Coincidence Detection on Octopus Cells

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Hearing

The Auditory Pathway

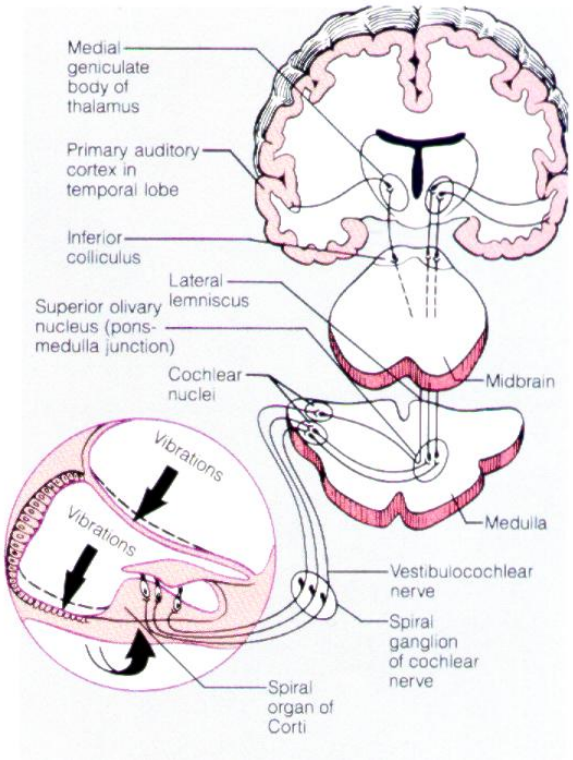

Figure: auditory pathway

Information Organization

- the information is brought via the cochlear nerve
- tonotopic organization
- information extraction begins on the cochlear nuclei
- different frequencies impinge on distinct areas

Cochlear Nucleus

The cochlear nucleus consists of a wide variety of different types of cells with different characteristics.
We think of the cochlear nucleus as a centre for concentrating, sharpening and enhancing features in the Neural Activity Pattern (NAP) prior to distributing the results to the superior olivary complex (SOC) and the inferior colliculus (IC), either via the lateral lemniscus or direct.

Cochlear Nucleus

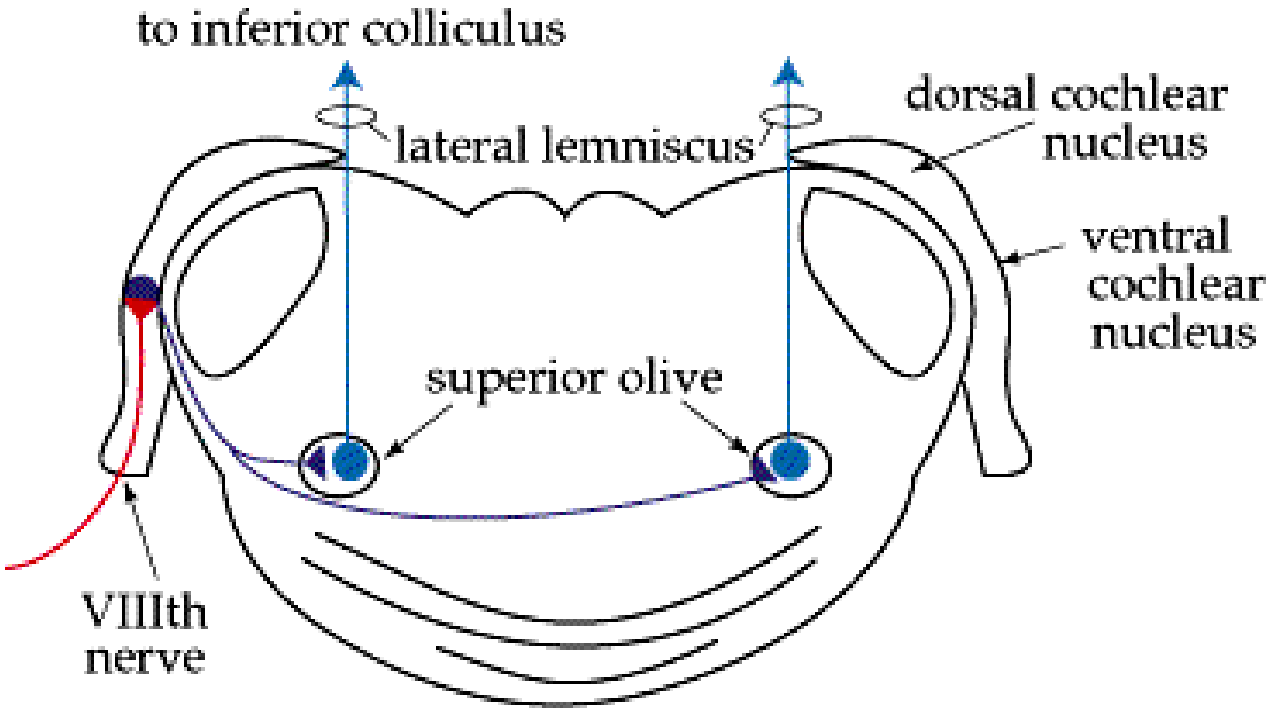

Figure: cochlear nucleus

Cochlear Nucleus' Cells

There are four types of cells found in the cochlear nucleus

- stellate cells - star like shape
- chopper cells - fire consistently despite backgroud noise
- bushy cells - single and very short dendrite with numerous small branchings
- fusiform cells - the word "fusiform" comes from the Latin "fusus" meaning "spindle"
- octopus cells - octopus is any of a genus (Octopus) of cephalopod mollusks that have eight muscular arms equipped with two rows of suckers

Octopus Cells

- convey the presence of acoustic transients, periodicity, and direction of frequency sweeps in their temporal firing patterns
- detect the coincident input of auditory nerve fibers

Octopus Cells

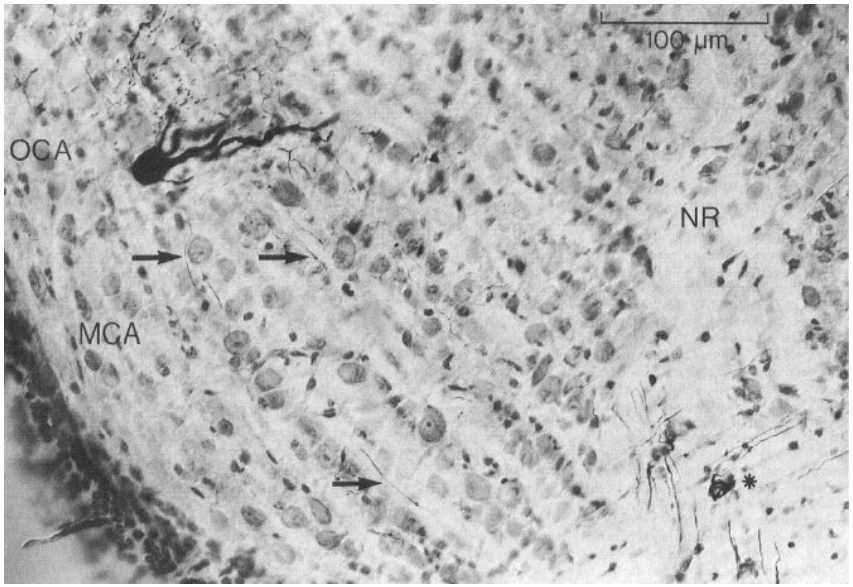

Figure: octopus cell

Octopus Cells

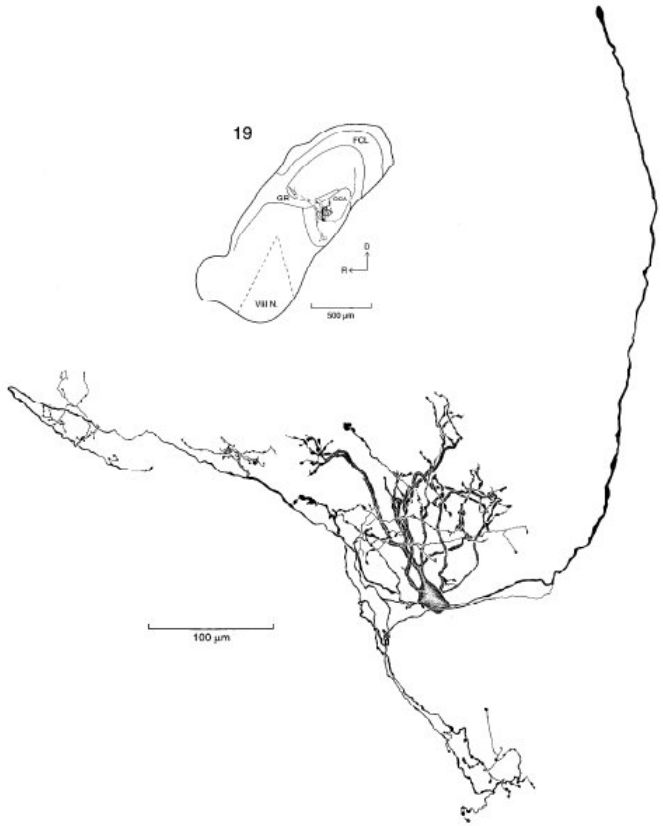

Figure: octopus cell

Some Properties

- octopus cells spread their dendrites perpendicularly across the array of auditory nerve fibers from which they receive their major excitatory input
- on the averange ate least 50 auditory nerve fibers terminate on the dendrites of one octopus cell
- auditory nerve fibers excite octopus cell through glutamate receptors of the AMPA [1] subtype that have rapid kinetics (decay time constants average $350\mu s$)

[1] AMPA (alpha-amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid) is a specific agonist for AMPA receptor. AMPA mimicks the effect of glutamate. It is used in experiments to distinguish a receptor from the other ionotropic receptors for glutamate that are activated by different agonists: NMDA and kainate.

Some Properties

- the low input resistence and short time constants of octopus cells allow the rapid synaptic currents to produce synaptic potentials whose duration is short, generally around $1ms$
- input resistence is between 2 and $6M\Omega$
- time constants are about $200\mu s$
- firing of the octopus cells might be sensitive to the rate at which they are depolarized
- resting potential is about $-60,6mV$

Simulation under Genesis

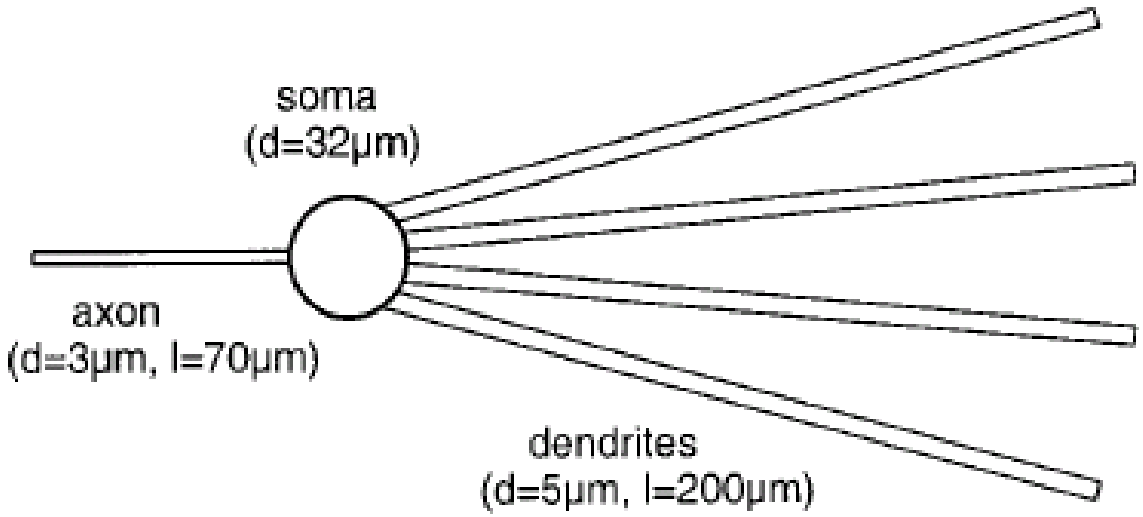

Figure: model

delay1: 0ms, delay2: 0ms

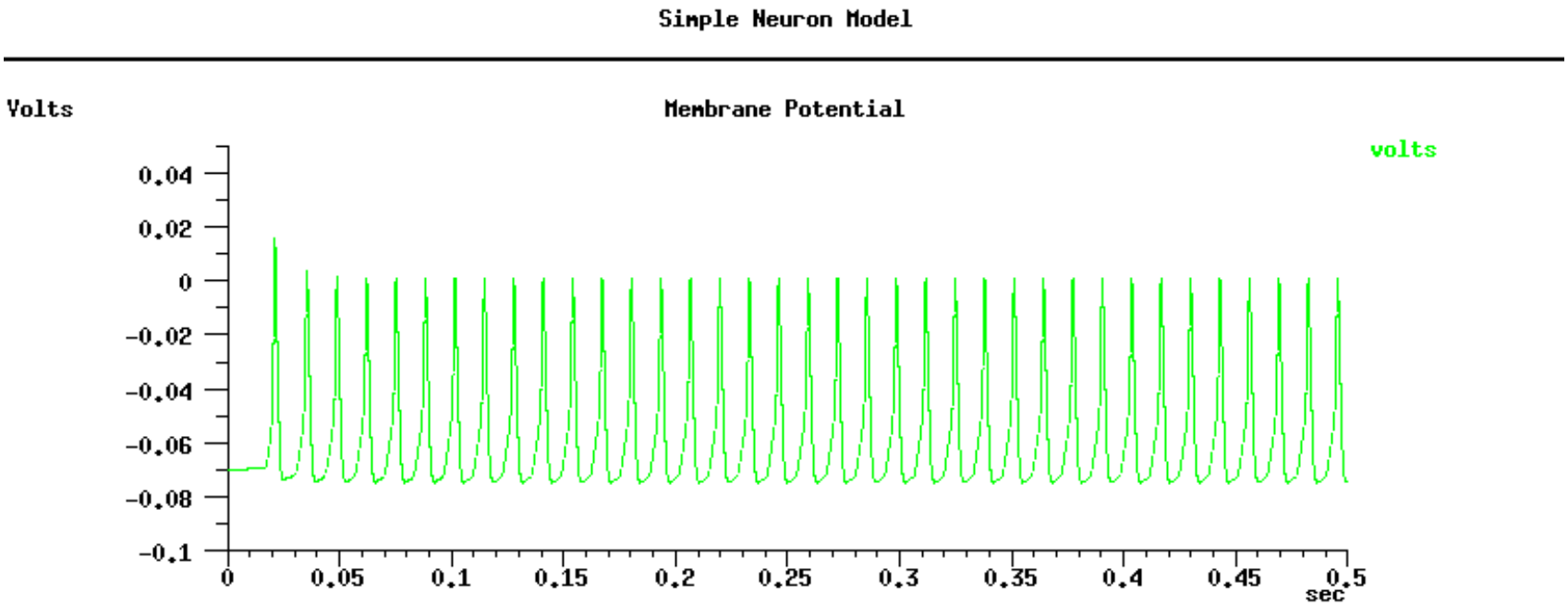

Figure: delay1: 0ms, delay2: 0ms

delay1: 1ms, delay2: 2ms

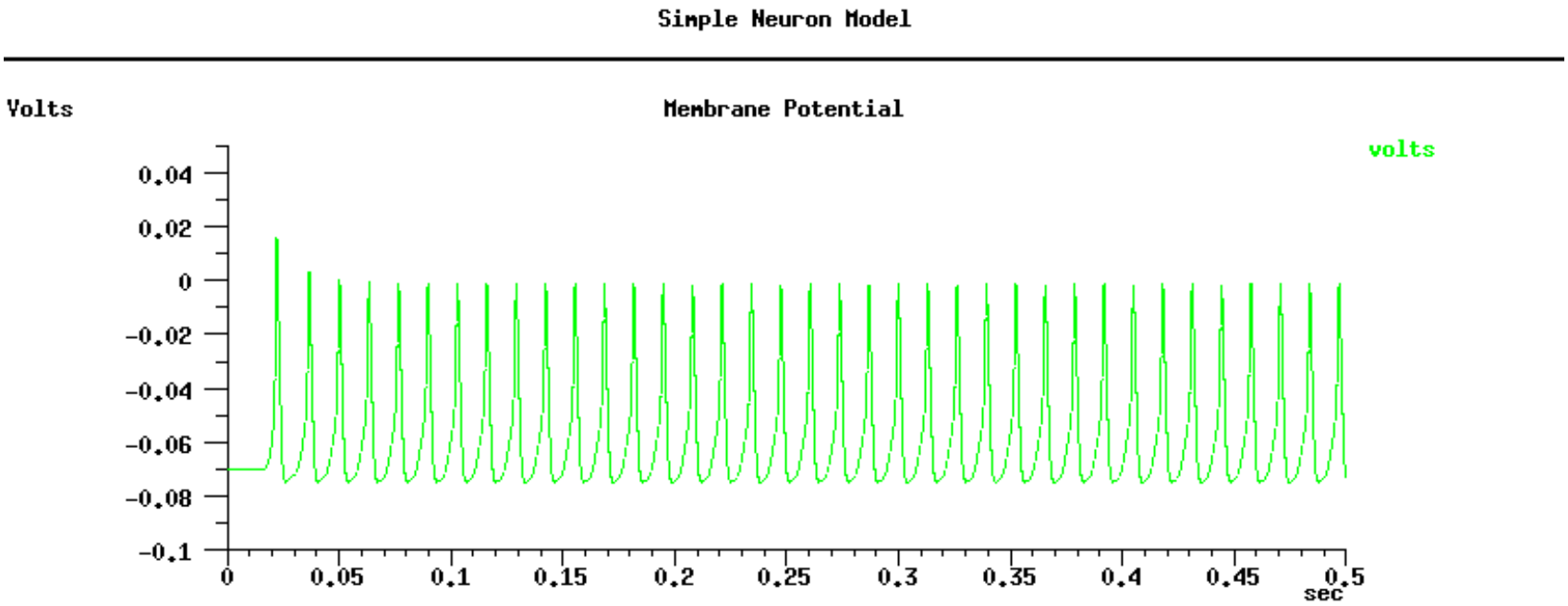

Figure: delay1: 1ms, delay2: 2ms

delay1: 2ms, delay2: 4ms

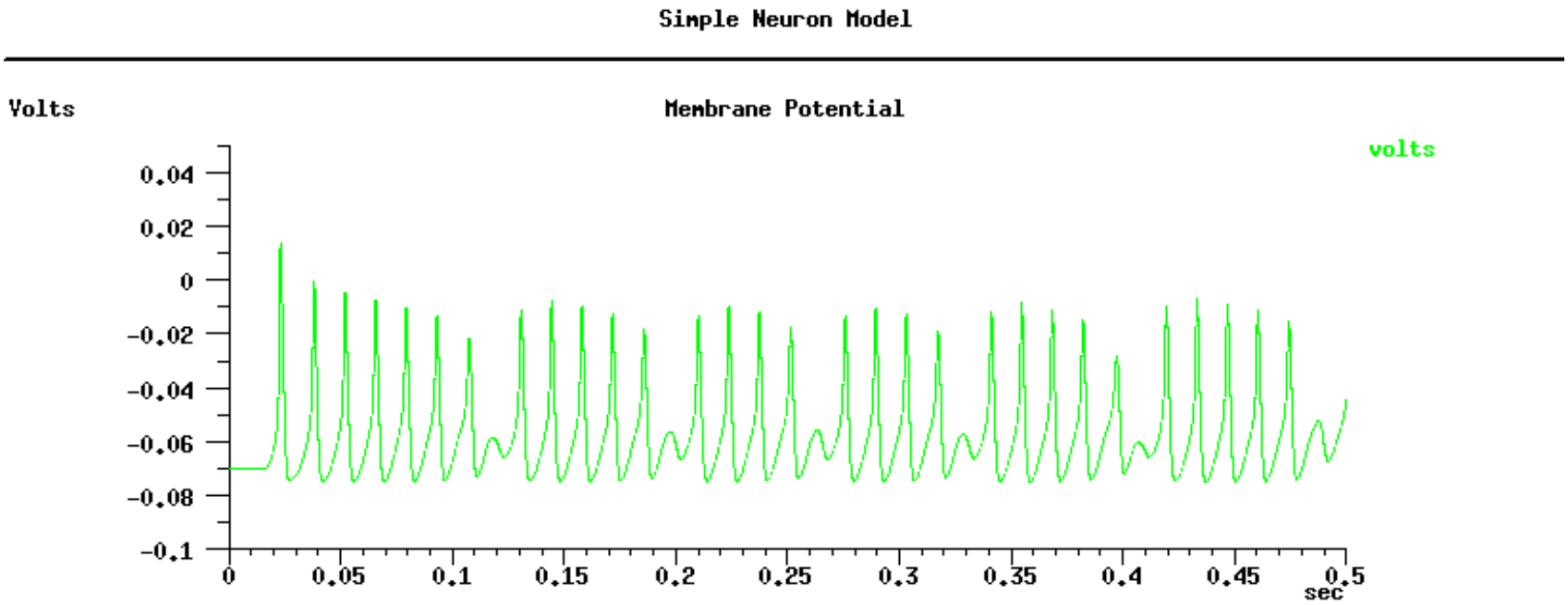

Figure: delay1: 2ms, delay2: 4ms

delay1: 4ms, delay2: 8ms

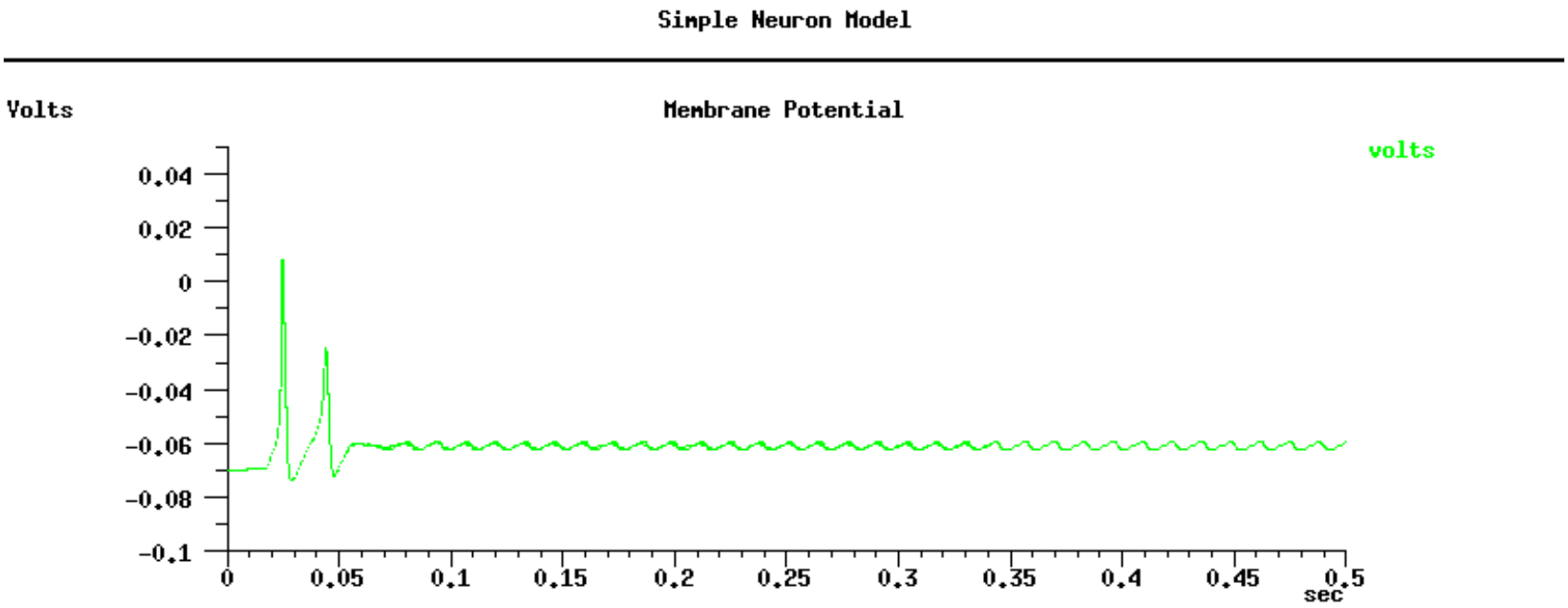

Figure: delay1: 4ms, delay2: 8ms

delay1: 8ms, delay2: 16ms

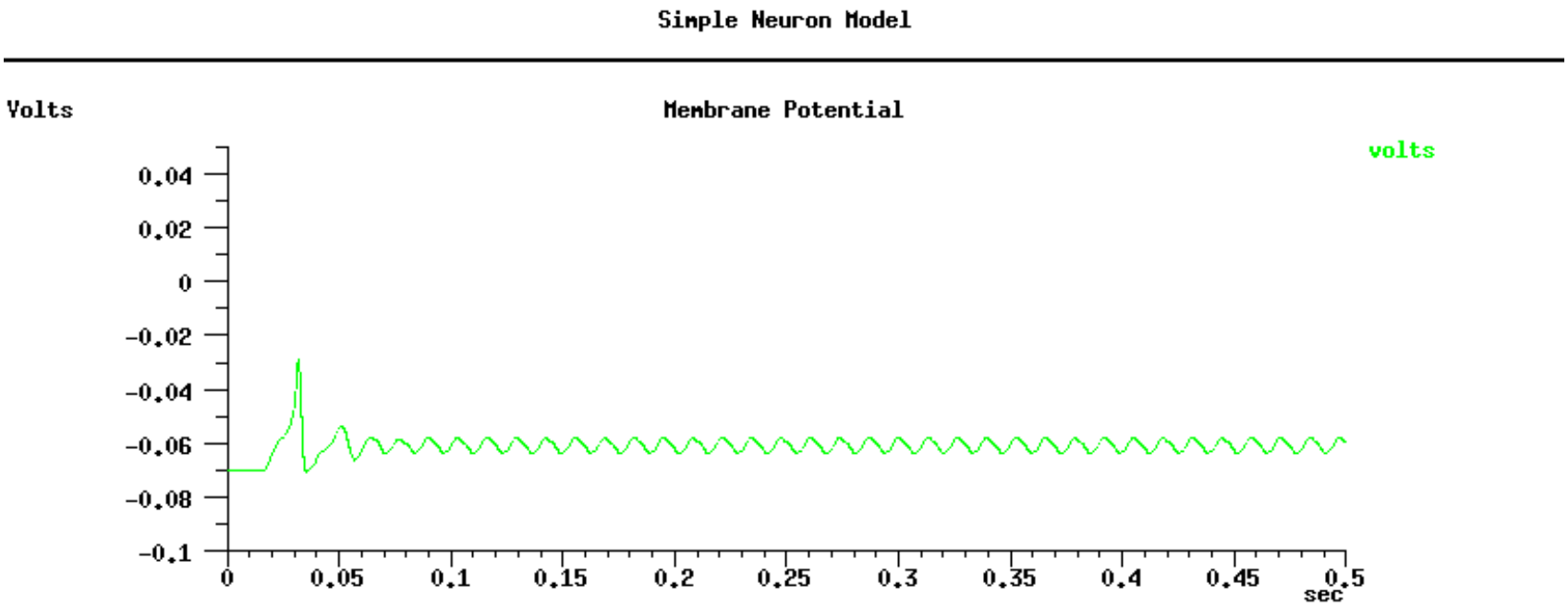

Figure: delay1: 8ms, delay2: 16ms

delay1: 10ms, delay2: 20ms

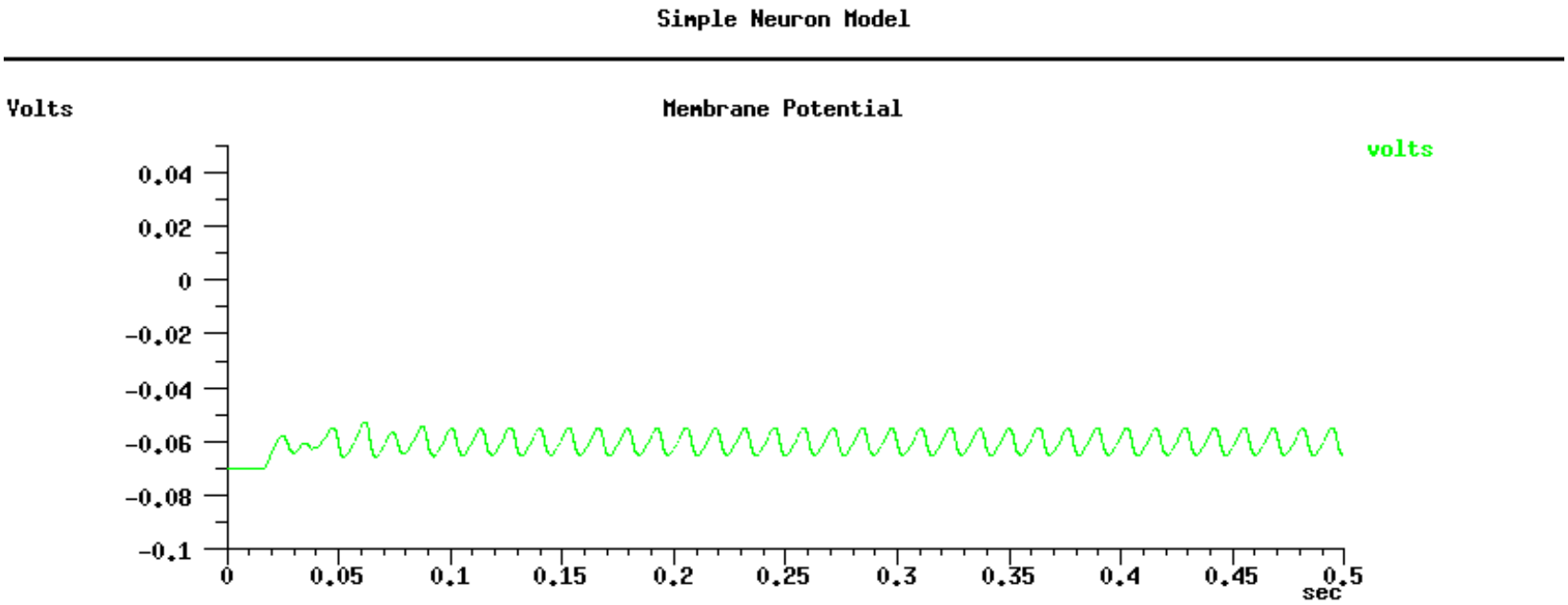

Figure: delay1: 10ms, delay2: 20ms

delay1: 11ms, delay2: 22ms

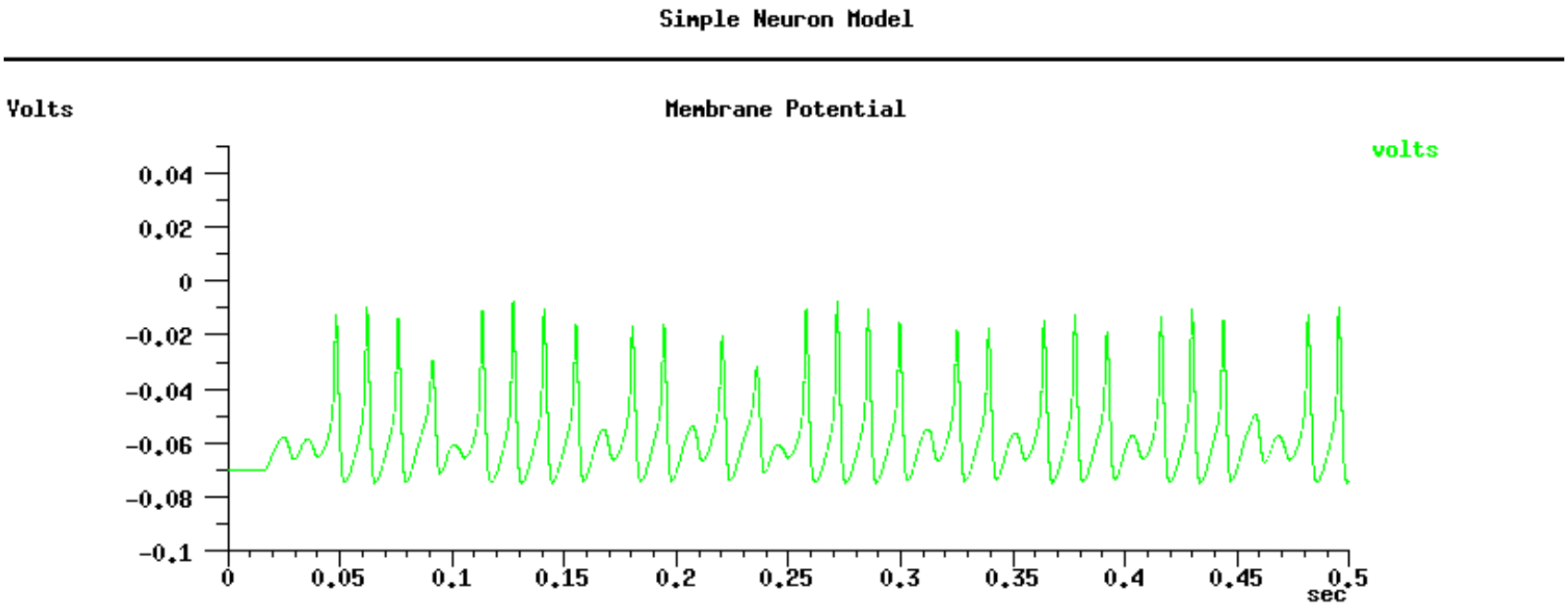

Figure: delay1: 11ms, delay2: 22ms

delay1: 12ms, delay2: 24ms

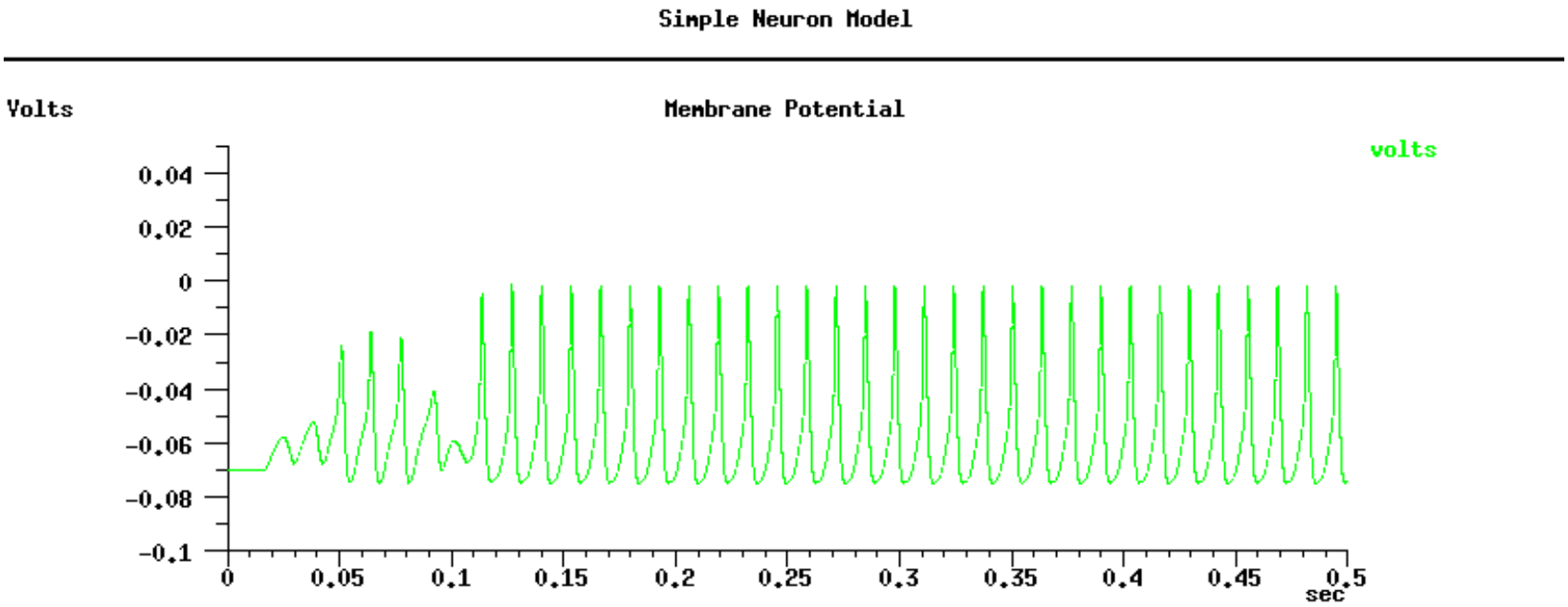

Figure: delay1: 12ms, delay2: 24ms

delay1: 13ms, delay2: 26ms

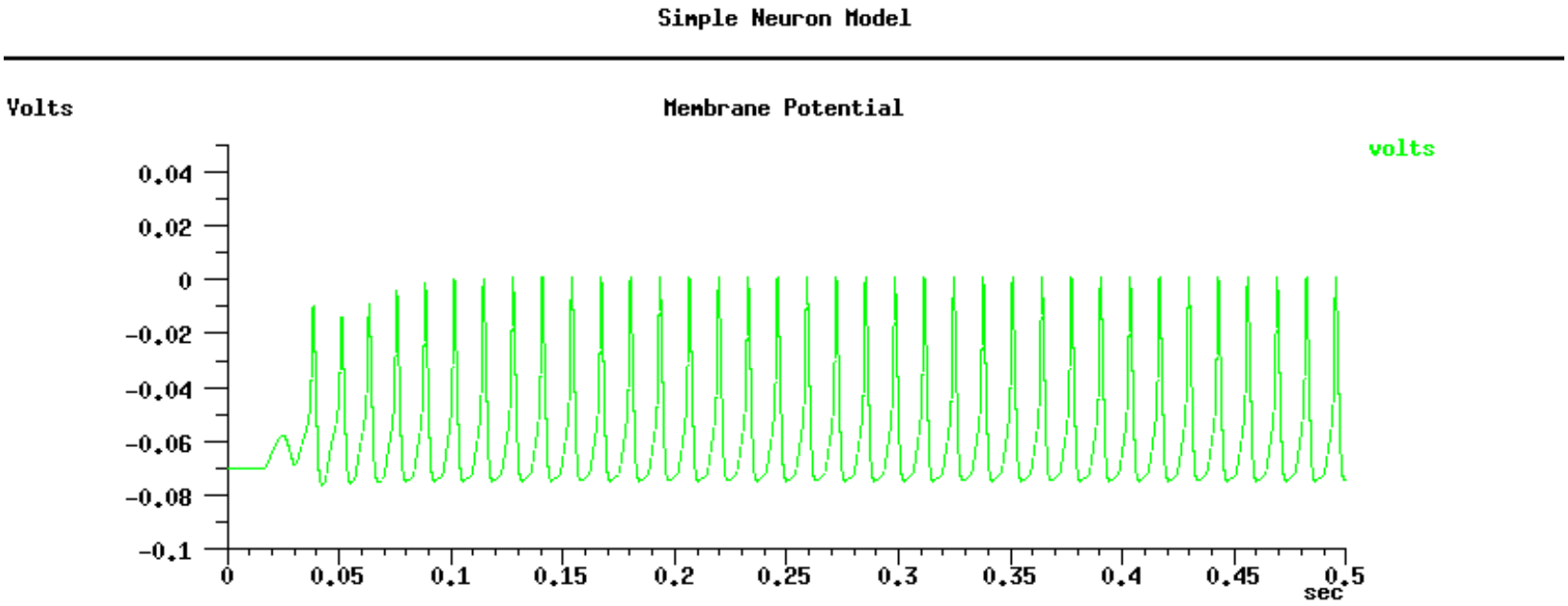

Figure: delay1: 13ms, delay2: 26ms

The End

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