

ECE 1259: Electromagnetics - Capacitor Simulation Documentation

By Zebulon Smith, Kyle Montrose, and Nicholas Genco

April 25, 2023

Table of Contents

- Matlab Application Purpose:..... 1
- Program Requirements:..... 2
 - Dielectric Material Properties Table:..... 2
- System Inputs:..... 3
 - Capacitor Type Selection..... 4
 - Parallel Plate Capacitor System Inputs:..... 4
 - Cylindrical Capacitor System Inputs:..... 4
 - Spherical Capacitor System Inputs:..... 4
- System Outputs:..... 5
 - Electric Field Vs. Distance Plot:..... 5
 - Magnitude Bode Plot:..... 5
 - Phase Angle Bode Plot..... 6
- Program Functionality:..... 6
 - Generating Output:..... 6
 - Full Program Output:..... 6
 - Edge Cases and Error Mitigation:..... 7
 - Case 1: User Inputs Negative value for distance, length, width, height, inner radius, or outer radius..... 7
 - Case 2: Required User Input for Capacitor Type is left blank or set to 0..... 7
 - Case 3: User Inputs an Inner Radius value greater than the inputted Outer Radius value..... 7
 - Case 4: User inputs Inner and Outer Radii values that are equal to one another..... 7

Matlab Application Purpose:

This file outlines the code for the ECE 1259 Capacitor Simulation project in April 2023.

This project script is partnered with an Matlab application that contains all code described in this live editor.

The purpose of this live editor is to help the user gain a deeper understanding of this application. Program inputs, outputs, and requirements are described within.

Inputs

Capacitor Type

☒ Parallel Plate
 ☐ Cylindrical
 ☐ Spherical

Dielectric Material (P, C, S)

Air

Distance (P, C, S)

0

Voltage (P, C, S)

0

Length (P)

0

Width (P)

0

Height (C)

0

Inner Radius (C, S)

0

Outer Radius (C, S)

0

Outputs

Capacitance (nF)

0

Conductance (pS)

0

Leakage Current (pA)

0

Breakdown Voltage

0

E-Field vs Distance

Bode Plot (Mag)

Bode Plot (Phase)

Get Values

Units: Voltage (V), Distance (m), Length (m), Width (m), Height (m), Inner Radius (m), Outer Radius(m)

Note: Conductivity for alumina and barium titanate assumed to be 0

Program Requirements:

- Dielectric_Table.xlsx must be stored in the same repository as the CapacitorStatics Matlab Application.

Dielectric Material Properties Table:

name	Er	Ebr	sigma
Air	1.0005	3000000	0
Alumina	9.9	0	
Barium Titanate	1200	7500000	
Glass	10	30000000	1.00E-12
Ice	4.2	0	
Mica	5.4	200000000	1.00E-15
Polyethylene	2.26	47000000	1.00E-16
Polystyrene	2.56	20000000	1.00E-17
Quartz (fused)	3.8	30000000	1.00E-17
Silicon	11.8	0	4.40E-04
Soil	3.5	0	2.00E-03
Teflon	2.1	60000000	1.00E-15
Water (distilled)	81	0	1.00E-04
Seawater	72	0	5.00E+00

System Inputs:

- Capacitor Selection
- Dielectric Material
- Distance (with units: meters) - Distance between capacitor plates
- Voltage (with units: volts)
- Length (with units: meters) - length of capacitor plate
- Width (with units: meters) - width of capacitor plate
- Height (with units: meters) - height of capacitor cylinder
- Inner Radius (with units: meters) - radius of capacitor
- Outer Radius (with units: meters) - radius of capacitor

Inputs

Capacitor Type

☒ Parallel Plate

☐ Cylindrical

☐ Spherical

Dielectric Material (P, C, S)

Air

Distance (P, C, S)

0.05

Voltage (P, C, S)

10

Length (P)

1

Width (P)

1.5

Height (C)

0

Inner Radius (C, S)

0

Outer Radius (C, S)

0

Capacitor Type Selection

- Parallel Plate Capacitor (P)
- Cylindrical Capacitor (C)
- Spherical Capacitor (S)

Parallel Plate Capacitor System Inputs:

- Dielectric Material
- Distance
- Voltage
- Length
- Width

Cylindrical Capacitor System Inputs:

- Dielectric Material
- Distance
- Voltage
- Height
- Inner Radius
- Outer Radius

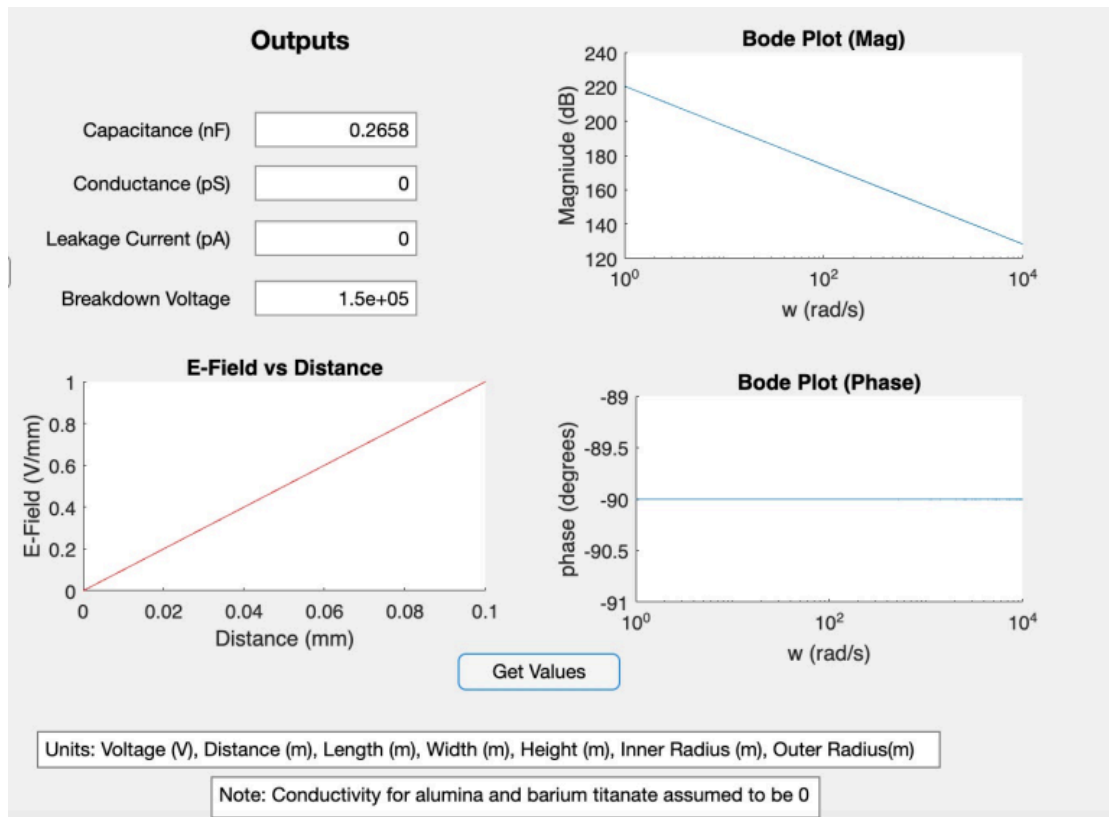
Spherical Capacitor System Inputs:

- Dielectric Material

- Distance
- Voltage
- Inner Radius
- Outer Radius

System Outputs:

- Capacitance (with units: nanoferads)
- Conductance (with units: picosiemans)
- Leakage Current (with units: picoamps)
- Breakdown Voltage (with units: volts)
- Plot of **Electric Field vs. Distance**
- **Bode Plot Magnitude**
- **Bode Plote Phase Angle**



Electric Field Vs. Distance Plot:

- **X Axis:** Distance in millimeters
- **Y Axis:** Voltage per millimeter

Magnitude Bode Plot:

- **X Axis:** ω (radians per second)

- **Y Axis:** Magnitude (dB)

Phase Angle Bode Plot

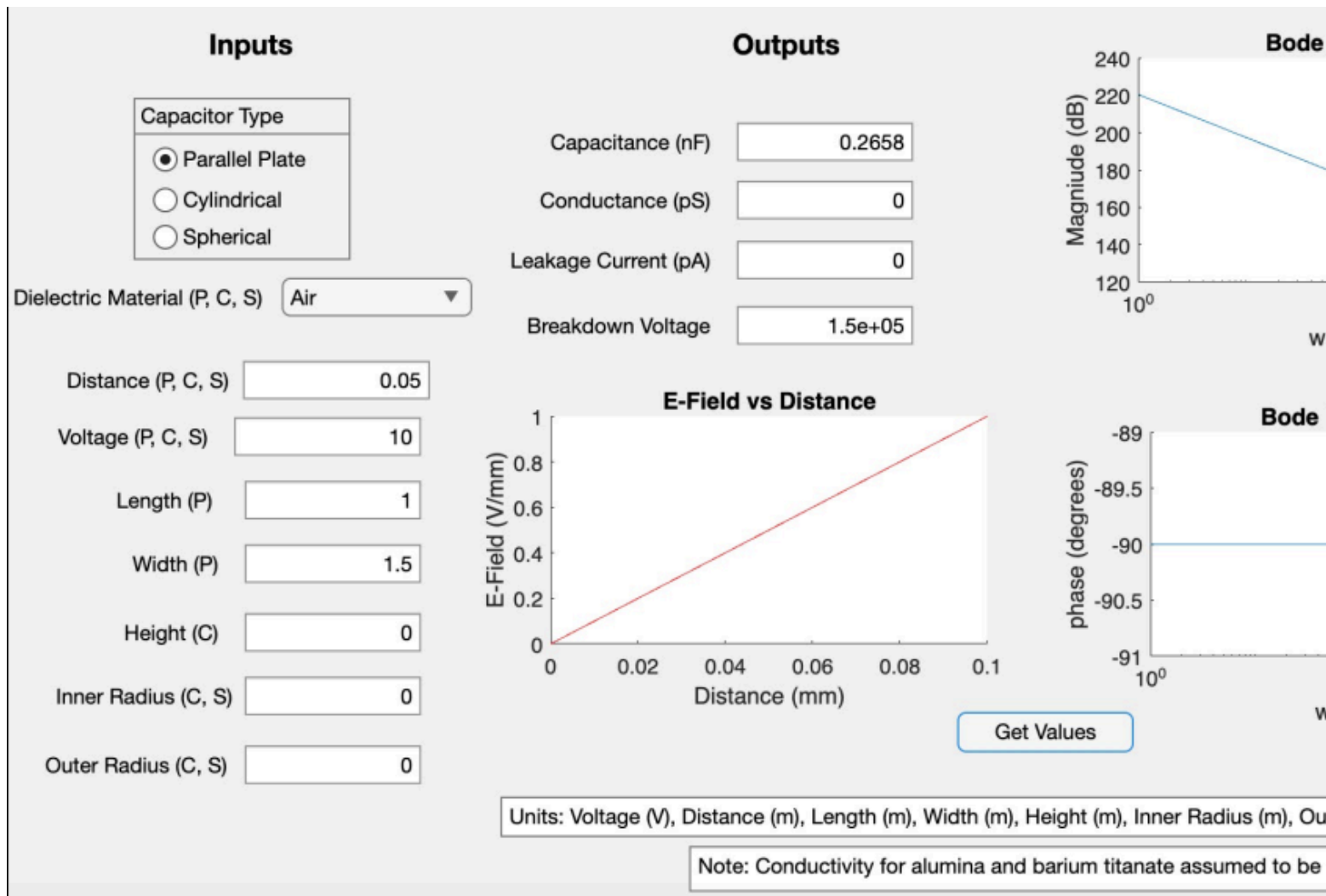
- **X Axis:** ω (radians per second)
- **Y Axis:** Degrees

Program Functionality:

Generating Output:

1. Select Capacitor Type
2. Select Dielectric Material from dropdown menu, and fill out remaining inputs (dielectric material options shown in dropdown menu below)
3. Click "Get Values" button and output will generate

Full Program Output:



Edge Cases and Error Mitigation:

Case 1: User Inputs Negative value for distance, length, width, height, inner radius, or outer radius

- Error Mitigation Employed - Take the absolute value of the user input and display program outputs

Case 2: Required User Input for Capacitor Type is left blank or set to 0

- Error Mitigation Employed - Return an error and ask the user to enter a value for missing input

Case 3: User Inputs an Inner Radius value greater than the inputted Outer Radius value

- Error Mitigation Employed - Swap the inner and outer radius values

Case 4: User inputs Inner and Outer Radii values that are equal to one another

- Error Mitigation Employed - Return an error and ask the user to change one of the values