

Resonant dendrites with active spines:  
sub-threshold dynamics in  
the spike-diffuse-spike model

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**Abstract**

Dendrites, the major components of neurons, have many different types of branching structures and are involved in receiving and integrating thousands of synaptic inputs from other neurons. Dendritic spines with excitable channels can be present in large densities on the dendrites of many cells. The recently proposed spike-diffuse-spike model that is described by a system of point hot-spots (with an integrate-and-fire process) embedded throughout a passive tree has been shown to provide a reasonable caricature of a dendritic tree with supra-threshold dynamics. Interestingly, real dendrites equipped with voltage-gated ion channels can exhibit not only supra-threshold responses, but also sub-threshold dynamics. This sub-threshold resonant-like oscillatory behaviour has already been shown to be adequately described by a quasi-active (linearised active) membrane. Here I introduce a mathematical model of a branched dendritic tree based upon a generalisation of the spike-diffuse-spike model where the active spines are assumed to be distributed along a resonant dendritic structure. The solution of the model can be expressed in part using the Greens function for the resonant tree without spines and this function can be constructed by using the recently developed “sum-over-trips” techniques for dendrites with a quasi-active membrane.