Bioimpedance Simulations using QuickField

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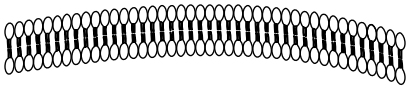
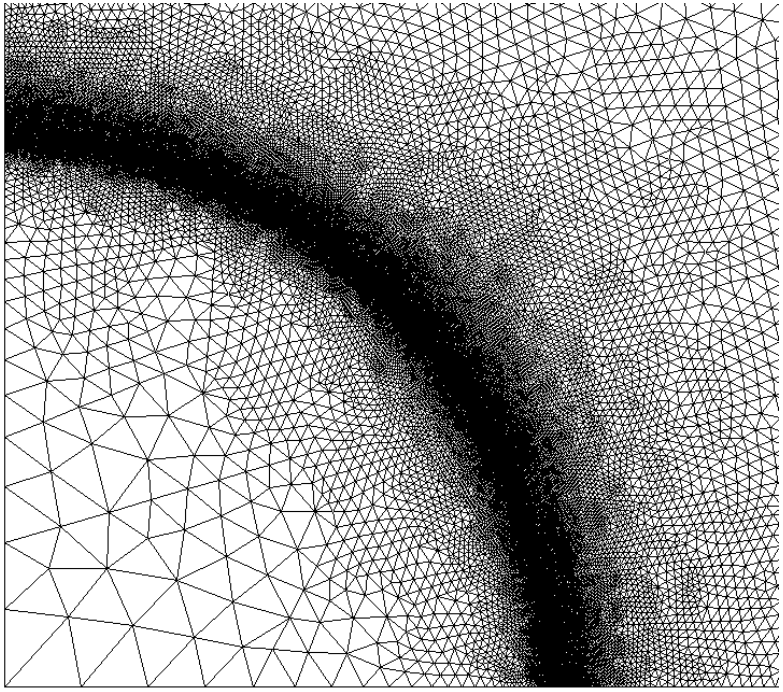
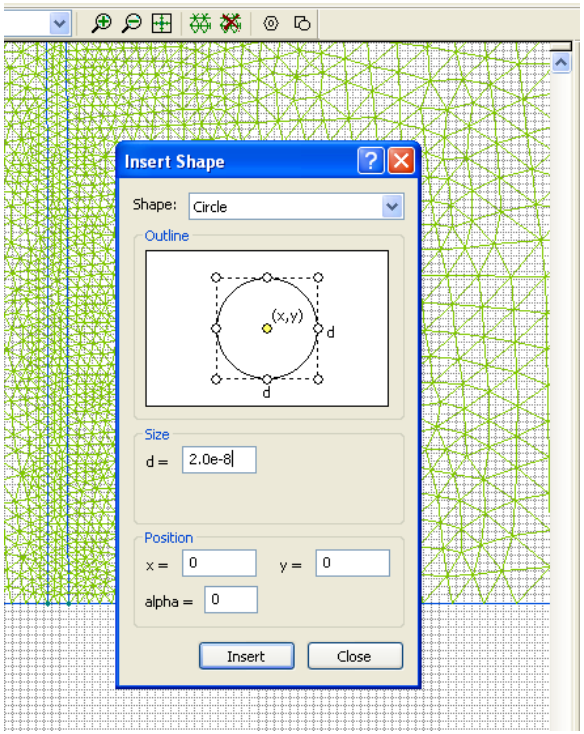
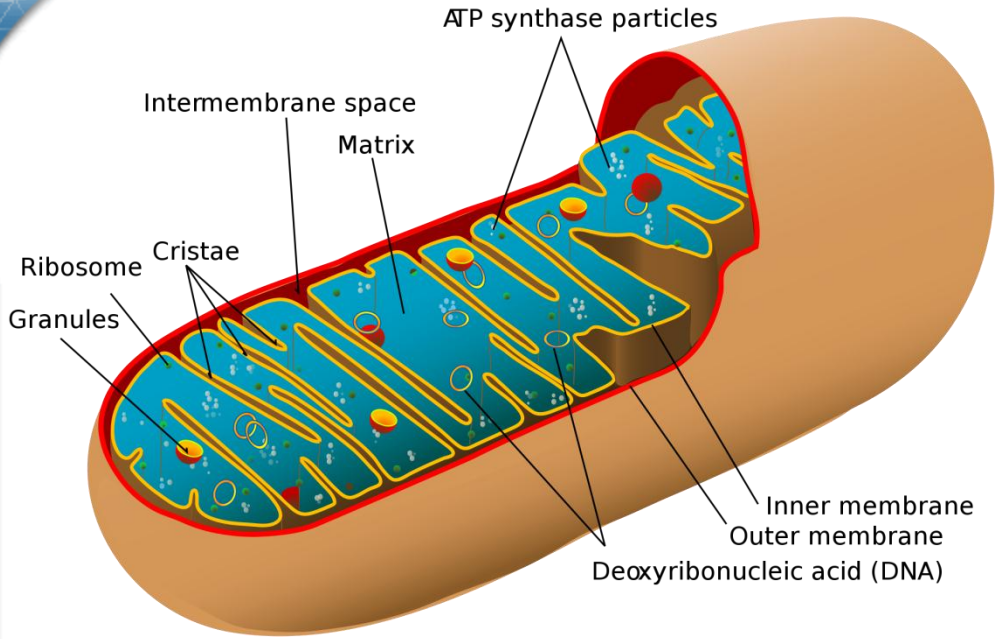
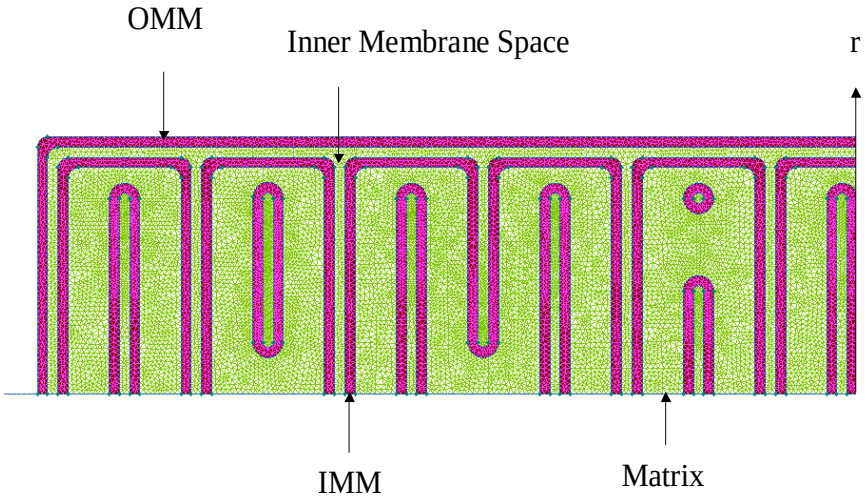
Membrane Construction

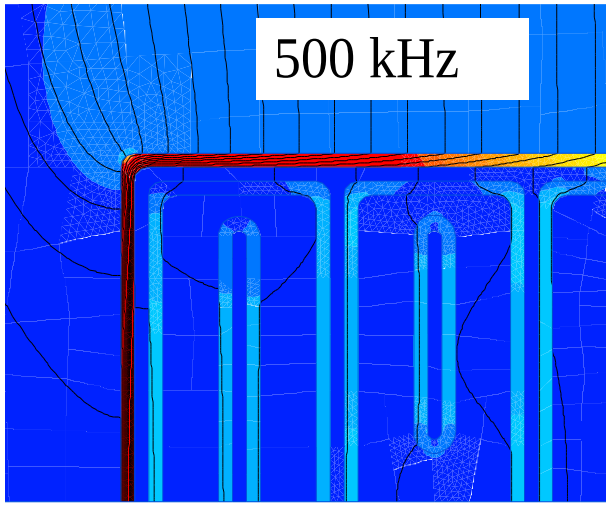


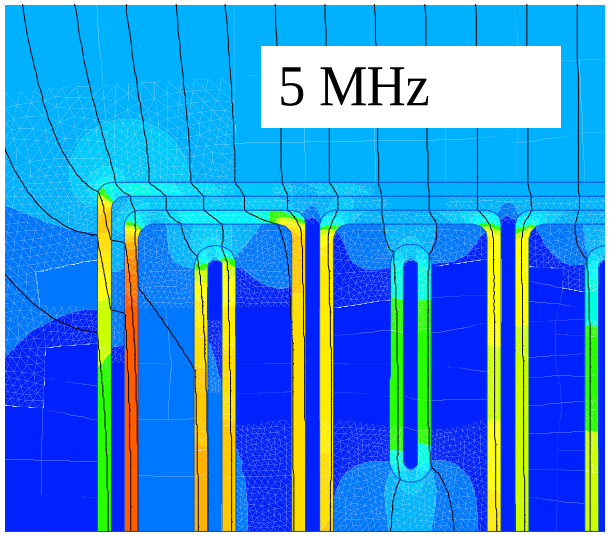





ATP synthase particles
Intermembrane space
Matrix
Cristae
Ribosome
Granules
Inner membrane
Outer membrane
Deoxyribonucleic acid (DNA)


OMM
Inner Membrane Space
r
IMM
Matrix


500 kHz


5 MHz

Electrical Circuit Models of Biological Systems

Circuit models may be constructed in QuickField to model the electrical response of

- Cells
- Organelles
- Neuronal Dendrites
- Maxwell- Wagner Dispersion
- Debye relaxations
- Skin Impedance
- Polarization Impedance

Current density (FEM)

- Determine the effective σ and ε of tissue or cell suspension

$$J = \sigma E + i\omega\varepsilon E$$

J_{active} J_{reactive}

$$\sigma = \frac{J_{\text{active}}}{E} \qquad \varepsilon = \frac{J_{\text{reactive}}}{E\omega}$$

Modeled using the AC Current Flow Module

Circuit Models

$$V = IZ$$

Z= impedance

$$I = Y^{*}V$$

*Y**= admittance

$$Y^{*} = G + iB$$

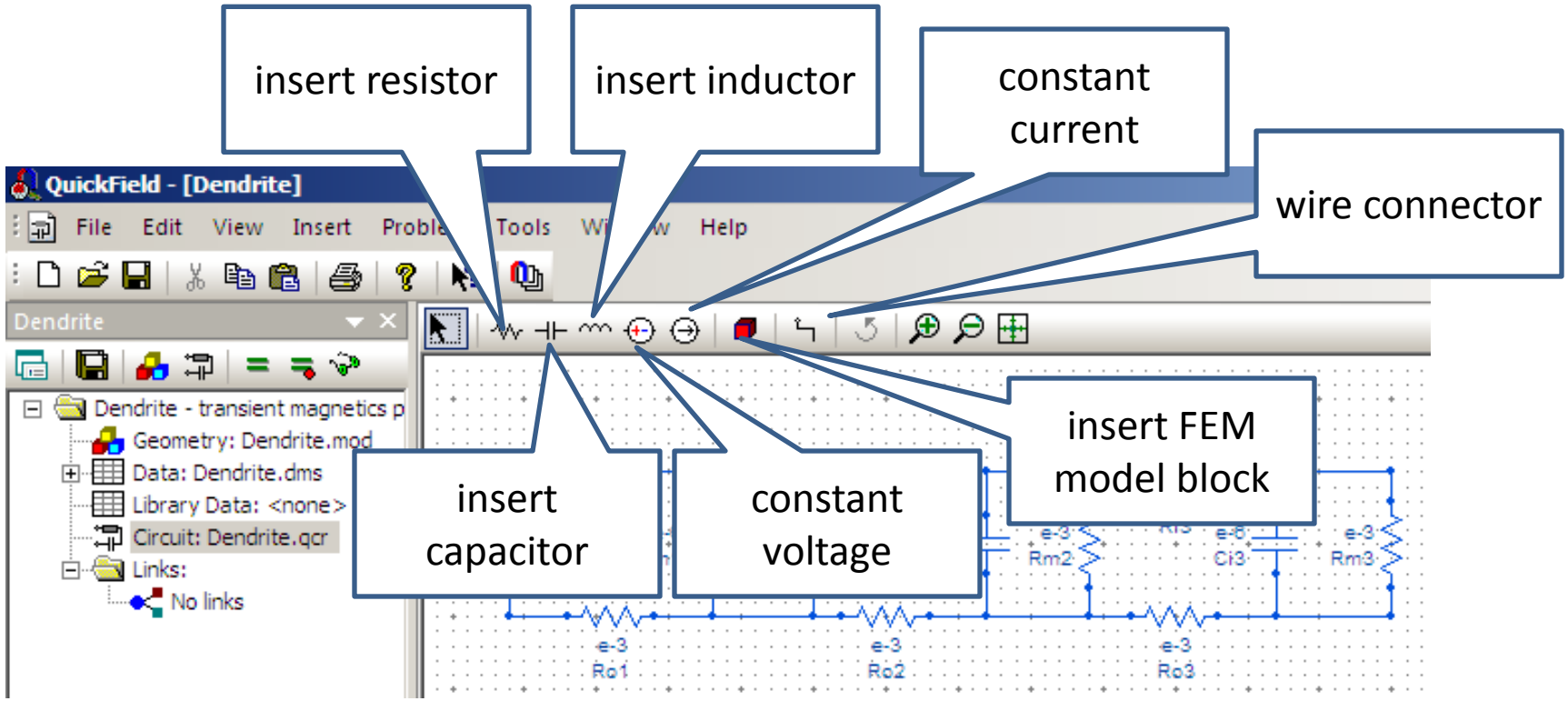
$$G \propto \sigma(\omega)$$

G = conductance

$$B \propto \varepsilon(\omega)$$

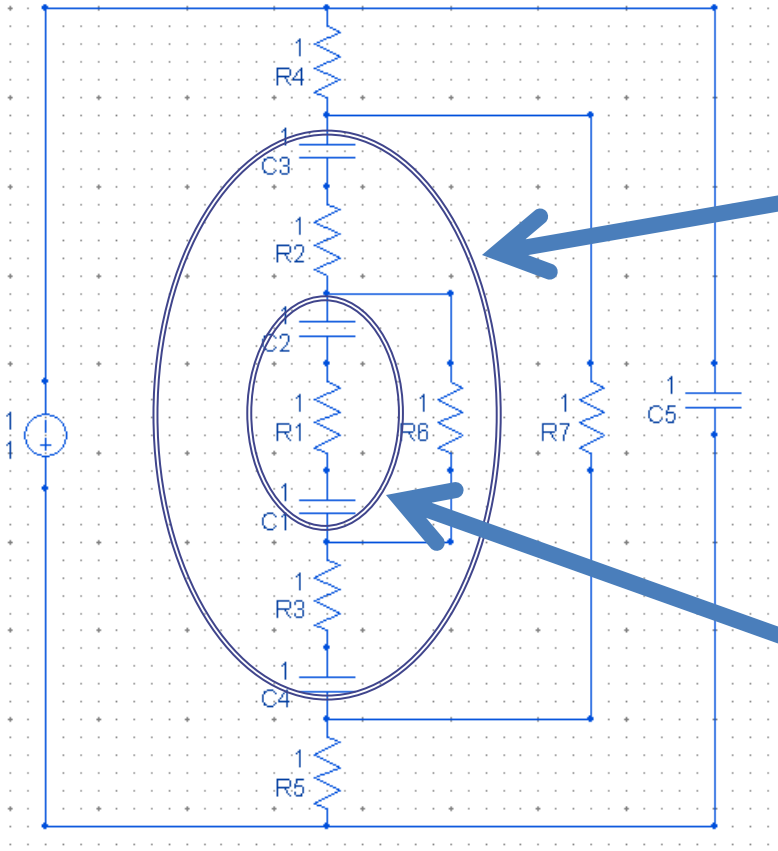
B = susceptance

QuickField electrical circuit construction



Circuit must be associated with a model file
(AC magnetics, transient magnetics)

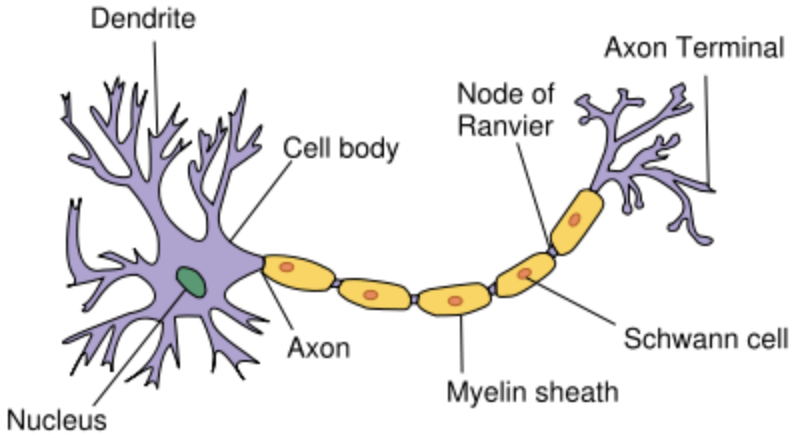
Cell Circuit Model

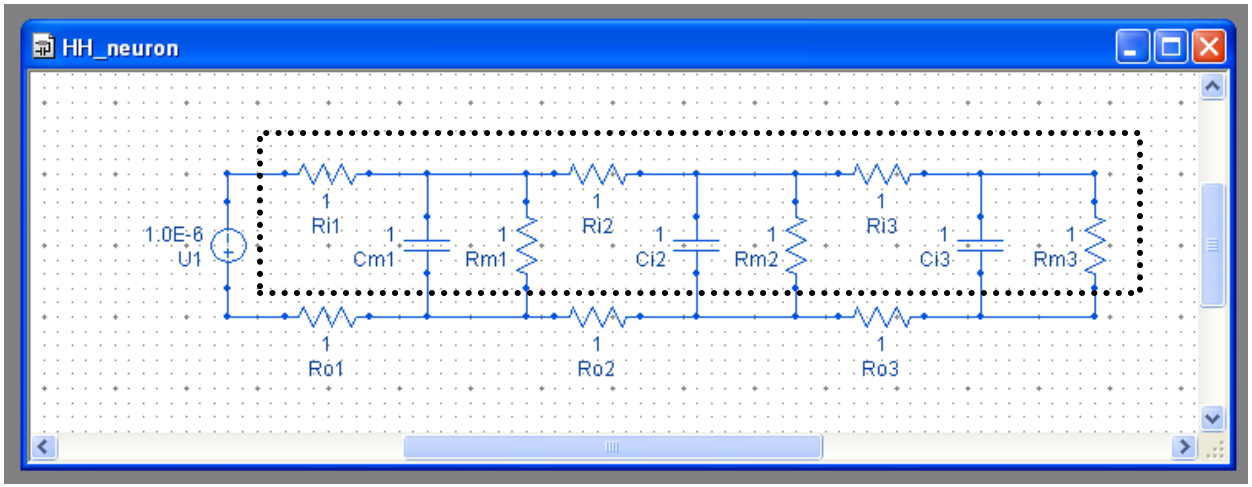


cell membrane surrounding cytoplasm

nuclear membrane surrounding the nucleoplasm

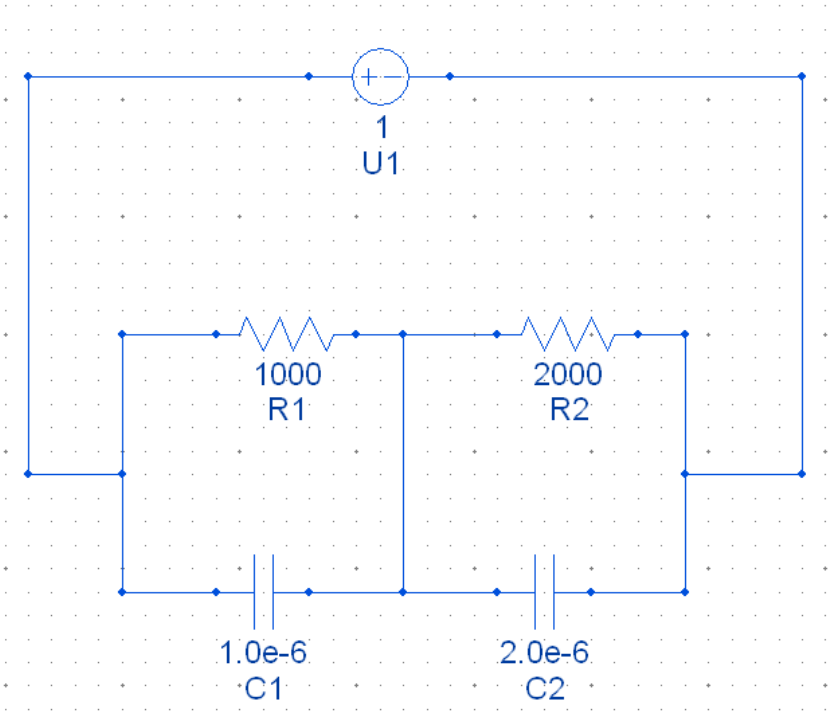
Dendrite Model

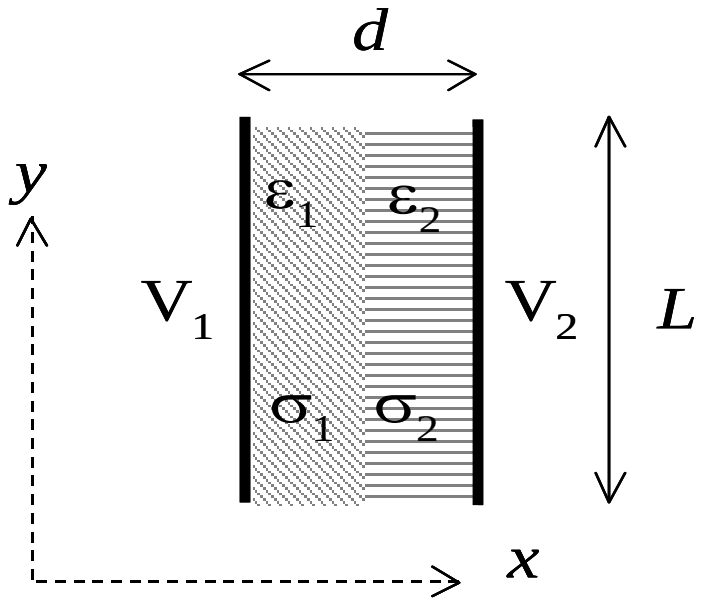




Passive circuit model of a dendrite (contained in the boxed region) with R_i resistance per unit length, R_m and C_m are membrane resistance and capacitance per unit length. R_0 is the resistance outside the dendrite.

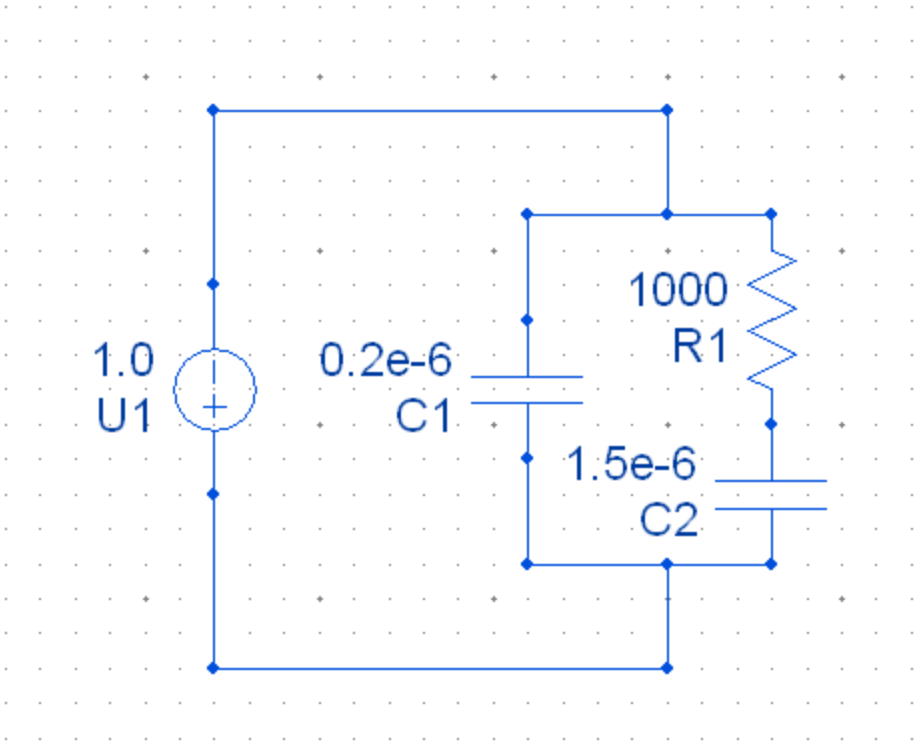
Maxwell-Wagner dispersion



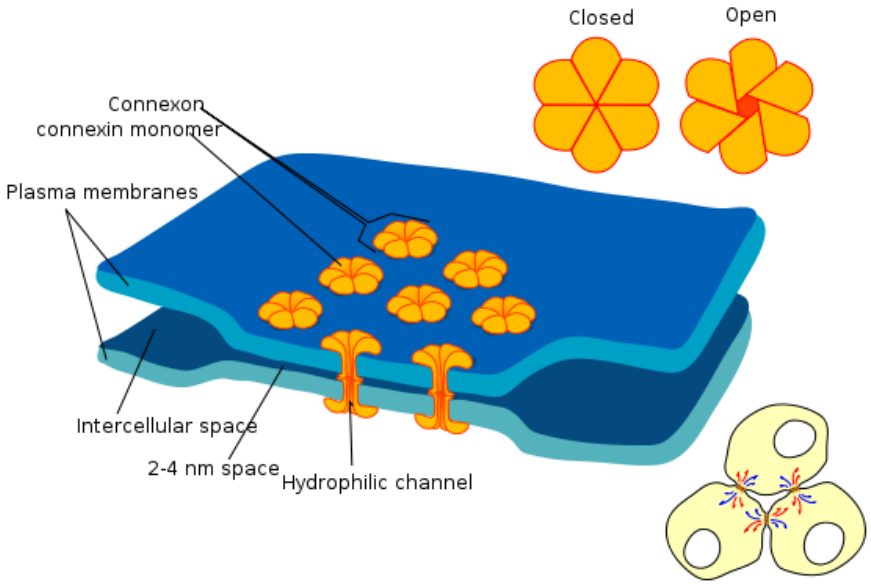


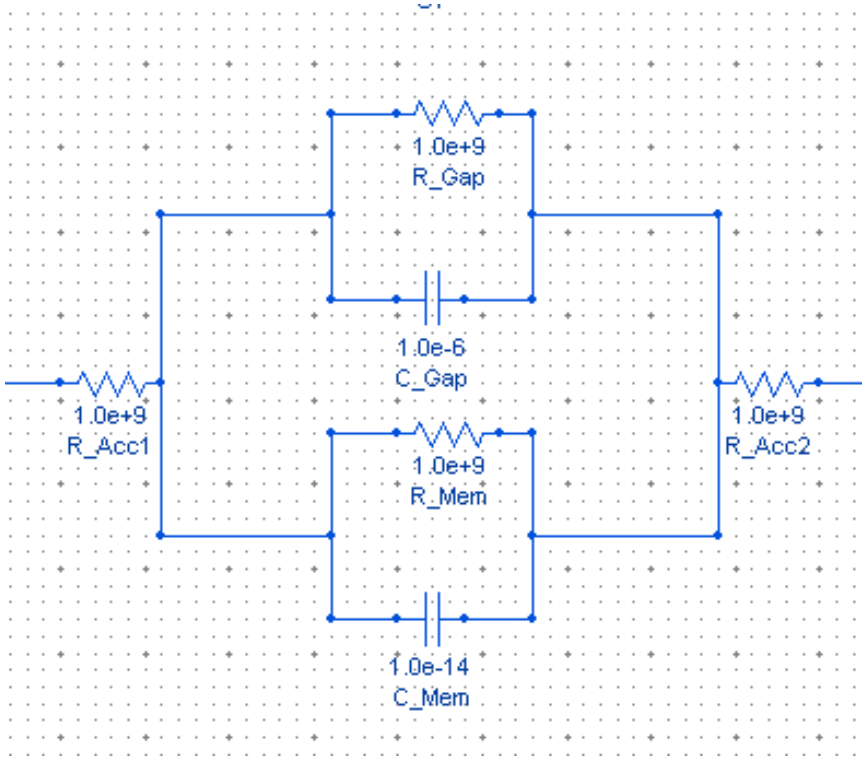
Equivalent circuit model of two lossy dielectric slabs in series giving rise to Maxwell-Wagner dispersion

Debye-relaxation circuit model

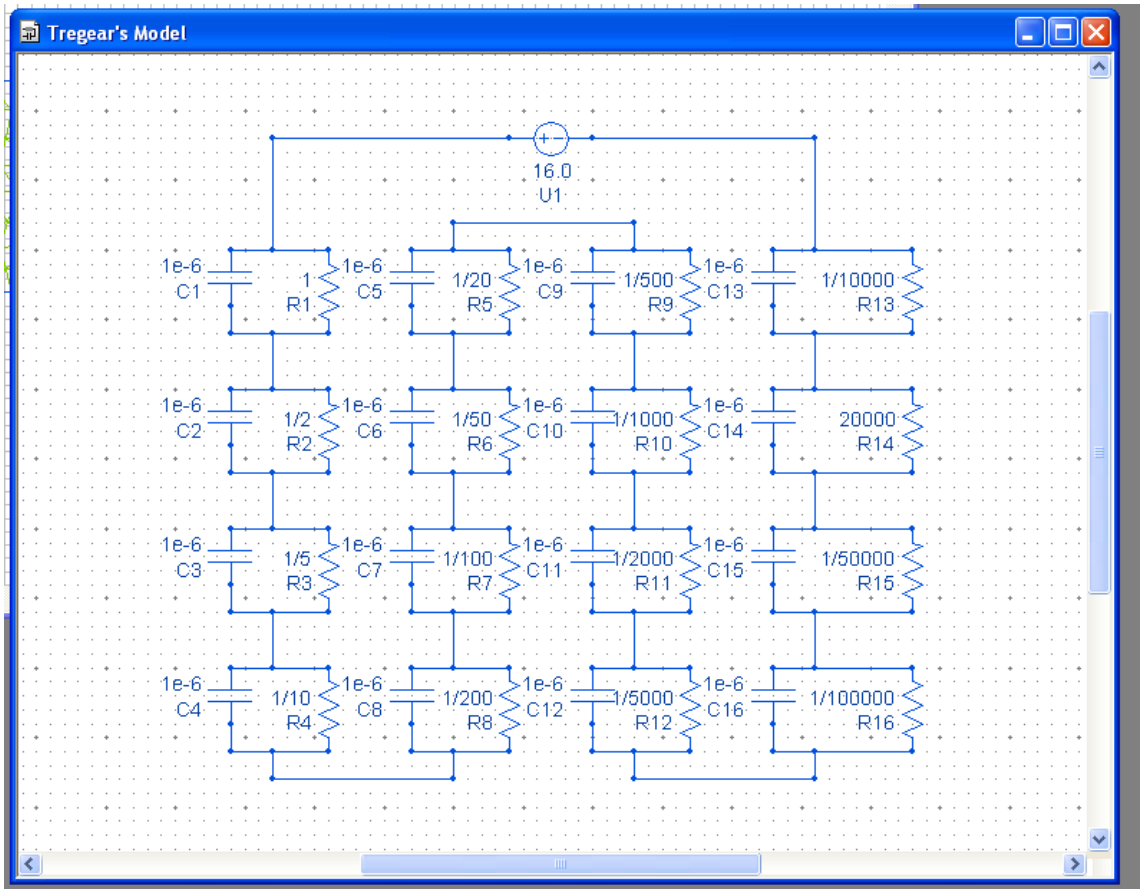


Gap Junction Model



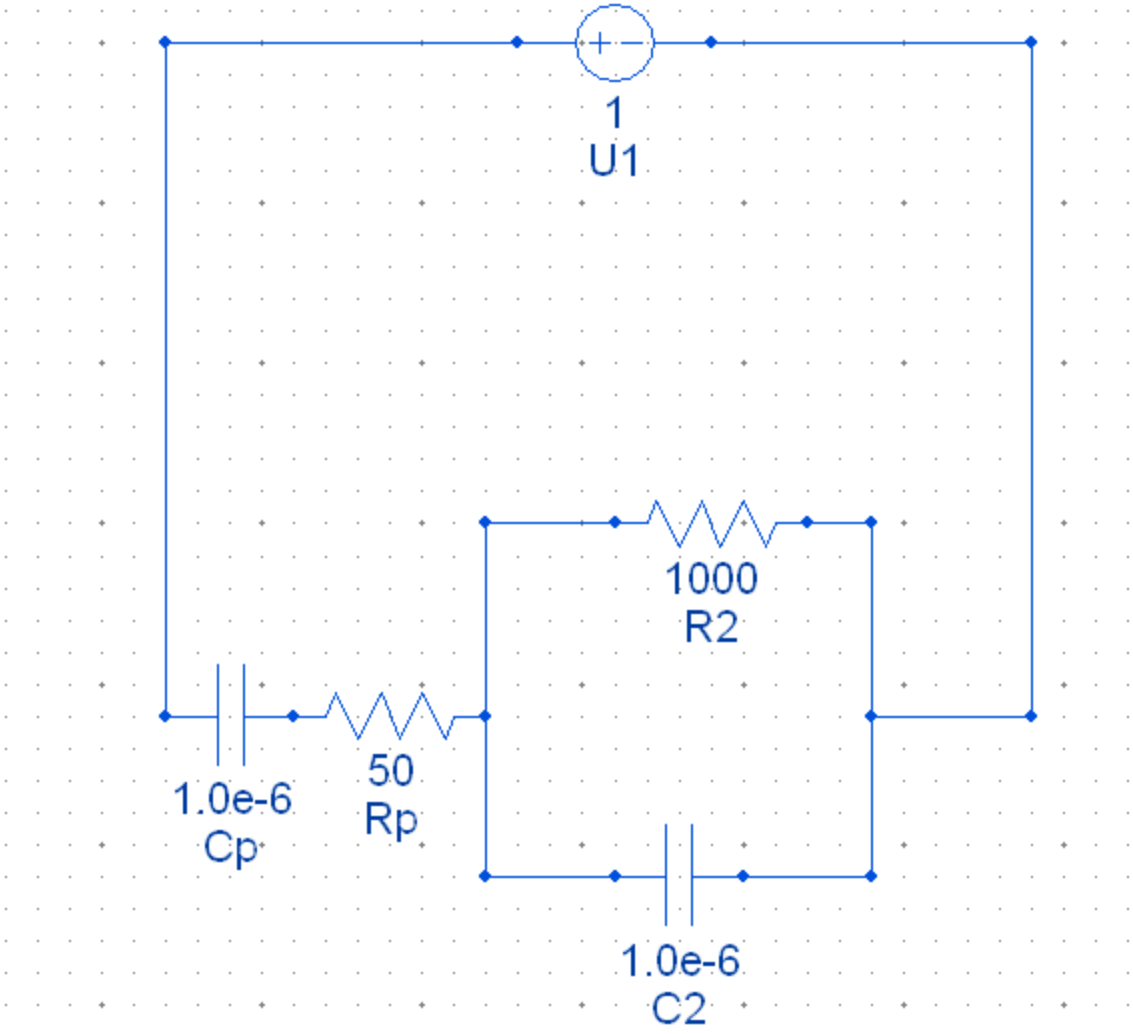


Skin Impedance

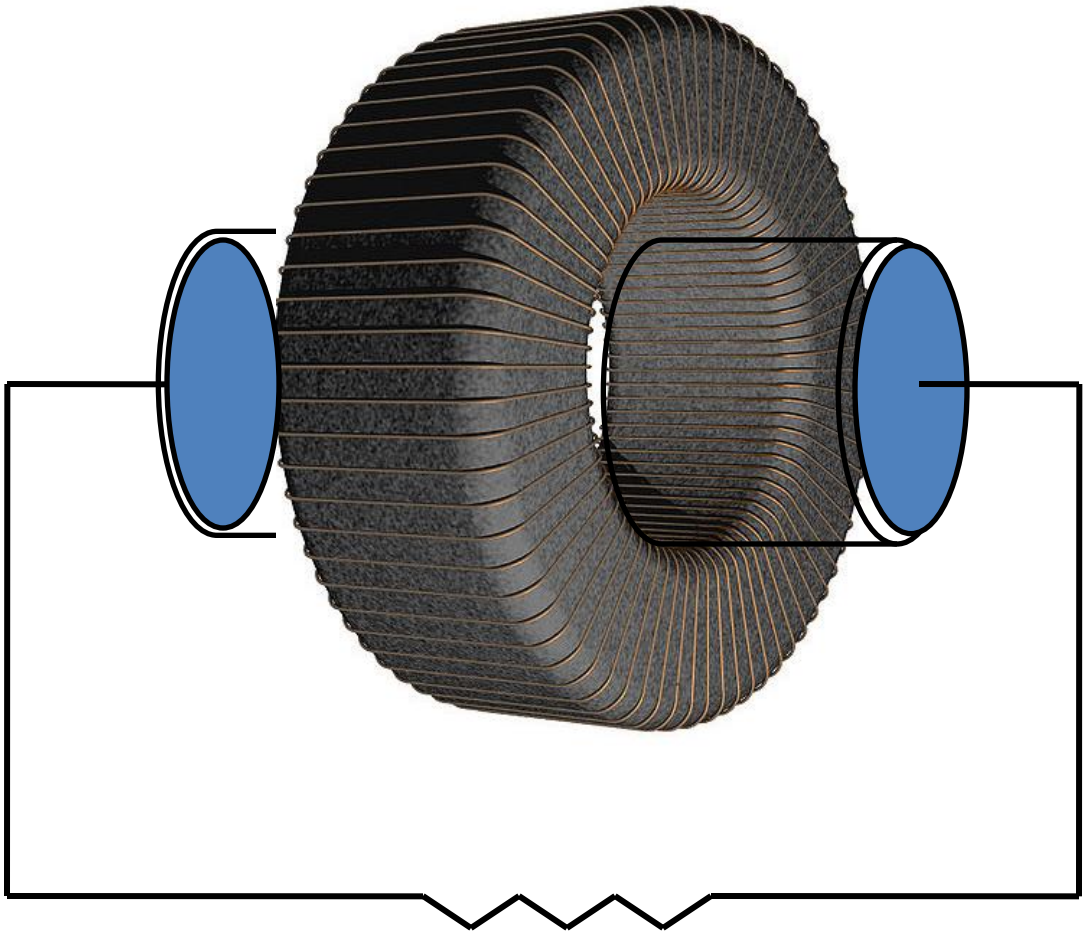


Modified Tregear's electrical circuit model of skin impedance consisting of sixteen resistors and sixteen capacitors where the capacitors have equal values

Polarization Impedance



Polarization Impedance



Books by Dr. James Claycomb: