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NEUR 603 Assignment 2

Note – code will run assuming spiketrain1.mat and spiketrain2.mat are in the same directory as the provided neural_encoding.m file.

Part I. A)

1) The sampling frequency for V_m was measured at 10417 Hz (the sampling period is simply the difference between adjacent sample times; the inverse of the sampling period gives the sampling frequency).

2) An array consisting of times at which membrane potential crossed a threshold at -60 mV was created. See submitted code under "Part 1 A)".

3) A binary representation of the spike train was created with timesteps of 1 ms, 0.5 ms, and 0.1 ms. Again, see submitted code under "Part 1 A)".

Part I. B)

1) The interspike interval sequence from the spike times was computed; see submitted code under "Part 1 B)".

2) The interspike interval histogram (for intervals up to 200 ms) with bin-width of 1 ms is shown in Figure 1. Note that changing the threshold potential will affect the shape of this histogram.

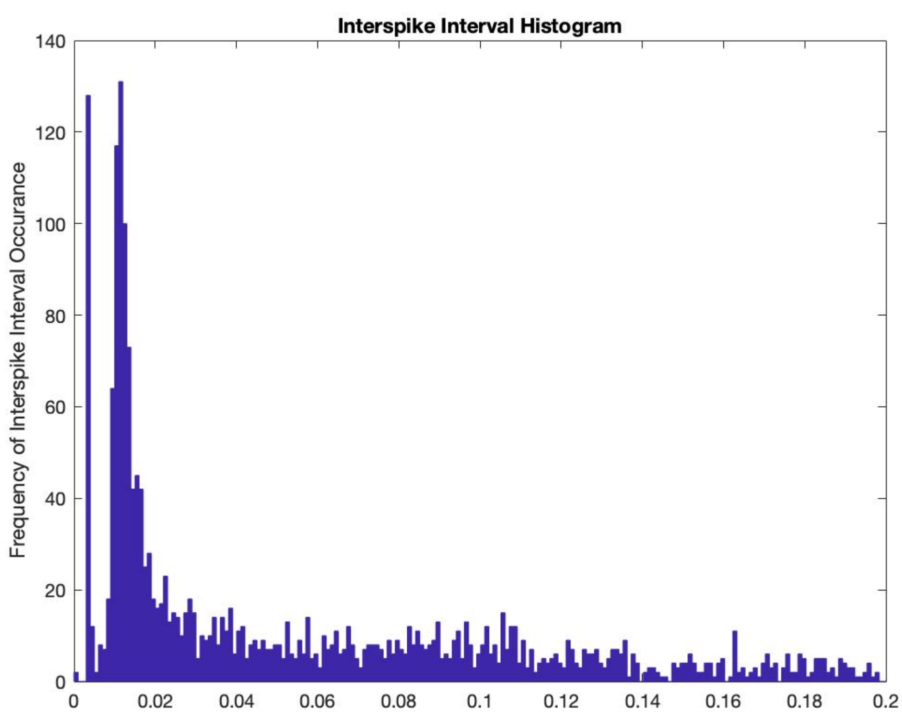

Figure 1 - Interspike interval histogram with bin-width of 1 ms

3) The coefficient of variance for this neuron was found to be 1.107 (see submitted code under "Part 1 B)"), and so the variation of the interspike intervals of the neuron is comparable to, but somewhat more than, the variation of a Poisson Process (which has a unity coefficient of variance).

4) The interspike interval correlation coefficients were computed and plotted (Figure 2). Since the interspike interval autocorrelation $\rho \neq 0$ for $\tau \neq 0$, this spike train is *not* a renewal process (a renewal process requires $\rho = 0$ for all $\tau \neq 0$).

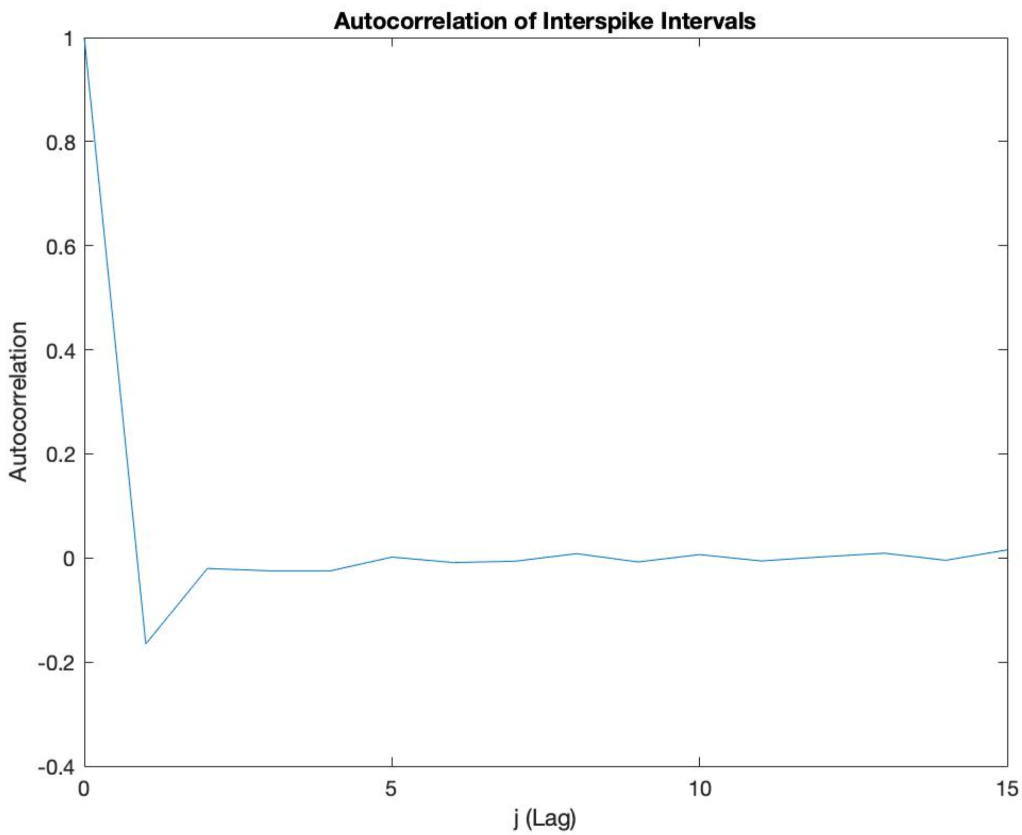

Figure 2 - Interspike interval correlation as a function of the lag, j, illustrating that this spike train is not a renewal process

Part I. C)

1) From the autocorrelation functions of the binary representations from Part A (Figure 3), the neuron's absolute refractory period is approximately 3.4 $\pm$ 0.1 ms. The neuron has a slight tendency to produce packets of action potentials (the autocorrelation is small, but non-zero, at a lag of approximately 3.5 ms, and again at a lag of approximately 11 ms).

2) The power spectra of the binary representations from Part A are plotted in Figure 4. Based on the spectral power at high frequencies, the firing rate of the neuron is approximately 29 spikes/sec. A Poisson process with the same firing rate would have approximately constant power at 29 spikes/sec across all frequencies.

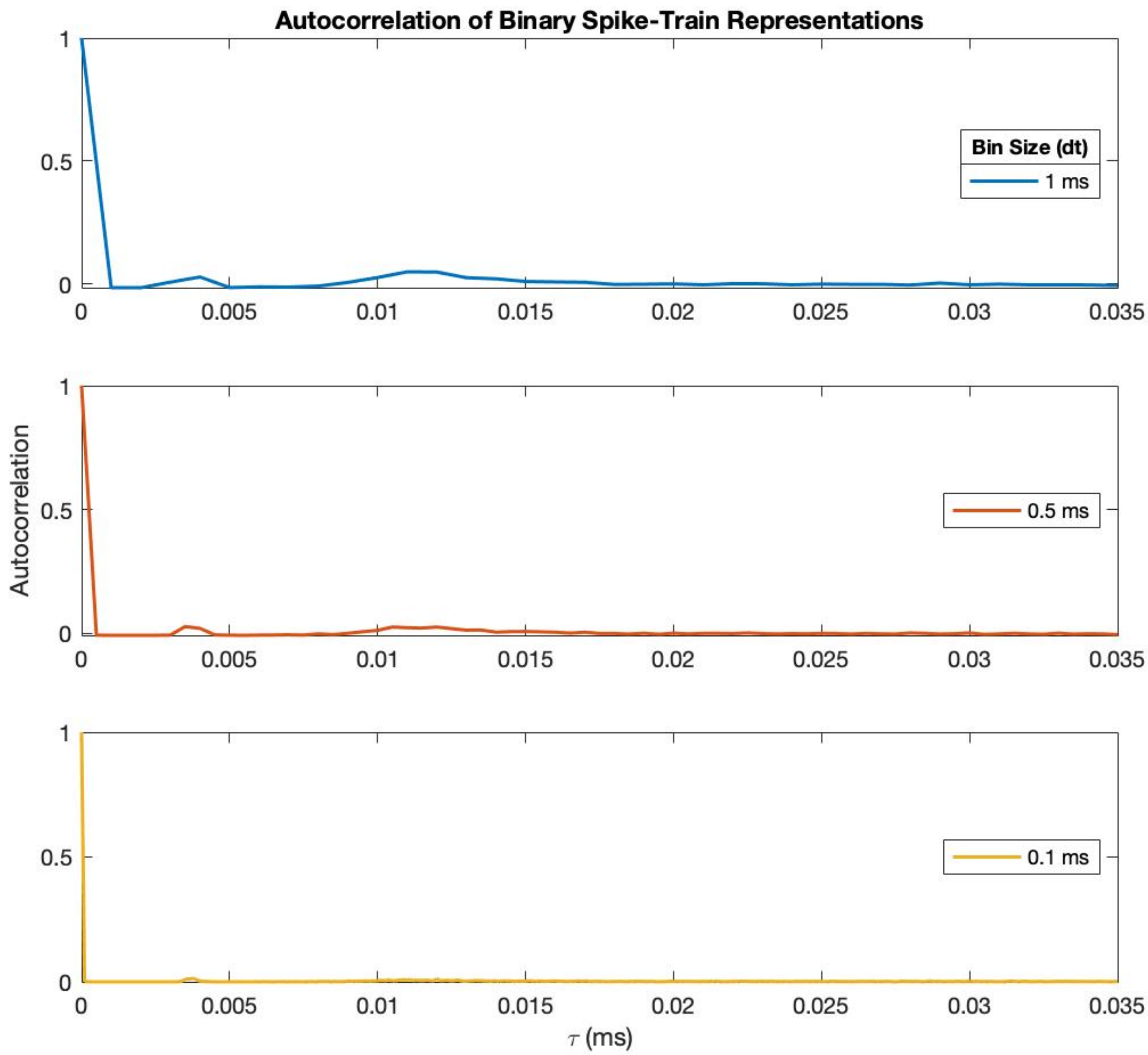

Figure 3 - Autocorrelation of binary representations computed in Part A)

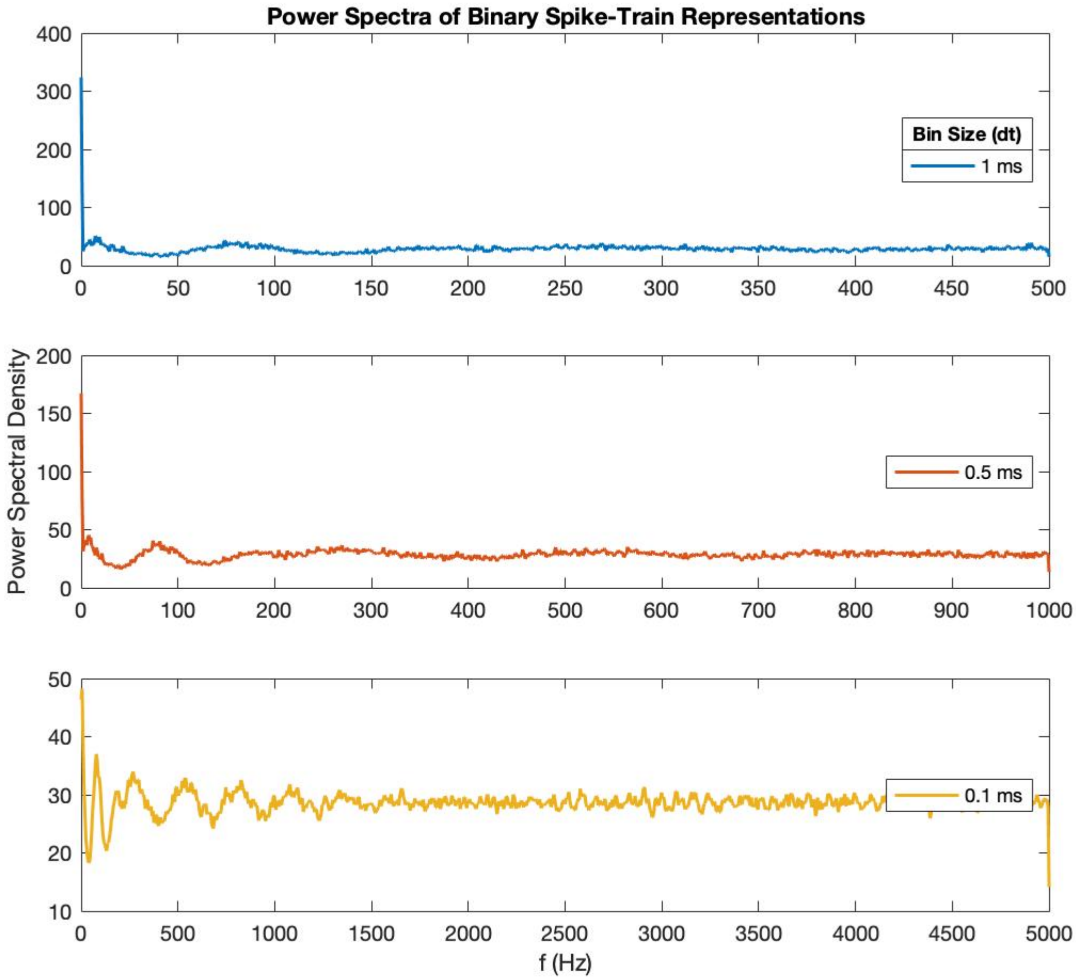

Figure 4 - Power spectra of binary representations computed in Part A)

Part II. A)

1) The data is plotted in raster format in Figure 5 (note only trials 1-40 are plotted, from time 0 – 0.5 s).

2) A PSTH from the data was built with a bin-width of 1 ms. The histogram is plotted in Figure 6 (note only the first 500 ms of the PSTH is plotted).

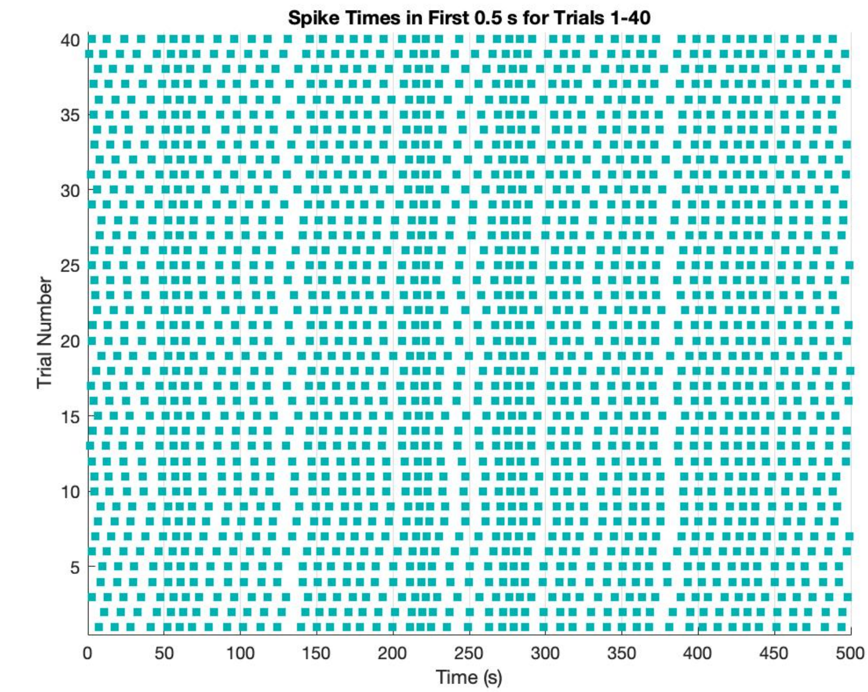

Figure 5 - Data in raster format for first 500 ms for trials 1-40

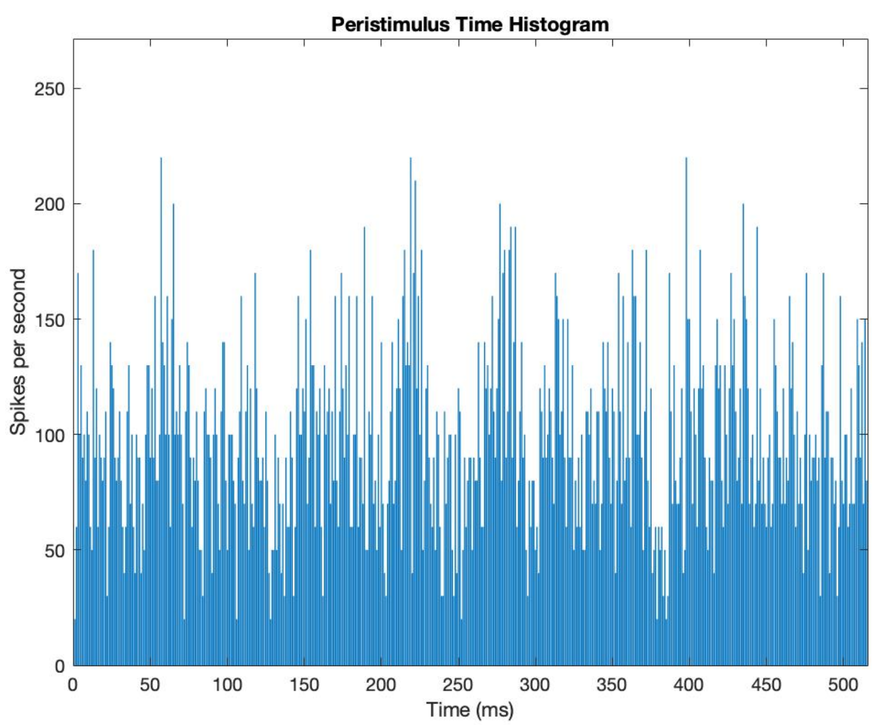

Figure 6 - Peristimulus time histogram from data with bin-width 1 ms (note only first 0.5 s are shown)

Part II. B)

1) The stimulus-response cross-correlation functions for trial 1 and trial 20, as well as the average cross-correlation across all trials, are shown in Figure 7. The cross-correlation functions across trials are similar, indicating that the stimulus and the response are correlated in a predictable manner.

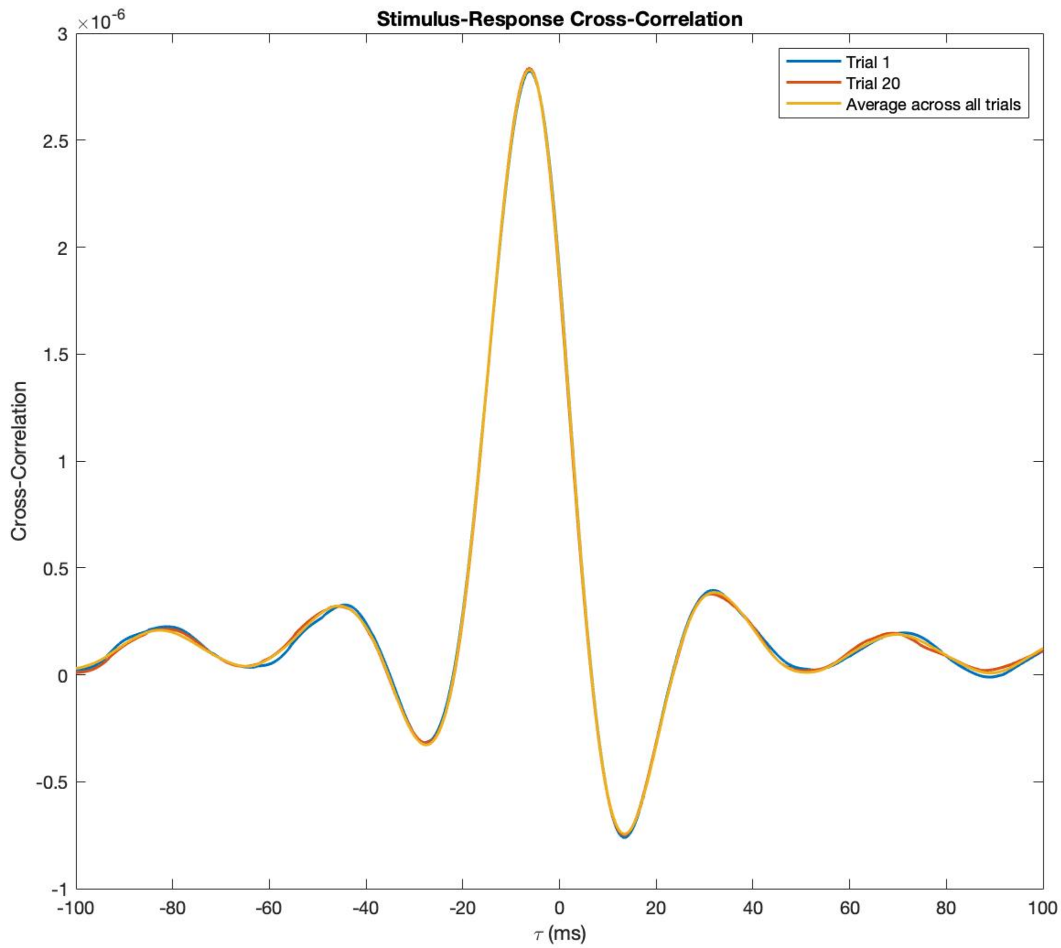

Figure 7 - Stimulus-response cross-correlation functions for trials 1 and 20, and for the average across all trials

2) The gain and phase as a function of frequency corresponding to the stimulus-trial 1 response cross spectrum are plotted in Figure 8 and Figure 9, respectively. The frequency range of 0 – 30 Hz is shown only, because this is the frequency band in which the stimulus has non-zero power.

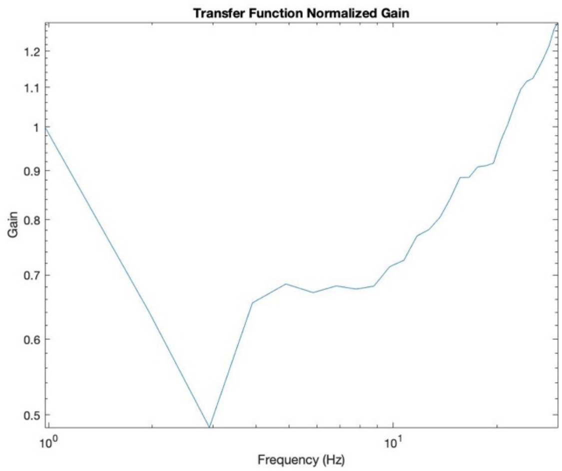

Figure 8 – Normalized transfer function gain for epoch 1 as a function of frequency

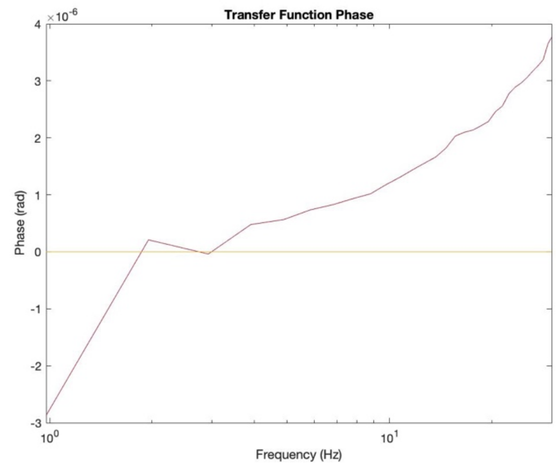

Figure 9 - Transfer function phase for epoch 1 as a function of frequency

Part II. B)

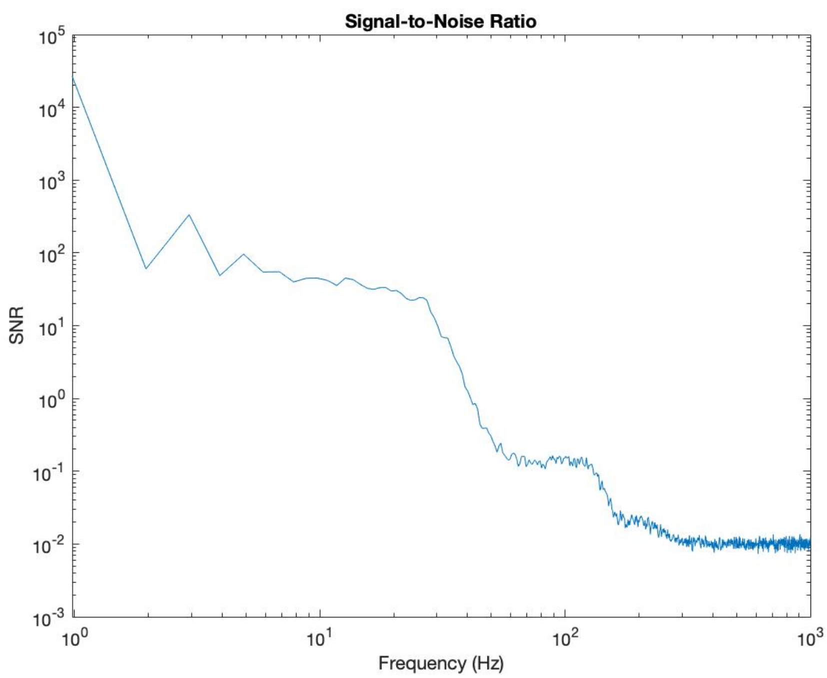

Figure 10 - Signal-to-noise ratio as a function of frequency

1) The signal to noise ratio (SNR) as a function of frequency is plotted in Figure 10. Where SNR decreases at a frequency of approximately 11 Hz, the transfer function gain increases (in other

words, at high frequency inputs there is a high gain, but much of the response is noise). Similarly, the maximum SNR occurs at a frequency of 1 Hz; there is also a local maximum of the transfer function gain at 1 Hz. This suggests that at low frequency inputs there is both high gain, and a high signal-to-noise ratio in the response. We might conclude that this neuron responds best to low-frequency inputs.