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Approximating the phase response curves of square wave bursting neurons

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Background

The phase response curve (PRC) measures the response of an oscillator to the timing of stimulus and here we construct and study the PRC of the bursting PD neuron of the STG in the crab, *Cancer borealis*. For bursting neurons whose oscillation is composed of an active phase of fast spiking activity and a silent phase, the response is determined by the change in timing of the start of the active phase after the stimulus. PRCs prove useful, when trying to predict the output of neural networks. We compare experimental results with numerical simulations of a Morris-Lecar type bursting model. We see, for instance, that in both cases, the PRCs saturate with large amplitude perturbations. Our new method is to reconstruct the PRC of the active phase by measuring the changes in the timings of the spikes in the active phase when the stimulus occurs while ignoring the effect of the stimulus in the silent phase. This approach should prove insightful in describ-

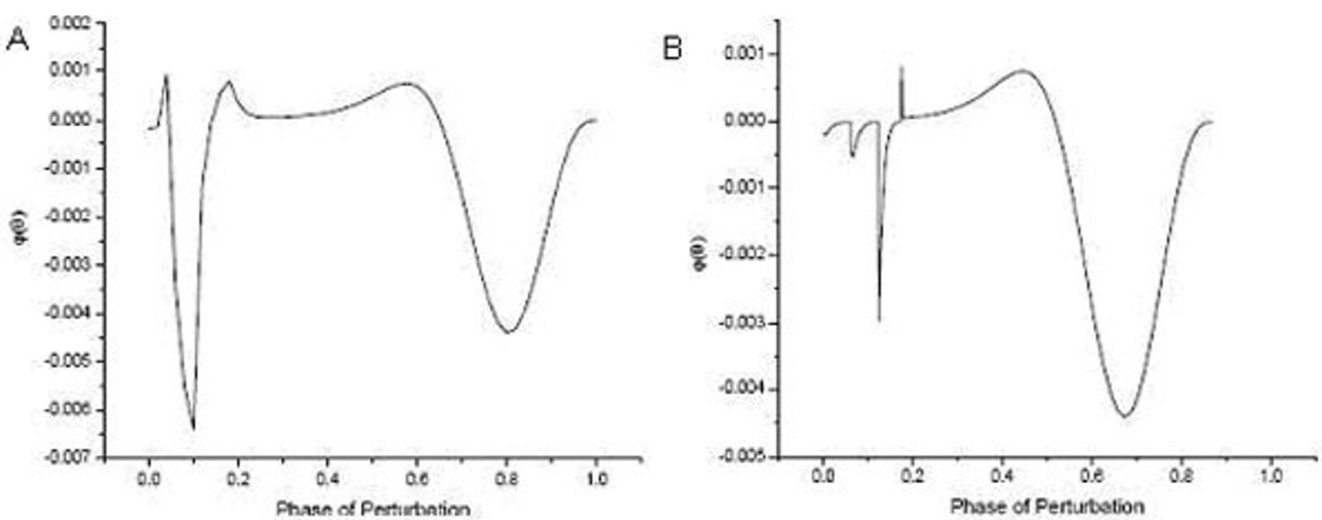

Figure 1
Model PRCs. A. Model burst PRC. B. Model PRC constructed from inter-spike PRCs.

ing more intricate synchronization patterns in coupled bursting cells. We also use ideas from geometric singular perturbation theory to shed some light on the saturation phenomenon.

Results

The PRC and its approximant for the model neuron are shown in Figure 1. We also show that much of the phase response is due to spike addition (more spikes in active phase), spike deletion (fewer spikes) and burst truncation which is the termination of the active phase. For example, strong inhibition and excitation cause burst truncation and spike addition, respectively, in the active phase. Burst truncation is thus seen to be the key mechanism behind the saturation of the PRCs with amplitude.

Conclusion

To a first order approximation, we have shown that one can predict the PRC by assuming linear spike shifting in the active phase. We also show the importance of phenomena such as spike addition, deletion and burst truncation in determining the phase response properties of the oscillator.

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