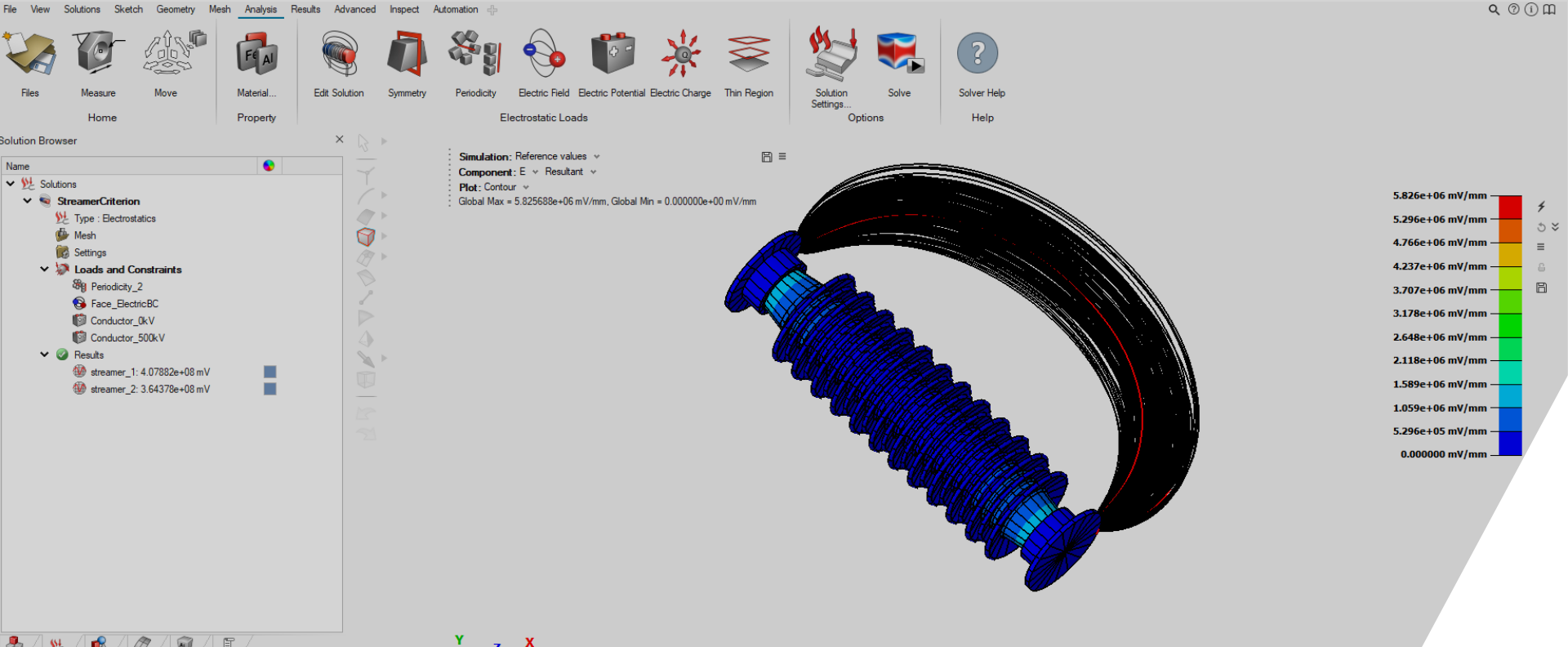




INSULATOR: STREAMER CRITERION

ELECTROMAGNETIC APPLICATION WITH SIMLAB

October 2024, Altair Engineering Inc.

TUTORIAL OUTLINE

I. Introduction

II. 3D Electrostatic Analysis

- II.1: Solution creation
- II.2: Geometry and mesh
- II.2: Physical description
- II.3: Solving process
- II.4: Basic post-processing

III. Conclusion

INTRODUCTION

INTRODUCTION

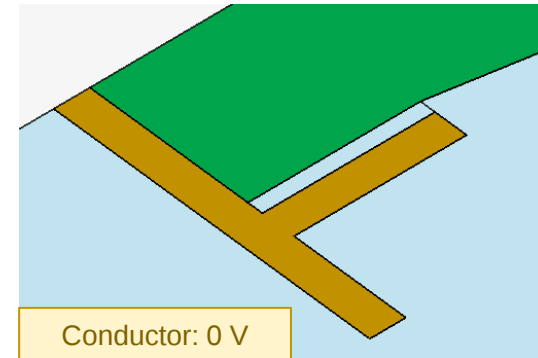
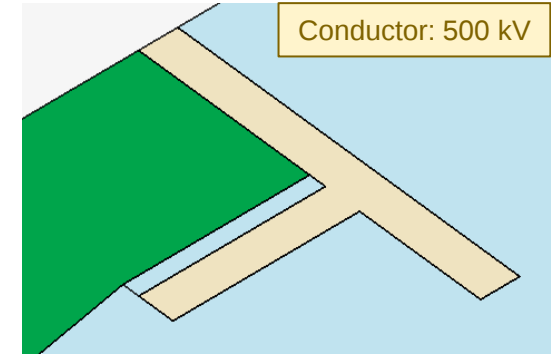
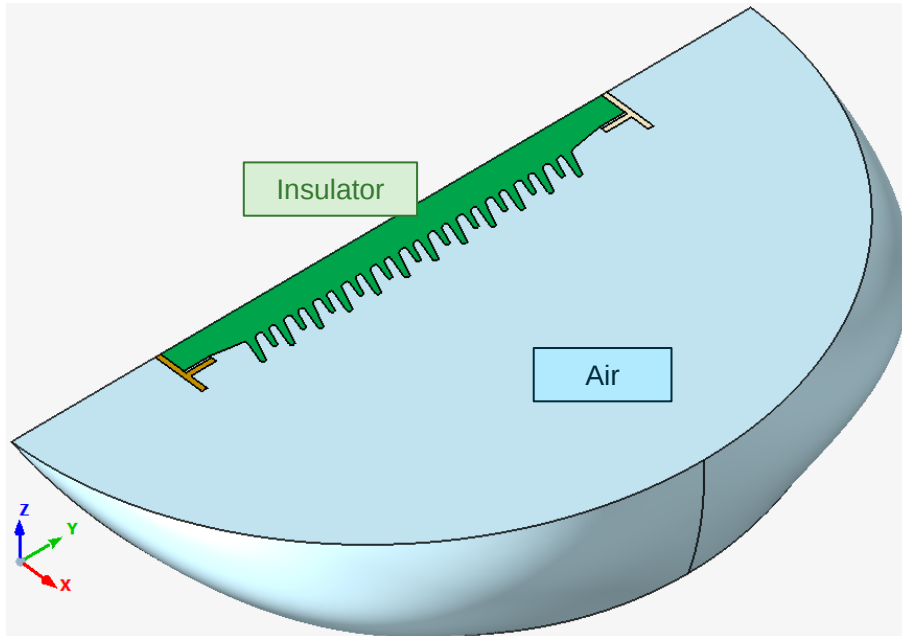
Physical Principle

- A dielectric breakdown can occur in a dielectric gas when the applied potential difference is higher than the breakdown voltage. It is illustrated by the apparition of an electric arc in the dielectric area which can destroy definitively the device.
- The complete simulation of every physical processes yielding to an electrical discharge development is highly complex (Boltzmann equations, drift-diffusion models...), and not applicable yet to determine the breakdown voltage value in real industrial devices, due to their complexity and calculation time.
- **The streamer criterion** do not intend to be a complete simulation of the breakdown process in gases, it is only a criteria that is applied on the field obtained by an electrostatic simulation (i.e. the background field, before any discharge phenomena occurrence)*.
- This criterion gives an estimation of the threshold voltage that can trigger the electronic avalanche process leading to an electrical breakdown in the gas. This voltage is called “Streamer inception voltage”.

INTRODUCTION

Application Case: Insulator

- Study device: an insulator
- Analysis: 3D electrostatic

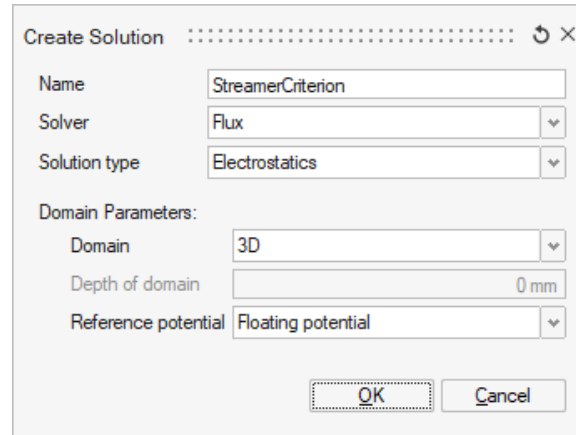
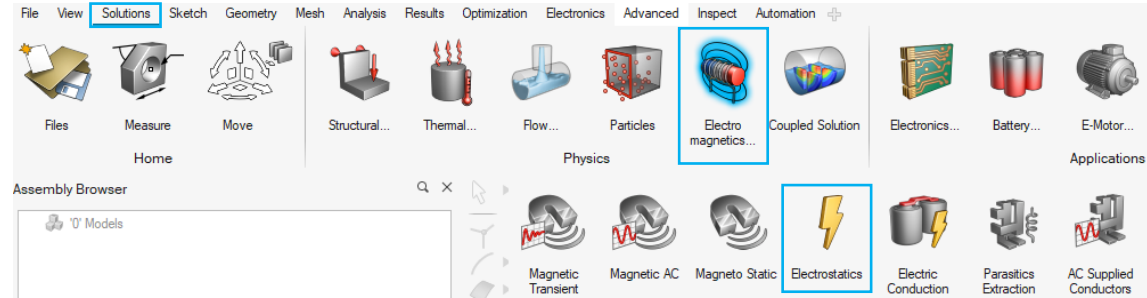


3D ELECTROSTATICS ANALYSIS

SOLUTION CREATION

3D ELECTROSTATIC ANALYSIS

- Create a SimLab solution for electromagnetic applications
 - [Solutions] – [Electromagnetics] [Electrostatics]



GEOMETRY AND MESH

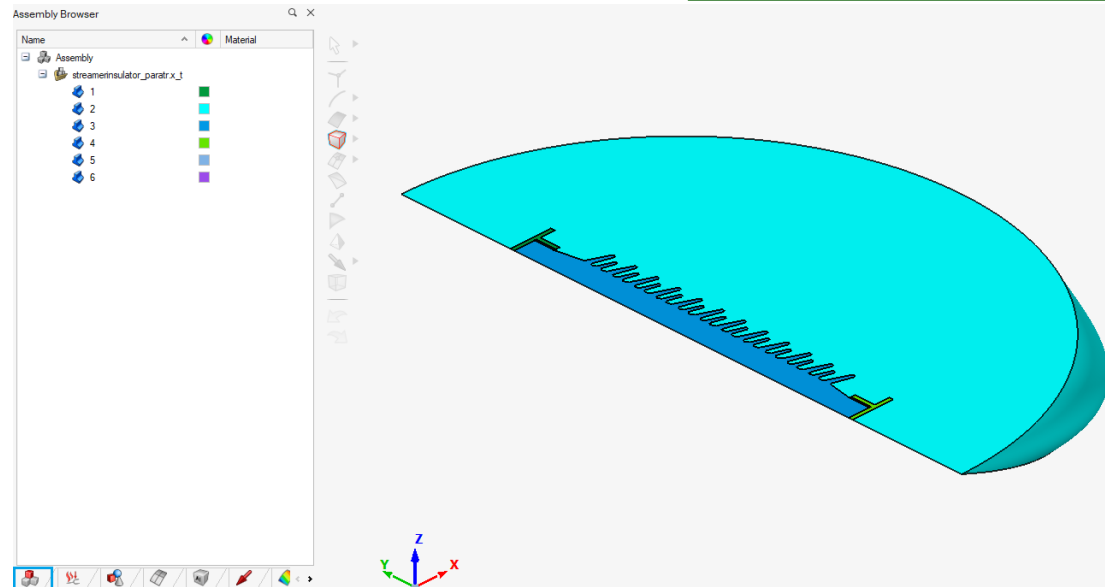
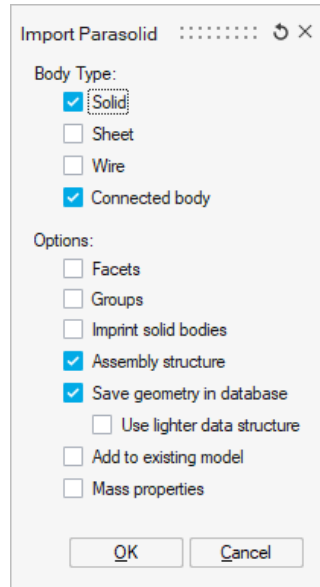
3D ELECTROSTATIC ANALYSIS

Geometry and Mesh

- Geometry import
 - [File] → [Import] → [CAD]

... \ Input \ insulator.xmt_txt

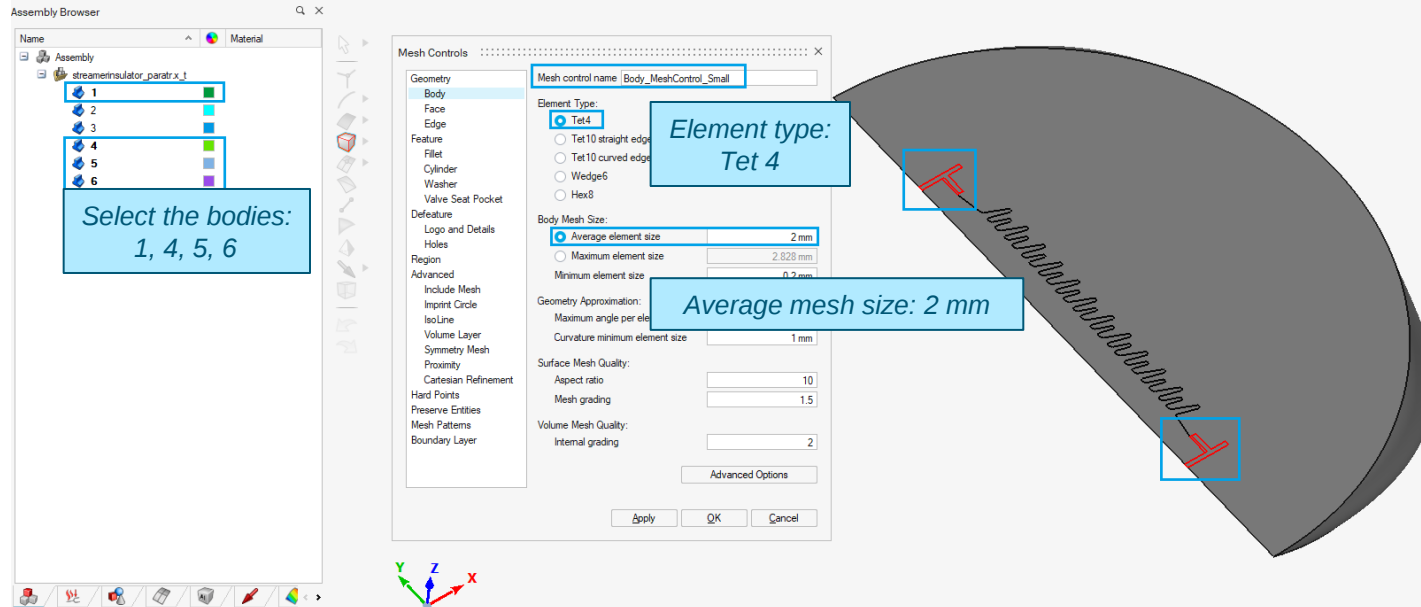
Imported insulator CAD model



3D ELECTROSTATIC ANALYSIS

Geometry and Mesh

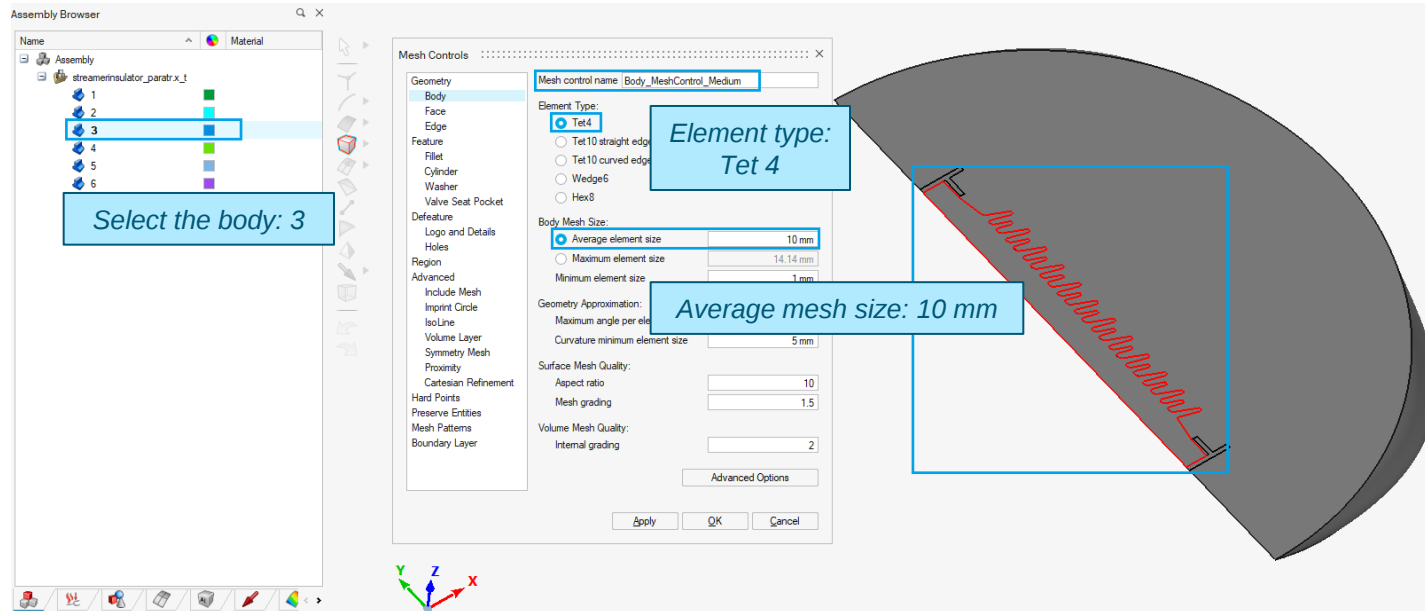
- Mesh description
 - [Mesh] – [Mesh Controls]
 - Define body mesh control: small (2 mm)



3D ELECTROSTATIC ANALYSIS

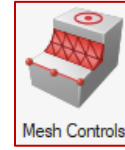
Geometry and Mesh

- Mesh description
 - [Mesh] – [Mesh Controls]
 - Define body mesh control: medium (10 mm)

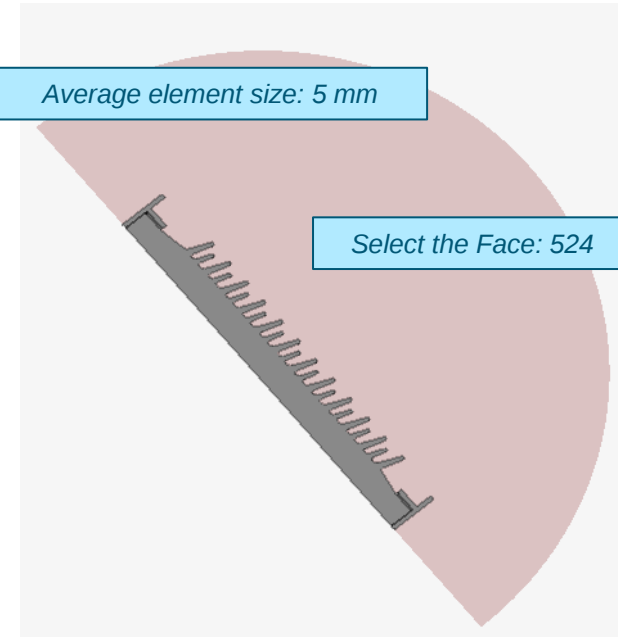
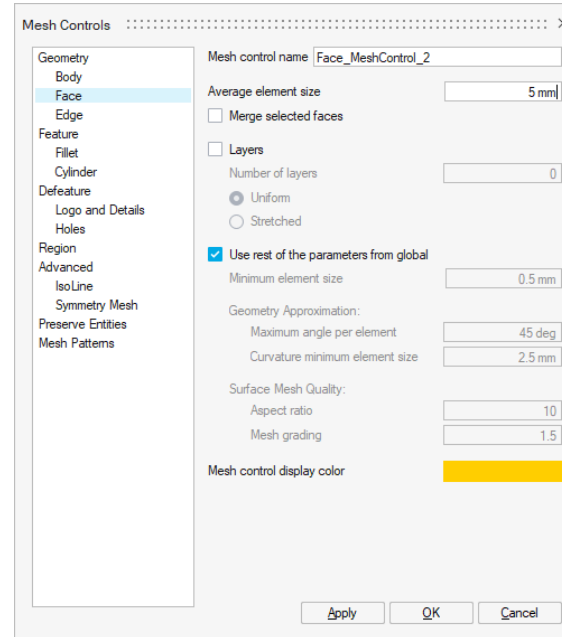


3D ELECTROSTATIC ANALYSIS

Geometry and Mesh

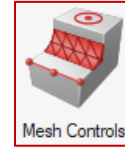


- Mesh description
 - [Mesh] – [Mesh Controls]
 - Define face mesh control

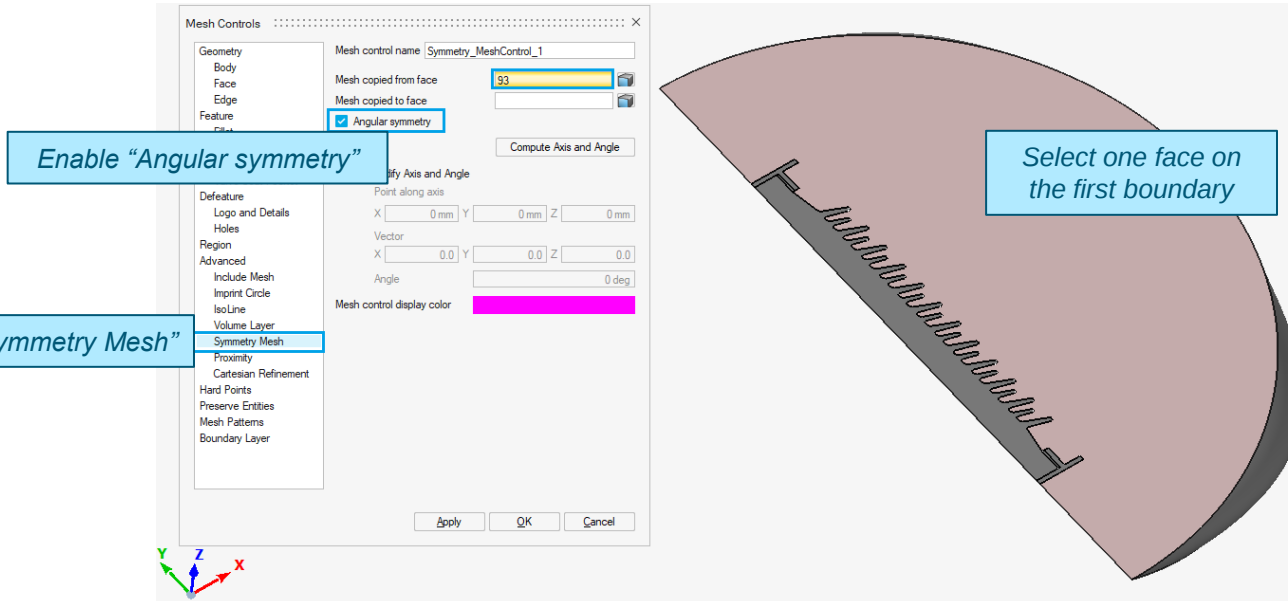


3D ELECTROSTATIC ANALYSIS

Geometry and Mesh

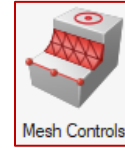


- Mesh description
 - [Mesh] – [Mesh Controls]
 - Define angular **symmetry mesh controls** for the boundary faces

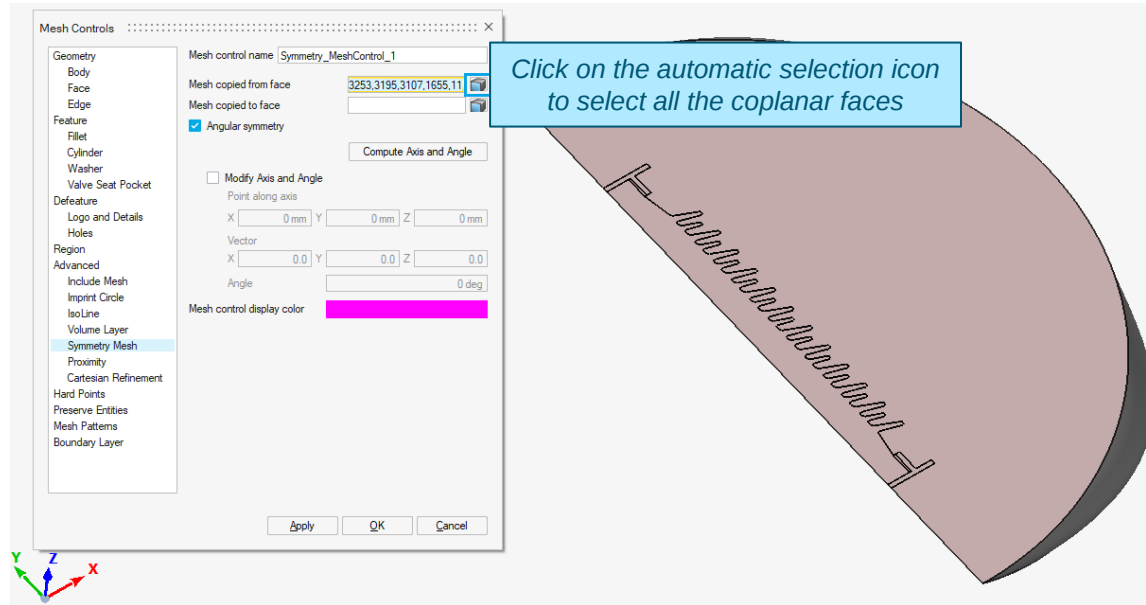


3D ELECTROSTATIC ANALYSIS

Geometry and Mesh

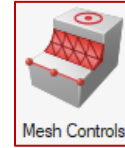


- Mesh description
 - [Mesh] – [Mesh Controls]
 - Define angular **symmetry** mesh controls for the boundary faces

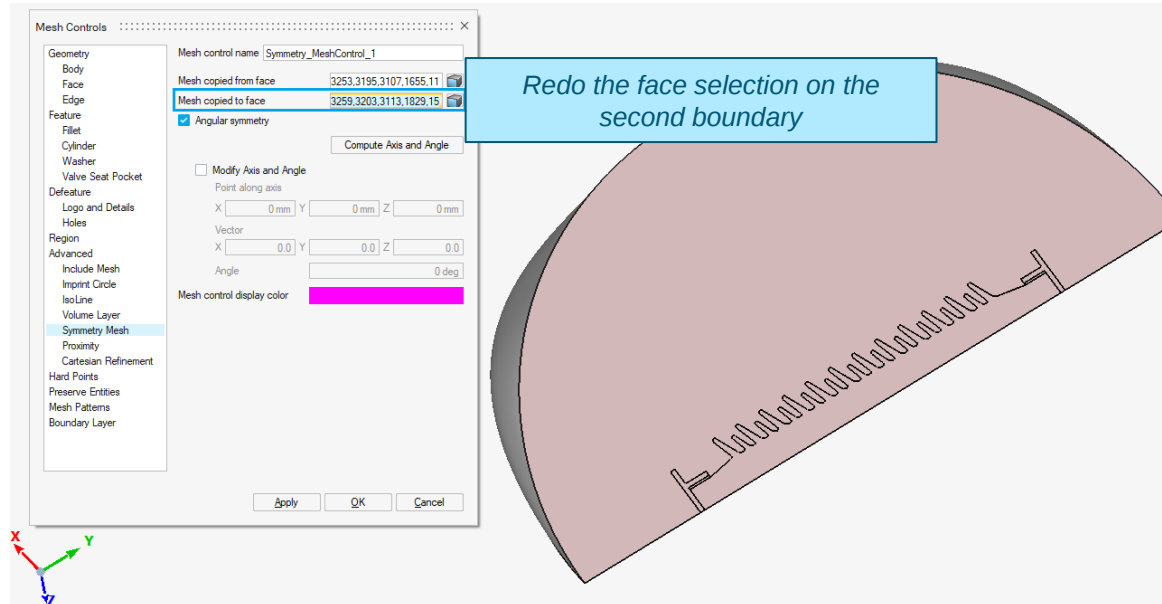


3D ELECTROSTATIC ANALYSIS

Geometry and Mesh



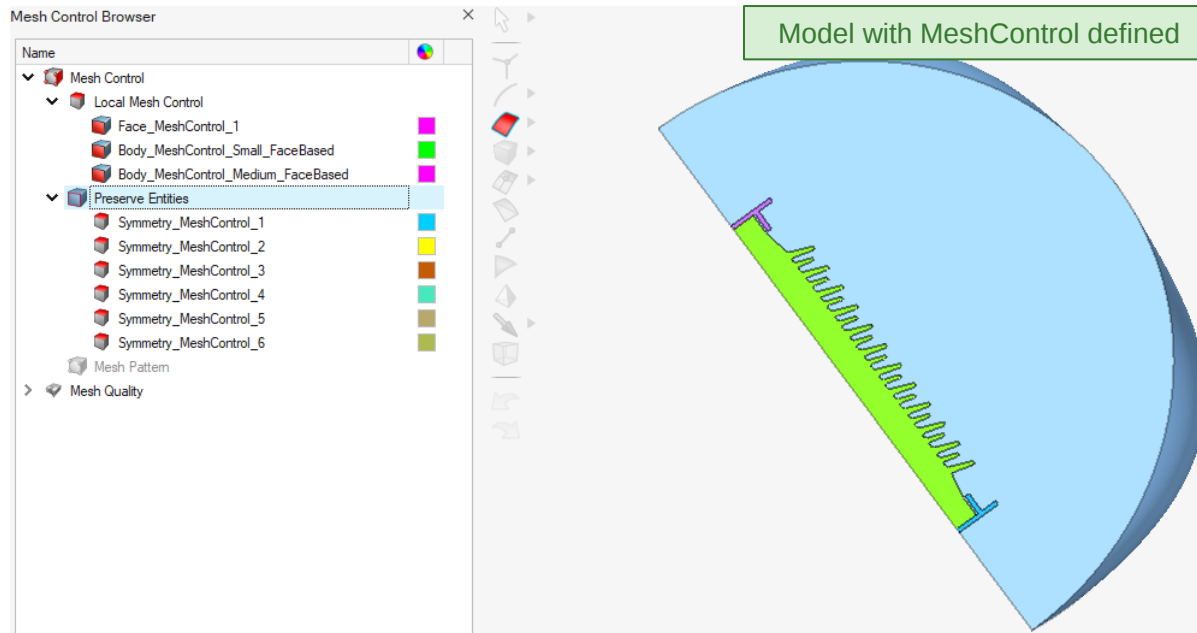
- Mesh description
 - [Mesh] – [Mesh Controls]
 - Define angular **symmetry** mesh controls for the boundary faces



3D ELECTROSTATIC ANALYSIS

Geometry and Mesh

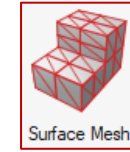
- Mesh description
- Final mesh control list



3D ELECTROSTATIC ANALYSIS

Geometry and Mesh

- Surface mesh generation
 - [Mesh] – [Surface Mesh]
 - Select All Faces
 - Fill Average element size: 10 mm
 - Validate by clicking on OK



Surface Mesh X

Select bodies or faces

Element Type:

☒ Tri3

☐ Tri6

☐ Quad4 ⌵

Mesh Size:

☒ Average element size 10 mm

☐ Maximum element size 14.14 mm

Minimum element size 1 mm

Grade factor 1.5

Geometry Approximation:

Maximum angle per element 45 deg

Curvature minimum element size 5 mm

Surface Mesh Quality:

Aspect ratio 10

☒ Identify features and mesh on CAD body

☒ Merge tiny fillets

☒ Create matching mesh (Parasolid)

Advanced Options

OK Cancel

3D ELECTROSTATIC ANALYSIS

Geometry and Mesh



- Volume mesh generation
 - [Mesh] – [Tet]
 - Select All Bodies
 - Fill Average element size: 15 mm
 - Validate by clicking on OK

Tet Mesh

Element Type:

☒ TET4

☐ TET10 straight edge

☐ TET10 curved edge

Mesh Size:

Average element size

☐ Maximum element size

Internal grading

Quality:

Minimum value	Quality 1	Maximum value
0.1	Stretch	1

☐ Identify features and mesh on CAD body

☐ Merge tiny fillets

☒ Create matching mesh (Parasolid)

☐ Transfer mesh control from CAD

Surface mesh parameters for CAD input:

3D ELECTROSTATIC ANALYSIS

Geometry and Mesh

- Final Mesh and Check mesh details

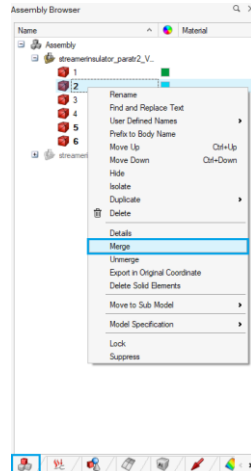
Select all the mesh bodies

Body Details	
Nodes:	
Internal	143196
Surface	124664
Total	267860
Element:	
Bar2	4780
Tri3	251648
Tet4	1244376
Geom:	
Face	151
Edge	416
Vertex	272
<button>Cancel</button>	

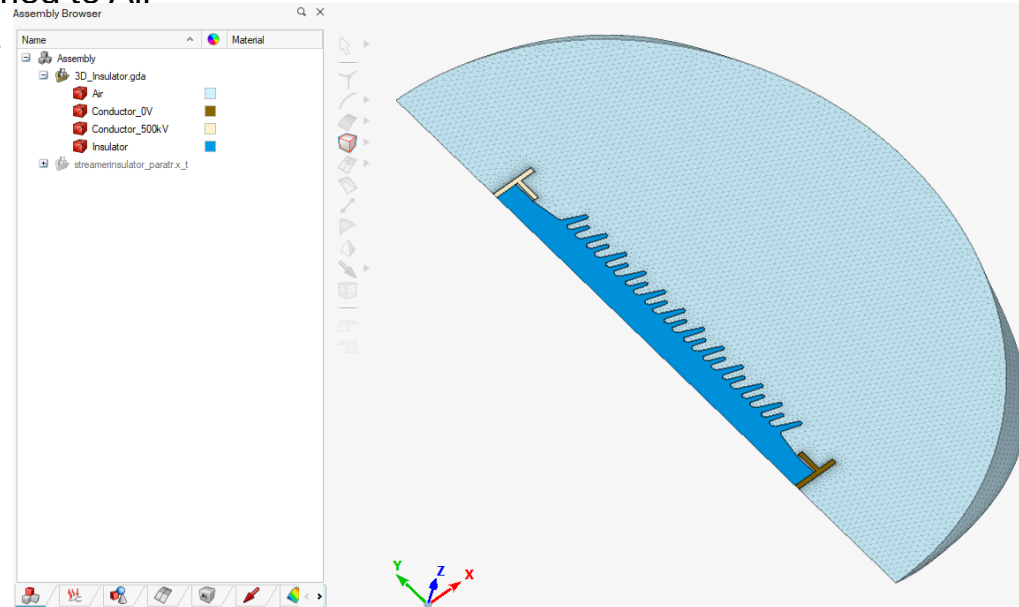
3D ELECTROSTATIC ANALYSIS

Geometry and Mesh

- Merge and rename bodies
 - Bodies 2, 5 and 6 are merged and renamed to Air
 - Body 1 is renamed to Conductor_500kV
 - Body 4 is renamed to Conductor_0kV
 - Body 3 is renamed to Insulator



Merge all the air bodies



3D ELECTROSTATIC ANALYSIS

Geometry and Mesh

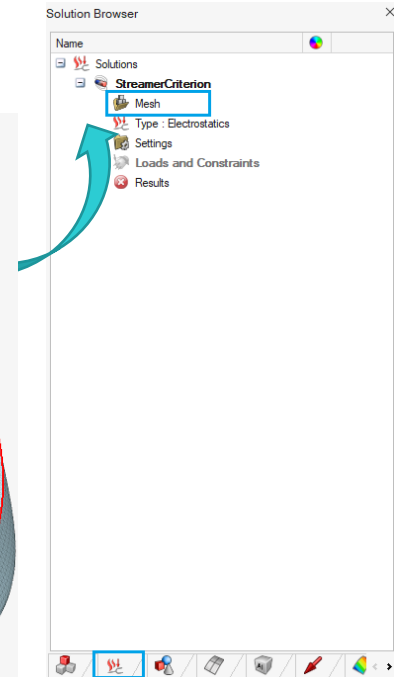
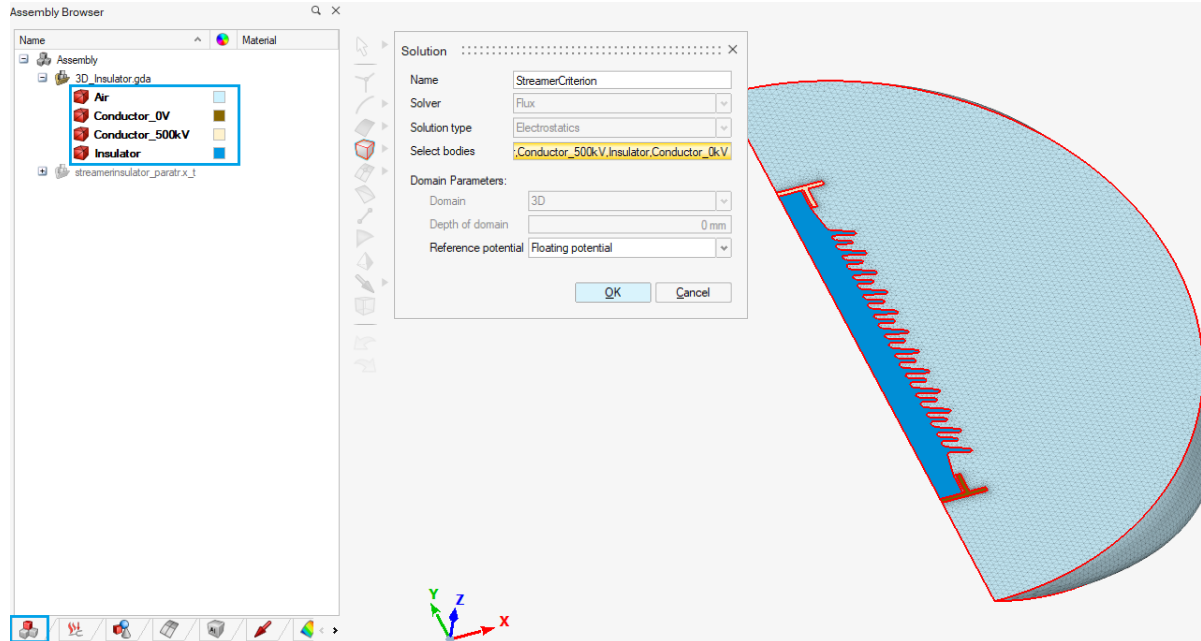
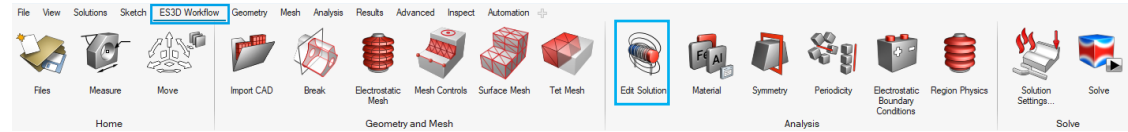
- Final mesh model
 - Save the project [File] – [Save As]
 - Save the project as “3D_ES_Insulator_Mesh.slb”

PHYSICAL DESCRIPTION

3D ELECTROSTATIC ANALYSIS

Physical Description

- Complete the **Solution** definition
- [ES3D Workflow] – [Edit Solution]

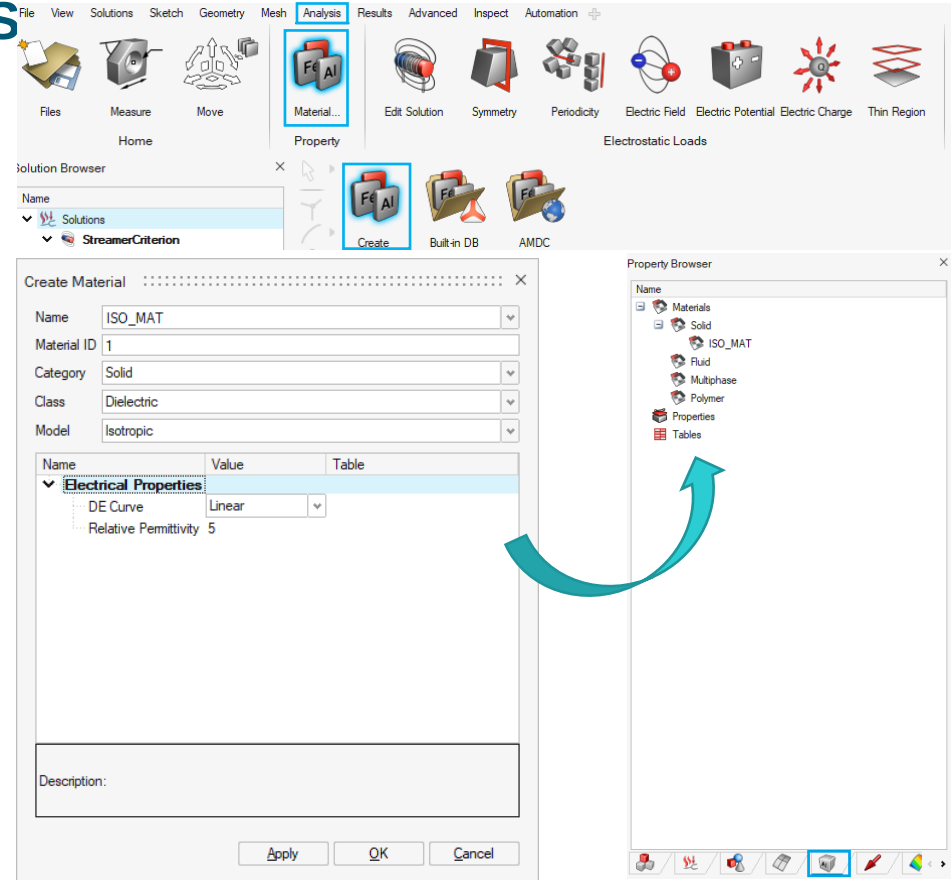


3D ELECTROSTATIC ANALYSIS

Physical Description

- Define dielectric **material**
- [Analysis] – [Material] – [Create]

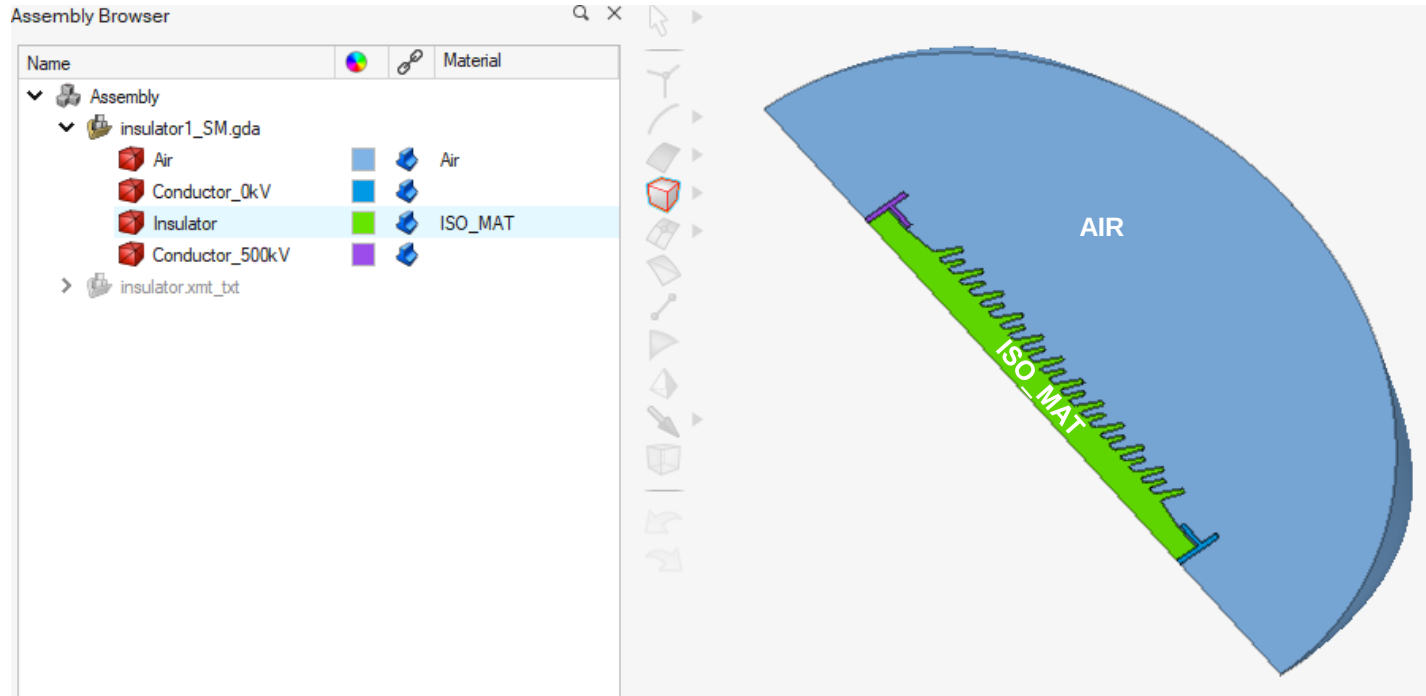
Parameter	Type / value
Name	ISO_MAT
Category	Solid
Class	Dielectric
Model	Isotropic
Dielectric relative permittivity	5



3D ELECTROSTATIC ANALYSIS

Physical Description

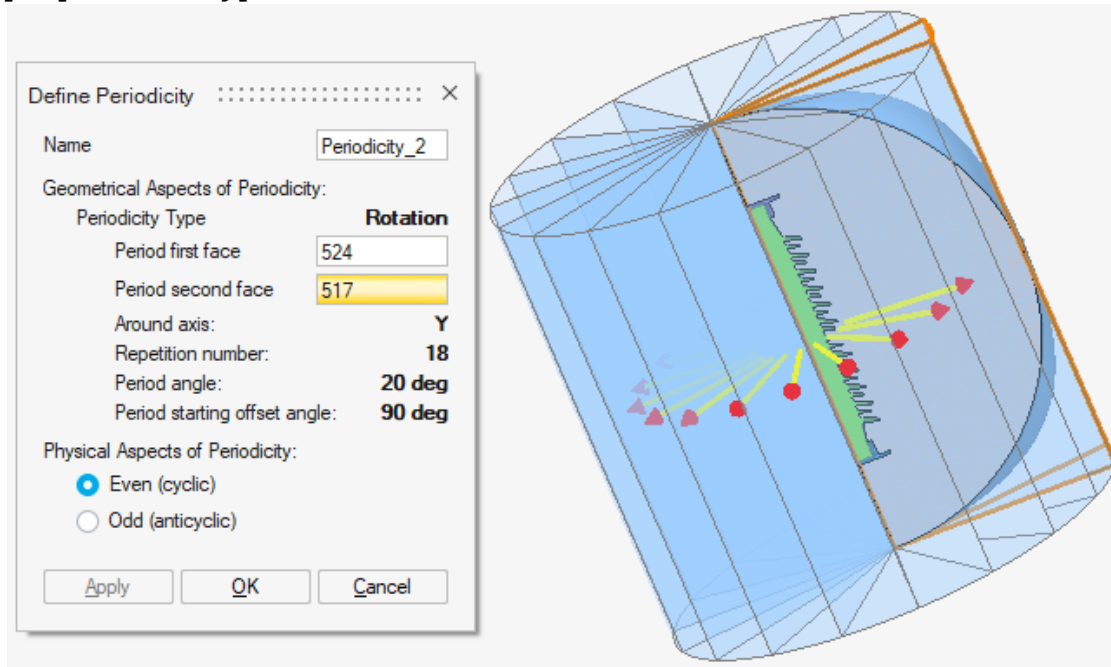
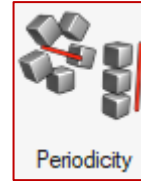
- Assign **materials**



3D ELECTROSTATIC ANALYSIS

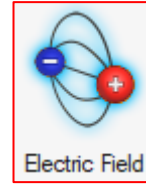
Physical Description

- Define **periodicity**
 - [Analysis] – [Periodicity]

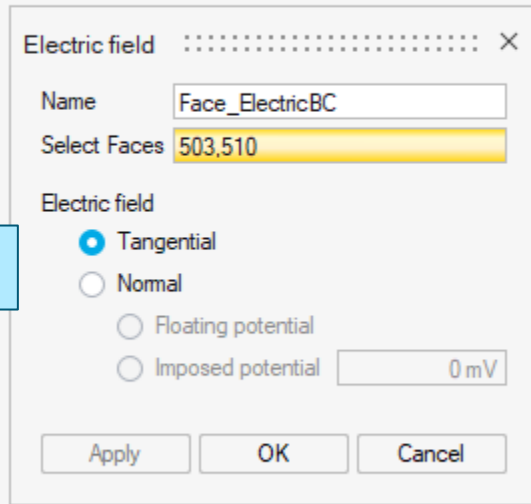


3D ELECTROSTATIC ANALYSIS

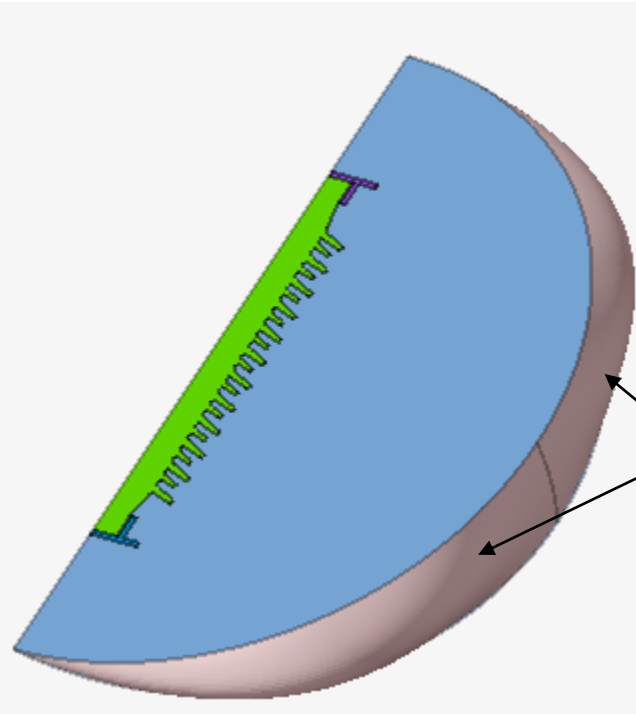
Physical Description



- Define **boundary conditions**
 - [Analysis] – [Electrostatic Field]



Boundary condition:
tangential electric field

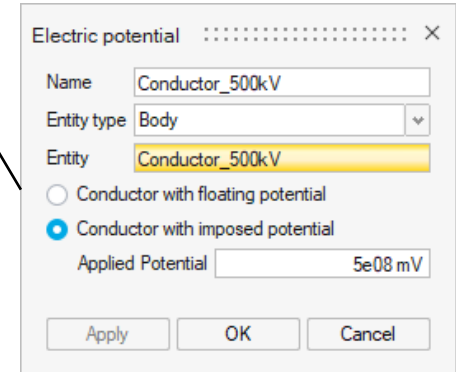
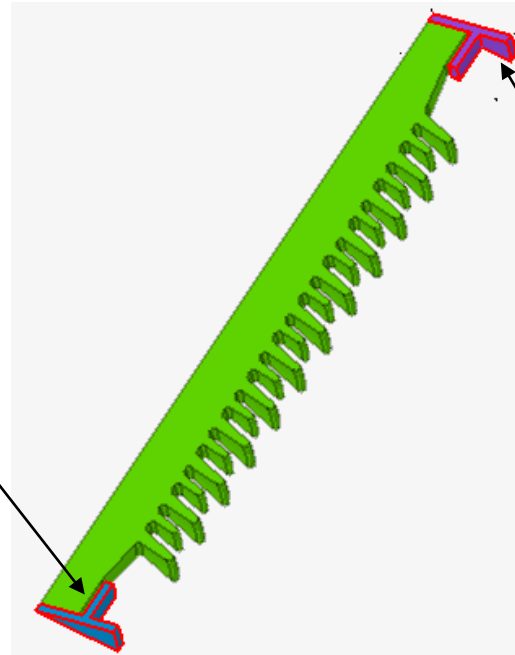
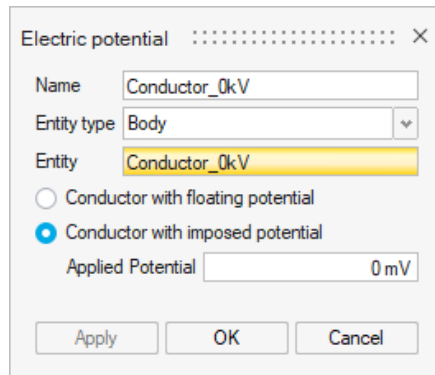


Select the two
outside faces

3D ELECTROSTATIC ANALYSIS

Physical Description

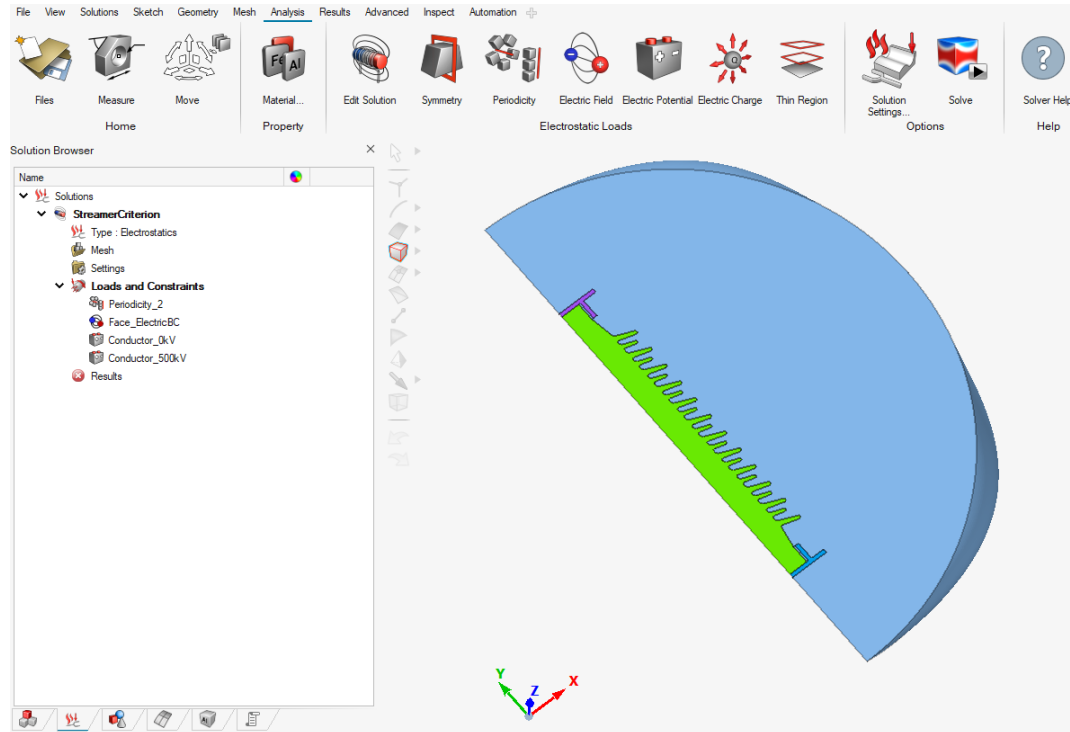
- Define Electric Potential
 - [Analysis] – [Electric Potential]
 - Conductor_0kV
 - Conductor_500kV



3D ELECTROSTATIC ANALYSIS

Physical Description

- Final physics-defined model



3D ELECTROSTATIC ANALYSIS

Physical Description

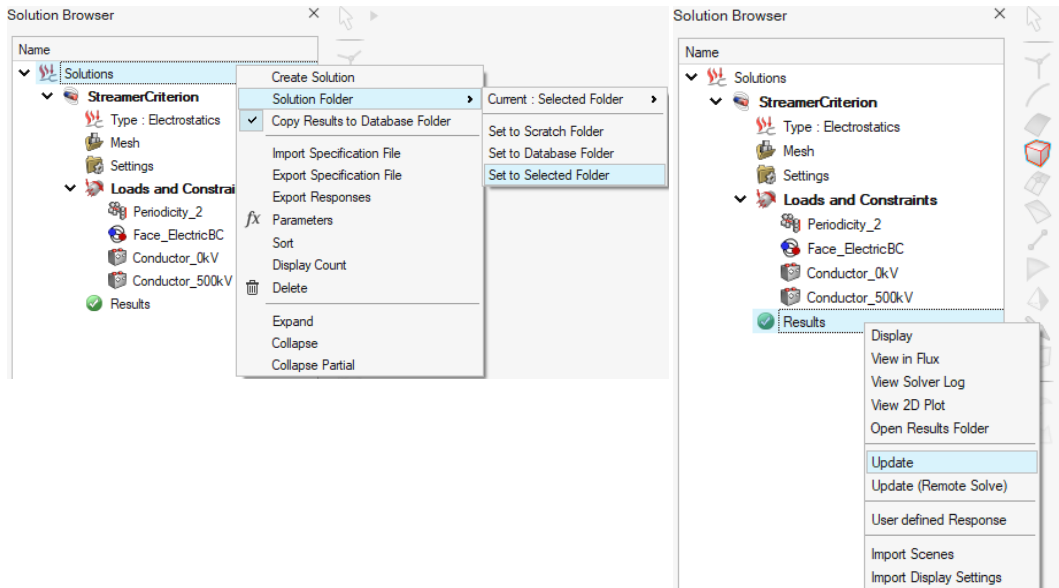
- Final physics-defined model
 - Save the project [File] – [Save As]
 - Save the project as “3D_ES_Insulator_Phys.slb”

SOLVING PROCESS

3D ELECTROSTATIC ANALYSIS

Solving Process

- Solve the electrostatic simulation project
- Right click on the “Solutions” and select the solving folder for Flux



Notes:

The solving process takes about 2 min depending on the computer on which it is run.

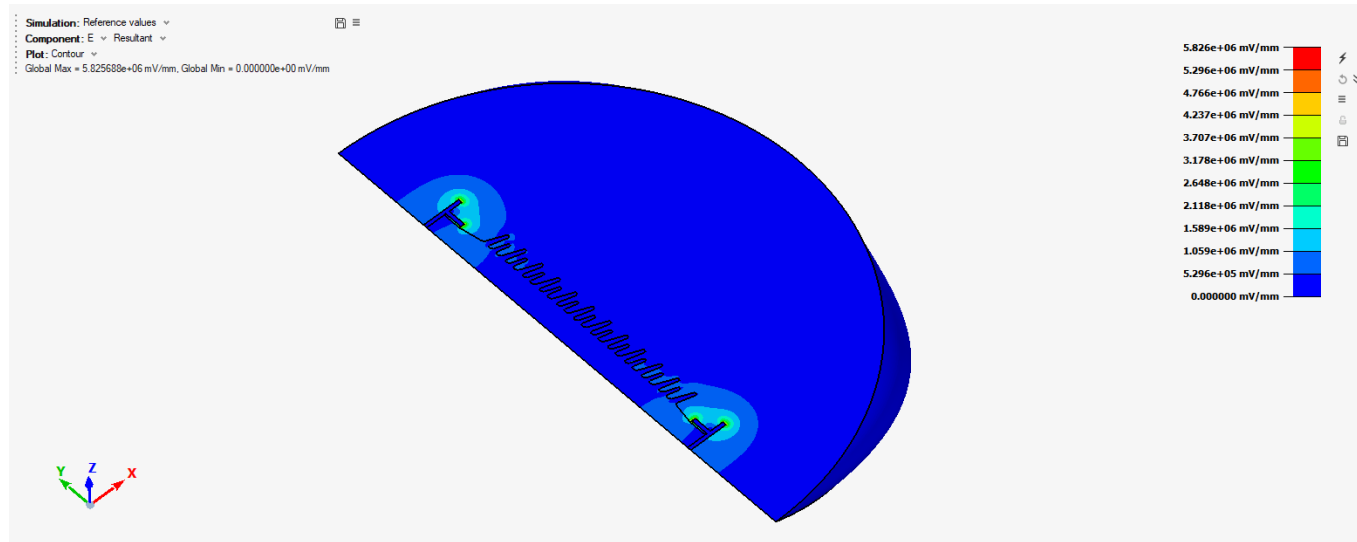
- ✓ Results means that the solving process is completed
- Results means that the solving process is in progress

BASIC POST-PROCESSING

3D ELECTROSTATIC ANALYSIS

Basic Post-Processing

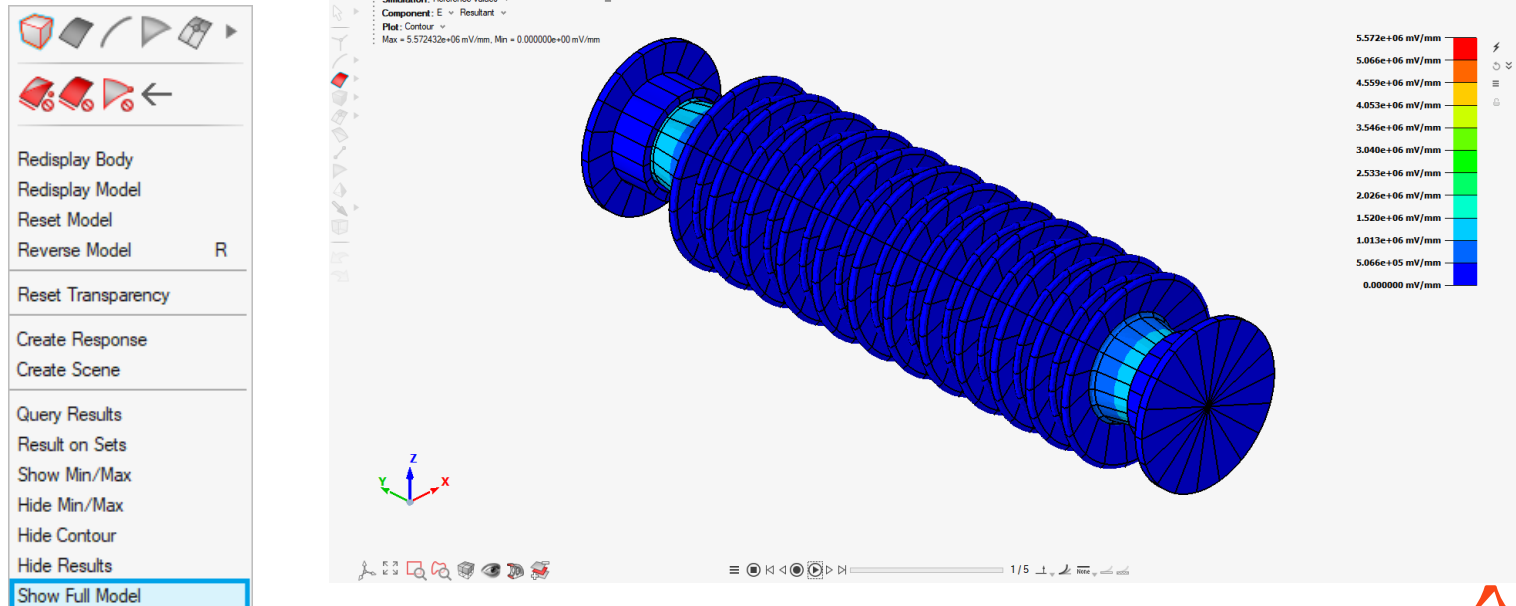
- Insulator simulation
 - Isovalues display (electric field E)



3D ELECTROSTATIC ANALYSIS

Basic Post-Processing

- Insulator simulation
- Isovalue display (electric field E) – on full model



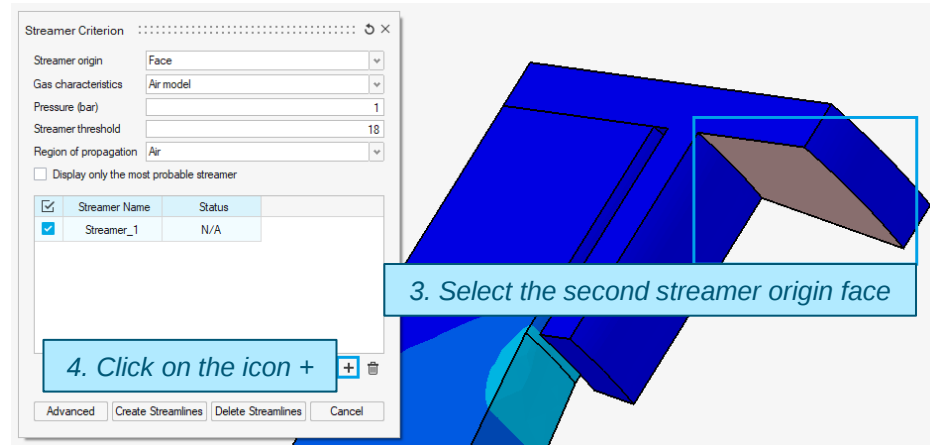
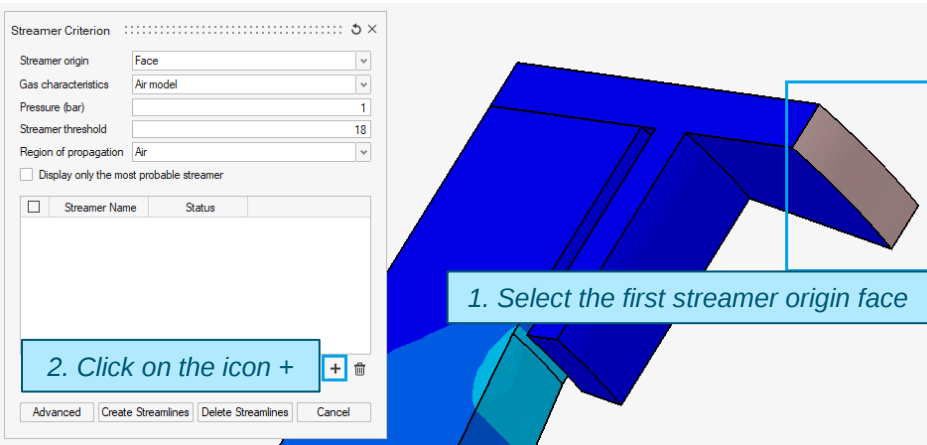
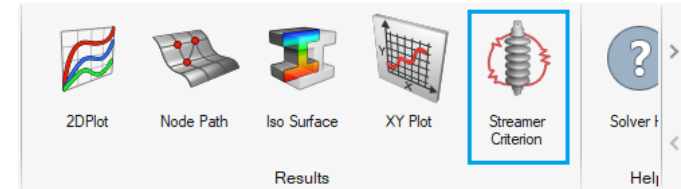
36

Click on "Show Full Model" to show the results on full motor model

3D ELECTROSTATIC ANALYSIS

Basic Post-Processing

- Streamer criterion simulation
 - Streamer criterion display
 - Create streamer



3D ELECTROSTATIC ANALYSIS

Basic Post-Processing

- Streamer criterion simulation
- Streamer criterion display
- Create streamlines



Streamer Criterion

Streamer origin: Face

Gas characteristics: Air model

Pressure (bar): 1

Streamer threshold: 18

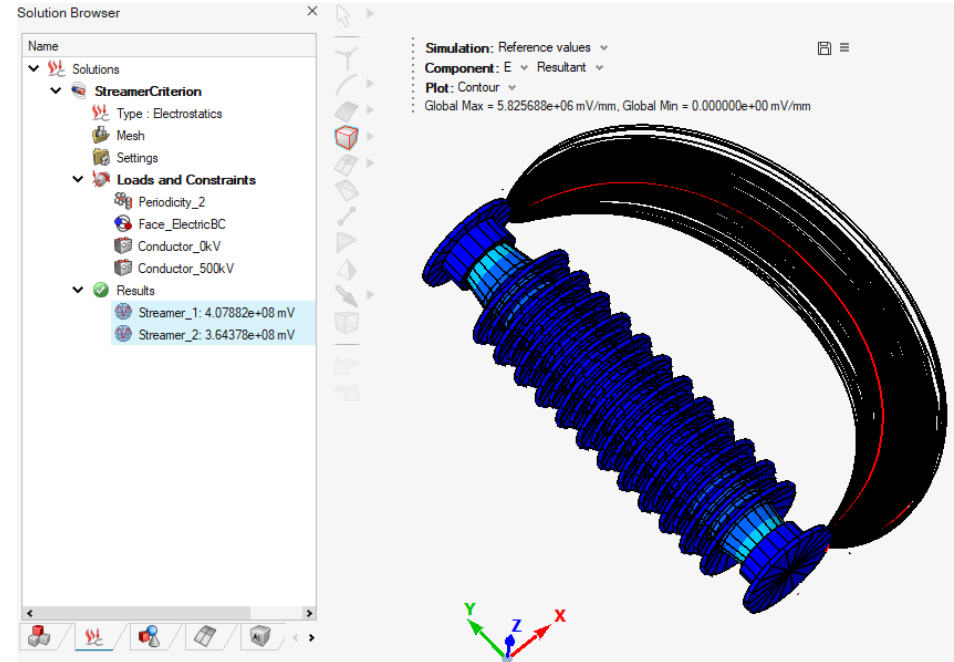
Region of propagation: Air

☐ Display only the most probable streamer

☒	Streamer Name	Status
☒	Streamer_1	N/A
☒	Streamer_2	N/A

Click on [Create Streamlines]

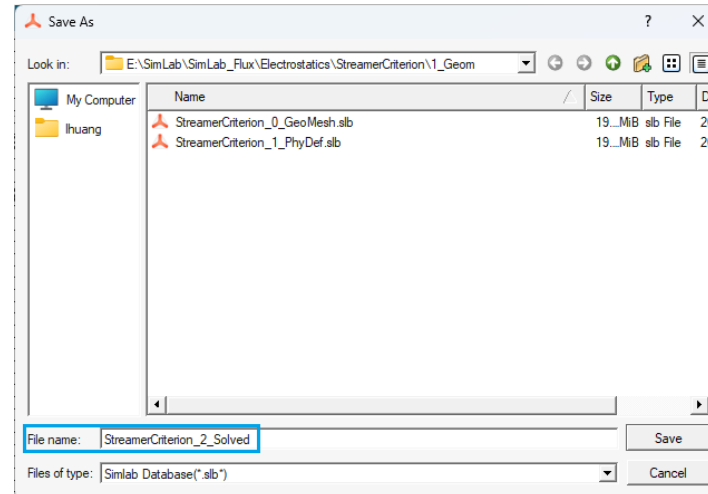
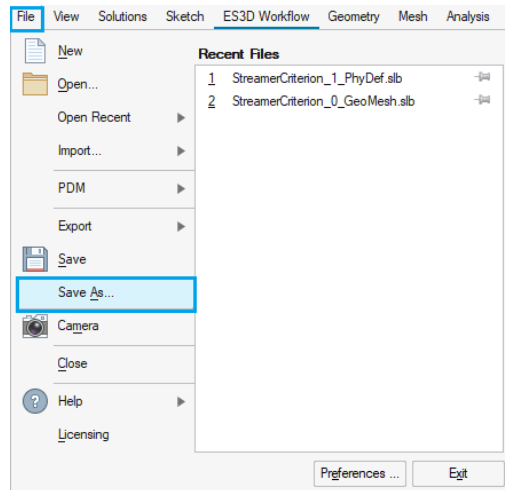
Advanced Create Streamlines Delete Streamlines Cancel

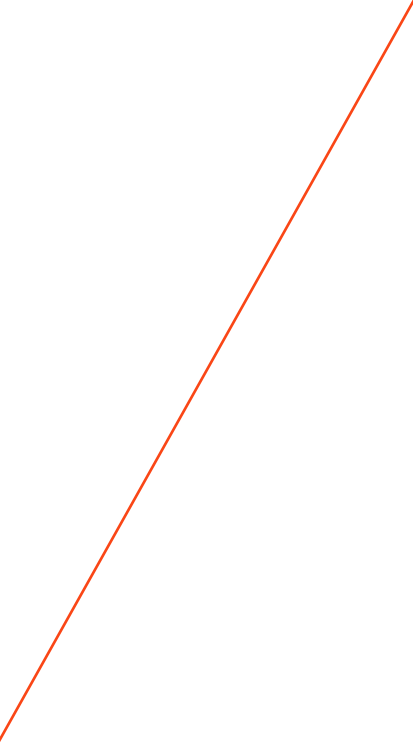


3D ELECTROSTATIC ANALYSIS

Basic Post-Processing

- Final solved model
 - Save the project [File] – [Save As]
 - Save the project as “StreamerCriterion_2_Solved”





THANK YOU

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#ONLYFORWARD