

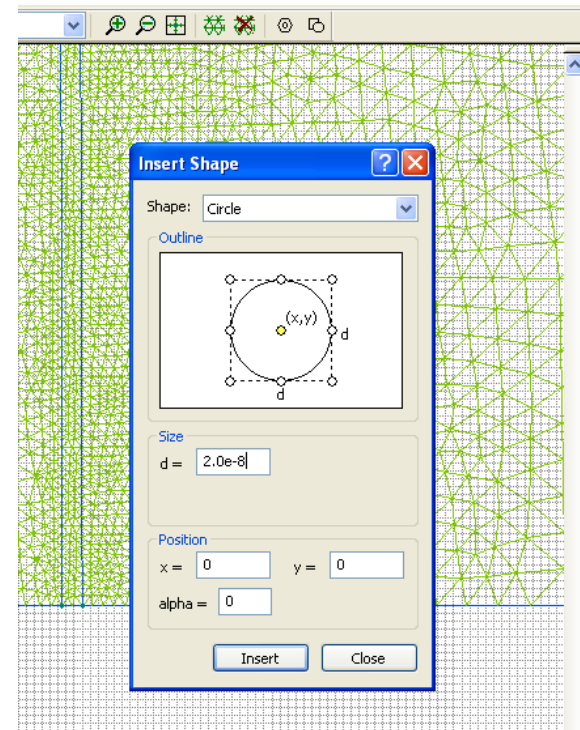
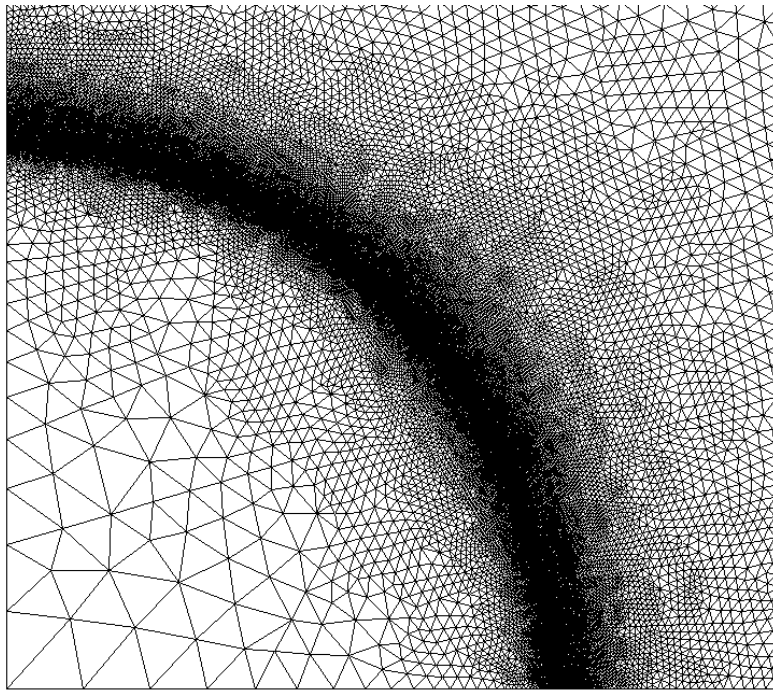
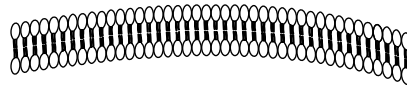


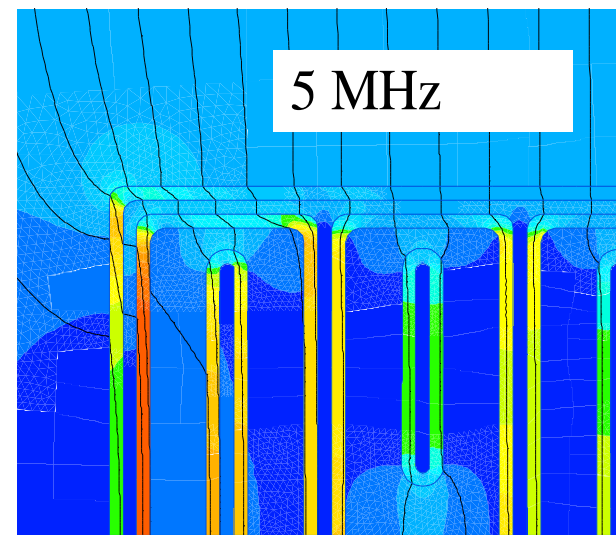
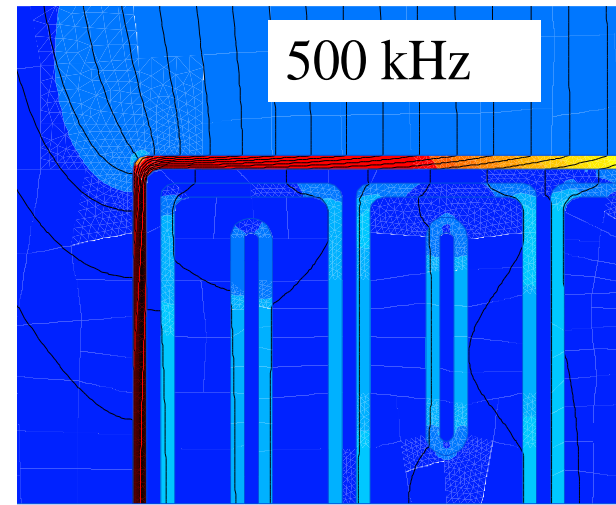
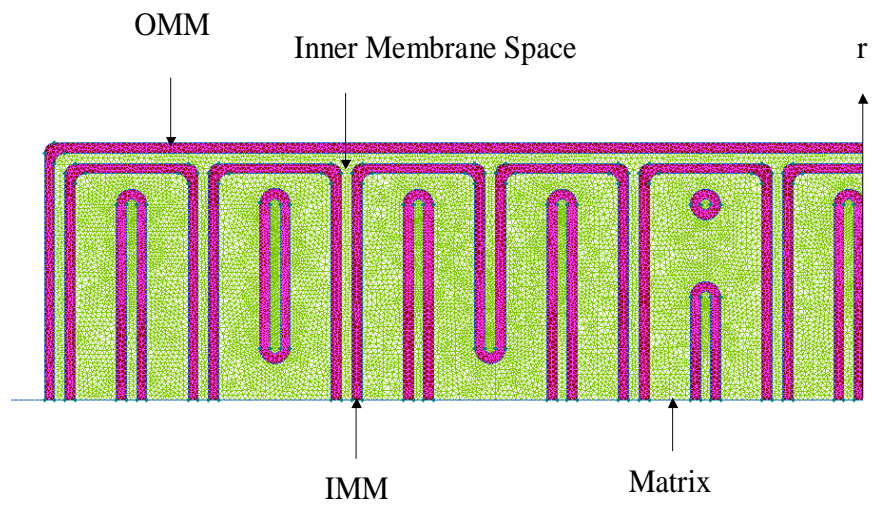
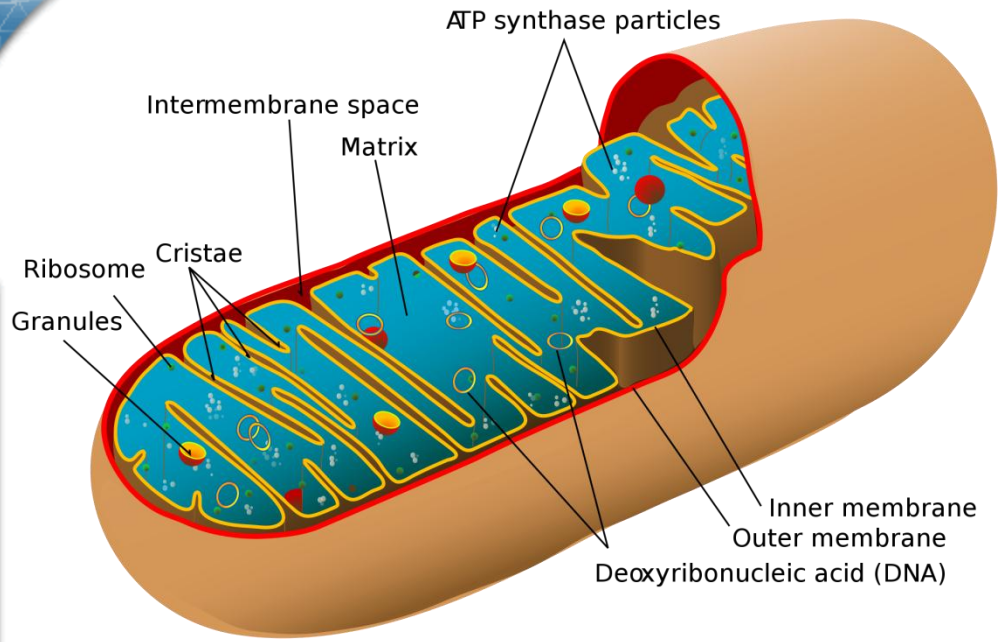
Bioimpedance Simulations using QuickField



James R. Claycomb
Department of Mathematics
and Physics,
Houston Baptist University

Membrane Construction







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

$$J = \underbrace{\sigma E}_{J_{\text{active}}} + i \underbrace{\omega \varepsilon E}_{J_{\text{reactive}}}$$

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

Modeled using the AC Current Flow Module



Circuit Models

$$V = IZ$$

Z = impedance

$$I = Y^*V$$

Y^* = admittance

$$Y^* = G + iB$$

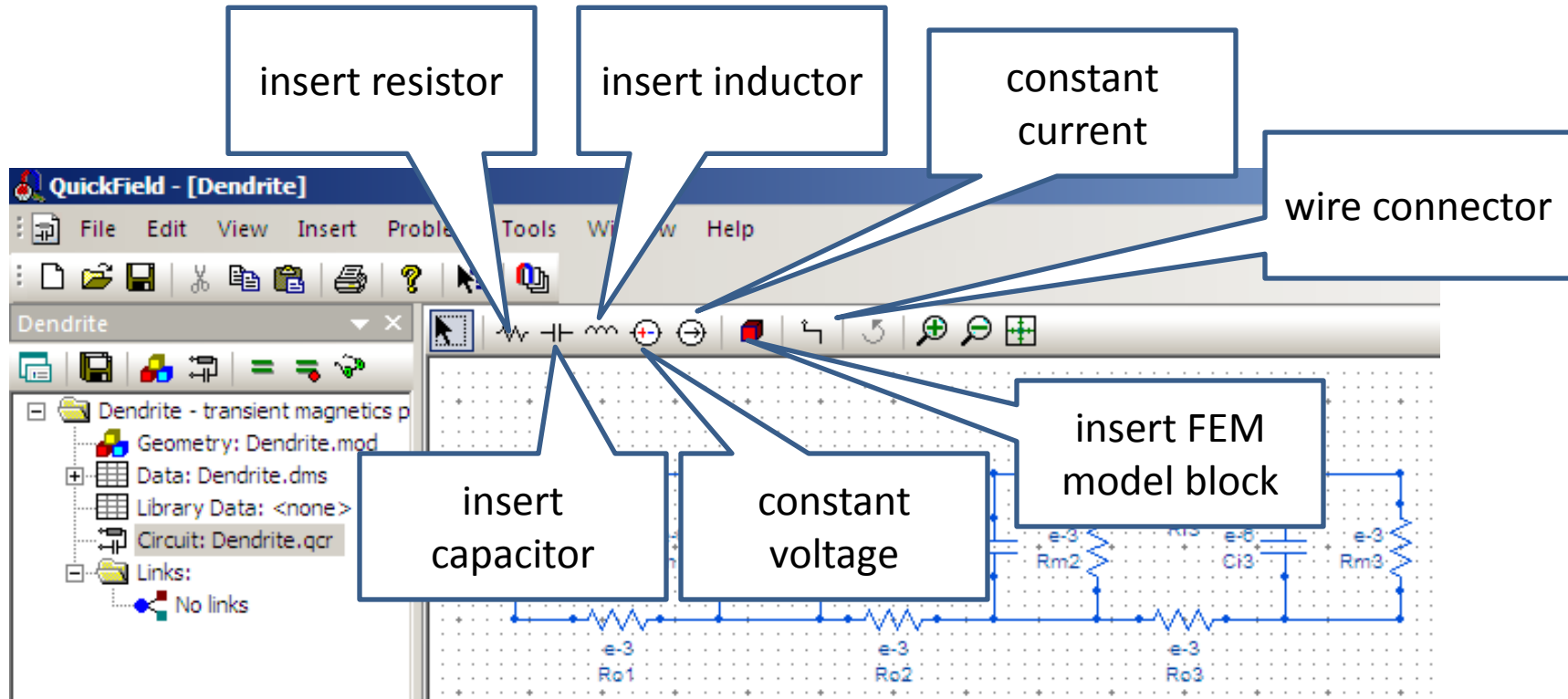
$$G \propto \sigma(\omega)$$

G = conductance

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

B = susceptance

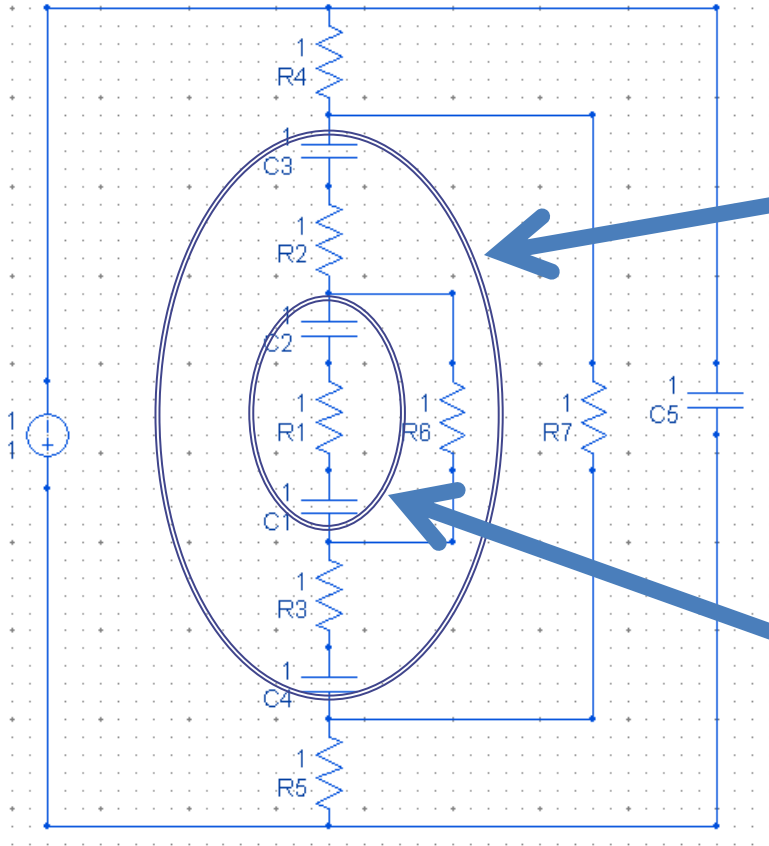
QuickField electrical circuit construction



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



Cell Circuit Model

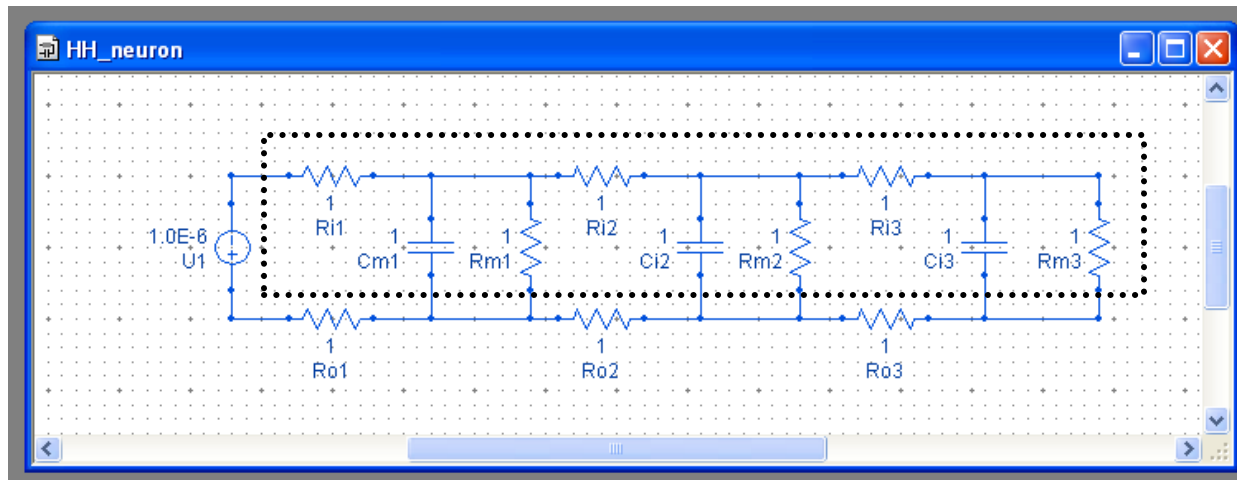
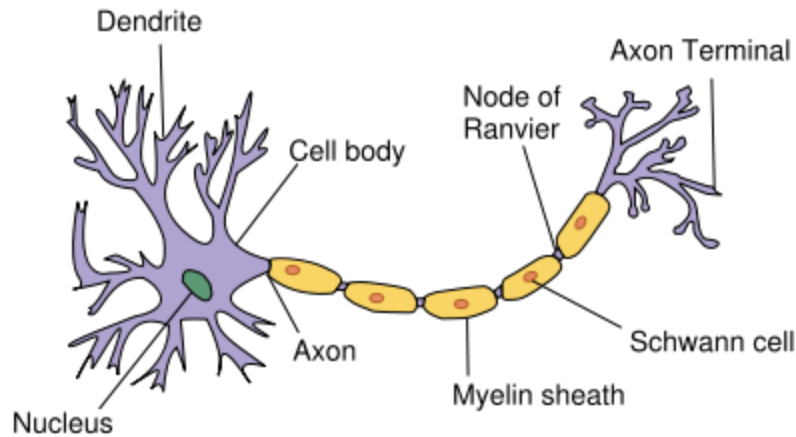


cell membrane surrounding cytoplasm

nuclear membrane surrounding the nucleoplasm

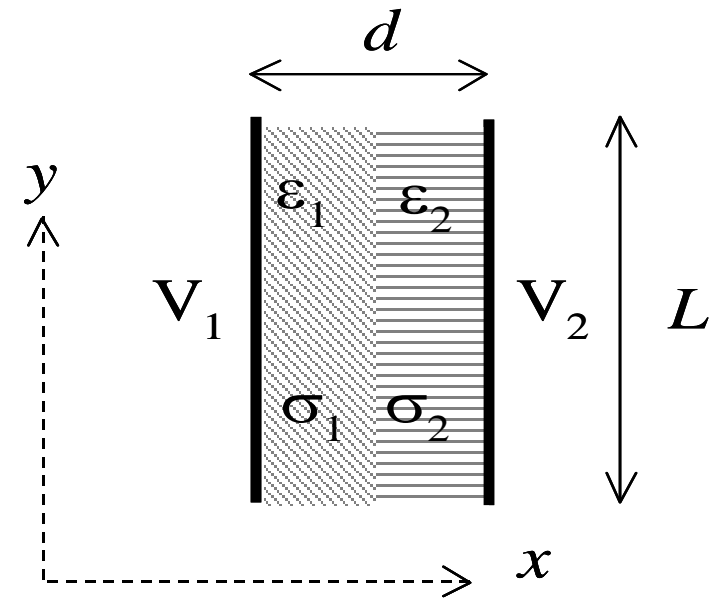
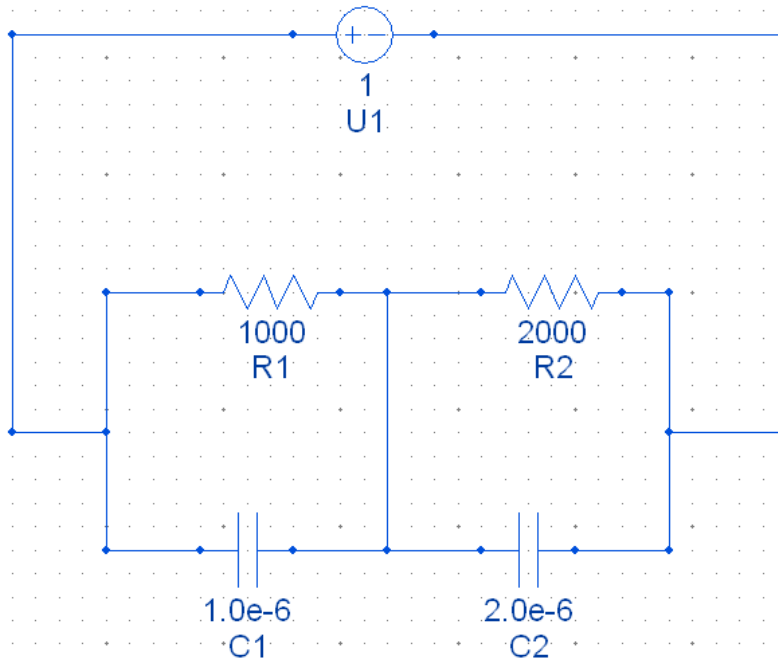


Dendrite Model



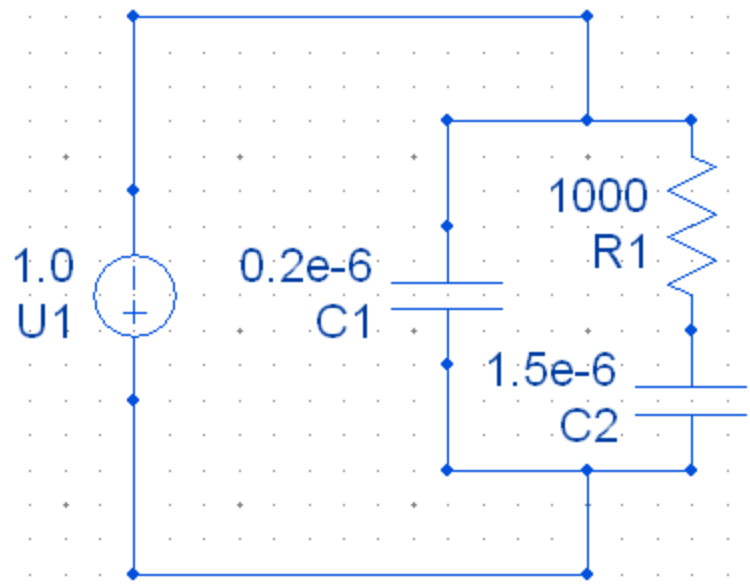
Passive circuit model of a dendrite (contained in the boxed region) with R_i resistance per unit length, R_m and C_m are membrane resistance and capacitance per unit length. R_0 is the resistance outside the dendrite.

Maxwell-Wagner dispersion



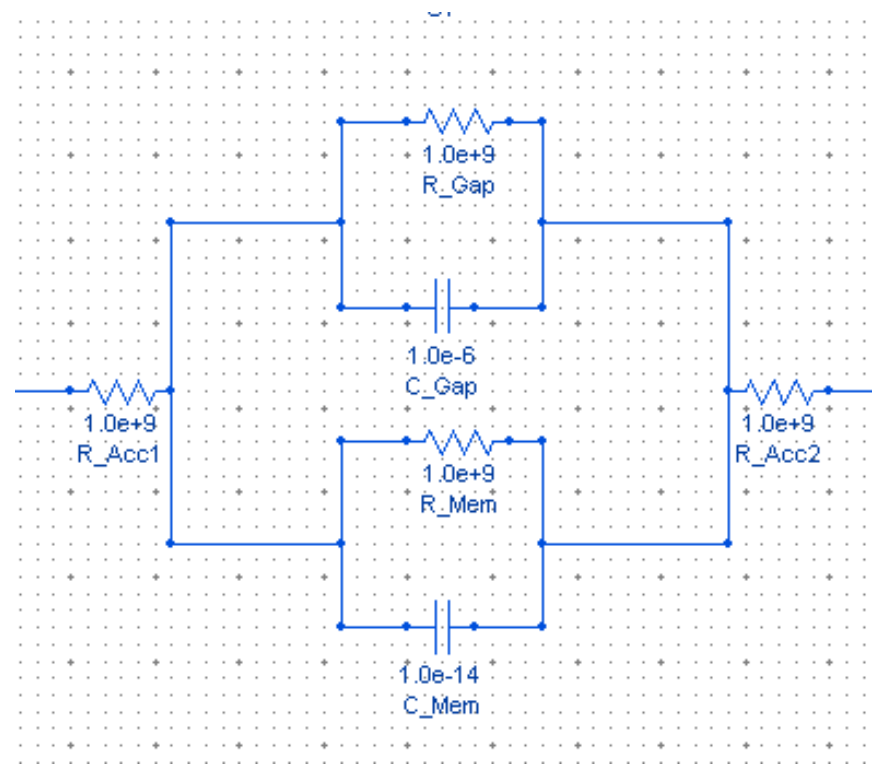
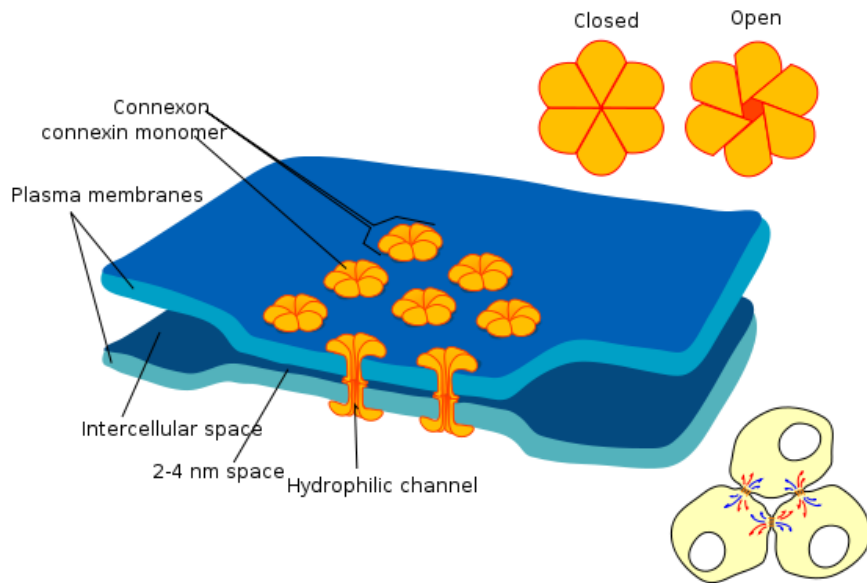
Equivalent circuit model of two lossy dielectric slabs in series giving rise to Maxwell-Wagner dispersion

Debye-relaxation circuit model



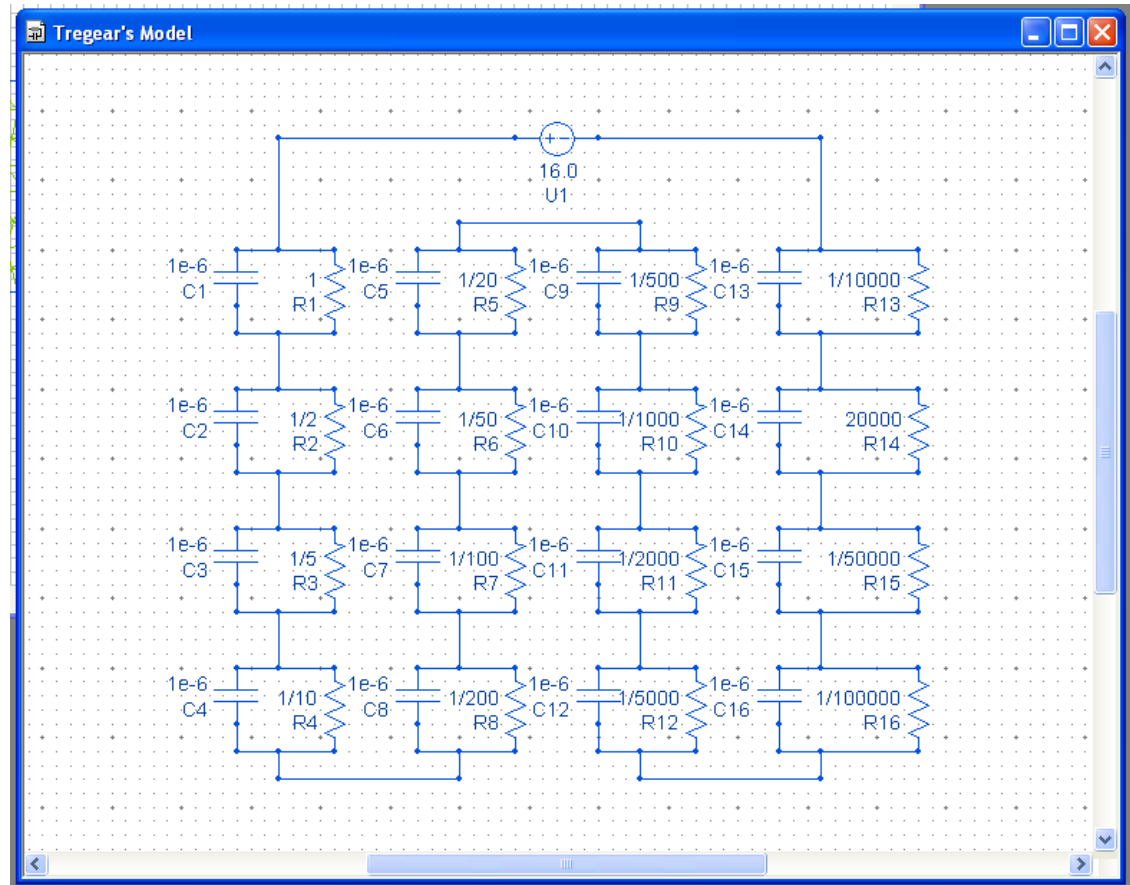


Gap Junction Model



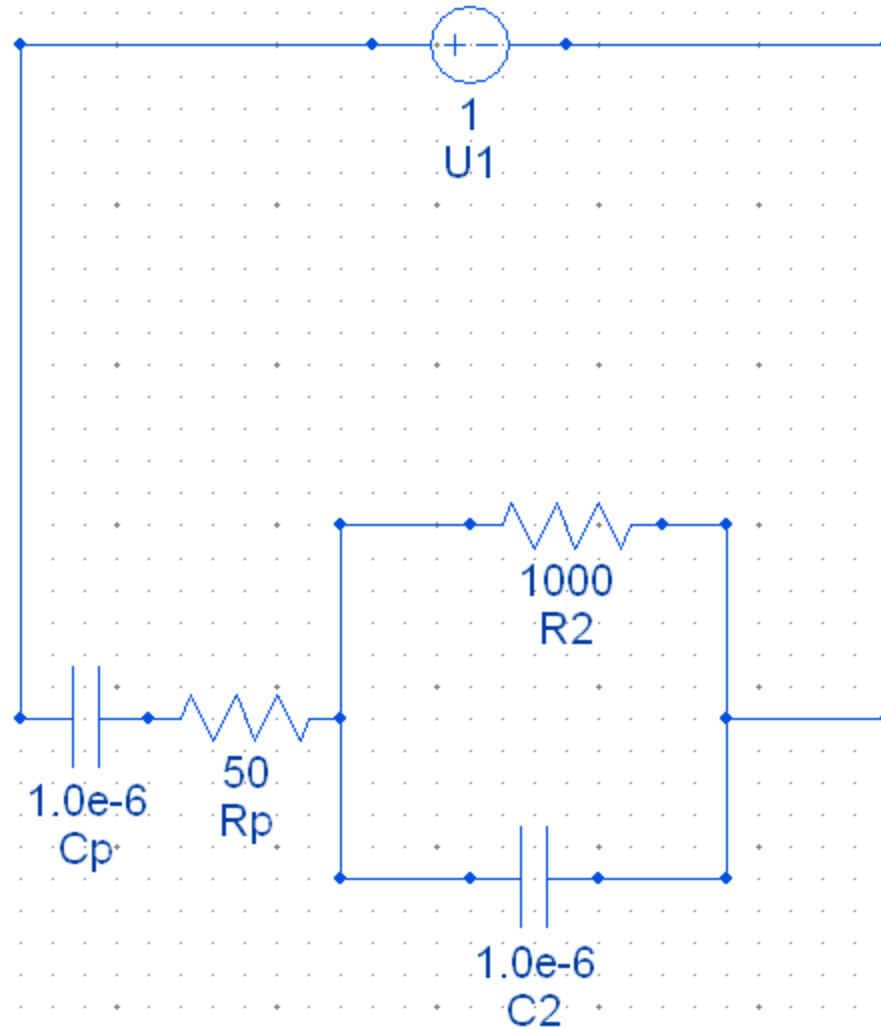


Skin Impedance



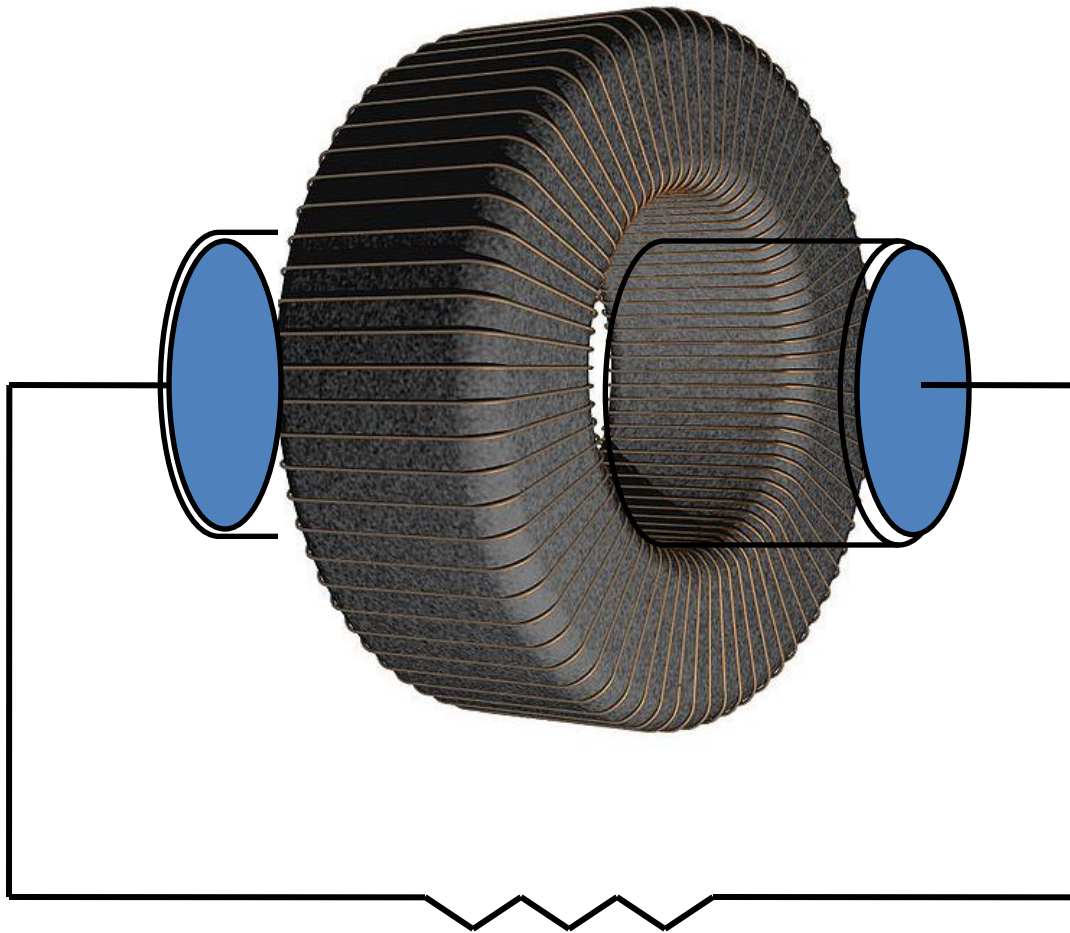
Modified Tregear's electrical circuit model of skin impedance consisting of sixteen resistors and sixteen capacitors where the capacitors have equal values

Polarization Impedance





Polarization Impedance





Books by Dr. James Claycomb:

