Band-pass and band-stop electrochemical filters: Electrical resonance and antiresonance of the electrochemical interface

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Resonance seems to play a crucial role in the response of neural cells and the communication in physiological neural networks. Due to its physicochemical and biological structure, the neural membrane is able to respond to external stimuli by producing electric pulses, the so-called action potentials. Action potentials are the carriers of information and their properties determine the functioning of the neural system. One striking property of certain neural membranes is their ability to resonate at specific frequencies and thus act as band-pass filters. Band-pass filtering results in the isolation of specific frequencies and the selective communication between neurons.

Among other physicochemical systems, electrochemical systems present several similarities to neural membranes. The structure of the electrochemical interface and the neural membrane is often modeled as a capacitor. In both systems the current carriers are ions moving in aqueous solutions. The electrode potential and the membrane potential represent the potential drop across the respective interfaces. Moreover, electrochemical systems have the ability to produce spontaneous electric pulses (potential or current spikes), or to be excited under appropriate control. It is to be expected that electrochemical systems are able also to exhibit resonance and thus mimic neural behavior. Moreover, it is possible that among other uses in electronics, electrochemical capacitors can be utilized for low-frequency electrical filtering.

In the present work it is shown that the electrochemical interface can act as a band-pass filter under specific conditions [1]. This behavior is based on the combination of the dynamics close to a Hopf bifurcation point and electric properties of the electrochemical interface enabling the system to resonate, that is, to exhibit a maximum of the admittance at a specific resonance frequency. Moreover, it is shown that the electrochemical interface can act as a band-stop (band-rejection) filter [2]. Band-stop filters are utilized as wave traps based on their antiresonance properties. A simple but general model for the electrochemical interface is employed in order to elucidate whether electrical resonance and antiresonance can be observed, *i.e.* whether the admittance can exhibit a minimum (ideally becoming zero) at a specific antiresonance frequency. The theoretical findings are supported by experimental evidence of both resonance and antiresonance [3, 4].

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