Presented at the COMSOL Conference 2009 Boston

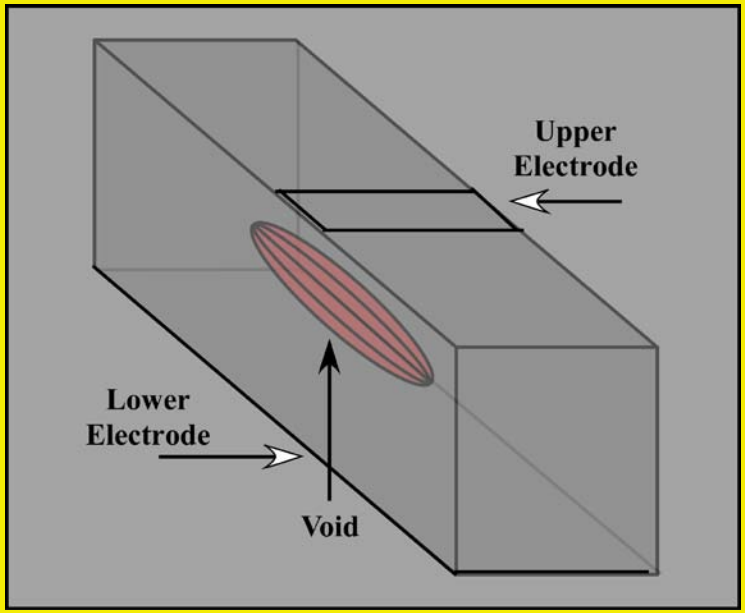
Expanding Your Materials Horizons

Roger W. Pryor, Ph.D.,VP Research

Pryor Knowledge Systems, Inc.

Electrical Impedance Tomography (EIT)

EIT is a Non-Invasive Methodology developed for the Measurement of Differential Impedance and Void Detection.



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Reference information can now be found under several different acronyms in the literature.

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1. Medical Imaging (electrical impedance tomography {EIT})
2. Geophysics (electrical resistivity tomography {ERT} or electrical resistivity imaging {ERI})
3. Civil Engineering (electrical resistance tomography)
4. Industrial Processes (possibly other acronyms)

The problem of diverse reference sources with different acronyms (names) in different disciplines is commonly found in many of the disciplines that employ mathematical modeling and simulation.

In this presentation, EIT is chosen as the demonstrative modeling methodology area.

Consider the following diverse reference sources typically employed for the acquisition of materials properties data.

Materials Properties Data Sources

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6. Proprietary COMSOL Materials Library (direct data selection)

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6. Proprietary COMSOL Materials Library (direct data selection)
7. Proprietary PKS-MPD Materials Properties Database (direct data search, COMSOL library file creation and entry)

EIT Model Parameter Space

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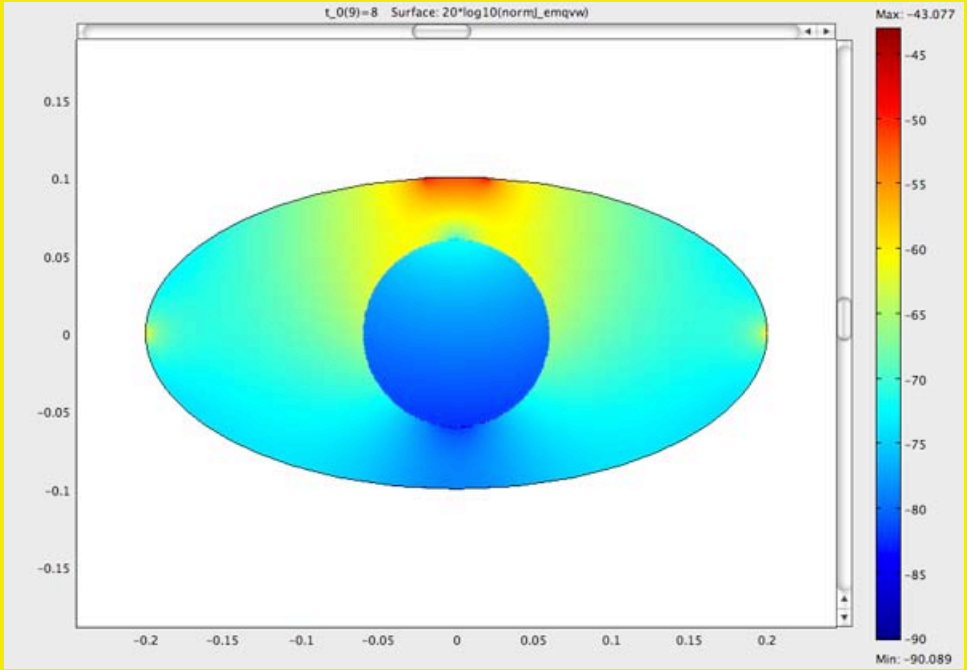
4. Materials and Tissue Properties: Conductivity, Density, Permeability, Permittivity, Resistivity, etc.

COMSOL Multiphysics First Principles
EIT Ovine Lung Function Model



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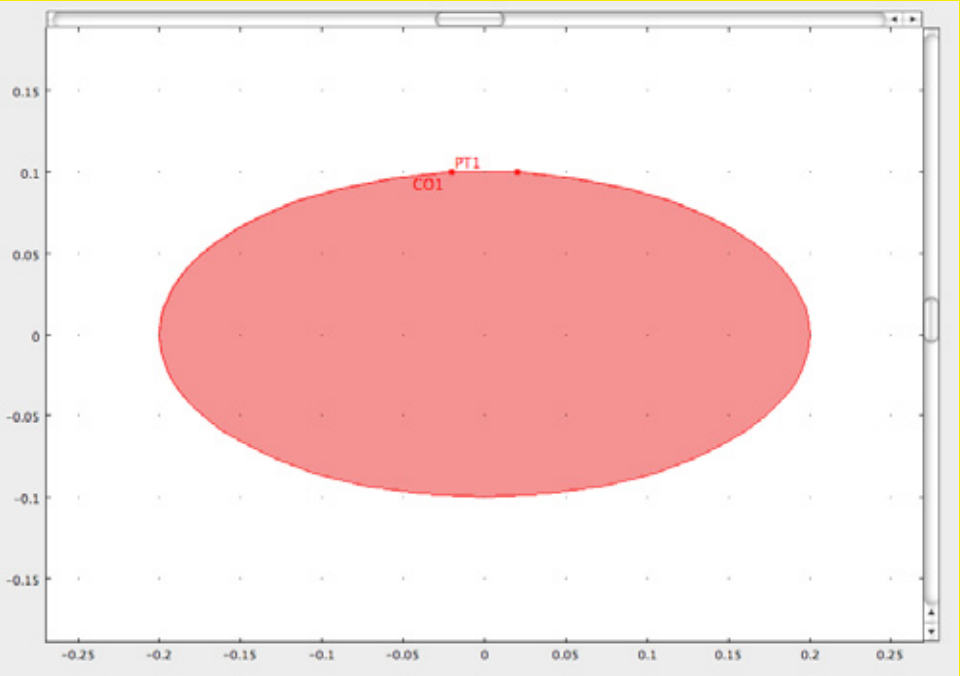
This EIT Model Parameter Space

1. Frequency 1 x 10^4 Hz.
2. Mammalian Species: Ovine (Sheep).
3. Types of Tissue: Muscle, Lung.
4. Inorganic Materials: Air.
5. Materials and Tissue Properties: Conductivity, Permittivity
6. Temperature of Property Value Measurement

This EIT Model Subdomain Space

1. In this EIT Model, Subdomain Regions (muscle, lung, air) are not defined geometrically.
2. In this EIT Model, Subdomain Regions (muscle, lung, air) are defined logically through the use of a set of Scalar Equations.
3. Defining the Subdomain Parameters logically reduces the model's geometrical complexity and eliminates the need to use ALE (moving mesh) techniques.

EIT Ovine Lung Function Model
Single Geometric Subdomain



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EIT Ovine Lung Function Model
Single Geometric Subdomain

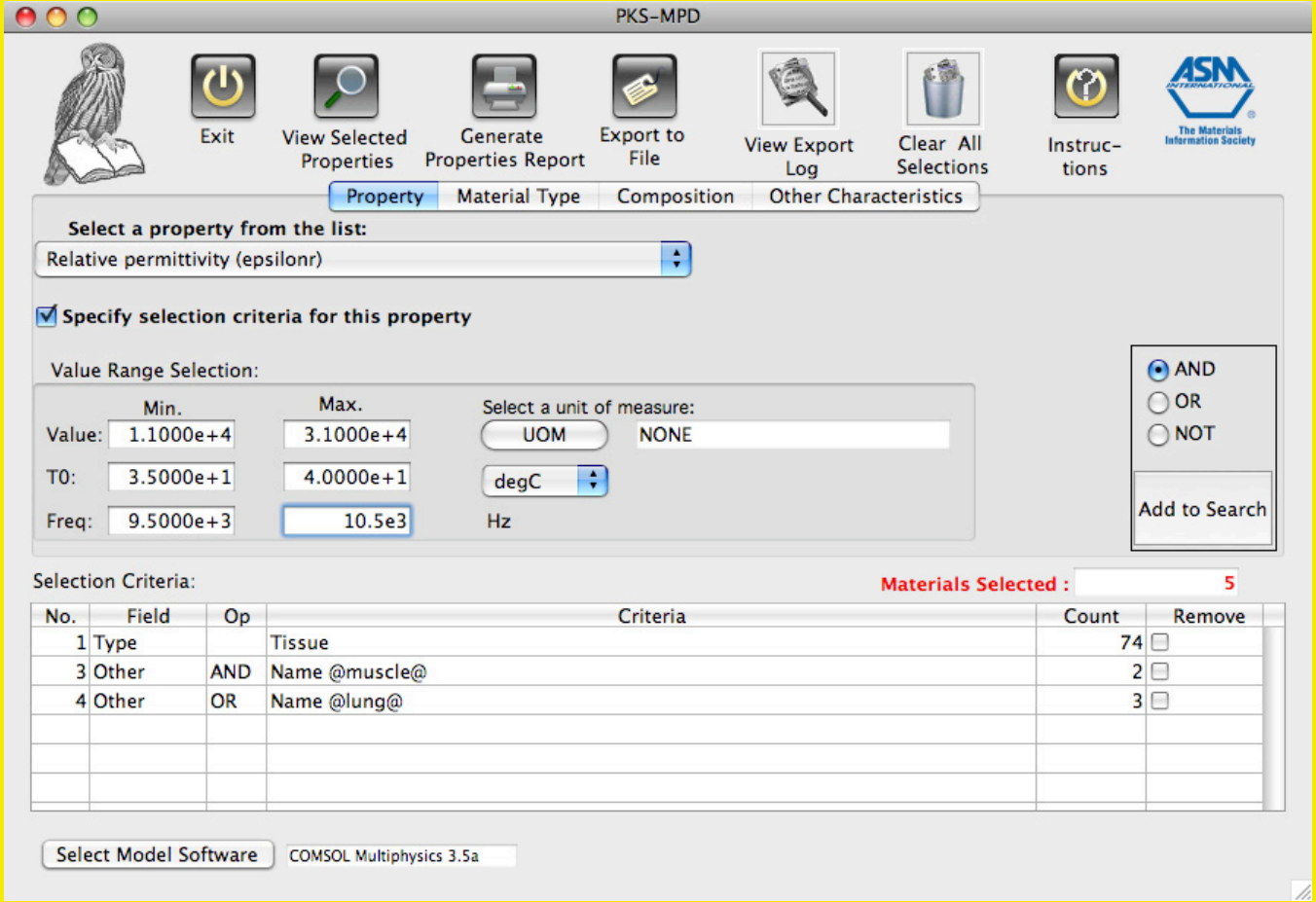
Materials Properties Data Retrieval

Consider the following reference source (PKS-MPD) employed for the acquisition of this model's materials properties data.

This source generates and exports a file for the selected materials properties matched to the COMSOL Version (e.g. 3.5a) that can imported directly into the COMSOL Model's Material Library through the Add Library function.

EIT Ovine Lung Function Model

Tissue Relative Permittivity Retrieval



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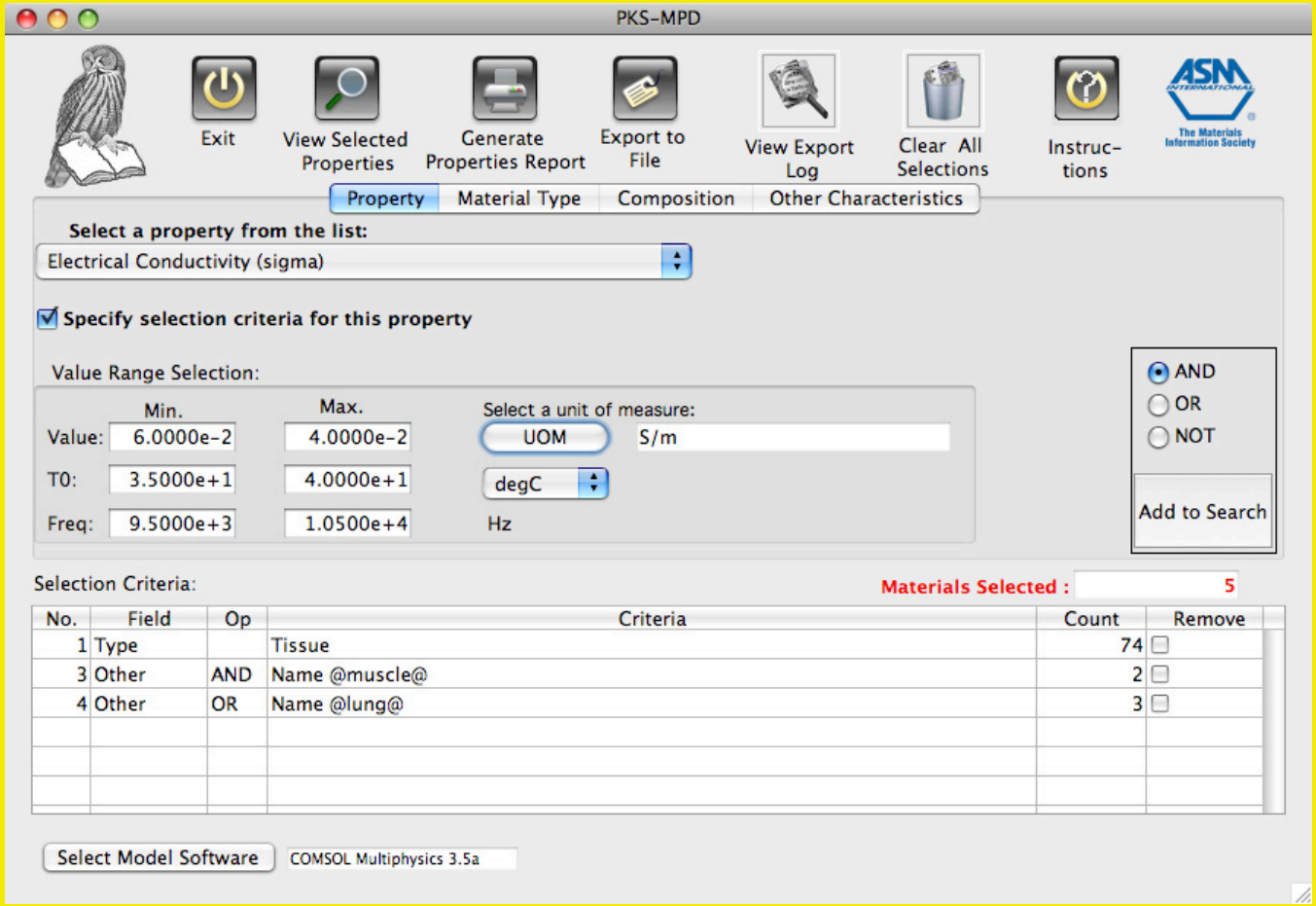
EIT Ovine Lung Function Model

Tissue Electrical Conductivity Retrieval



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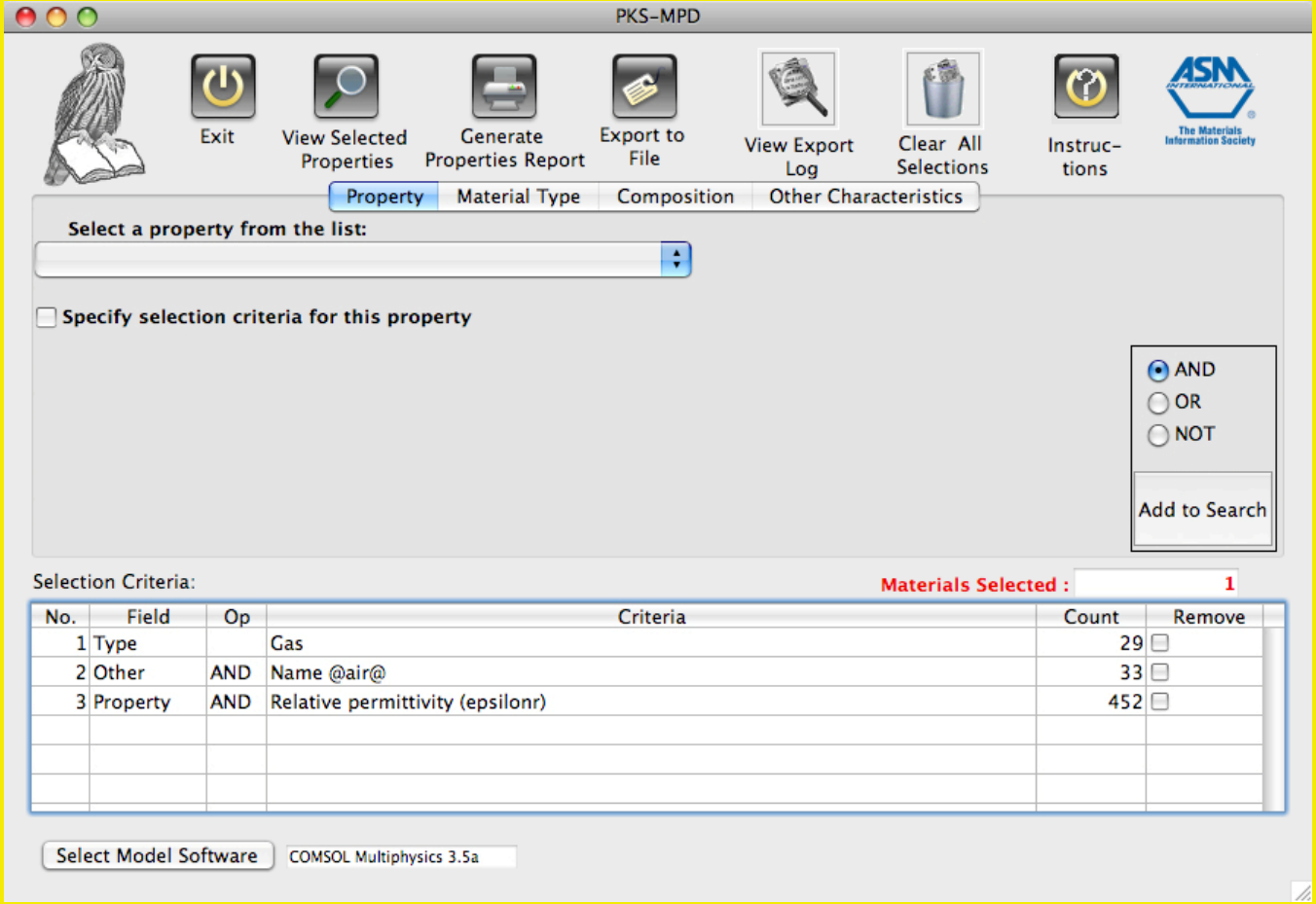
EIT Ovine Lung Function Model

Air Relative Permittivity Retrieval



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EIT Ovine Lung Function Model, Constants Values Table

Selected Materials Properties, Variables and Values

Variable	Value	Parameter
sig_m	0.3621[S/m]	Muscle conductivity
eps_r_m	3.043e4	Muscle relative permittivity
x_0	0.0[m]	x position of cavity center
y_0	0.0[m]	y position of cavity center
r_0	0.05[m]	Cavity radius
t_0	0.0[s]	Time init
sig_L	0.06366[S/m]	Lung inflated conductivity
eps_r_L	1.634e4	Lung inflated relative permittivity
freq_01	1.0e4[Hz]	Frequency
sig_air	1e-15 [S/m]	Conductivity of air
eps_r_air	1	Relative permittivity of air

EIT Ovine Lung Function Model Scalar Equations Table

Equation	Value	Parameter
sigma_0	(sig_m*(((x-x_0)^2+(y-y_0)^2)>r_00^2))+ (sig_L*(r_00^2>=((x-x_0)^2+(y-y_0)^2)>=r_02^2))+ (sig_air*(((x-x_0)^2+(y-y_0)^2)<r_02^2))	Model conductivity
epsilon_r_0	1+(eps_r_m-1)*(((x-x_0)^2+(y-y_0)^2)>r_00^2)+ (eps_r_L-1)*(r_00^2>=((x-x_0)^2+(y-y_0)^2)>=r_02^2)+ (eps_r_air*(((x-x_0)^2+(y-y_0)^2)<r_02^2))	Model permittivity
r_00	r_0*(1.4-cos((t_0[1/s]*pi)/8))/2	Lung Outer Wall Radius
r_02	r_00-0.01	Lung Inner Wall Radius

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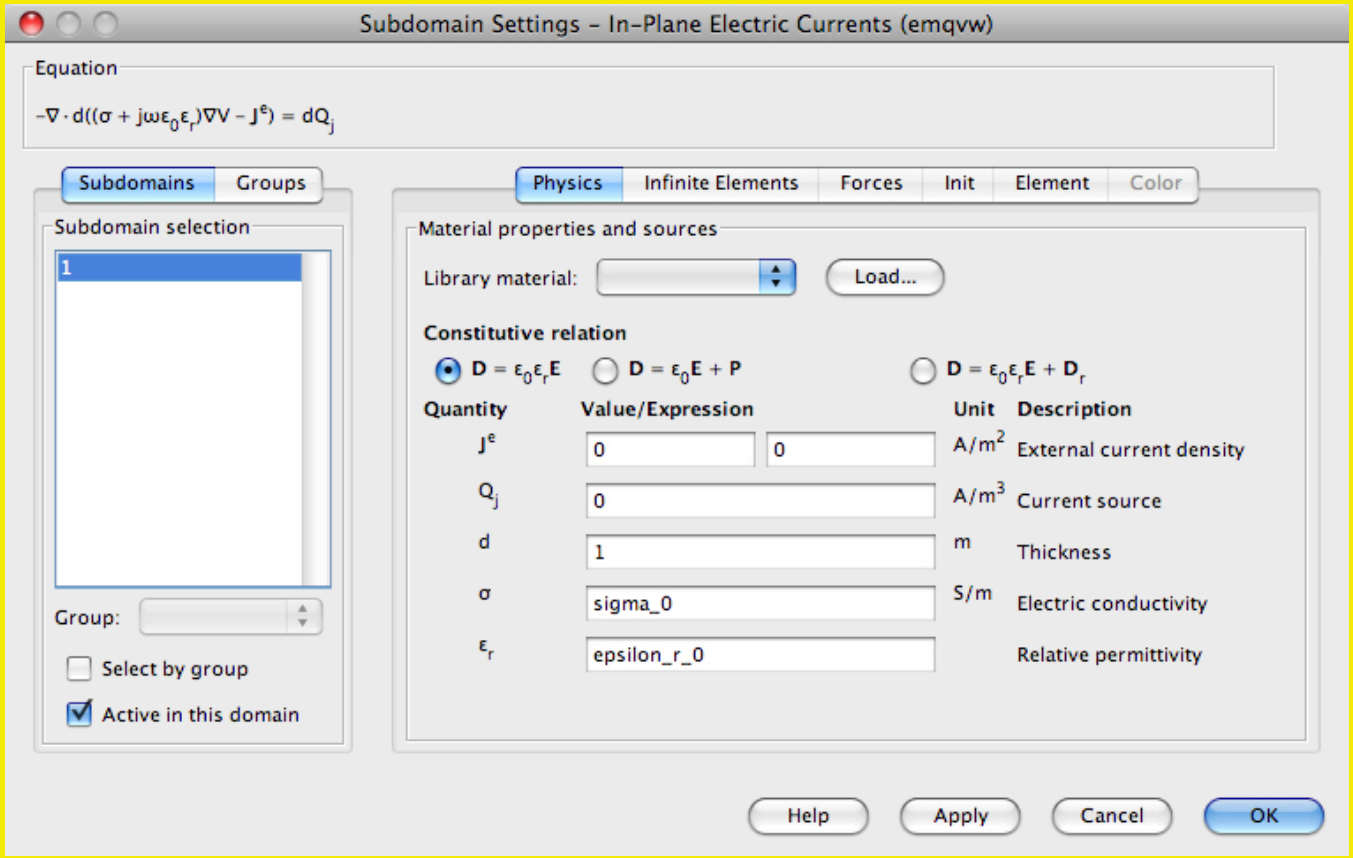
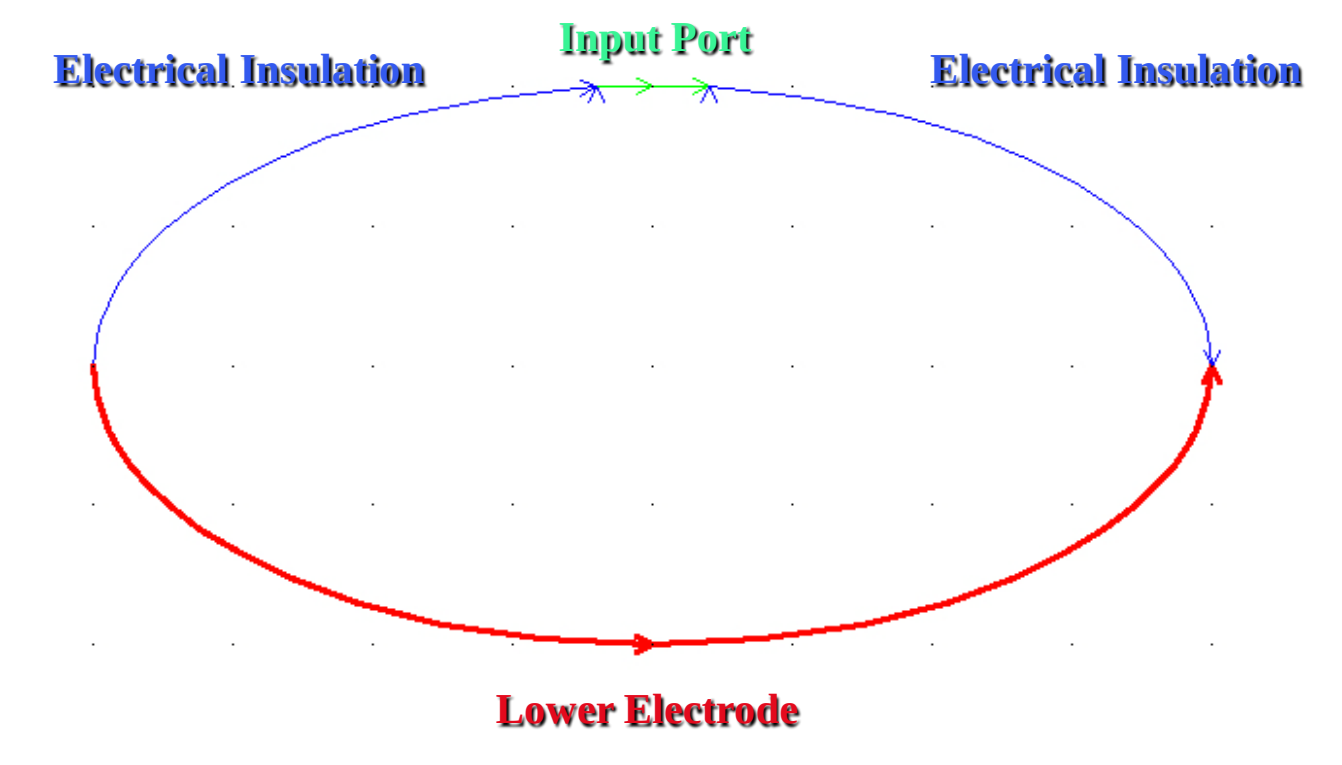
This EIT Model Subdomain Settings



This EIT Model Boundary Settings

Boundary	Setting
1,4,5,8 (blue)	Electrical Insulation
2,3 (green)	Port
6,7 (red)	Ground
Port Tab	Setting
Port Number	1
Input property	Fixed current density
Use port as input	Check Checkbox
Input current	1e-4 [A]

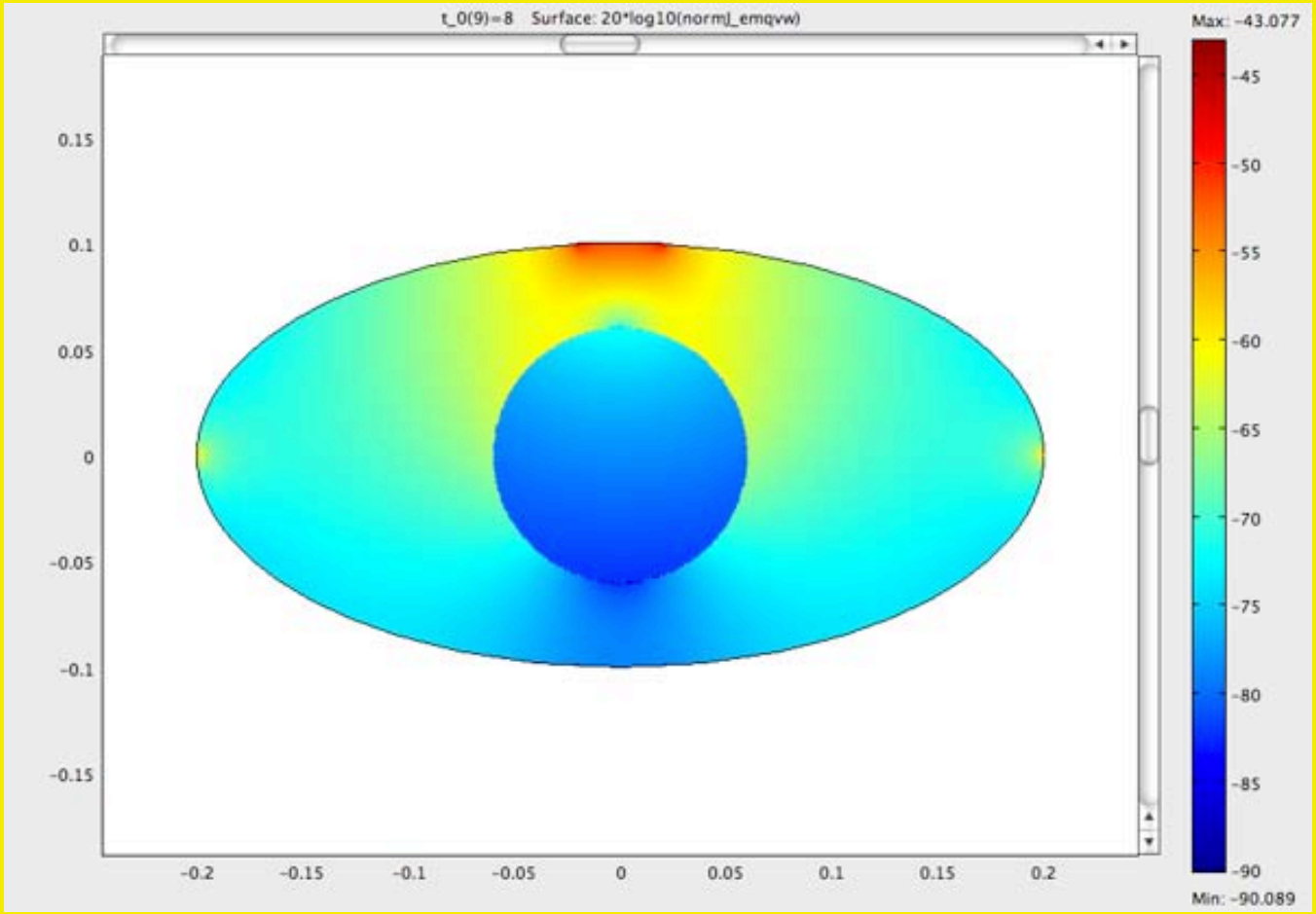
This EIT Model Boundary Settings, Graphic



This EIT Model Meshing and Solution

1. **Model meshed with a size limit of 0.001, using a Triangle (advancing front) mesh.**
2. **Model solved with Parametric Solver on t_0, range(0,32/32,32).**

This EIT Model Solution Graphic
Single Solution, Maximum Inflation



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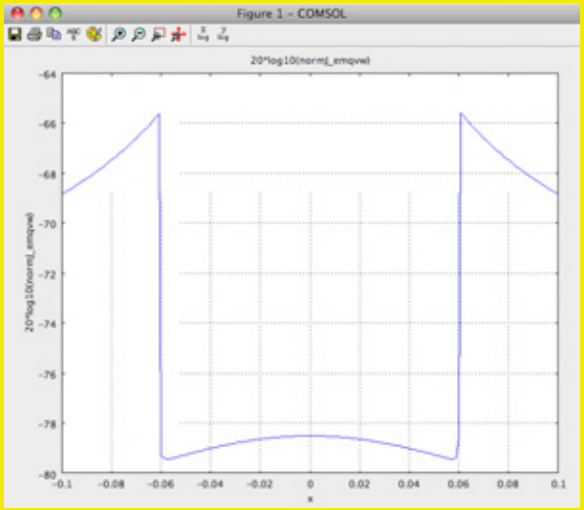
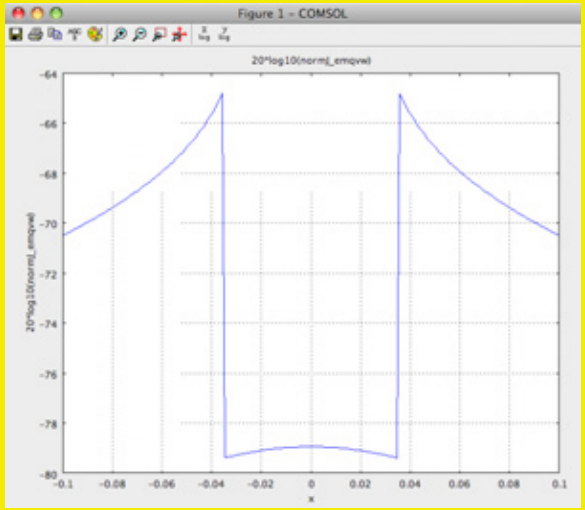
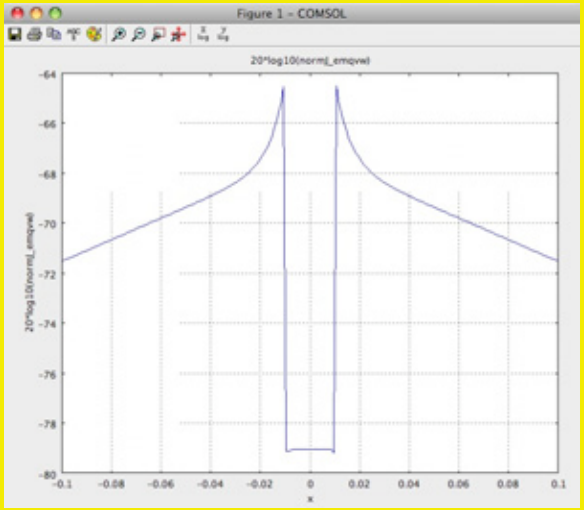
This EIT Model Solution Graphic Cross-Section Plots



Maximum-Inflation



Half-Inflation



Minimum-Inflation

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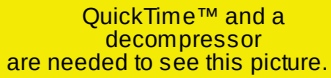
This EIT Model Solution Movie



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Thank You!