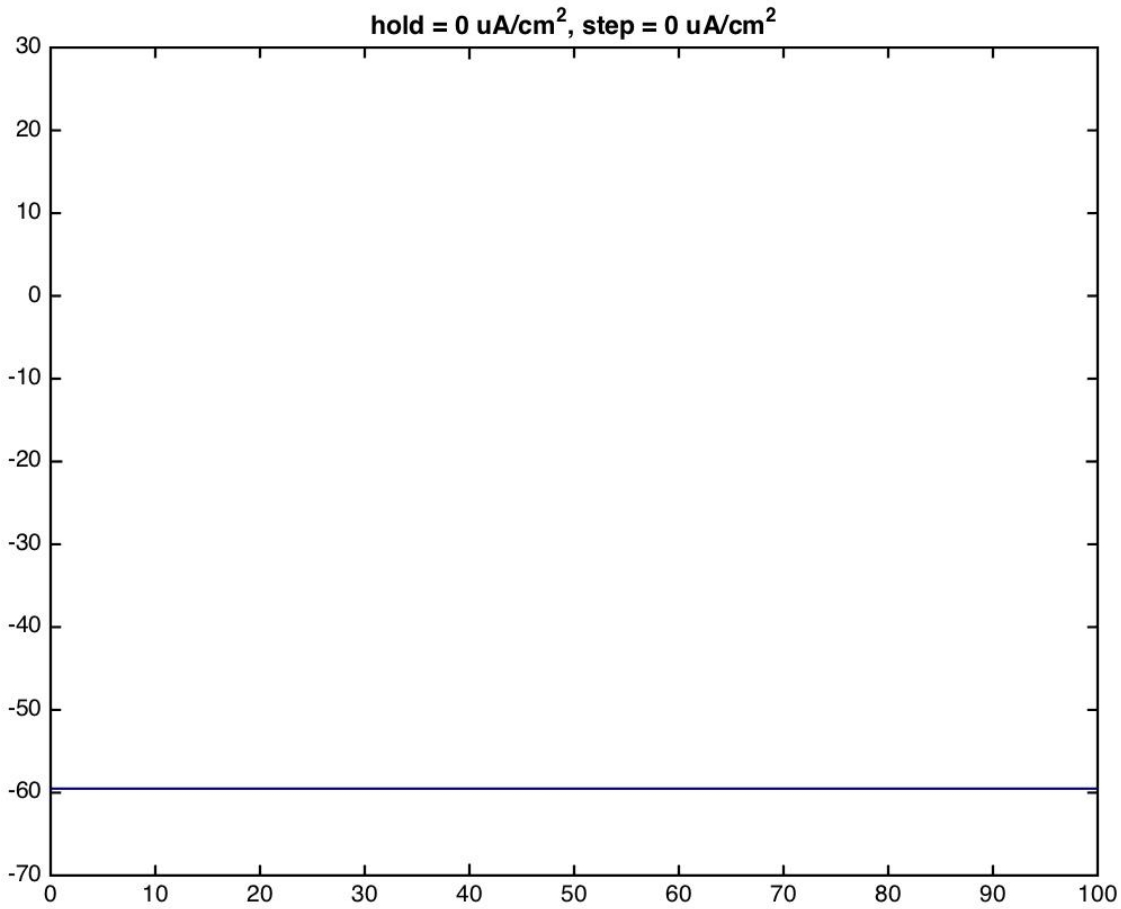
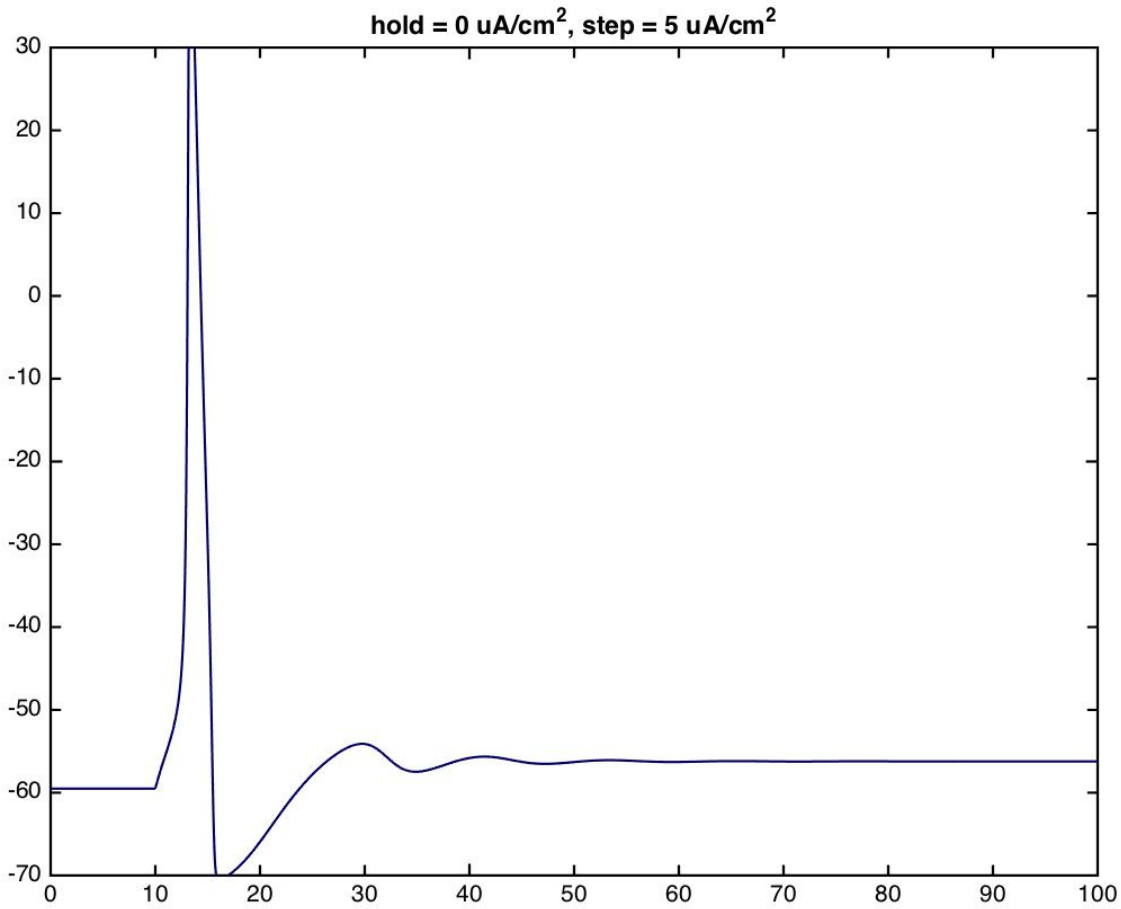


Figure : HH Model's step current response starting at 0 $\mu A/cm^2$



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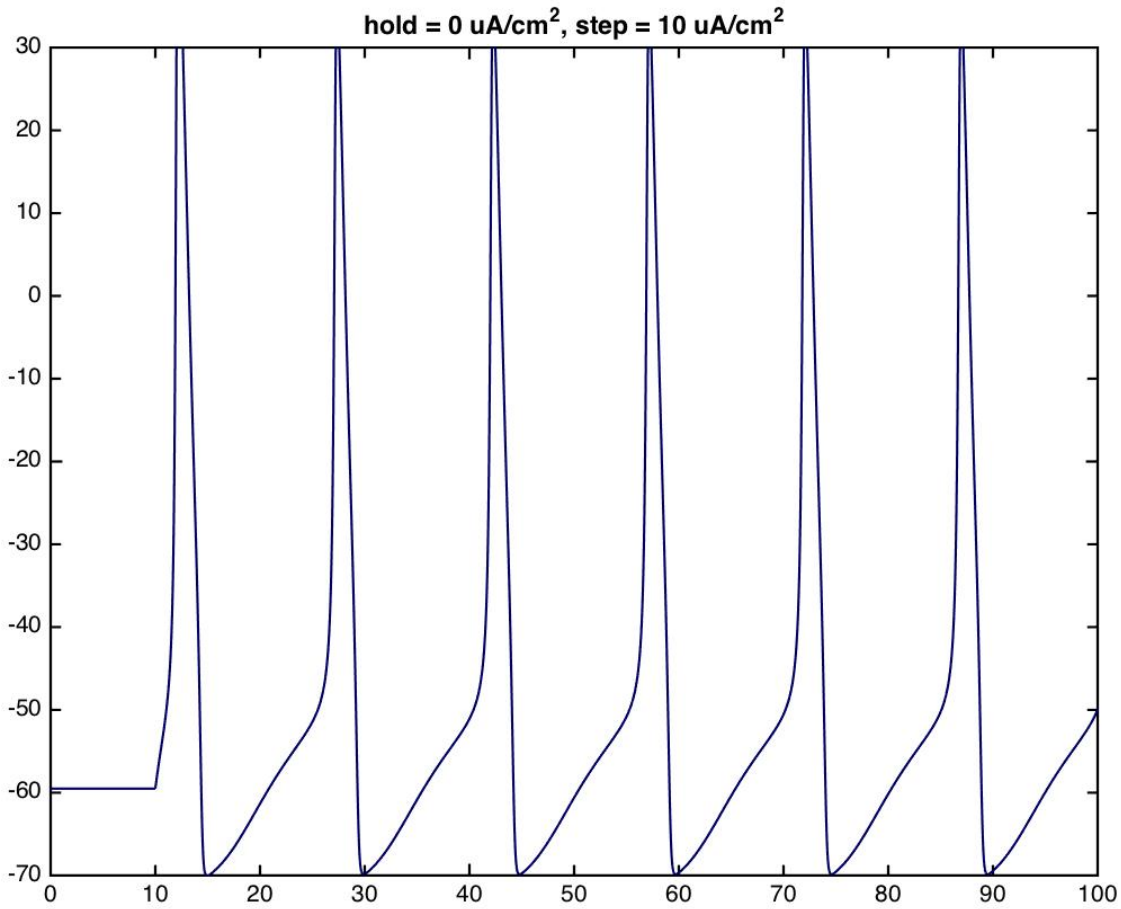

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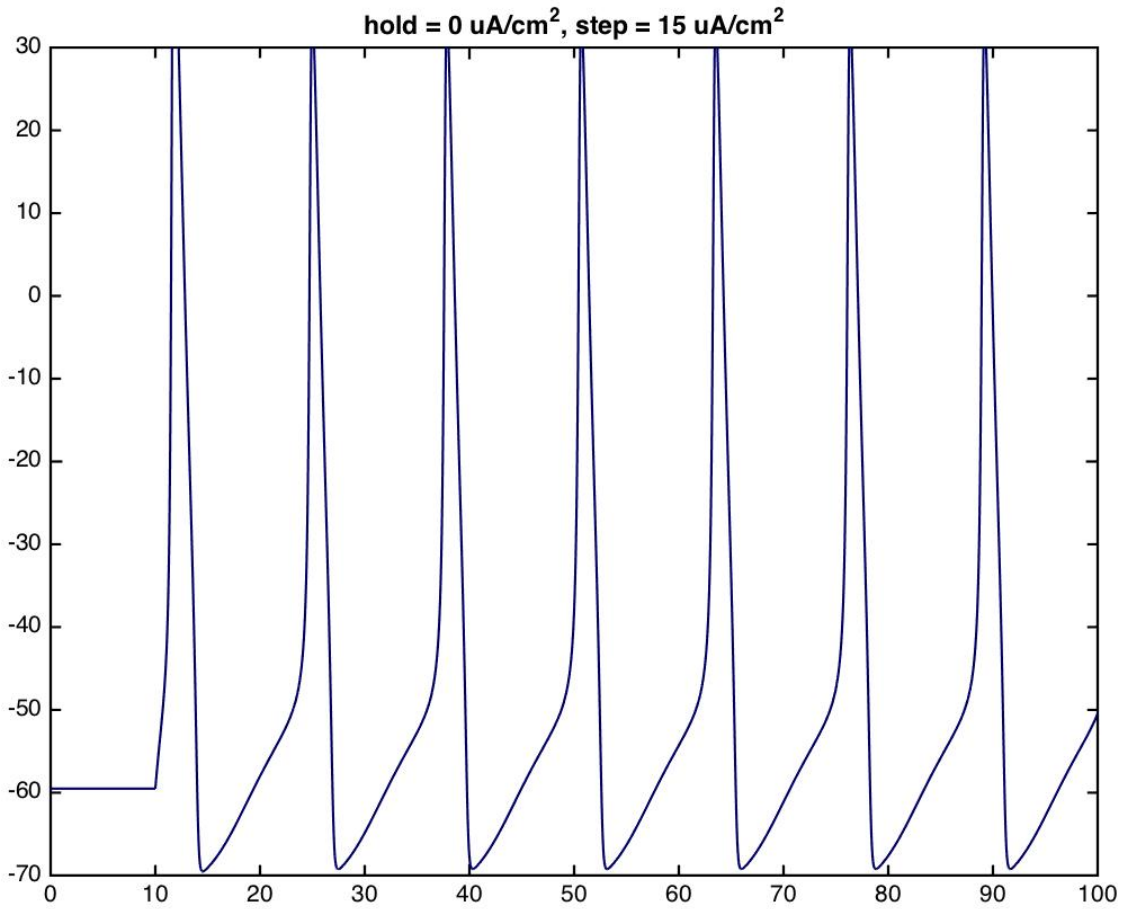

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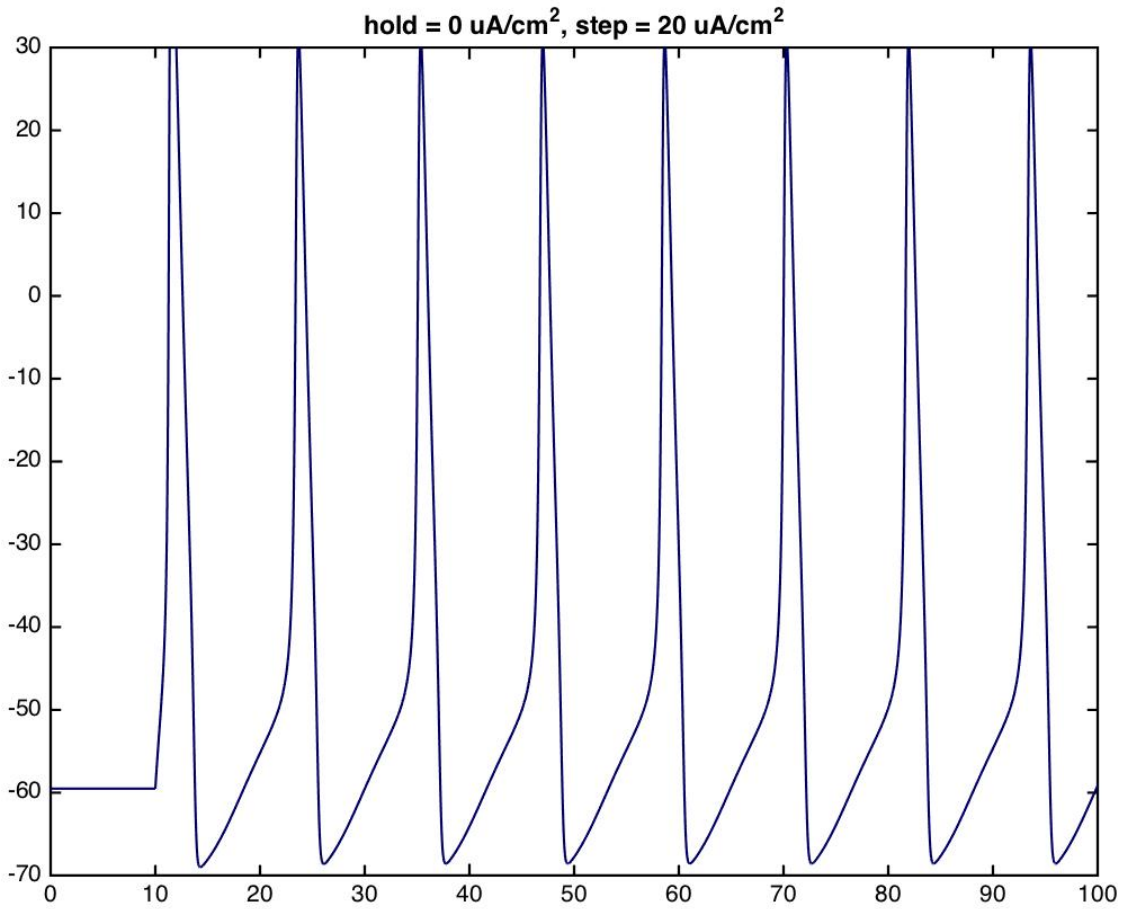

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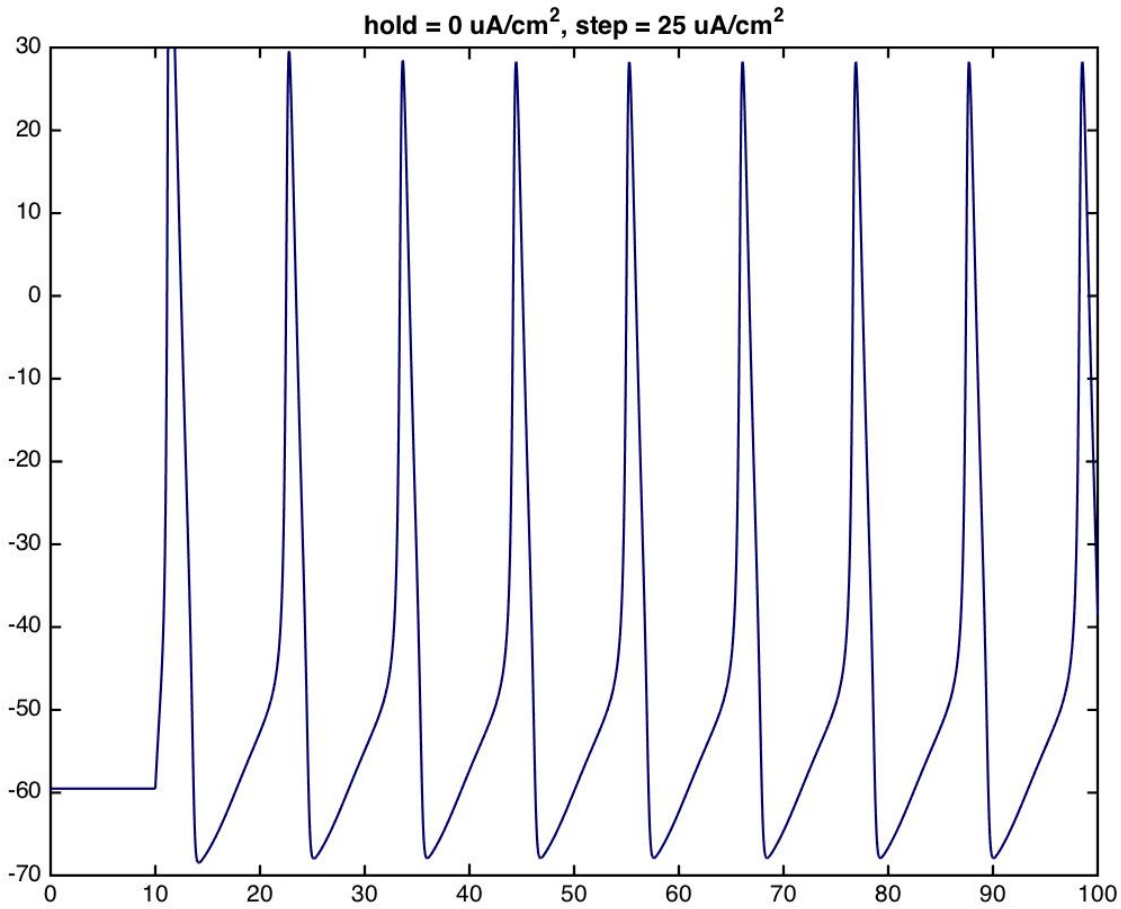

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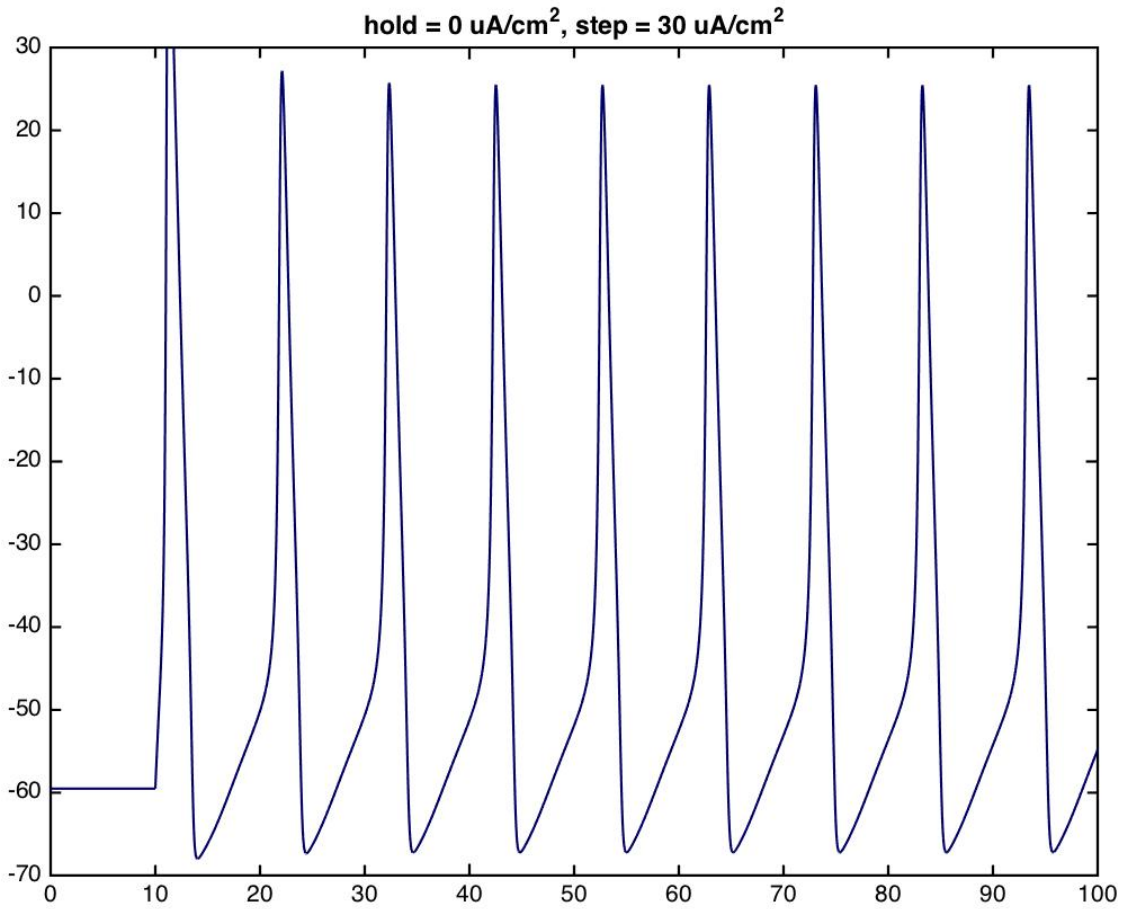

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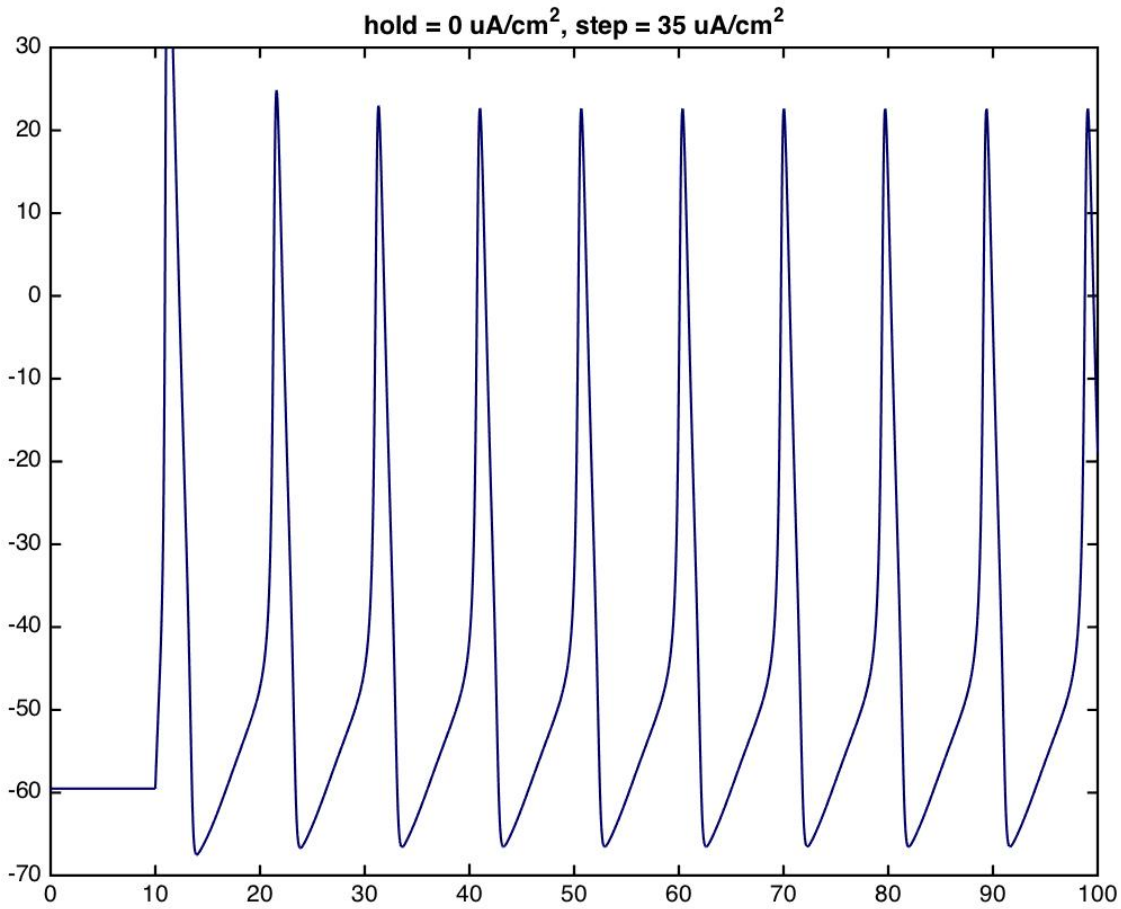

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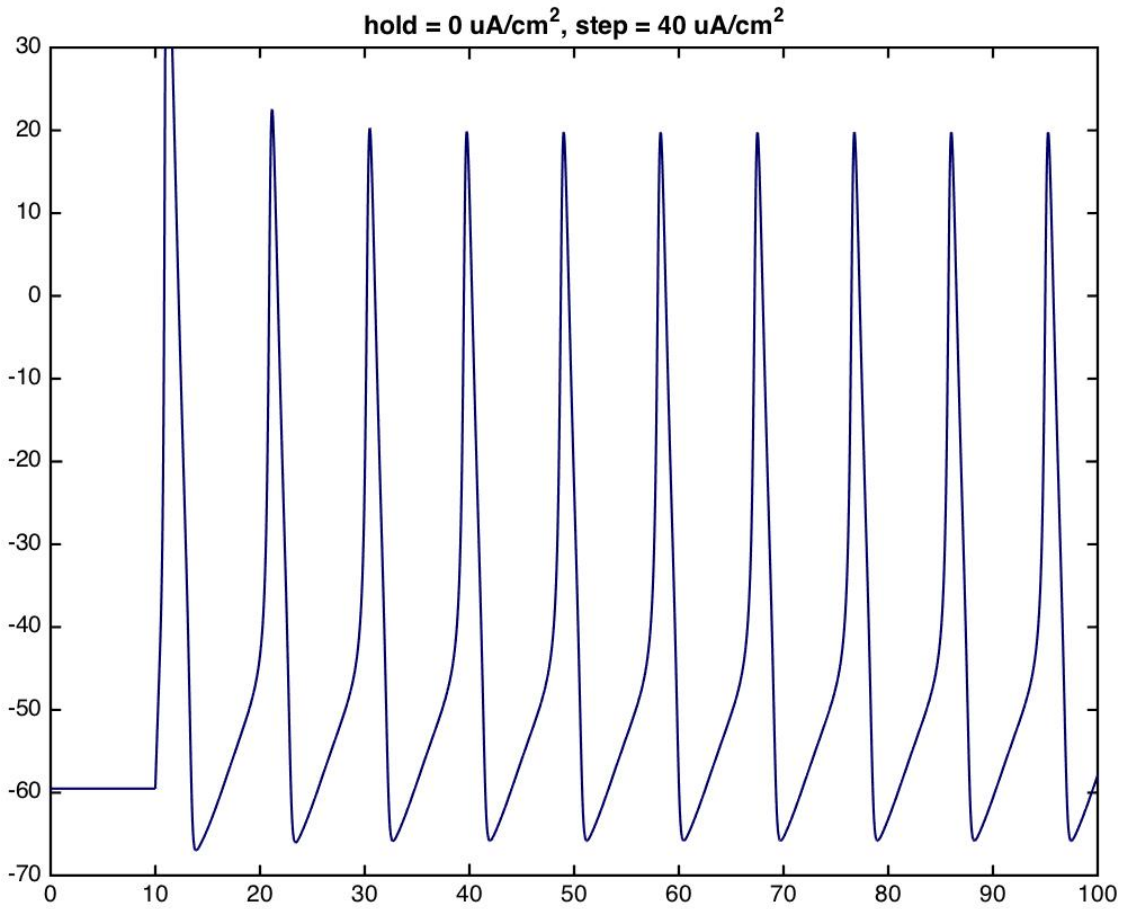

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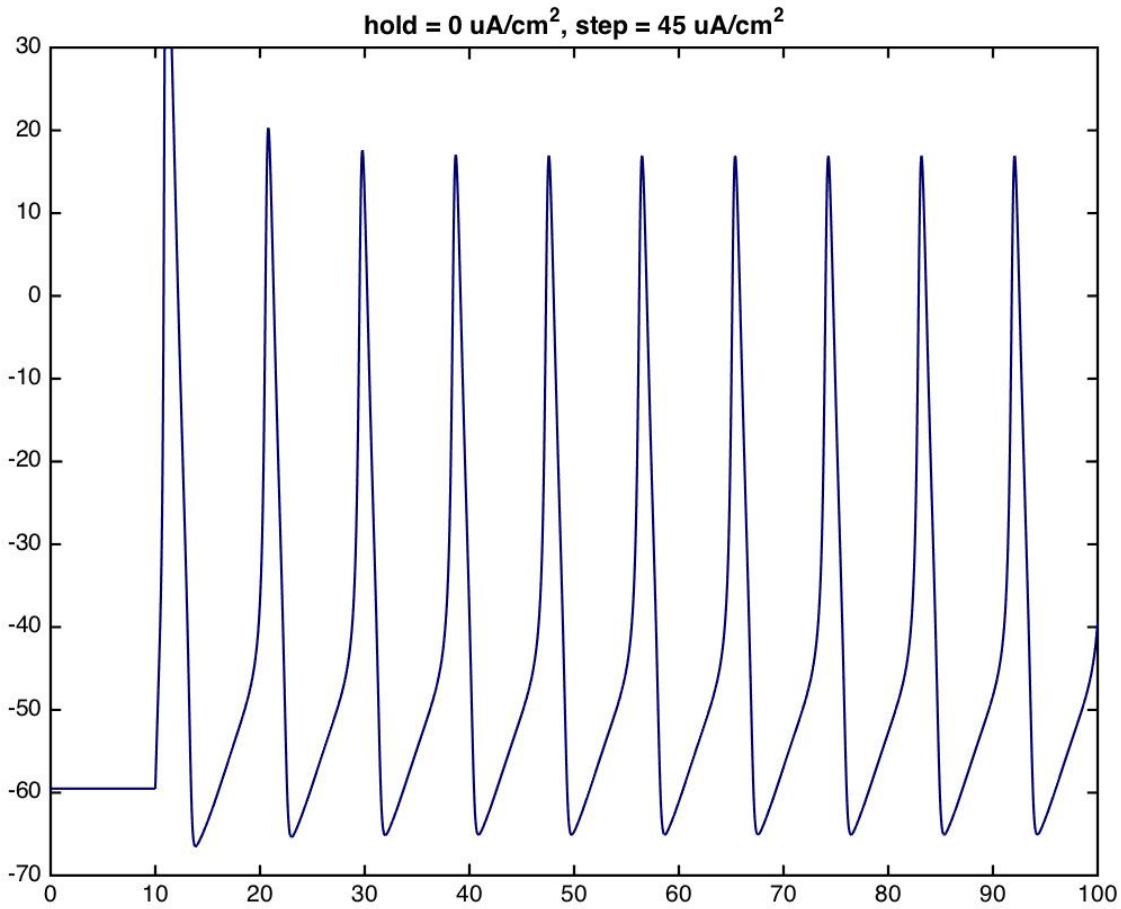

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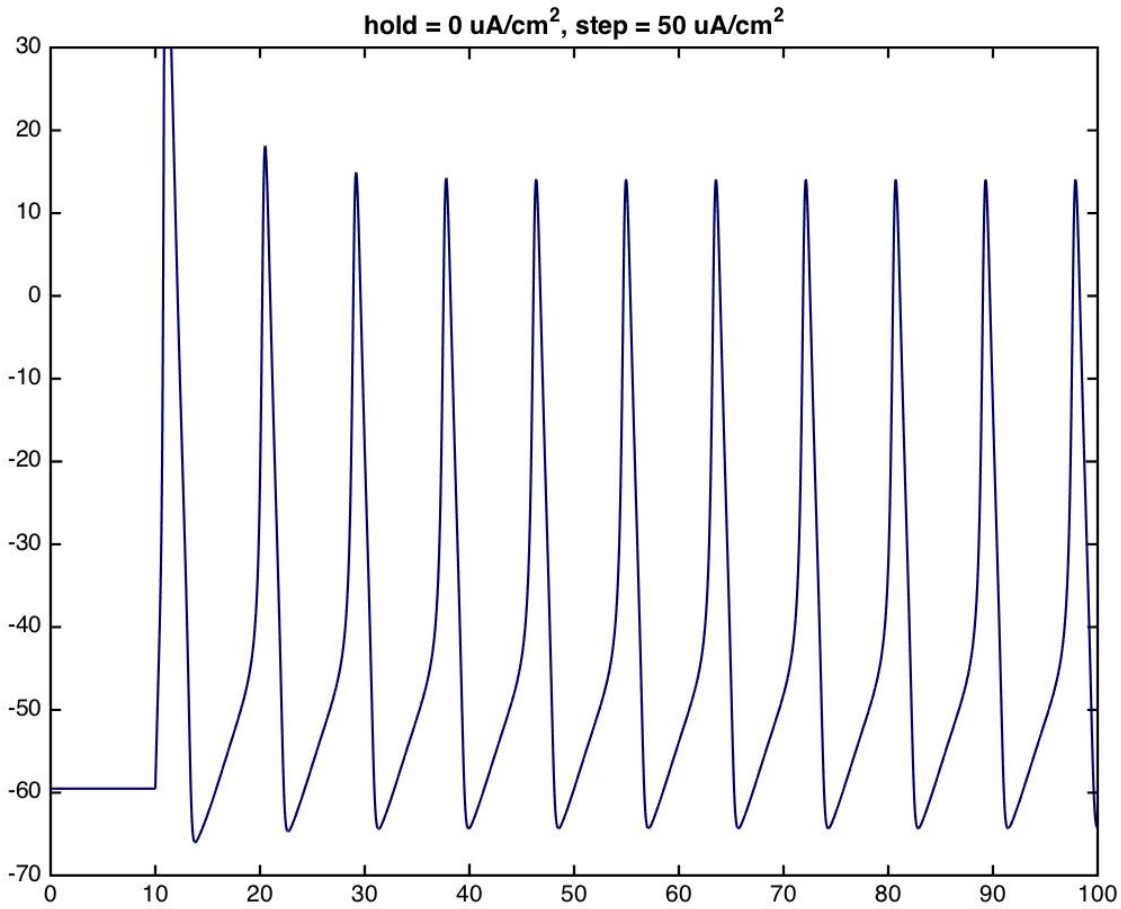

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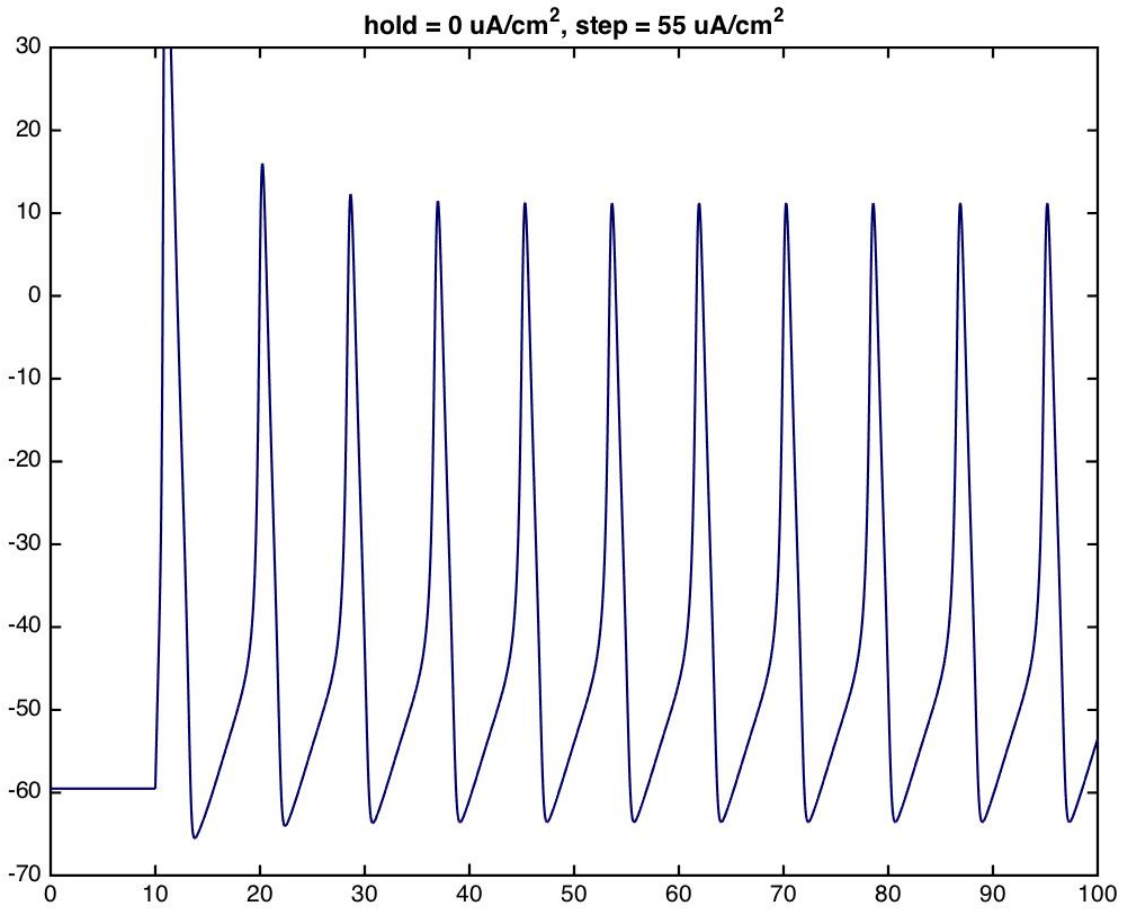

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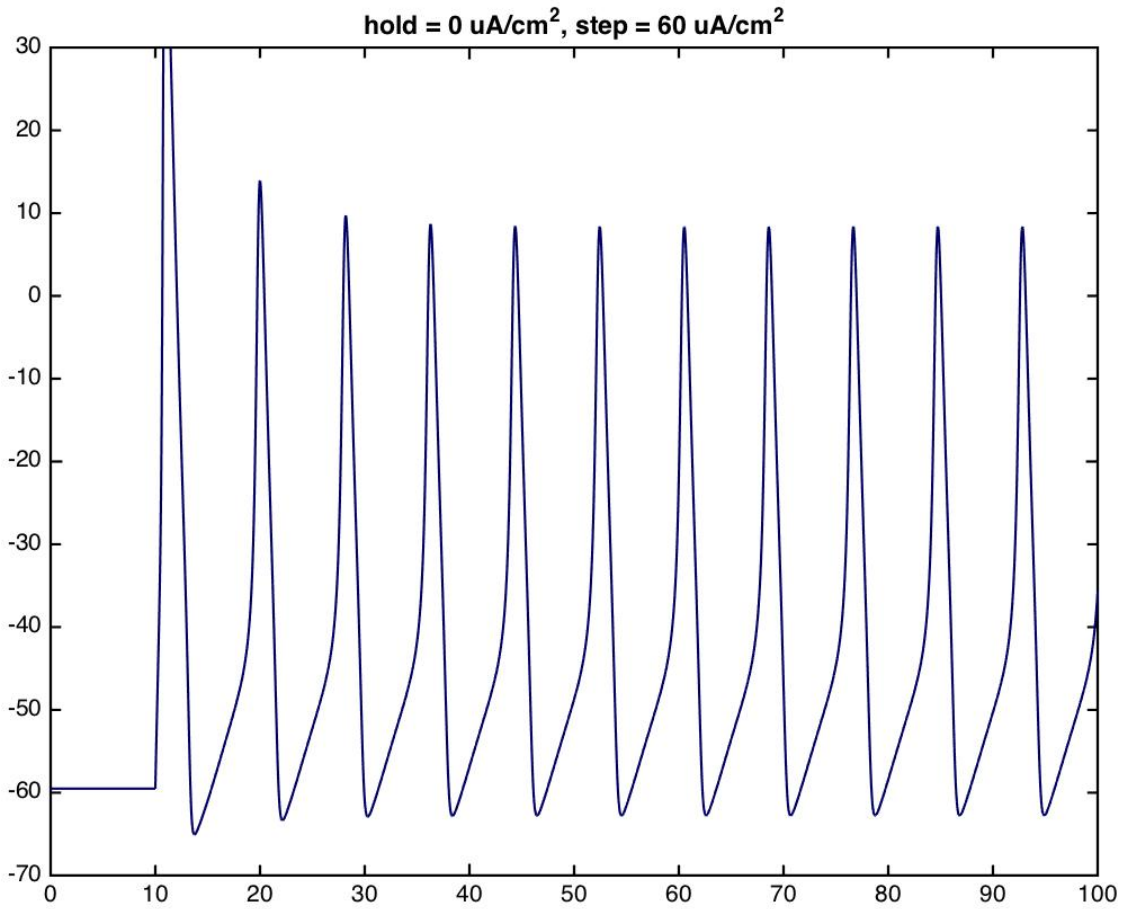

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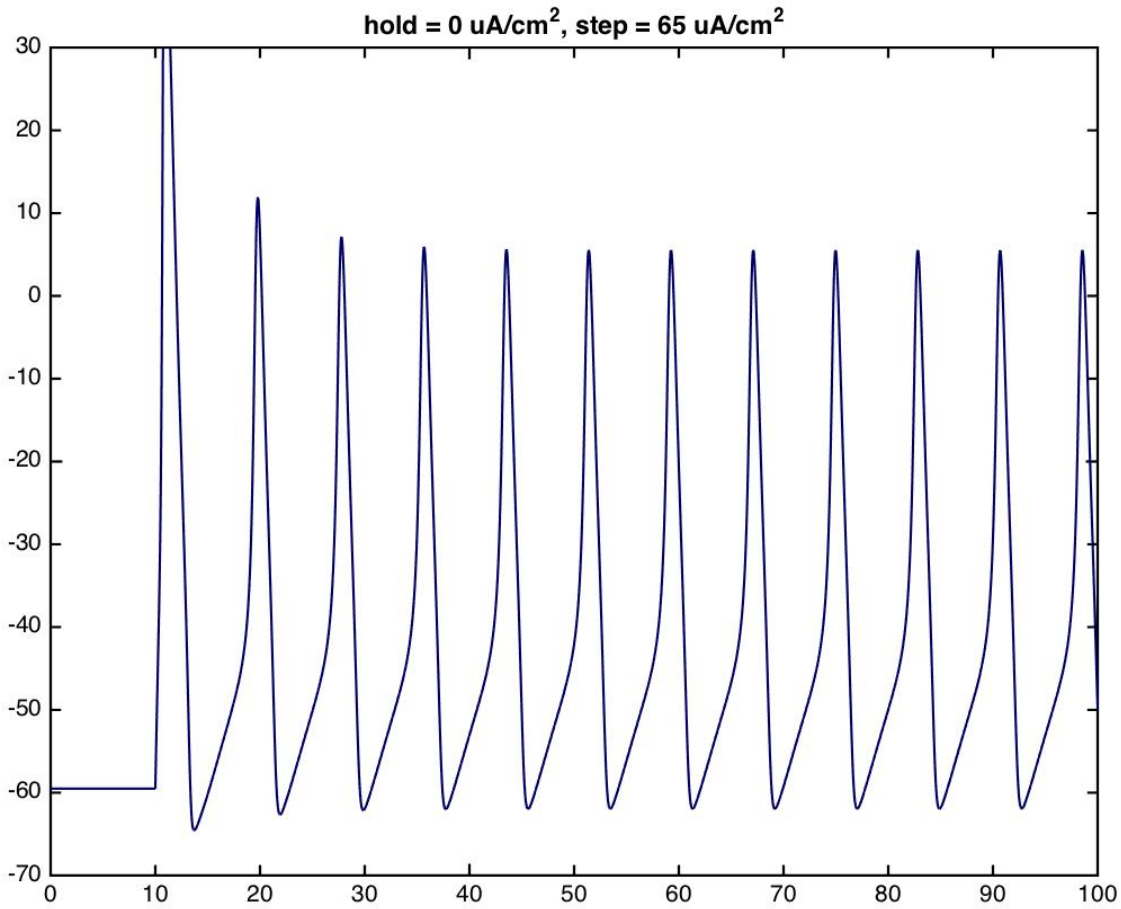

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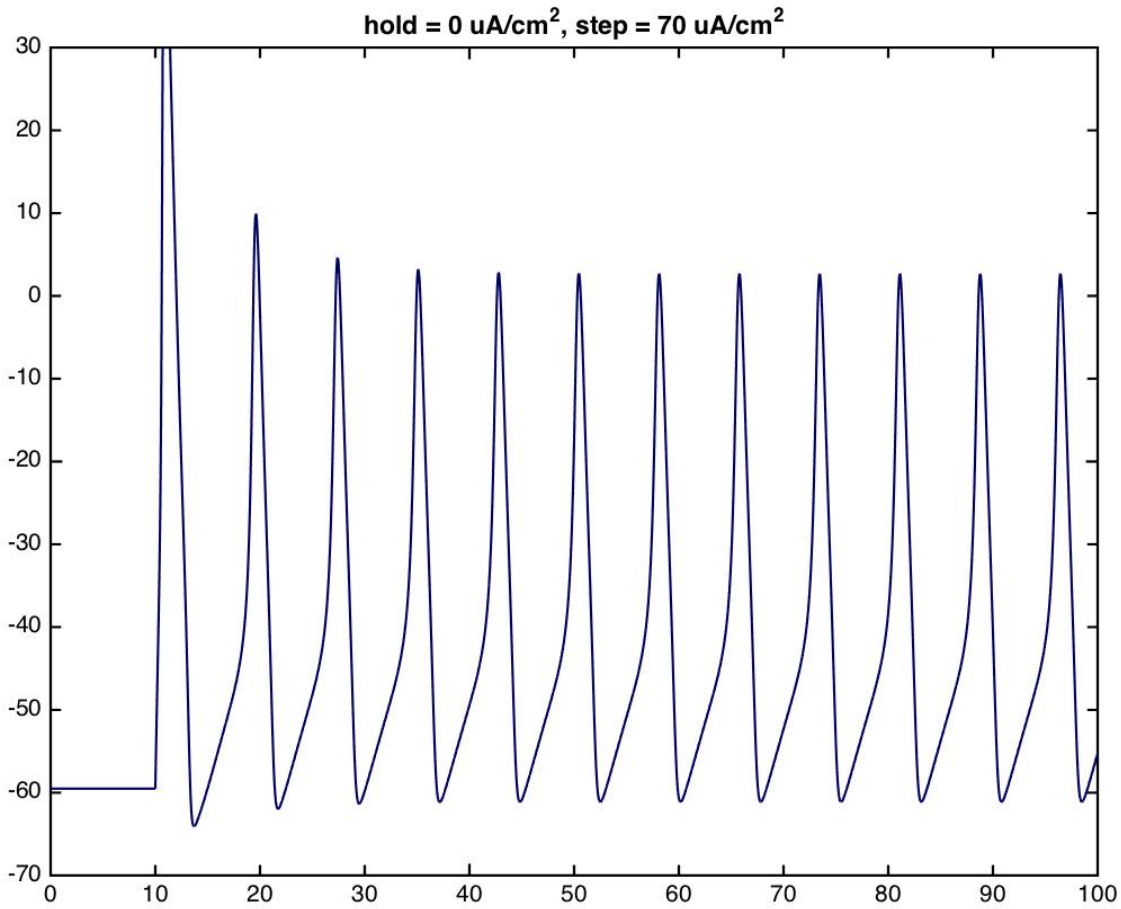

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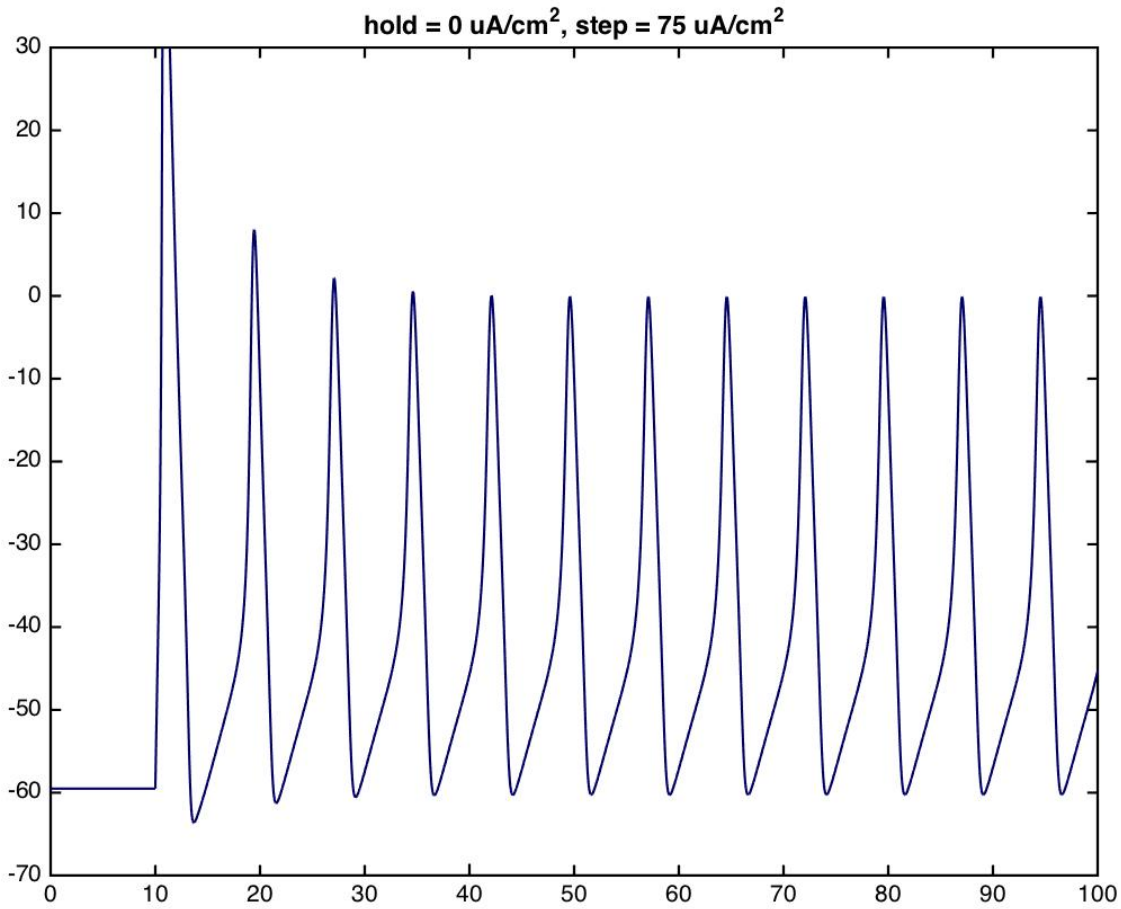

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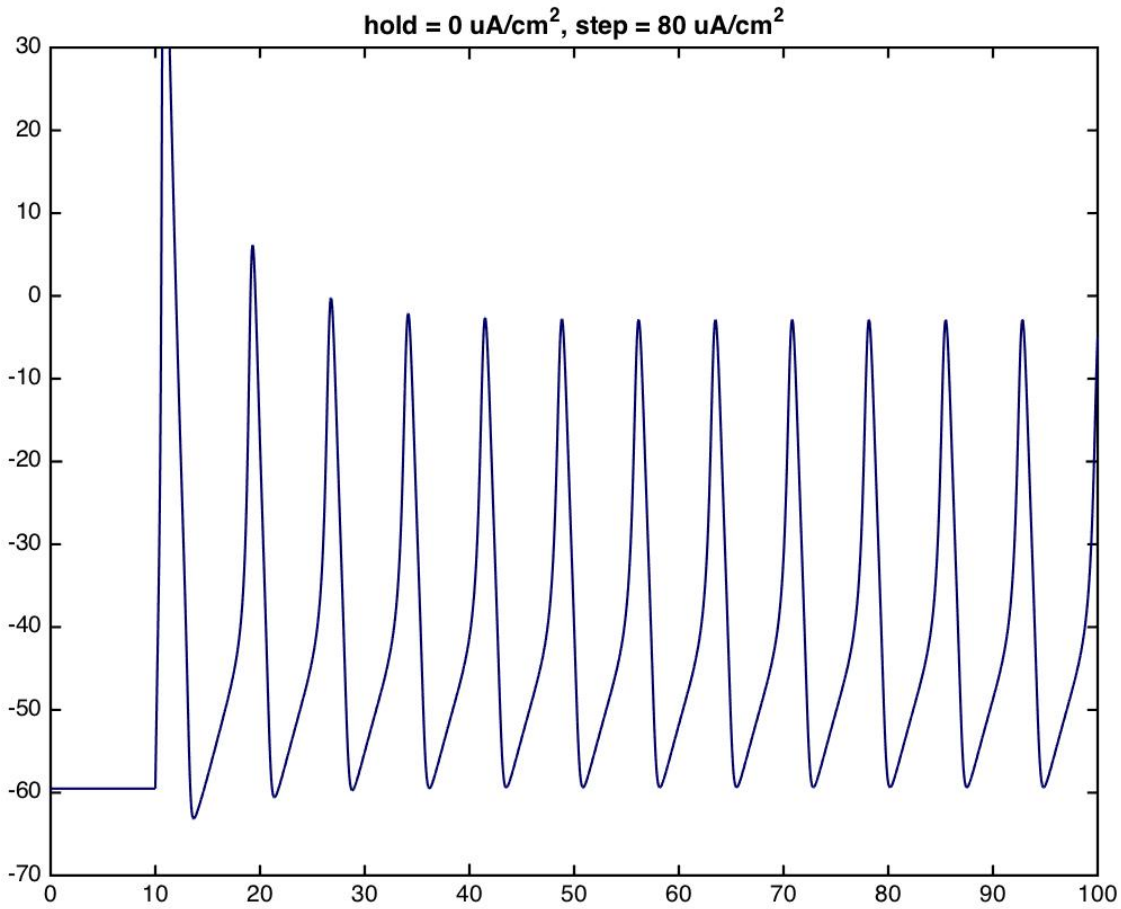

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DFT insufficient

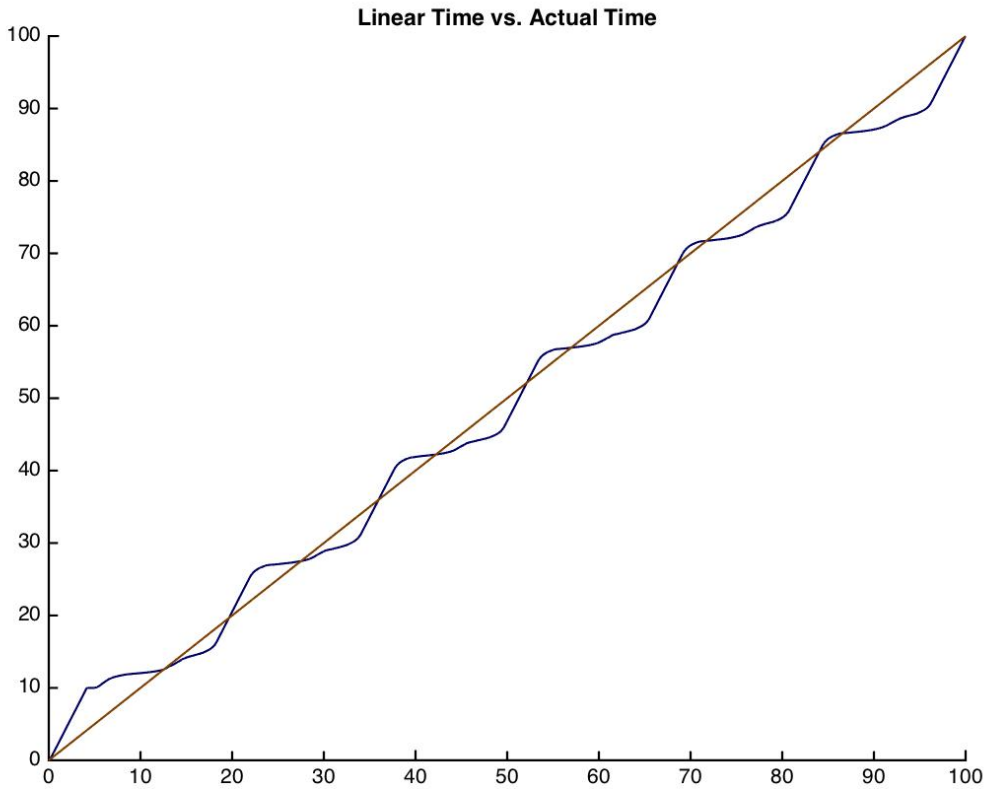


Figure : Discrete Fourier Transform insufficient due to variable time intervals.

Least-squares spectral analysis

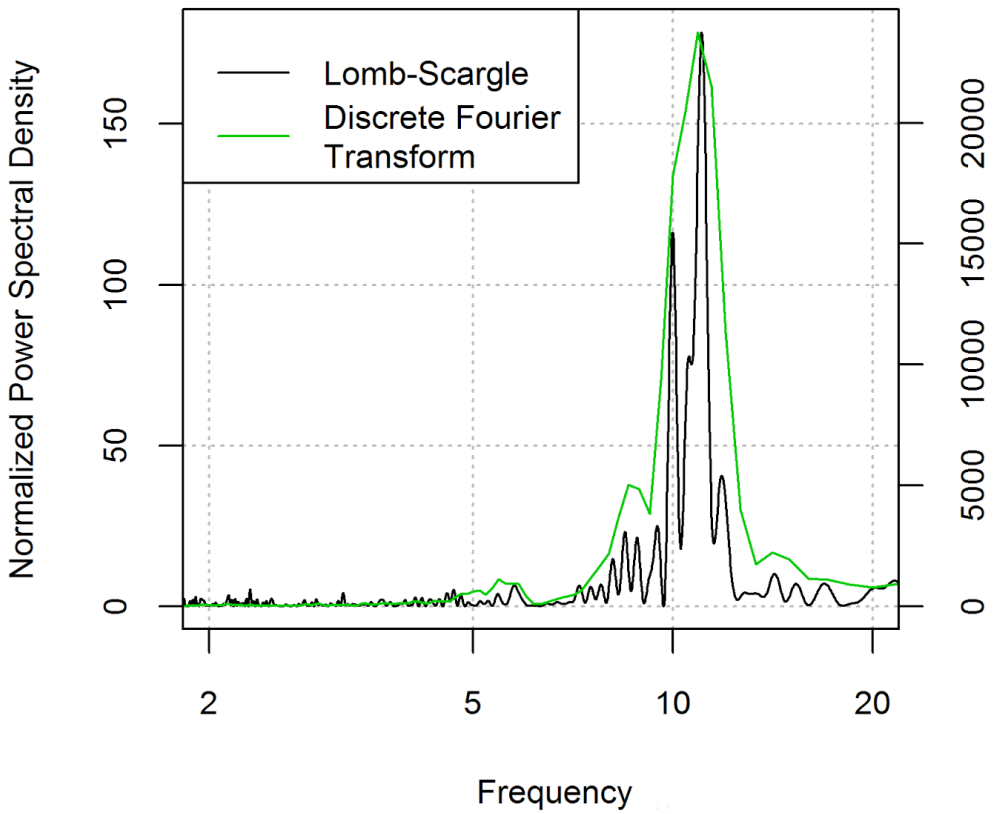
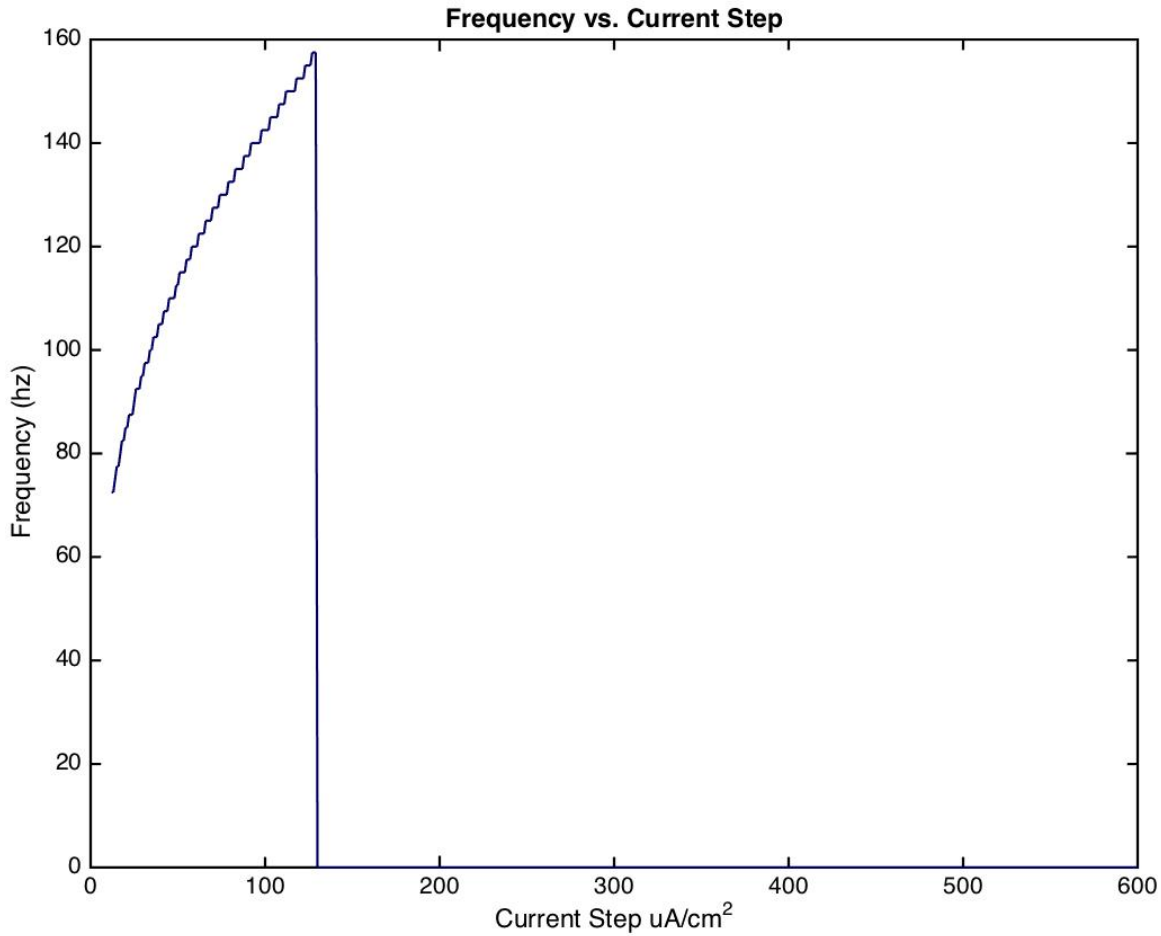


Figure : The LombScargle Periodogram works with variable intervals.

Train frequency over increasing input step



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Issues with precision approximation

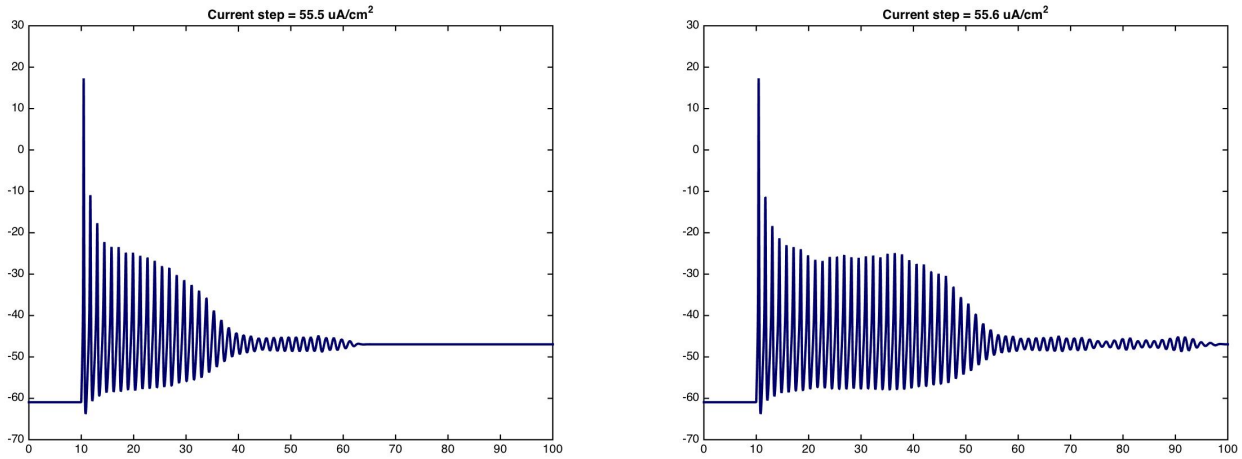

Figure : Incorrect behavior due to low precision

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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.