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Simulation PPF report

|  |  |
| --- | --- |
| Report date | Nov 16, 2022, 9:54:44 PM |

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1. Global Definitions

|  |  |
| --- | --- |
| Date | Nov 16, 2022, 7:08:19 PM |

Global settings

|  |  |
| --- | --- |
| Name | Simulation PPF report.mph |
| Path | G:\xty\Simulation PPF report.mph |
| Version | COMSOL Multiphysics 6.0 (Build: 318) |

Used products

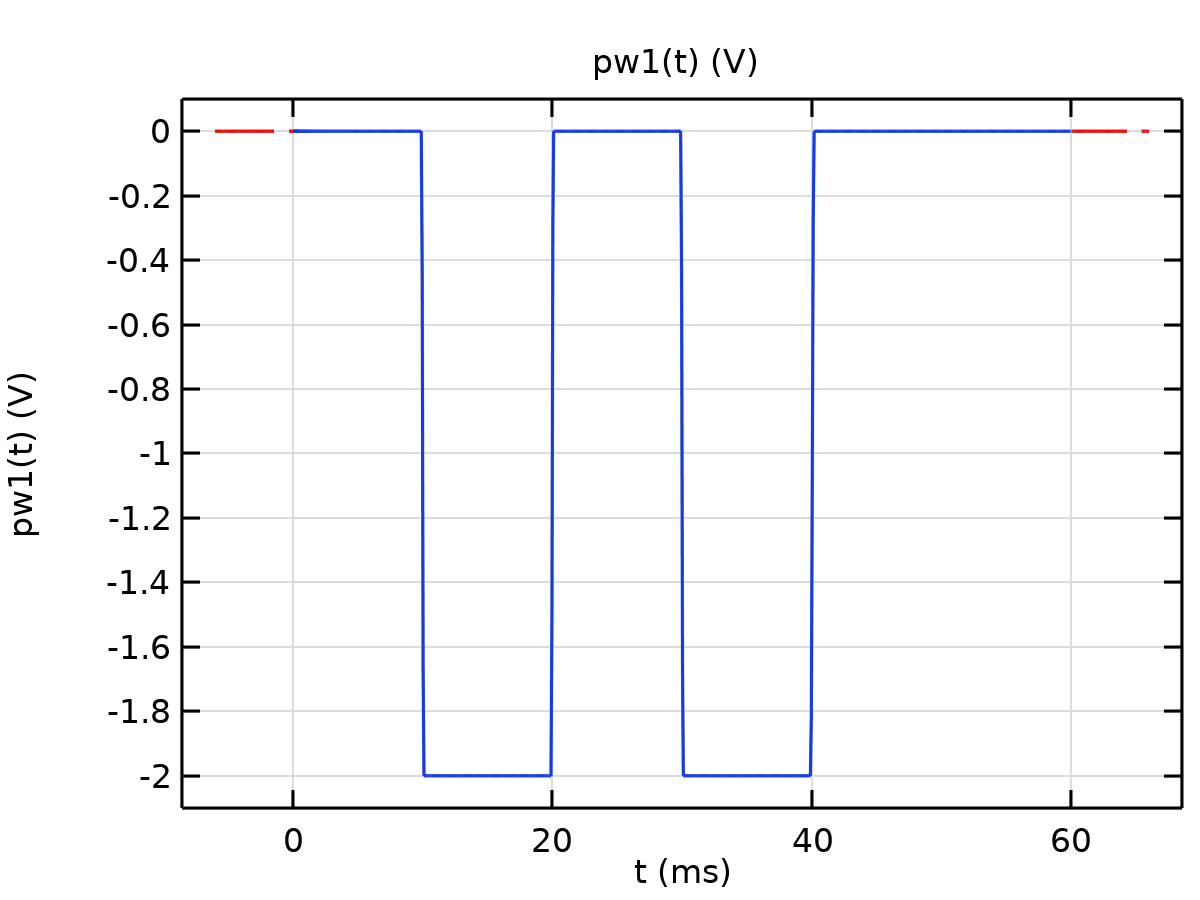
|  |
| --- |
| COMSOL Multiphysics |
| Chemical Reaction Engineering Module |

Computer information

|  |  |
| --- | --- |
| CPU | Intel(R) Xeon(R) CPU E5-2680 v4 @ 2.40GHz, 56 cores |
| Operating system | Windows 7 |

* 1. Functions
     1. Piecewise 1

|  |  |
| --- | --- |
| Function name | pw1 |
| Function type | Piecewise |



Piecewise 1

Definition

| **Description** | **Value** |
| --- | --- |
| Argument | t |
| Extrapolation | Constant |
| Smoothing | Continuous second derivative |
| Size of transition zone | 0.01 |
| Smooth at endpoints | On |

Definition

| **Start** | **End** | **Function** |
| --- | --- | --- |
| 0 | 10 | 0 |
| 10 | 20 | 2 |
| 20 | 30 | 0 |
| 30 | 40 | 2 |
| 40 | 60 | 0 |

Units

| **Description** | **Value** |
| --- | --- |
| Arguments | ms |
| Function | V |

* 1. Shared Properties
     1. Default Model Inputs

|  |  |
| --- | --- |
| Tag | cminpt |

1. Component

Settings

| **Description** | **Value** |
| --- | --- |
| Unit system | Same as global system (SI) |
| Avoid inverted elements by curving interior domain elements | Off |

* 1. Definitions
     1. Coordinate Systems

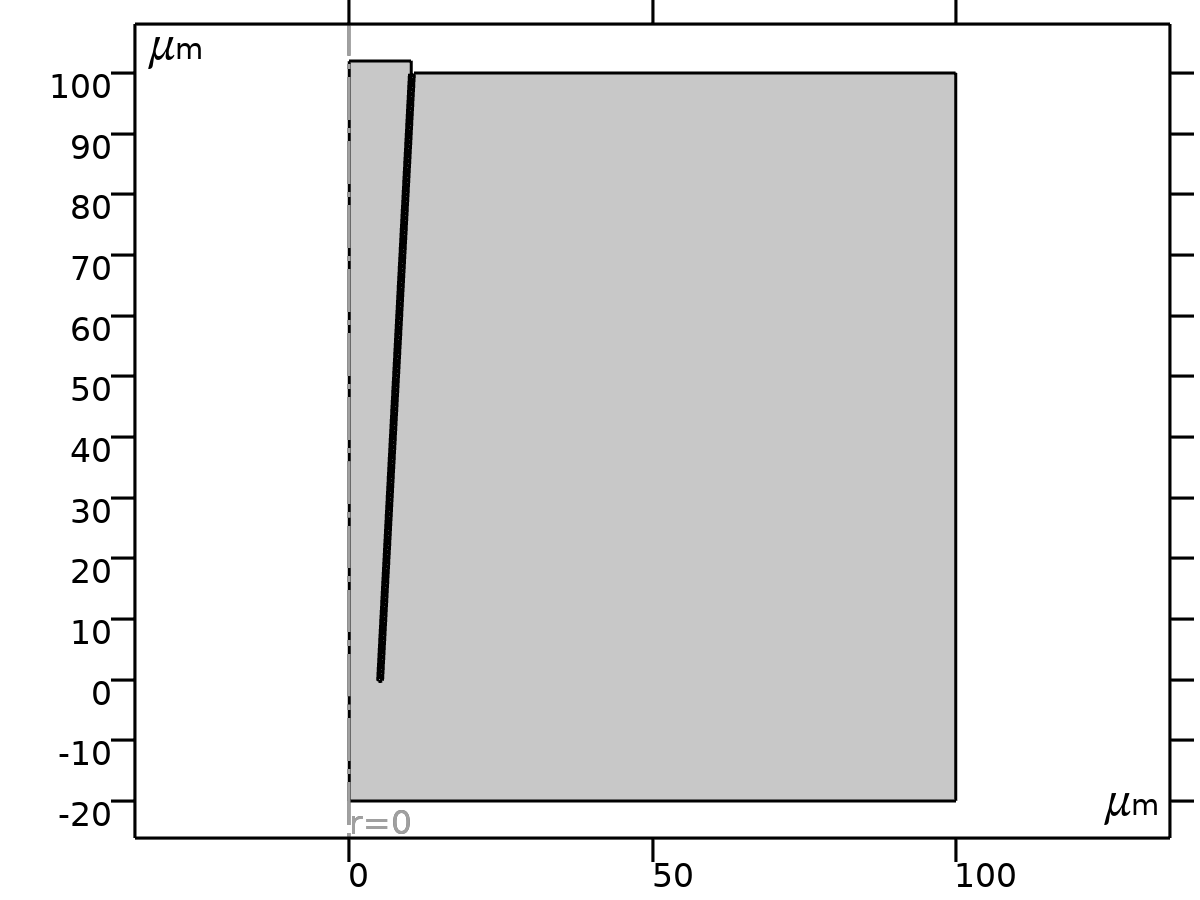
#### Boundary System

|  |  |
| --- | --- |
| Coordinate system type | Boundary system |
| Tag | sys1 |

Coordinate names

| **First** | **Second** | **Third** |
| --- | --- | --- |
| t1 | to | n |

* 1. Geometry



Geometry

Units

|  |  |
| --- | --- |
| Length unit | µm |
| Angular unit | deg |

Geometry statistics

| **Description** | **Value** |
| --- | --- |
| Space dimension | 2 |
| Number of domains | 2 |
| Number of boundaries | 19 |
| Number of vertices | 18 |

* + 1. Polygon (pol1)

Object type

| **Description** | **Value** |
| --- | --- |
| Type | Solid |

Coordinates

| **Description** | **Value** |
| --- | --- |
| Data source | Table |

Coordinates

| **r (µm)** | **z (µm)** |
| --- | --- |
| 0 | -20 |
| 100 | -20 |
| 100 | 100 |
| 10.74 | 100 |
| 5.5 | 0 |
| 5 | 0 |
| 10.24 | 100 |
| 10.24 | 102 |
| 0 | 102 |
| 0 | -20 |

* + 1. Bezier Polygon (b1)

Polygon segments

| **Description** | **Value** |
| --- | --- |
| Control points | {{10.24, 9.94, 4.7, 4.7, 5.5, 5.5, 5, 10.24}, {100, 100, 0, -0.3, -0.3, 0, 0, 100}} |
| Degree | {1, 1, 1, 1, 1, 1, 1} |
| Weights | {1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1} |
| Type | Solid |

* + 1. Fillet (fil1)

Settings

| **Description** | **Value** |
| --- | --- |
| Radius | 0.28 |

* + 1. Fillet 2 (fil2)

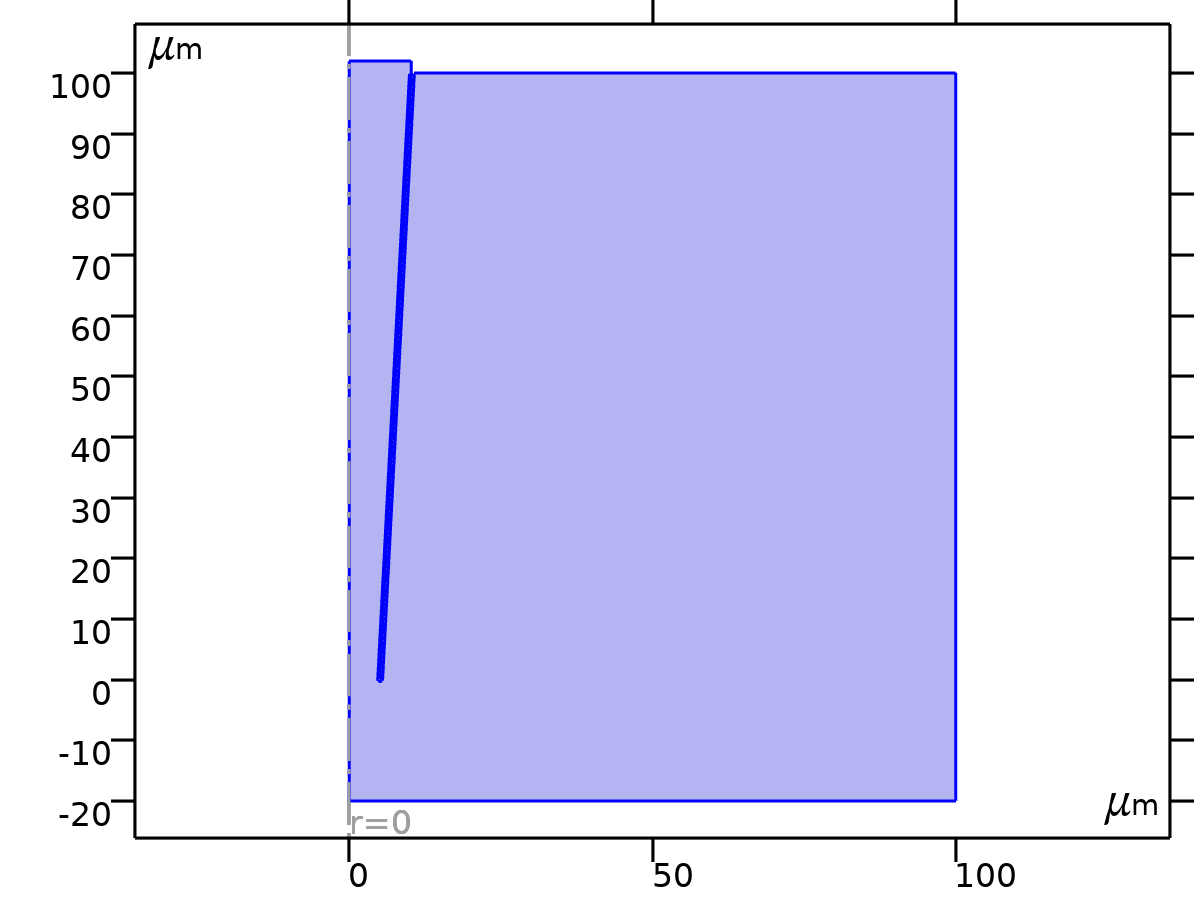
Settings

| **Description** | **Value** |
| --- | --- |
| Radius | 0.28 |

* 1. Transport of Diluted Species

Used products

|  |
| --- |
| COMSOL Multiphysics |
| Chemical Reaction Engineering Module |



Transport of Diluted Species

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Geometry geom1: Dimension 2: All domains |

Equations





* + 1. Interface Settings

#### Discretization

Settings

| **Description** | **Value** |
| --- | --- |
| Concentration | Linear |

Settings

| **Description** | **Value** |
| --- | --- |
| Equation form | Study controlled |

#### Transport Mechanisms

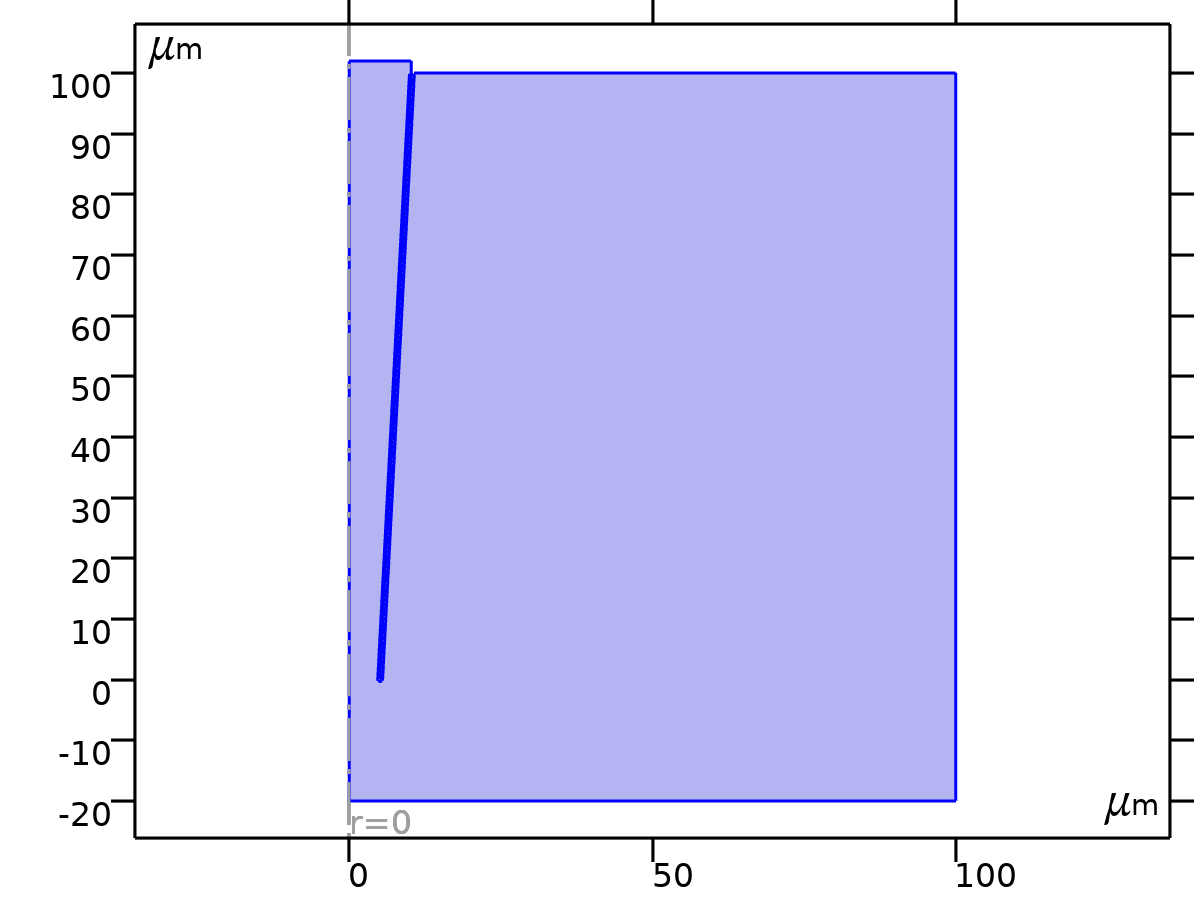
Settings

| **Description** | **Value** |
| --- | --- |
| Convection | Off |
| Migration in electric field | On |
| Mass transfer in porous media | Off |

* + 1. Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** | **Details** |
| --- | --- | --- | --- | --- | --- |
| tds.d | 1 | 1 | Out-of-plane geometry extension | Global |  |
| tds.nr | nr | 1 | Normal vector, r component | Boundaries 4–6, 9, 11, 15–16, 18–19 |  |
| tds.nphi | 0 | 1 | Normal vector, phi component | Boundaries 4–6, 9, 11, 15–16, 18–19 |  |
| tds.nz | nz | 1 | Normal vector, z component | Boundaries 4–6, 9, 11, 15–16, 18–19 |  |
| tds.nr | dnr | 1 | Normal vector, r component | Boundaries 1–3, 7–8, 10, 12–14, 17 |  |
| tds.nphi | 0 | 1 | Normal vector, phi component | Boundaries 1–3, 7–8, 10, 12–14, 17 |  |
| tds.nz | dnz | 1 | Normal vector, z component | Boundaries 1–3, 7–8, 10, 12–14, 17 |  |
| tds.nrmesh | nrmesh | 1 | Normal vector (mesh), r component | Boundaries 4–6, 9, 11, 15–16, 18–19 |  |
| tds.nphimesh | 0 | 1 | Normal vector (mesh), phi component | Boundaries 4–6, 9, 11, 15–16, 18–19 |  |
| tds.nzmesh | nzmesh | 1 | Normal vector (mesh), z component | Boundaries 4–6, 9, 11, 15–16, 18–19 |  |
| tds.nrmesh | dnrmesh | 1 | Normal vector (mesh), r component | Boundaries 1–3, 7–8, 10, 12–14, 17 |  |
| tds.nphimesh | 0 | 1 | Normal vector (mesh), phi component | Boundaries 1–3, 7–8, 10, 12–14, 17 |  |
| tds.nzmesh | dnzmesh | 1 | Normal vector (mesh), z component | Boundaries 1–3, 7–8, 10, 12–14, 17 |  |
| tds.nrc | root.nrc/tds.ncLen | 1 | Normal vector, r component | Boundaries 1–19 |  |
| tds.nphic | 0 | 1 | Normal vector, phi component | Boundaries 1–19 |  |
| tds.nzc | root.nzc/tds.ncLen | 1 | Normal vector, z component | Boundaries 1–19 |  |
| tds.ncLen | sqrt(root.nrc^2+root.nzc^2+eps) | 1 | Help variable | Boundaries 1–19 |  |
| tds.R\_c | 0 | mol/(m³·s) | Total rate expression | Domains 1–2 | + operation |
| tds.cP\_c | 0 | mol/kg | Concentration species adsorbed to the solid | Domains 1–2 | + operation |
| tds.cP\_c | 0 | mol/kg | Concentration species adsorbed to the solid | Boundaries 1–19 | + operation |
| tds.KP\_c | 0 | m³/kg | Adsorption isotherm, first concentration derivative | Domains 1–2 | + operation |
| tds.KP\_c | 0 | m³/kg | Adsorption isotherm, first concentration derivative | Boundaries 1–19 | + operation |
| tds.Rads\_c | 0 | mol/(m³·s) | Total adsorption rate | Domains 1–2 | + operation |
| tds.DiT\_c | 0 | m²/s | Turbulent diffusivity | Domains 1–2 |  |
| tds.cVar\_c | c | mol/m³ | Species | Boundaries 1–19 |  |
| tds.R\_c2 | 0 | mol/(m³·s) | Total rate expression | Domains 1–2 | + operation |
| tds.cP\_c2 | 0 | mol/kg | Concentration species adsorbed to the solid | Domains 1–2 | + operation |
| tds.cP\_c2 | 0 | mol/kg | Concentration species adsorbed to the solid | Boundaries 1–19 | + operation |
| tds.KP\_c2 | 0 | m³/kg | Adsorption isotherm, first concentration derivative | Domains 1–2 | + operation |
| tds.KP\_c2 | 0 | m³/kg | Adsorption isotherm, first concentration derivative | Boundaries 1–19 | + operation |
| tds.Rads\_c2 | 0 | mol/(m³·s) | Total adsorption rate | Domains 1–2 | + operation |
| tds.DiT\_c2 | 0 | m²/s | Turbulent diffusivity | Domains 1–2 |  |
| tds.cVar\_c2 | c2 | mol/m³ | Species | Boundaries 1–19 |  |
| tds.poro | 1 | 1 | Porosity | Domains 1–2 |  |
| tds.theta\_g | 0 | 1 | Gas volume fraction | Domains 1–2 |  |
| tds.theta\_l | 1 | 1 | Liquid volume fraction | Domains 1–2 |  |
| tds.theta | tds.poro | 1 | Mobile fluid volume fraction | Domains 1–2 |  |

* + 1. Transport Properties



Transport Properties

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Geometry geom1: Dimension 2: All domains |

Equations





#### Diffusion

Settings

| **Description** | **Value** |
| --- | --- |
| Source | Material |
| Material | None |
| Diffusion coefficient | User defined |
| Diffusion coefficient | {{1.957e-9[m^2/s], 0, 0}, {0, 1.957e-9[m^2/s], 0}, {0, 0, 1.957e-9[m^2/s]}} |
| Diffusion coefficient | User defined |
| Diffusion coefficient | {{2.032e-9[m^2/s], 0, 0}, {0, 2.032e-9[m^2/s], 0}, {0, 0, 2.032e-9[m^2/s]}} |

#### Migration in Electric Field

Settings

| **Description** | **Value** |
| --- | --- |
| Electric potential | Electric potential (es) |
| Mobility | Nernst - Einstein relation |
| Charge number | {1, -1} |

#### Coordinate System Selection

Settings

| **Description** | **Value** |
| --- | --- |
| Coordinate system | Global coordinate system |

#### Model Input

Settings

| **Description** | **Value** |
| --- | --- |
| Temperature | User defined |
| Temperature | 293.15[K] |

#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** | **Details** |
| --- | --- | --- | --- | --- | --- |
| domflux.cr | 2\*(tds.dflux\_cr+tds.mflux\_cr)\*pi\*r\*tds.d | mol/(m·s) | Domain flux, r component | Domains 1–2 |  |
| domflux.cz | 2\*(tds.dflux\_cz+tds.mflux\_cz)\*pi\*r\*tds.d | mol/(m·s) | Domain flux, z component | Domains 1–2 |  |
| domflux.c2r | 2\*(tds.dflux\_c2r+tds.mflux\_c2r)\*pi\*r\*tds.d | mol/(m·s) | Domain flux, r component | Domains 1–2 |  |
| domflux.c2z | 2\*(tds.dflux\_c2z+tds.mflux\_c2z)\*pi\*r\*tds.d | mol/(m·s) | Domain flux, z component | Domains 1–2 |  |
| tds.ndflux\_c | tds.dflux\_cr\*tds.nrc+tds.dflux\_cphi\*tds.nphic+tds.dflux\_cz\*tds.nzc | mol/(m²·s) | Normal diffusive flux | Boundaries 2–19 |  |
| tds.nmflux\_c | tds.mflux\_cr\*tds.nrc+tds.mflux\_cphi\*tds.nphic+tds.mflux\_cz\*tds.nzc | mol/(m²·s) | Normal electrophoretic flux | Boundaries 2–19 |  |
| tds.ntflux\_c | tds.bndFlux\_c | mol/(m²·s) | Normal total flux | Boundaries 2–19 |  |
| tds.ndflux\_c2 | tds.dflux\_c2r\*tds.nrc+tds.dflux\_c2phi\*tds.nphic+tds.dflux\_c2z\*tds.nzc | mol/(m²·s) | Normal diffusive flux | Boundaries 2–19 |  |
| tds.nmflux\_c2 | tds.mflux\_c2r\*tds.nrc+tds.mflux\_c2phi\*tds.nphic+tds.mflux\_c2z\*tds.nzc | mol/(m²·s) | Normal electrophoretic flux | Boundaries 2–19 |  |
| tds.ntflux\_c2 | tds.bndFlux\_c2 | mol/(m²·s) | Normal total flux | Boundaries 2–19 |  |
| tds.bndFlux\_c | 0.25\*(uflux\_spatial(c)-dflux\_spatial(c))/(pi\*r\*tds.d) | mol/(m²·s) | Boundary flux | Boundaries 4–6, 9, 11, 15–16, 18–19 | Meta |
| tds.bndFlux\_c | -dflux\_spatial(c)/tds.d | mol/(m²·s) | Boundary flux | Boundary 1 |  |
| tds.bndFlux\_c | -0.5\*dflux\_spatial(c)/(pi\*r\*tds.d) | mol/(m²·s) | Boundary flux | Boundaries 2–3, 7–8, 10, 12–14, 17 | Meta |
| tds.bndFlux\_c2 | 0.25\*(uflux\_spatial(c2)-dflux\_spatial(c2))/(pi\*r\*tds.d) | mol/(m²·s) | Boundary flux | Boundaries 4–6, 9, 11, 15–16, 18–19 | Meta |
| tds.bndFlux\_c2 | -dflux\_spatial(c2)/tds.d | mol/(m²·s) | Boundary flux | Boundary 1 |  |
| tds.bndFlux\_c2 | -0.5\*dflux\_spatial(c2)/(pi\*r\*tds.d) | mol/(m²·s) | Boundary flux | Boundaries 2–3, 7–8, 10, 12–14, 17 | Meta |
| tds.DF\_crr | 1.957E-9[m^2/s] | m²/s | Fluid diffusion coefficient, rr component | Domains 1–2 |  |
| tds.DF\_cphir | 0 | m²/s | Fluid diffusion coefficient, phir component | Domains 1–2 |  |
| tds.DF\_czr | 0 | m²/s | Fluid diffusion coefficient, zr component | Domains 1–2 |  |
| tds.DF\_crphi | 0 | m²/s | Fluid diffusion coefficient, rphi component | Domains 1–2 |  |
| tds.DF\_cphiphi | 1.957E-9[m^2/s] | m²/s | Fluid diffusion coefficient, phiphi component | Domains 1–2 |  |
| tds.DF\_czphi | 0 | m²/s | Fluid diffusion coefficient, zphi component | Domains 1–2 |  |
| tds.DF\_crz | 0 | m²/s | Fluid diffusion coefficient, rz component | Domains 1–2 |  |
| tds.DF\_cphiz | 0 | m²/s | Fluid diffusion coefficient, phiz component | Domains 1–2 |  |
| tds.DF\_czz | 1.957E-9[m^2/s] | m²/s | Fluid diffusion coefficient, zz component | Domains 1–2 |  |
| tds.D\_crr | tds.DF\_crr+tds.DiT\_c | m²/s | Diffusion coefficient, rr component | Domains 1–2 |  |
| tds.D\_cphir | tds.DF\_cphir | m²/s | Diffusion coefficient, phir component | Domains 1–2 |  |
| tds.D\_czr | tds.DF\_czr | m²/s | Diffusion coefficient, zr component | Domains 1–2 |  |
| tds.D\_crphi | tds.DF\_crphi | m²/s | Diffusion coefficient, rphi component | Domains 1–2 |  |
| tds.D\_cphiphi | tds.DF\_cphiphi+tds.DiT\_c | m²/s | Diffusion coefficient, phiphi component | Domains 1–2 |  |
| tds.D\_czphi | tds.DF\_czphi | m²/s | Diffusion coefficient, zphi component | Domains 1–2 |  |
| tds.D\_crz | tds.DF\_crz | m²/s | Diffusion coefficient, rz component | Domains 1–2 |  |
| tds.D\_cphiz | tds.DF\_cphiz | m²/s | Diffusion coefficient, phiz component | Domains 1–2 |  |
| tds.D\_czz | tds.DF\_czz+tds.DiT\_c | m²/s | Diffusion coefficient, zz component | Domains 1–2 |  |
| tds.DF\_c2rr | 2.032E-9[m^2/s] | m²/s | Fluid diffusion coefficient, rr component | Domains 1–2 |  |
| tds.DF\_c2phir | 0 | m²/s | Fluid diffusion coefficient, phir component | Domains 1–2 |  |
| tds.DF\_c2zr | 0 | m²/s | Fluid diffusion coefficient, zr component | Domains 1–2 |  |
| tds.DF\_c2rphi | 0 | m²/s | Fluid diffusion coefficient, rphi component | Domains 1–2 |  |
| tds.DF\_c2phiphi | 2.032E-9[m^2/s] | m²/s | Fluid diffusion coefficient, phiphi component | Domains 1–2 |  |
| tds.DF\_c2zphi | 0 | m²/s | Fluid diffusion coefficient, zphi component | Domains 1–2 |  |
| tds.DF\_c2rz | 0 | m²/s | Fluid diffusion coefficient, rz component | Domains 1–2 |  |
| tds.DF\_c2phiz | 0 | m²/s | Fluid diffusion coefficient, phiz component | Domains 1–2 |  |
| tds.DF\_c2zz | 2.032E-9[m^2/s] | m²/s | Fluid diffusion coefficient, zz component | Domains 1–2 |  |
| tds.D\_c2rr | tds.DF\_c2rr+tds.DiT\_c2 | m²/s | Diffusion coefficient, rr component | Domains 1–2 |  |
| tds.D\_c2phir | tds.DF\_c2phir | m²/s | Diffusion coefficient, phir component | Domains 1–2 |  |
| tds.D\_c2zr | tds.DF\_c2zr | m²/s | Diffusion coefficient, zr component | Domains 1–2 |  |
| tds.D\_c2rphi | tds.DF\_c2rphi | m²/s | Diffusion coefficient, rphi component | Domains 1–2 |  |
| tds.D\_c2phiphi | tds.DF\_c2phiphi+tds.DiT\_c2 | m²/s | Diffusion coefficient, phiphi component | Domains 1–2 |  |
| tds.D\_c2zphi | tds.DF\_c2zphi | m²/s | Diffusion coefficient, zphi component | Domains 1–2 |  |
| tds.D\_c2rz | tds.DF\_c2rz | m²/s | Diffusion coefficient, rz component | Domains 1–2 |  |
| tds.D\_c2phiz | tds.DF\_c2phiz | m²/s | Diffusion coefficient, phiz component | Domains 1–2 |  |
| tds.D\_c2zz | tds.DF\_c2zz+tds.DiT\_c2 | m²/s | Diffusion coefficient, zz component | Domains 1–2 |  |
| tds.Dav\_c | 0.5\*(tds.D\_crr+tds.D\_czz) | m²/s | Average diffusion coefficient | Domains 1–2 |  |
| tds.Dav\_c2 | 0.5\*(tds.D\_c2rr+tds.D\_c2zz) | m²/s | Average diffusion coefficient | Domains 1–2 |  |
| tds.tflux\_cr | tds.dflux\_cr+tds.mflux\_cr | mol/(m²·s) | Total flux, r component | Domains 1–2 | + operation |
| tds.tflux\_cphi | tds.dflux\_cphi+tds.mflux\_cphi | mol/(m²·s) | Total flux, phi component | Domains 1–2 | + operation |
| tds.tflux\_cz | tds.dflux\_cz+tds.mflux\_cz | mol/(m²·s) | Total flux, z component | Domains 1–2 | + operation |
| tds.dfluxMag\_c | sqrt(tds.dflux\_cr^2+tds.dflux\_cphi^2+tds.dflux\_cz^2) | mol/(m²·s) | Diffusive flux magnitude | Domains 1–2 |  |
| tds.tfluxMag\_c | sqrt(tds.tflux\_cr^2+tds.tflux\_cphi^2+tds.tflux\_cz^2) | mol/(m²·s) | Total flux magnitude | Domains 1–2 |  |
| tds.dpflux\_cr | 0 | mol/(m²·s) | Dispersive flux, r component | Domains 1–2 |  |
| tds.dpflux\_cphi | 0 | mol/(m²·s) | Dispersive flux, phi component | Domains 1–2 |  |
| tds.dpflux\_cz | 0 | mol/(m²·s) | Dispersive flux, z component | Domains 1–2 |  |
| tds.mflux\_cr | tds.z\_c\*F\_const\*c\*(-tds.um\_crr\*d(tds.V,r)-tds.um\_crz\*d(tds.V,z)) | mol/(m²·s) | Electrophoretic flux, r component | Domains 1–2 |  |
| tds.mflux\_cphi | tds.z\_c\*F\_const\*c\*(-tds.um\_cphir\*d(tds.V,r)-tds.um\_cphiz\*d(tds.V,z)) | mol/(m²·s) | Electrophoretic flux, phi component | Domains 1–2 |  |
| tds.mflux\_cz | tds.z\_c\*F\_const\*c\*(-tds.um\_czr\*d(tds.V,r)-tds.um\_czz\*d(tds.V,z)) | mol/(m²·s) | Electrophoretic flux, z component | Domains 1–2 |  |
| tds.mfluxMag\_c | sqrt(tds.mflux\_cr^2+tds.mflux\_cphi^2+tds.mflux\_cz^2) | mol/(m²·s) | Electrophoretic flux magnitude | Domains 1–2 |  |
| tds.tflux\_c2r | tds.dflux\_c2r+tds.mflux\_c2r | mol/(m²·s) | Total flux, r component | Domains 1–2 | + operation |
| tds.tflux\_c2phi | tds.dflux\_c2phi+tds.mflux\_c2phi | mol/(m²·s) | Total flux, phi component | Domains 1–2 | + operation |
| tds.tflux\_c2z | tds.dflux\_c2z+tds.mflux\_c2z | mol/(m²·s) | Total flux, z component | Domains 1–2 | + operation |
| tds.dfluxMag\_c2 | sqrt(tds.dflux\_c2r^2+tds.dflux\_c2phi^2+tds.dflux\_c2z^2) | mol/(m²·s) | Diffusive flux magnitude | Domains 1–2 |  |
| tds.tfluxMag\_c2 | sqrt(tds.tflux\_c2r^2+tds.tflux\_c2phi^2+tds.tflux\_c2z^2) | mol/(m²·s) | Total flux magnitude | Domains 1–2 |  |
| tds.dpflux\_c2r | 0 | mol/(m²·s) | Dispersive flux, r component | Domains 1–2 |  |
| tds.dpflux\_c2phi | 0 | mol/(m²·s) | Dispersive flux, phi component | Domains 1–2 |  |
| tds.dpflux\_c2z | 0 | mol/(m²·s) | Dispersive flux, z component | Domains 1–2 |  |
| tds.mflux\_c2r | tds.z\_c2\*F\_const\*c2\*(-tds.um\_c2rr\*d(tds.V,r)-tds.um\_c2rz\*d(tds.V,z)) | mol/(m²·s) | Electrophoretic flux, r component | Domains 1–2 |  |
| tds.mflux\_c2phi | tds.z\_c2\*F\_const\*c2\*(-tds.um\_c2phir\*d(tds.V,r)-tds.um\_c2phiz\*d(tds.V,z)) | mol/(m²·s) | Electrophoretic flux, phi component | Domains 1–2 |  |
| tds.mflux\_c2z | tds.z\_c2\*F\_const\*c2\*(-tds.um\_c2zr\*d(tds.V,r)-tds.um\_c2zz\*d(tds.V,z)) | mol/(m²·s) | Electrophoretic flux, z component | Domains 1–2 |  |
| tds.mfluxMag\_c2 | sqrt(tds.mflux\_c2r^2+tds.mflux\_c2phi^2+tds.mflux\_c2z^2) | mol/(m²·s) | Electrophoretic flux magnitude | Domains 1–2 |  |
| tds.dflux\_cr | -tds.D\_crr\*cr-tds.D\_crz\*cz | mol/(m²·s) | Diffusive flux, r component | Domains 1–2 | + operation |
| tds.dflux\_cphi | -tds.D\_cphir\*cr-tds.D\_cphiz\*cz | mol/(m²·s) | Diffusive flux, phi component | Domains 1–2 | + operation |
| tds.dflux\_cz | -tds.D\_czr\*cr-tds.D\_czz\*cz | mol/(m²·s) | Diffusive flux, z component | Domains 1–2 | + operation |
| tds.grad\_cr | cr | mol/m⁴ | Concentration gradient, r component | Domains 1–2 |  |
| tds.grad\_cphi | 0 | mol/m⁴ | Concentration gradient, phi component | Domains 1–2 |  |
| tds.grad\_cz | cz | mol/m⁴ | Concentration gradient, z component | Domains 1–2 |  |
| tds.dflux\_c2r | -tds.D\_c2rr\*c2r-tds.D\_c2rz\*c2z | mol/(m²·s) | Diffusive flux, r component | Domains 1–2 | + operation |
| tds.dflux\_c2phi | -tds.D\_c2phir\*c2r-tds.D\_c2phiz\*c2z | mol/(m²·s) | Diffusive flux, phi component | Domains 1–2 | + operation |
| tds.dflux\_c2z | -tds.D\_c2zr\*c2r-tds.D\_c2zz\*c2z | mol/(m²·s) | Diffusive flux, z component | Domains 1–2 | + operation |
| tds.grad\_c2r | c2r | mol/m⁴ | Concentration gradient, r component | Domains 1–2 |  |
| tds.grad\_c2phi | 0 | mol/m⁴ | Concentration gradient, phi component | Domains 1–2 |  |
| tds.grad\_c2z | c2z | mol/m⁴ | Concentration gradient, z component | Domains 1–2 |  |
| tds.um\_crr | tds.D\_crr/(R\_const\*tds.T) | s·mol/kg | Mobility, rr component | Domains 1–2 |  |
| tds.um\_cphir | tds.D\_cphir/(R\_const\*tds.T) | s·mol/kg | Mobility, phir component | Domains 1–2 |  |
| tds.um\_czr | tds.D\_czr/(R\_const\*tds.T) | s·mol/kg | Mobility, zr component | Domains 1–2 |  |
| tds.um\_crphi | tds.D\_crphi/(R\_const\*tds.T) | s·mol/kg | Mobility, rphi component | Domains 1–2 |  |
| tds.um\_cphiphi | tds.D\_cphiphi/(R\_const\*tds.T) | s·mol/kg | Mobility, phiphi component | Domains 1–2 |  |
| tds.um\_czphi | tds.D\_czphi/(R\_const\*tds.T) | s·mol/kg | Mobility, zphi component | Domains 1–2 |  |
| tds.um\_crz | tds.D\_crz/(R\_const\*tds.T) | s·mol/kg | Mobility, rz component | Domains 1–2 |  |
| tds.um\_cphiz | tds.D\_cphiz/(R\_const\*tds.T) | s·mol/kg | Mobility, phiz component | Domains 1–2 |  |
| tds.um\_czz | tds.D\_czz/(R\_const\*tds.T) | s·mol/kg | Mobility, zz component | Domains 1–2 |  |
| tds.z\_c | 1 | 1 | Charge number | Domains 1–2 |  |
| tds.um\_c2rr | tds.D\_c2rr/(R\_const\*tds.T) | s·mol/kg | Mobility, rr component | Domains 1–2 |  |
| tds.um\_c2phir | tds.D\_c2phir/(R\_const\*tds.T) | s·mol/kg | Mobility, phir component | Domains 1–2 |  |
| tds.um\_c2zr | tds.D\_c2zr/(R\_const\*tds.T) | s·mol/kg | Mobility, zr component | Domains 1–2 |  |
| tds.um\_c2rphi | tds.D\_c2rphi/(R\_const\*tds.T) | s·mol/kg | Mobility, rphi component | Domains 1–2 |  |
| tds.um\_c2phiphi | tds.D\_c2phiphi/(R\_const\*tds.T) | s·mol/kg | Mobility, phiphi component | Domains 1–2 |  |
| tds.um\_c2zphi | tds.D\_c2zphi/(R\_const\*tds.T) | s·mol/kg | Mobility, zphi component | Domains 1–2 |  |
| tds.um\_c2rz | tds.D\_c2rz/(R\_const\*tds.T) | s·mol/kg | Mobility, rz component | Domains 1–2 |  |
| tds.um\_c2phiz | tds.D\_c2phiz/(R\_const\*tds.T) | s·mol/kg | Mobility, phiz component | Domains 1–2 |  |
| tds.um\_c2zz | tds.D\_c2zz/(R\_const\*tds.T) | s·mol/kg | Mobility, zz component | Domains 1–2 |  |
| tds.z\_c2 | -1 | 1 | Charge number | Domains 1–2 |  |
| tds.V | model.input.V | V | Electric potential | Domains 1–2 | Meta |
| tds.T | tds.cdm1.minput\_temperature | K | Temperature | Domains 1–2 |  |
| tds.Res\_c | d(c\*tds.z\_c\*F\_const\*(-tds.um\_crr\*d(tds.V,r)-tds.um\_crz\*d(tds.V,z)),r)+if(abs(r)<0.001\*h\_spatial,d(c\*tds.z\_c\*F\_const\*(-tds.um\_crr\*d(tds.V,r)-tds.um\_crz\*d(tds.V,z)),r),c\*tds.z\_c\*F\_const\*(-tds.um\_crr\*d(tds.V,r)-tds.um\_crz\*d(tds.V,z))/r)+d(c\*tds.z\_c\*F\_const\*(-tds.um\_czr\*d(tds.V,r)-tds.um\_czz\*d(tds.V,z)),z)-tds.R\_c | mol/(m³·s) | Equation residual | Domains 1–2 |  |
| tds.Rlin\_c | 0 |  | Linear source term coefficient | Domains 1–2 |  |
| tds.Res\_c2 | d(c2\*tds.z\_c2\*F\_const\*(-tds.um\_c2rr\*d(tds.V,r)-tds.um\_c2rz\*d(tds.V,z)),r)+if(abs(r)<0.001\*h\_spatial,d(c2\*tds.z\_c2\*F\_const\*(-tds.um\_c2rr\*d(tds.V,r)-tds.um\_c2rz\*d(tds.V,z)),r),c2\*tds.z\_c2\*F\_const\*(-tds.um\_c2rr\*d(tds.V,r)-tds.um\_c2rz\*d(tds.V,z))/r)+d(c2\*tds.z\_c2\*F\_const\*(-tds.um\_c2zr\*d(tds.V,r)-tds.um\_c2zz\*d(tds.V,z)),z)-tds.R\_c2 | mol/(m³·s) | Equation residual | Domains 1–2 |  |
| tds.Rlin\_c2 | 0 |  | Linear source term coefficient | Domains 1–2 |  |

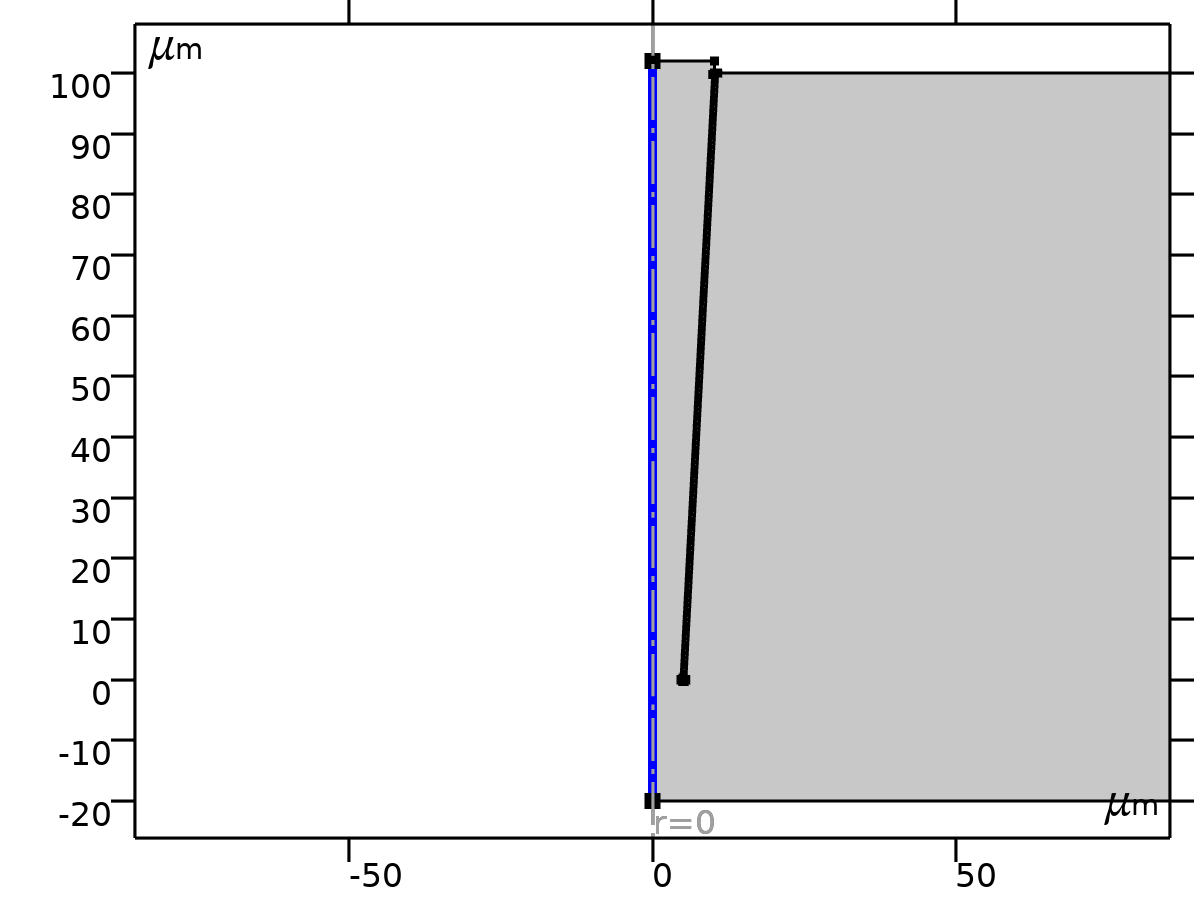
#### Shape functions

| **Name** | **Shape function** | **Unit** | **Description** | **Shape frame** | **Selection** |
| --- | --- | --- | --- | --- | --- |
| c | Lagrange (Linear) | mol/m³ | Concentration | Spatial | Domains 1–2 |
| c2 | Lagrange (Linear) | mol/m³ | Concentration | Spatial | Domains 1–2 |

#### Weak Expressions

| **Weak expression** | **Integration order** | **Integration frame** | **Selection** |
| --- | --- | --- | --- |
| 2\*(tds.dflux\_cr\*test(cr)+tds.dflux\_cz\*test(cz))\*tds.d\*pi\*r | 2 | Spatial | Domains 1–2 |
| 2\*(tds.dflux\_c2r\*test(c2r)+tds.dflux\_c2z\*test(c2z))\*tds.d\*pi\*r | 2 | Spatial | Domains 1–2 |
| 2\*tds.z\_c\*F\_const\*c\*((-tds.um\_crr\*d(tds.V,r)-tds.um\_crz\*d(tds.V,z))\*test(cr)+(-tds.um\_czr\*d(tds.V,r)-tds.um\_czz\*d(tds.V,z))\*test(cz))\*tds.d\*pi\*r | 2 | Spatial | Domains 1–2 |
| 2\*tds.z\_c2\*F\_const\*c2\*((-tds.um\_c2rr\*d(tds.V,r)-tds.um\_c2rz\*d(tds.V,z))\*test(c2r)+(-tds.um\_c2zr\*d(tds.V,r)-tds.um\_c2zz\*d(tds.V,z))\*test(c2z))\*tds.d\*pi\*r | 2 | Spatial | Domains 1–2 |
| 2\*tds.streamline\*(isScalingSystemDomain==0)\*tds.d\*pi\*r | 2 | Spatial | Domains 1–2 |
| 2\*tds.crosswind\*(isScalingSystemDomain==0)\*tds.d\*pi\*r | 4 | Spatial | Domains 1–2 |

* + 1. Axial Symmetry

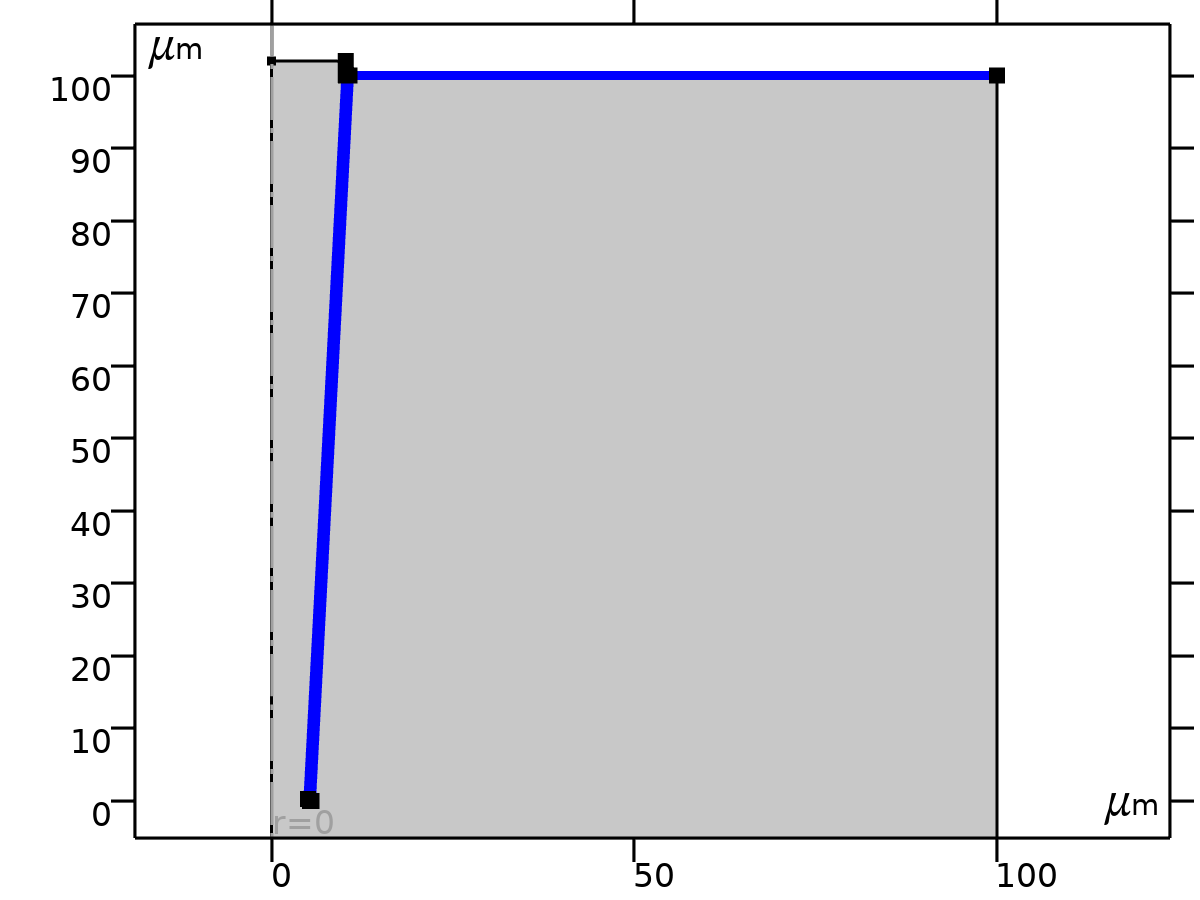


Axial Symmetry

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Geometry geom1: Dimension 1: All boundaries |

* + 1. No Flux



No Flux

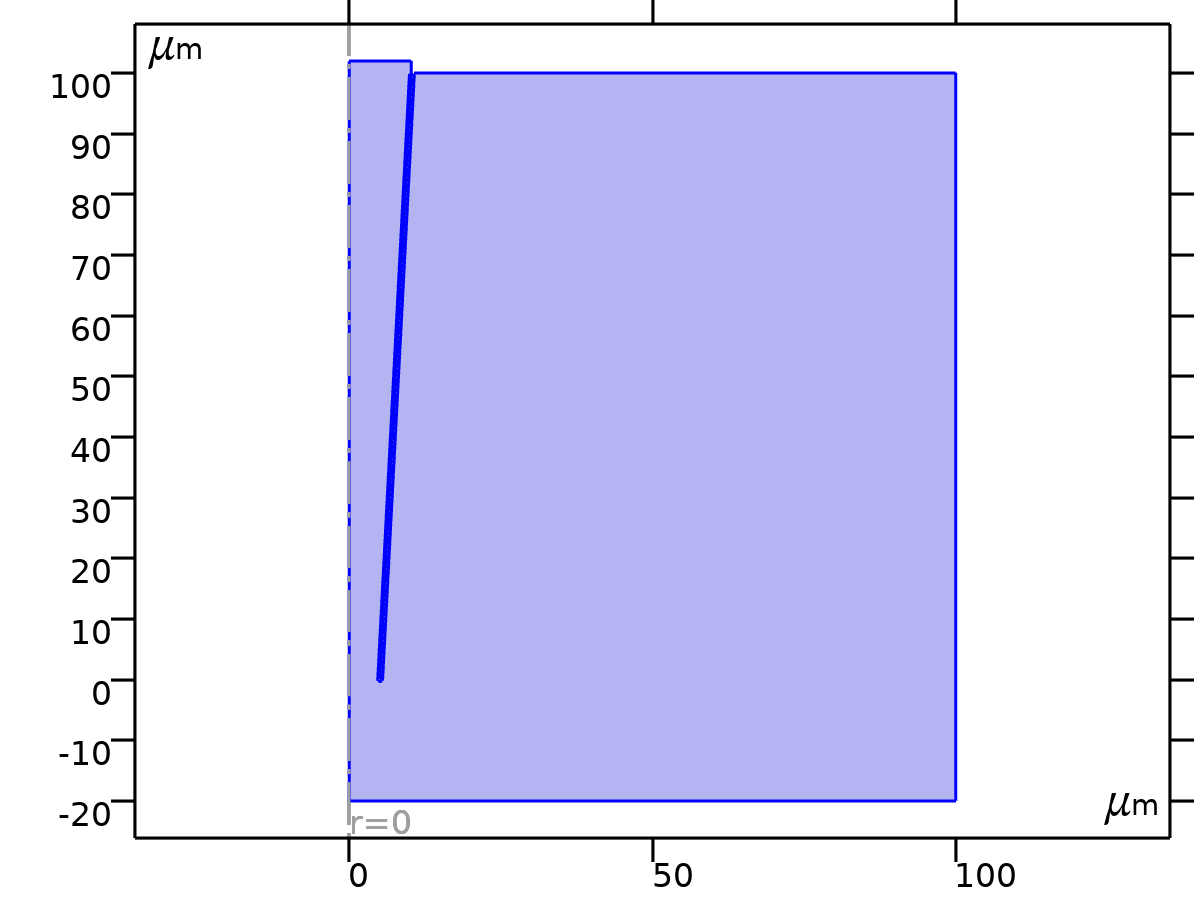
Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Geometry geom1: Dimension 1: All boundaries |

Equations



* + 1. Initial Values



Initial Values

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Geometry geom1: Dimension 2: All domains |

#### Initial Values

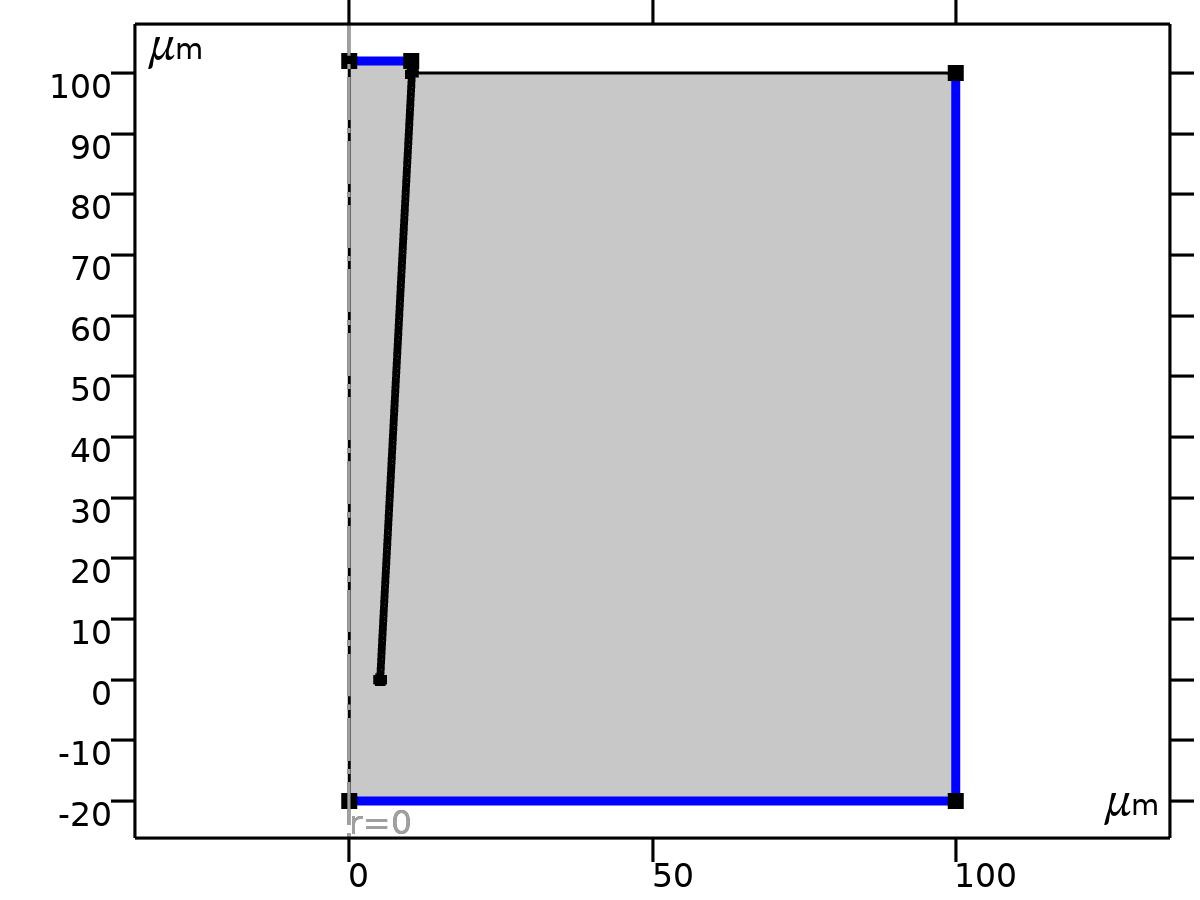
Settings

| **Description** | **Value** |
| --- | --- |
| Concentration | {10, 10} |

#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** | **Details** |
| --- | --- | --- | --- | --- | --- |
| tds.c0\_c | 10 | mol/m³ | Concentration | Domains 1–2 | + operation |
| tds.c0\_c2 | 10 | mol/m³ | Concentration | Domains 1–2 | + operation |

* + 1. Concentration



Concentration

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Geometry geom1: Dimension 1: Boundaries 2–3, 14 |

Equations



#### Concentration

Settings

| **Description** | **Value** |
| --- | --- |
| Species c | On |
| Species c2 | On |
| Concentration | {10, 10} |

#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** | **Details** |
| --- | --- | --- | --- | --- | --- |
| tds.c0\_c | 10 | mol/m³ | Concentration | Boundaries 2–3, 14 | + operation |
| tds.c0\_c2 | 10 | mol/m³ | Concentration | Boundaries 2–3, 14 | + operation |
| tds.conc1.nmflow\_c | tds.conc1.int(2\*tds.ntflux\_c\*pi\*r)\*tds.d | mol/s | Normal molar flow rate | Global |  |
| tds.conc1.nmflow\_c2 | tds.conc1.int(2\*tds.ntflux\_c2\*pi\*r)\*tds.d | mol/s | Normal molar flow rate | Global |  |

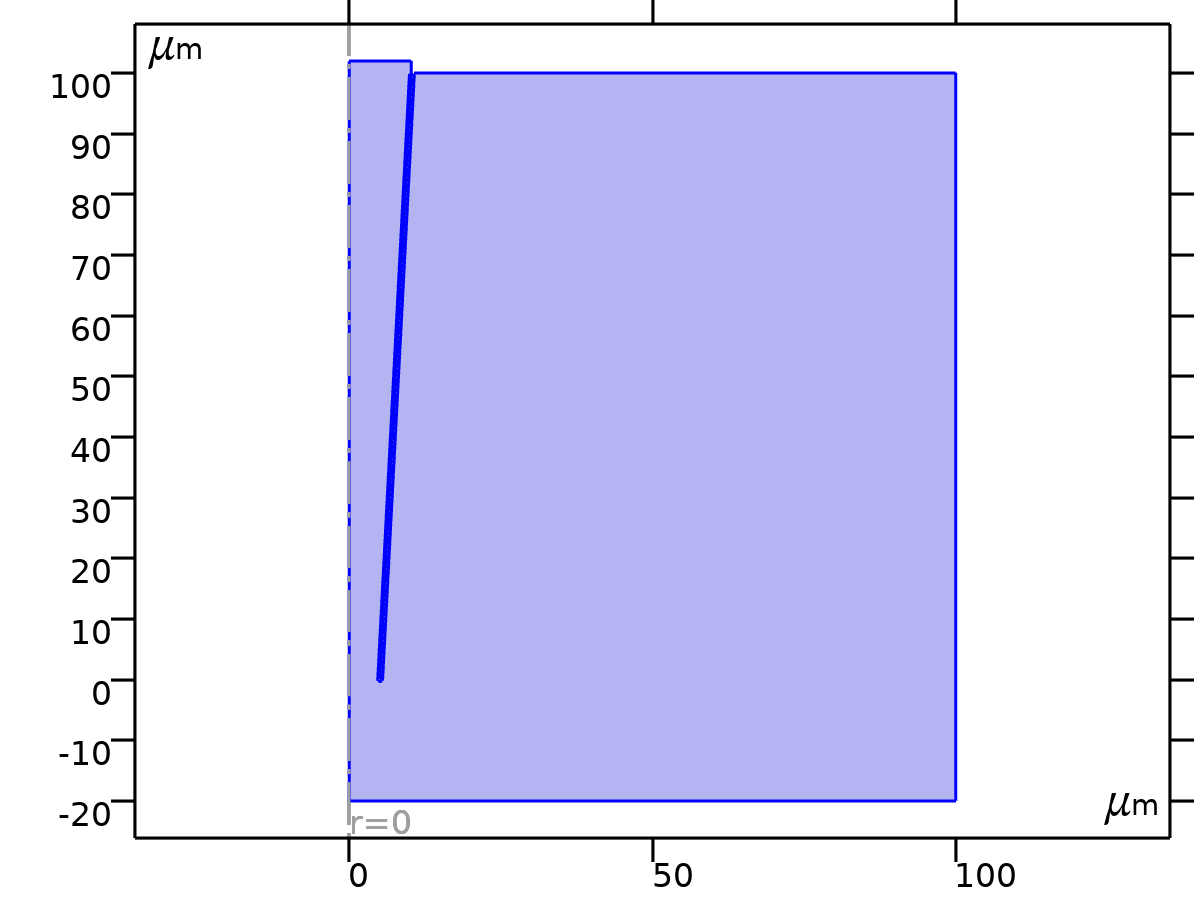
#### Constraints

| **Constraint** | **Constraint force** | **Shape function** | **Selection** | **Details** |
| --- | --- | --- | --- | --- |
| -tds.cVar\_c+tds.c0\_c | test(-tds.cVar\_c+tds.c0\_c) | Lagrange (Linear) | Boundaries 2–3, 14 | Elemental |
| -tds.cVar\_c2+tds.c0\_c2 | test(-tds.cVar\_c2+tds.c0\_c2) | Lagrange (Linear) | Boundaries 2–3, 14 | Elemental |

* 1. Electrostatics

Used products

|  |
| --- |
| COMSOL Multiphysics |



Electrostatics

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Geometry geom1: Dimension 2: All domains |

Equations





* + 1. Interface Settings

#### Discretization

Settings

| **Description** | **Value** |
| --- | --- |
| Electric potential | Quadratic |

#### Manual Terminal Sweep Settings

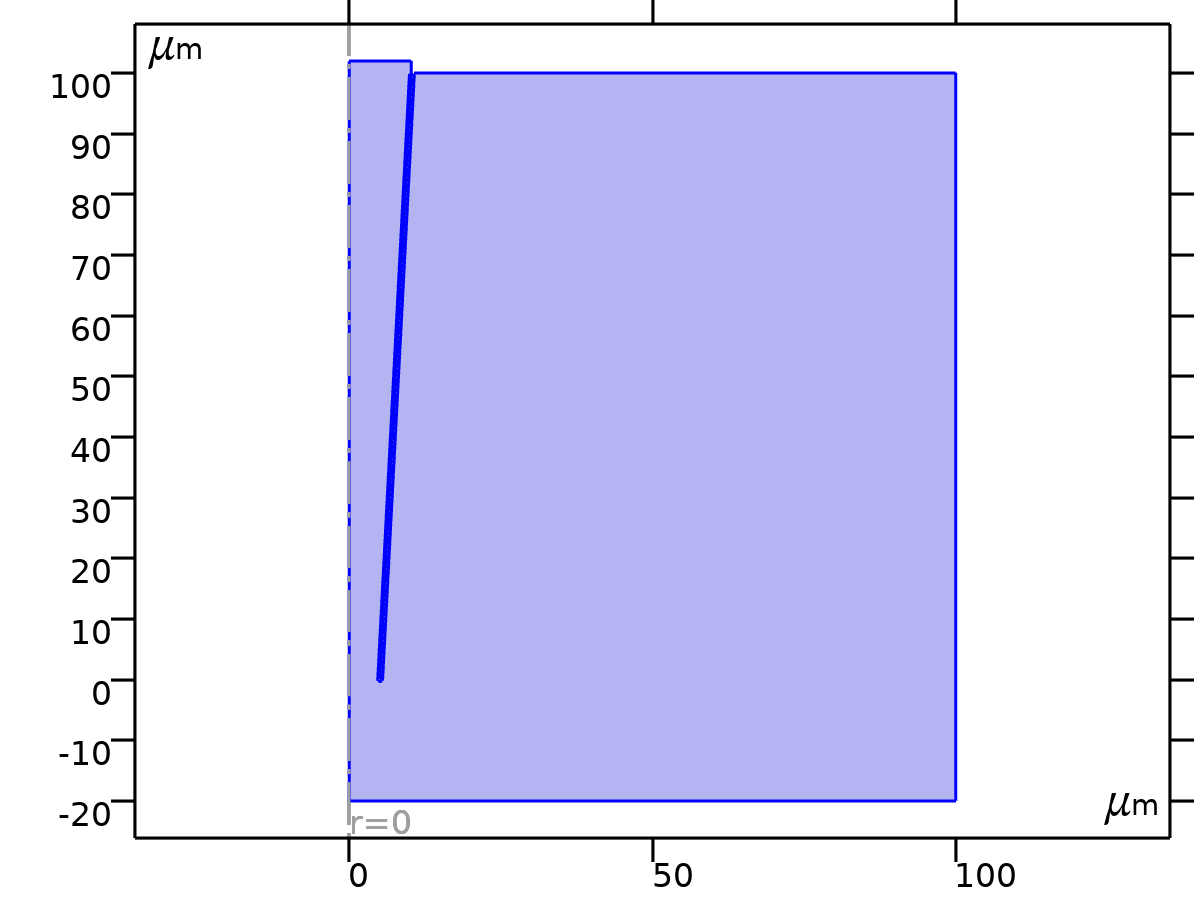
Settings

| **Description** | **Value** |
| --- | --- |
| Use manual terminal sweep | Off |
| Reference impedance | 50[ohm] |

* + 1. Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** | **Details** |
| --- | --- | --- | --- | --- | --- |
| es.d | 1 | 1 | Contribution | Domains 1–2 |  |
| es.nr | nr |  | Normal vector, r component | Boundaries 4–6, 9, 11, 15–16, 18–19 |  |
| es.nphi | 0 |  | Normal vector, phi component | Boundaries 4–6, 9, 11, 15–16, 18–19 |  |
| es.nz | nz |  | Normal vector, z component | Boundaries 4–6, 9, 11, 15–16, 18–19 |  |
| es.nr | dnr |  | Normal vector, r component | Boundaries 1–3, 7–8, 10, 12–14, 17 |  |
| es.nphi | 0 |  | Normal vector, phi component | Boundaries 1–3, 7–8, 10, 12–14, 17 |  |
| es.nz | dnz |  | Normal vector, z component | Boundaries 1–3, 7–8, 10, 12–14, 17 |  |
| es.nmeshr | nrmesh |  | Mesh normal vector, r component | Boundaries 4–6, 9, 11, 15–16, 18–19 |  |
| es.nmeshphi | 0 |  | Mesh normal vector, phi component | Boundaries 4–6, 9, 11, 15–16, 18–19 |  |
| es.nmeshz | nzmesh |  | Mesh normal vector, z component | Boundaries 4–6, 9, 11, 15–16, 18–19 |  |
| es.nmeshr | dnrmesh |  | Mesh normal vector, r component | Boundaries 1–3, 7–8, 10, 12–14, 17 |  |
| es.nmeshphi | 0 |  | Mesh normal vector, phi component | Boundaries 1–3, 7–8, 10, 12–14, 17 |  |
| es.nmeshz | dnzmesh |  | Mesh normal vector, z component | Boundaries 1–3, 7–8, 10, 12–14, 17 |  |
| es.unmeshr | unrmesh |  | Mesh normal vector, upside, r component | Boundaries 1–19 |  |
| es.unmeshphi | 0 |  | Mesh normal vector, upside, phi component | Boundaries 1–19 |  |
| es.unmeshz | unzmesh |  | Mesh normal vector, upside, z component | Boundaries 1–19 |  |
| es.dnmeshr | dnrmesh |  | Mesh normal vector, downside, r component | Boundaries 1–19 |  |
| es.dnmeshphi | 0 |  | Mesh normal vector, downside, phi component | Boundaries 1–19 |  |
| es.dnmeshz | dnzmesh |  | Mesh normal vector, downside, z component | Boundaries 1–19 |  |
| es.I\_sRR | (spatial.invF11\*(spatial.invF11\*es.I\_srr+spatial.invF31\*es.I\_szr)+spatial.invF31\*(spatial.invF11\*es.I\_srz+spatial.invF31\*es.I\_szz))\*spatial.detF | 1 | Spatial identity matrix, material frame, RR component | Domains 1–2 |  |
| es.I\_sPHIR | if(Rg>0.001\*h,R/r,Rr)\*(spatial.invF11\*es.I\_sphir+spatial.invF31\*es.I\_sphiz)\*spatial.detF | 1 | Spatial identity matrix, material frame, PHIR component | Domains 1–2 |  |
| es.I\_sZR | (spatial.invF11\*(spatial.invF13\*es.I\_srr+spatial.invF33\*es.I\_szr)+spatial.invF31\*(spatial.invF13\*es.I\_srz+spatial.invF33\*es.I\_szz))\*spatial.detF | 1 | Spatial identity matrix, material frame, ZR component | Domains 1–2 |  |
| es.I\_sRPHI | if(Rg>0.001\*h,R/r,Rr)\*(spatial.invF11\*es.I\_srphi+spatial.invF31\*es.I\_szphi)\*spatial.detF | 1 | Spatial identity matrix, material frame, RPHI component | Domains 1–2 |  |
| es.I\_sPHIPHI | if(Rg>0.001\*h,R/r,Rr)^2\*es.I\_sphiphi\*spatial.detF | 1 | Spatial identity matrix, material frame, PHIPHI component | Domains 1–2 |  |
| es.I\_sZPHI | if(Rg>0.001\*h,R/r,Rr)\*(spatial.invF13\*es.I\_srphi+spatial.invF33\*es.I\_szphi)\*spatial.detF | 1 | Spatial identity matrix, material frame, ZPHI component | Domains 1–2 |  |
| es.I\_sRZ | (spatial.invF13\*(spatial.invF11\*es.I\_srr+spatial.invF31\*es.I\_szr)+spatial.invF33\*(spatial.invF11\*es.I\_srz+spatial.invF31\*es.I\_szz))\*spatial.detF | 1 | Spatial identity matrix, material frame, RZ component | Domains 1–2 |  |
| es.I\_sPHIZ | if(Rg>0.001\*h,R/r,Rr)\*(spatial.invF13\*es.I\_sphir+spatial.invF33\*es.I\_sphiz)\*spatial.detF | 1 | Spatial identity matrix, material frame, PHIZ component | Domains 1–2 |  |
| es.I\_sZZ | (spatial.invF13\*(spatial.invF13\*es.I\_srr+spatial.invF33\*es.I\_szr)+spatial.invF33\*(spatial.invF13\*es.I\_srz+spatial.invF33\*es.I\_szz))\*spatial.detF | 1 | Spatial identity matrix, material frame, ZZ component | Domains 1–2 |  |
| es.I\_srr | 1 | 1 | Spatial identity matrix, rr component | Domains 1–2 |  |
| es.I\_sphir | 0 | 1 | Spatial identity matrix, phir component | Domains 1–2 |  |
| es.I\_szr | 0 | 1 | Spatial identity matrix, zr component | Domains 1–2 |  |
| es.I\_srphi | 0 | 1 | Spatial identity matrix, rphi component | Domains 1–2 |  |
| es.I\_sphiphi | 1 | 1 | Spatial identity matrix, phiphi component | Domains 1–2 |  |
| es.I\_szphi | 0 | 1 | Spatial identity matrix, zphi component | Domains 1–2 |  |
| es.I\_srz | 0 | 1 | Spatial identity matrix, rz component | Domains 1–2 |  |
| es.I\_sphiz | 0 | 1 | Spatial identity matrix, phiz component | Domains 1–2 |  |
| es.I\_szz | 1 | 1 | Spatial identity matrix, zz component | Domains 1–2 |  |
| es.unTr | es.unTer | Pa | Maxwell upward surface stress tensor, r component | Boundaries 1–19 |  |
| es.unTphi | es.unTephi | Pa | Maxwell upward surface stress tensor, phi component | Boundaries 1–19 |  |
| es.unTz | es.unTez | Pa | Maxwell upward surface stress tensor, z component | Boundaries 1–19 |  |
| es.dnTr | es.dnTer | Pa | Maxwell downward surface stress tensor, r component | Boundaries 1–19 |  |
| es.dnTphi | es.dnTephi | Pa | Maxwell downward surface stress tensor, phi component | Boundaries 1–19 |  |
| es.dnTz | es.dnTez | Pa | Maxwell downward surface stress tensor, z component | Boundaries 1–19 |  |
| es.unr | unr |  | Normal vector up direction, r component | Boundaries 1–19 |  |
| es.unphi | 0 |  | Normal vector up direction, phi component | Boundaries 1–19 |  |
| es.unz | unz |  | Normal vector up direction, z component | Boundaries 1–19 |  |
| es.dnr | dnr |  | Normal vector down direction, r component | Boundaries 1–19 |  |
| es.dnphi | 0 |  | Normal vector down direction, phi component | Boundaries 1–19 |  |
| es.dnz | dnz |  | Normal vector down direction, z component | Boundaries 1–19 |  |
| es.unTer | -0.5\*es.dnr\*(real(up(es.Dr))\*real(up(es.Er))+real(up(es.Dphi))\*real(up(es.Ephi))+real(up(es.Dz))\*real(up(es.Ez)))+real(up(es.Dr))\*(real(up(es.Er))\*es.dnr+real(up(es.Ephi))\*es.dnphi+real(up(es.Ez))\*es.dnz) | Pa | Maxwell upward electric surface stress tensor, r component | Boundaries 4–6, 9, 11, 15–16, 18–19 |  |
| es.unTephi | -0.5\*es.dnphi\*(real(up(es.Dr))\*real(up(es.Er))+real(up(es.Dphi))\*real(up(es.Ephi))+real(up(es.Dz))\*real(up(es.Ez)))+real(up(es.Dphi))\*(real(up(es.Er))\*es.dnr+real(up(es.Ephi))\*es.dnphi+real(up(es.Ez))\*es.dnz) | Pa | Maxwell upward electric surface stress tensor, phi component | Boundaries 4–6, 9, 11, 15–16, 18–19 |  |
| es.unTez | -0.5\*es.dnz\*(real(up(es.Dr))\*real(up(es.Er))+real(up(es.Dphi))\*real(up(es.Ephi))+real(up(es.Dz))\*real(up(es.Ez)))+real(up(es.Dz))\*(real(up(es.Er))\*es.dnr+real(up(es.Ephi))\*es.dnphi+real(up(es.Ez))\*es.dnz) | Pa | Maxwell upward electric surface stress tensor, z component | Boundaries 4–6, 9, 11, 15–16, 18–19 |  |
| es.unTer | 0 | Pa | Maxwell upward electric surface stress tensor, r component | Boundaries 1–3, 7–8, 10, 12–14, 17 |  |
| es.unTephi | 0 | Pa | Maxwell upward electric surface stress tensor, phi component | Boundaries 1–3, 7–8, 10, 12–14, 17 |  |
| es.unTez | 0 | Pa | Maxwell upward electric surface stress tensor, z component | Boundaries 1–3, 7–8, 10, 12–14, 17 |  |
| es.dnTer | -0.5\*es.unr\*(real(down(es.Dr))\*real(down(es.Er))+real(down(es.Dphi))\*real(down(es.Ephi))+real(down(es.Dz))\*real(down(es.Ez)))+real(down(es.Dr))\*(real(down(es.Er))\*es.unr+real(down(es.Ephi))\*es.unphi+real(down(es.Ez))\*es.unz) | Pa | Maxwell downward electric surface stress tensor, r component | Boundaries 1–19 |  |
| es.dnTephi | -0.5\*es.unphi\*(real(down(es.Dr))\*real(down(es.Er))+real(down(es.Dphi))\*real(down(es.Ephi))+real(down(es.Dz))\*real(down(es.Ez)))+real(down(es.Dphi))\*(real(down(es.Er))\*es.unr+real(down(es.Ephi))\*es.unphi+real(down(es.Ez))\*es.unz) | Pa | Maxwell downward electric surface stress tensor, phi component | Boundaries 1–19 |  |
| es.dnTez | -0.5\*es.unz\*(real(down(es.Dr))\*real(down(es.Er))+real(down(es.Dphi))\*real(down(es.Ephi))+real(down(es.Dz))\*real(down(es.Ez)))+real(down(es.Dz))\*(real(down(es.Er))\*es.unr+real(down(es.Ephi))\*es.unphi+real(down(es.Ez))\*es.unz) | Pa | Maxwell downward electric surface stress tensor, z component | Boundaries 1–19 |  |
| es.intWe | es.int\_We(es.d\*es.dWe) | J | Total electric energy | Global | + operation |
| es.zref | 50[ohm] | Ω | Reference impedance | Global |  |

* + 1. Charge Conservation



Charge Conservation

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Geometry geom1: Dimension 2: All domains |

Equations





#### Constitutive Relation D-E

Settings

| **Description** | **Value** |
| --- | --- |
| Dielectric model | Relative permittivity |
| Relative permittivity | User defined |
| Relative permittivity | {{78, 0, 0}, {0, 78, 0}, {0, 0, 78}} |

#### Coordinate System Selection

Settings

| **Description** | **Value** |
| --- | --- |
| Coordinate system | Global coordinate system |

#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** | **Details** |
| --- | --- | --- | --- | --- | --- |
| es.nD | 0 | C/m² | Surface charge density | Boundaries 1–19 | + operation |
| es.epsilonrrr | 78 | 1 | Relative permittivity, rr component | Domains 1–2 |  |
| es.epsilonrphir | 0 | 1 | Relative permittivity, phir component | Domains 1–2 |  |
| es.epsilonrzr | 0 | 1 | Relative permittivity, zr component | Domains 1–2 |  |
| es.epsilonrrphi | 0 | 1 | Relative permittivity, rphi component | Domains 1–2 |  |
| es.epsilonrphiphi | 78 | 1 | Relative permittivity, phiphi component | Domains 1–2 |  |
| es.epsilonrzphi | 0 | 1 | Relative permittivity, zphi component | Domains 1–2 |  |
| es.epsilonrrz | 0 | 1 | Relative permittivity, rz component | Domains 1–2 |  |
| es.epsilonrphiz | 0 | 1 | Relative permittivity, phiz component | Domains 1–2 |  |
| es.epsilonrzz | 78 | 1 | Relative permittivity, zz component | Domains 1–2 |  |
| es.epsilonr\_iso | 78 | 1 | Relative permittivity, isotropic value | Domains 1–2 |  |
| es.DrR | 0 | C/m² | Remanent electric displacement, R component | Domains 1–2 |  |
| es.DrPHI | 0 | C/m² | Remanent electric displacement, PHI component | Domains 1–2 |  |
| es.DrZ | 0 | C/m² | Remanent electric displacement, Z component | Domains 1–2 |  |
| es.Dr | epsilon0\_const\*es.I\_srr\*es.Er+epsilon0\_const\*es.I\_srphi\*es.Ephi+epsilon0\_const\*es.I\_srz\*es.Ez+es.Pr+es.Per | C/m² | Electric displacement field, r component | Domains 1–2 |  |
| es.Dphi | epsilon0\_const\*es.I\_sphir\*es.Er+epsilon0\_const\*es.I\_sphiphi\*es.Ephi+epsilon0\_const\*es.I\_sphiz\*es.Ez+es.Pphi+es.Pephi | C/m² | Electric displacement field, phi component | Domains 1–2 |  |
| es.Dz | epsilon0\_const\*es.I\_szr\*es.Er+epsilon0\_const\*es.I\_szphi\*es.Ephi+epsilon0\_const\*es.I\_szz\*es.Ez+es.Pz+es.Pez | C/m² | Electric displacement field, z component | Domains 1–2 |  |
| es.Pr | epsilon0\_const\*(es.chirr\*es.Er+es.chirphi\*es.Ephi+es.chirz\*es.Ez) | C/m² | Polarization, r component | Domains 1–2 |  |
| es.Pphi | epsilon0\_const\*(es.chiphir\*es.Er+es.chiphiphi\*es.Ephi+es.chiphiz\*es.Ez) | C/m² | Polarization, phi component | Domains 1–2 |  |
| es.Pz | epsilon0\_const\*(es.chizr\*es.Er+es.chizphi\*es.Ephi+es.chizz\*es.Ez) | C/m² | Polarization, z component | Domains 1–2 |  |
| es.normD | sqrt(realdot(es.Dr,es.Dr)+realdot(es.Dphi,es.Dphi)+realdot(es.Dz,es.Dz)) | C/m² | Electric displacement field norm | Domains 1–2 |  |
| es.normP | sqrt(realdot(es.Pr,es.Pr)+realdot(es.Pphi,es.Pphi)+realdot(es.Pz,es.Pz)) | C/m² | Polarization norm | Domains 1–2 |  |
| es.Per | 0 | C/m² | Polarization contribution, r component | Domains 1–2 | + operation |
| es.Pephi | 0 | C/m² | Polarization contribution, phi component | Domains 1–2 | + operation |
| es.Pez | 0 | C/m² | Polarization contribution, z component | Domains 1–2 | + operation |
| es.chirr | -1+es.epsilonrrr | 1 | Electric susceptibility, rr component | Domains 1–2 |  |
| es.chiphir | es.epsilonrphir | 1 | Electric susceptibility, phir component | Domains 1–2 |  |
| es.chizr | es.epsilonrzr | 1 | Electric susceptibility, zr component | Domains 1–2 |  |
| es.chirphi | es.epsilonrrphi | 1 | Electric susceptibility, rphi component | Domains 1–2 |  |
| es.chiphiphi | -1+es.epsilonrphiphi | 1 | Electric susceptibility, phiphi component | Domains 1–2 |  |
| es.chizphi | es.epsilonrzphi | 1 | Electric susceptibility, zphi component | Domains 1–2 |  |
| es.chirz | es.epsilonrrz | 1 | Electric susceptibility, rz component | Domains 1–2 |  |
| es.chiphiz | es.epsilonrphiz | 1 | Electric susceptibility, phiz component | Domains 1–2 |  |
| es.chizz | -1+es.epsilonrzz | 1 | Electric susceptibility, zz component | Domains 1–2 |  |
| es.Er | -Vr | V/m | Electric field, r component | Domains 1–2 |  |
| es.Ephi | 0 | V/m | Electric field, phi component | Domains 1–2 |  |
| es.Ez | -Vz | V/m | Electric field, z component | Domains 1–2 |  |
| es.tEr | -VTr | V/m | Tangential electric field, r component | Boundaries 1–19 |  |
| es.tEphi | 0 | V/m | Tangential electric field, phi component | Boundaries 1–19 |  |
| es.tEz | -VTz | V/m | Tangential electric field, z component | Boundaries 1–19 |  |
| es.normE | sqrt(realdot(es.Er,es.Er)+realdot(es.Ephi,es.Ephi)+realdot(es.Ez,es.Ez)) | V/m | Electric field norm | Domains 1–2 |  |
| es.Jr | es.Jdr | A/m² | Current density, r component | Domains 1–2 | + operation |
| es.Jphi | es.Jdphi | A/m² | Current density, phi component | Domains 1–2 | + operation |
| es.Jz | es.Jdz | A/m² | Current density, z component | Domains 1–2 | + operation |
| es.JR | (spatial.invF11\*es.Jdr+spatial.invF31\*es.Jdz)\*spatial.detF | A/m² | Current density, R component | Domains 1–2 | + operation |
| es.JPHI | if(Rg>0.001\*h,R/r,Rr)\*es.Jdphi\*spatial.detF | A/m² | Current density, PHI component | Domains 1–2 | + operation |
| es.JZ | (spatial.invF13\*es.Jdr+spatial.invF33\*es.Jdz)\*spatial.detF | A/m² | Current density, Z component | Domains 1–2 | + operation |
| es.Jdr | 0 | A/m² | Displacement current density, r component | Domains 1–2 |  |
| es.Jdphi | 0 | A/m² | Displacement current density, phi component | Domains 1–2 |  |
| es.Jdz | 0 | A/m² | Displacement current density, z component | Domains 1–2 |  |
| es.normJ | sqrt(realdot(es.Jr,es.Jr)+realdot(es.Jphi,es.Jphi)+realdot(es.Jz,es.Jz)) | A/m² | Current density norm | Domains 1–2 |  |
| es.ccn1.nJ | es.unr\*down(es.Jr)+es.unphi\*down(es.Jphi)+es.unz\*down(es.Jz) | A/m² | Inward current density | Boundaries 1–3, 7–8, 10, 12–14, 17 |  |
| es.W | es.We | J/m³ | Energy density | Domains 1–2 | + operation |
| es.dWe | 2\*es.We\*pi\*r | J/m² | Integrand for total electric energy | Domains 1–2 | Meta |
| es.We | 0.5\*epsilon0\_const\*(((es.I\_srr+es.chirr)\*es.Er+(es.I\_srphi+es.chirphi)\*es.Ephi+(es.I\_srz+es.chirz)\*es.Ez)\*es.Er+((es.I\_sphir+es.chiphir)\*es.Er+(es.I\_sphiphi+es.chiphiphi)\*es.Ephi+(es.I\_sphiz+es.chiphiz)\*es.Ez)\*es.Ephi+((es.I\_szr+es.chizr)\*es.Er+(es.I\_szphi+es.chizphi)\*es.Ephi+(es.I\_szz+es.chizz)\*es.Ez)\*es.Ez) | J/m³ | Electric energy density | Domains 1–2 |  |

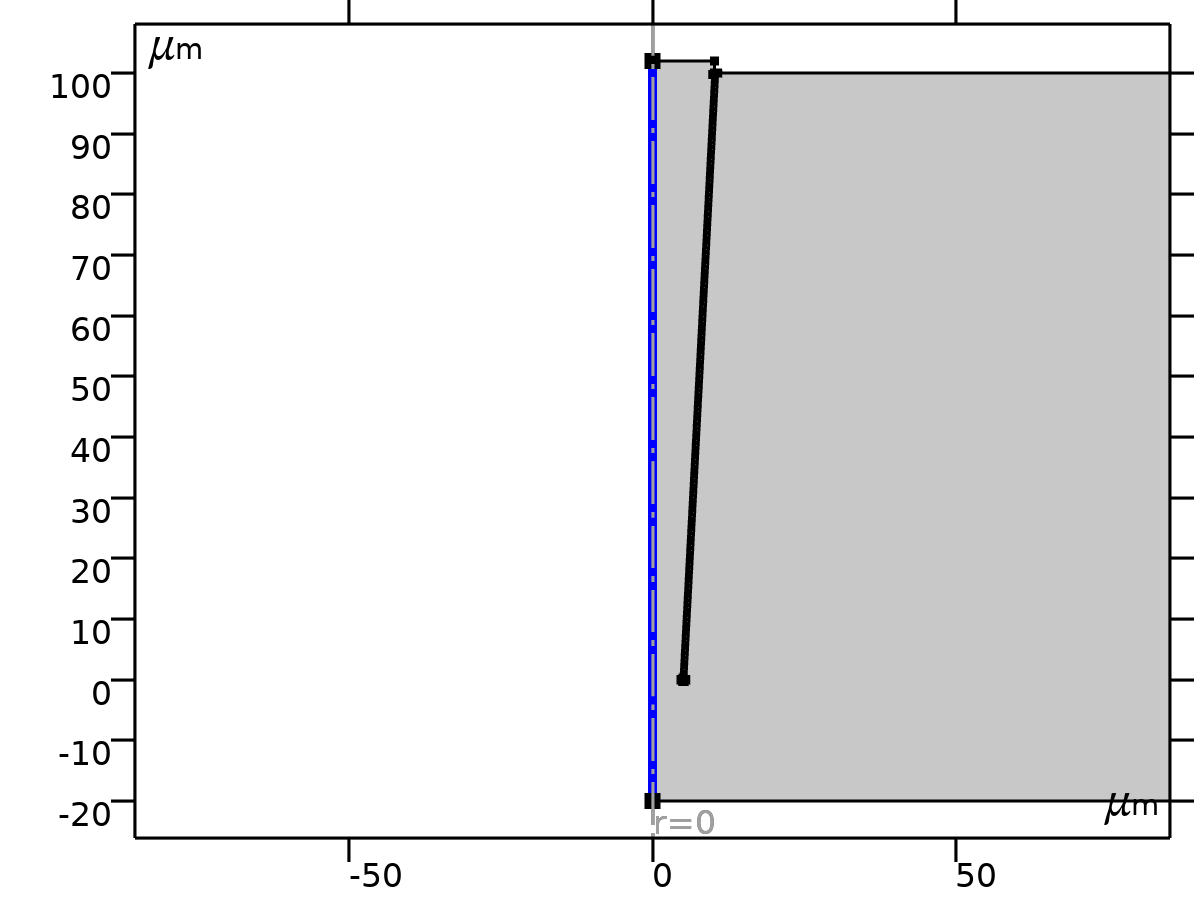
#### Shape functions

| **Name** | **Shape function** | **Unit** | **Description** | **Shape frame** | **Selection** |
| --- | --- | --- | --- | --- | --- |
| V | Lagrange (Quadratic) | V | Electric potential | Spatial | Domains 1–2 |
| V | Lagrange (Quadratic) | V | Electric potential | Material | Domains 1–2 |
| V | Lagrange (Quadratic) | V | Electric potential | Geometry | Domains 1–2 |
| V | Lagrange (Quadratic) | V | Electric potential | Mesh | Domains 1–2 |

#### Weak Expressions

| **Weak expression** | **Integration order** | **Integration frame** | **Selection** |
| --- | --- | --- | --- |
| -2\*(es.Dr\*test(Vr)+es.Dz\*test(Vz))\*es.d\*pi\*r | 4 | Spatial | Domains 1–2 |

* + 1. Axial Symmetry

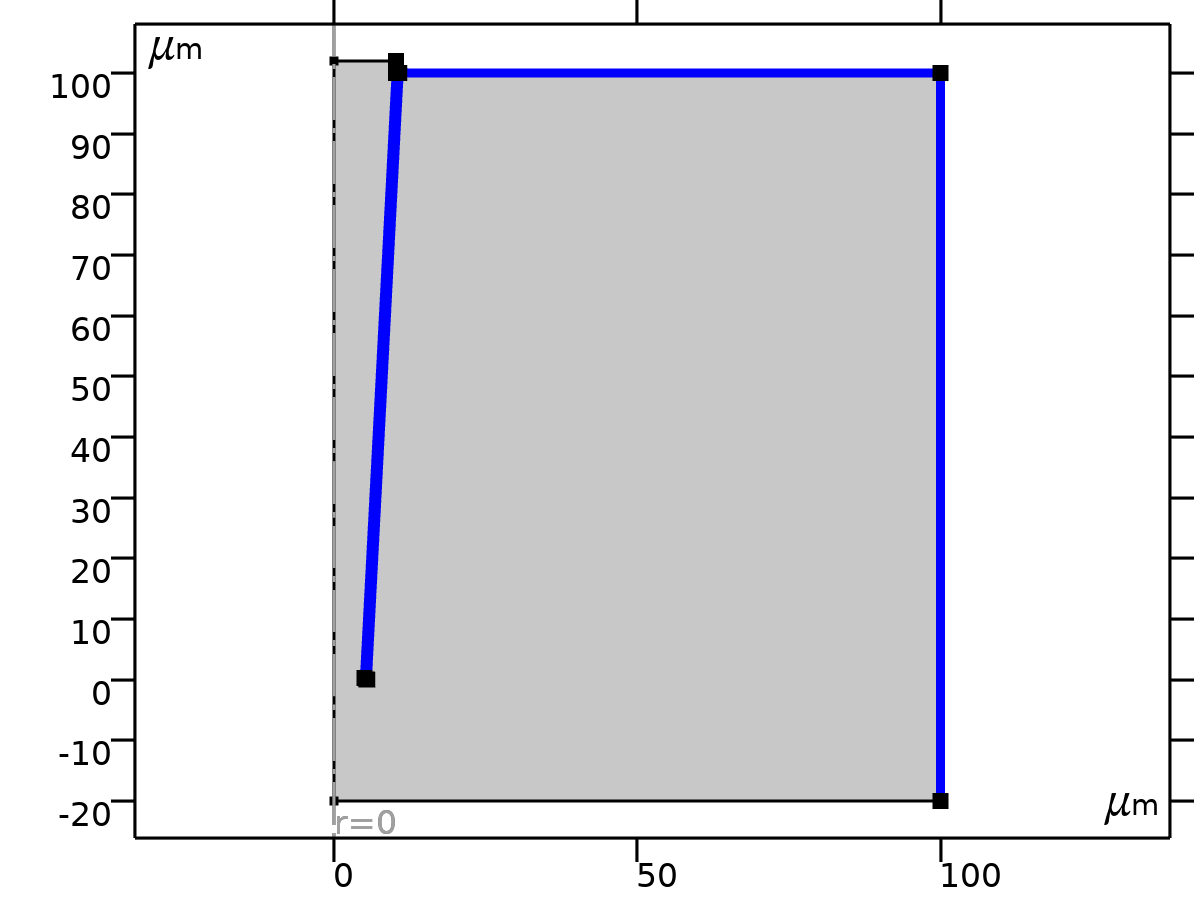


Axial Symmetry

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Geometry geom1: Dimension 1: All boundaries |

* + 1. Zero Charge



Zero Charge

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Geometry geom1: Dimension 1: All boundaries |

Equations



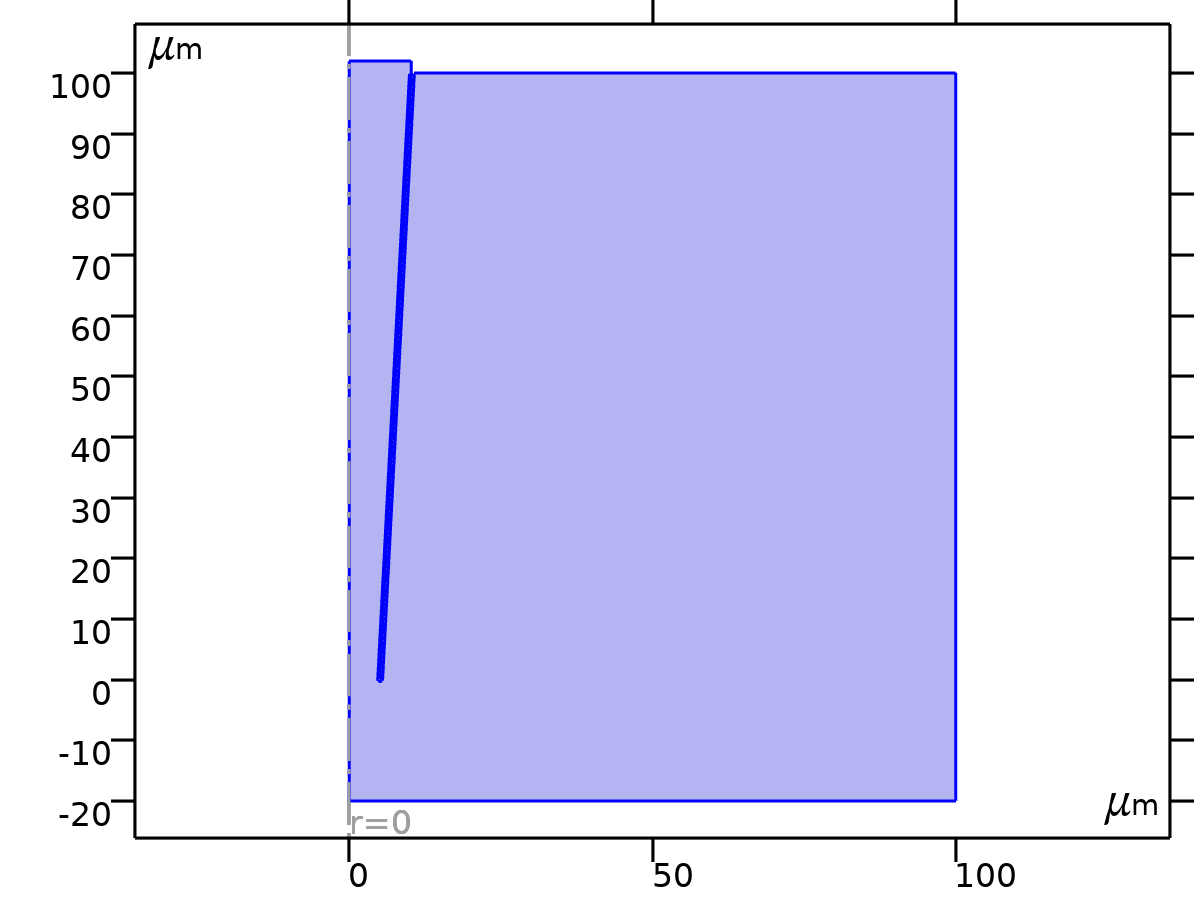
#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** | **Details** |
| --- | --- | --- | --- | --- | --- |
| es.nD | 0 | C/m² | Surface charge density | Boundaries 7–8, 10, 12–14, 17 | + operation |

#### Shape functions

| **Name** | **Shape function** | **Unit** | **Description** | **Shape frame** | **Selection** | **Details** |
| --- | --- | --- | --- | --- | --- | --- |
| V | Lagrange (Quadratic) | V | Electric potential | Spatial | No boundaries | Slit |
| V | Lagrange (Quadratic) | V | Electric potential | Material | No boundaries | Slit |
| V | Lagrange (Quadratic) | V | Electric potential | Geometry | No boundaries | Slit |
| V | Lagrange (Quadratic) | V | Electric potential | Mesh | No boundaries | Slit |

* + 1. Initial Values



Initial Values

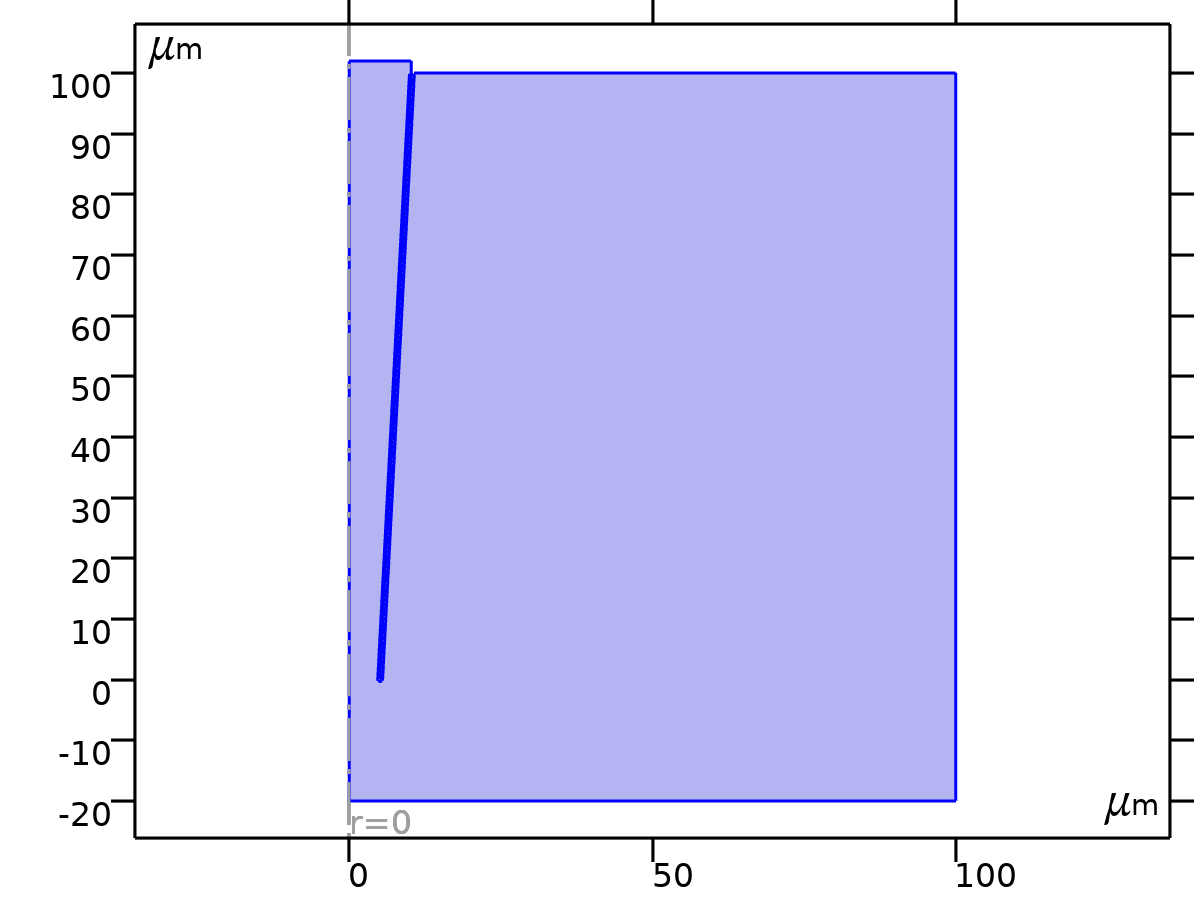
Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Geometry geom1: Dimension 2: All domains |

Settings

| **Description** | **Value** |
| --- | --- |
| Electric potential | 0 |

* + 1. Space Charge Density



Space Charge Density

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Geometry geom1: Dimension 2: Domains 1–2 |

Equations



#### Coordinate System Selection

Settings

| **Description** | **Value** |
| --- | --- |
| Coordinate system | Global coordinate system |

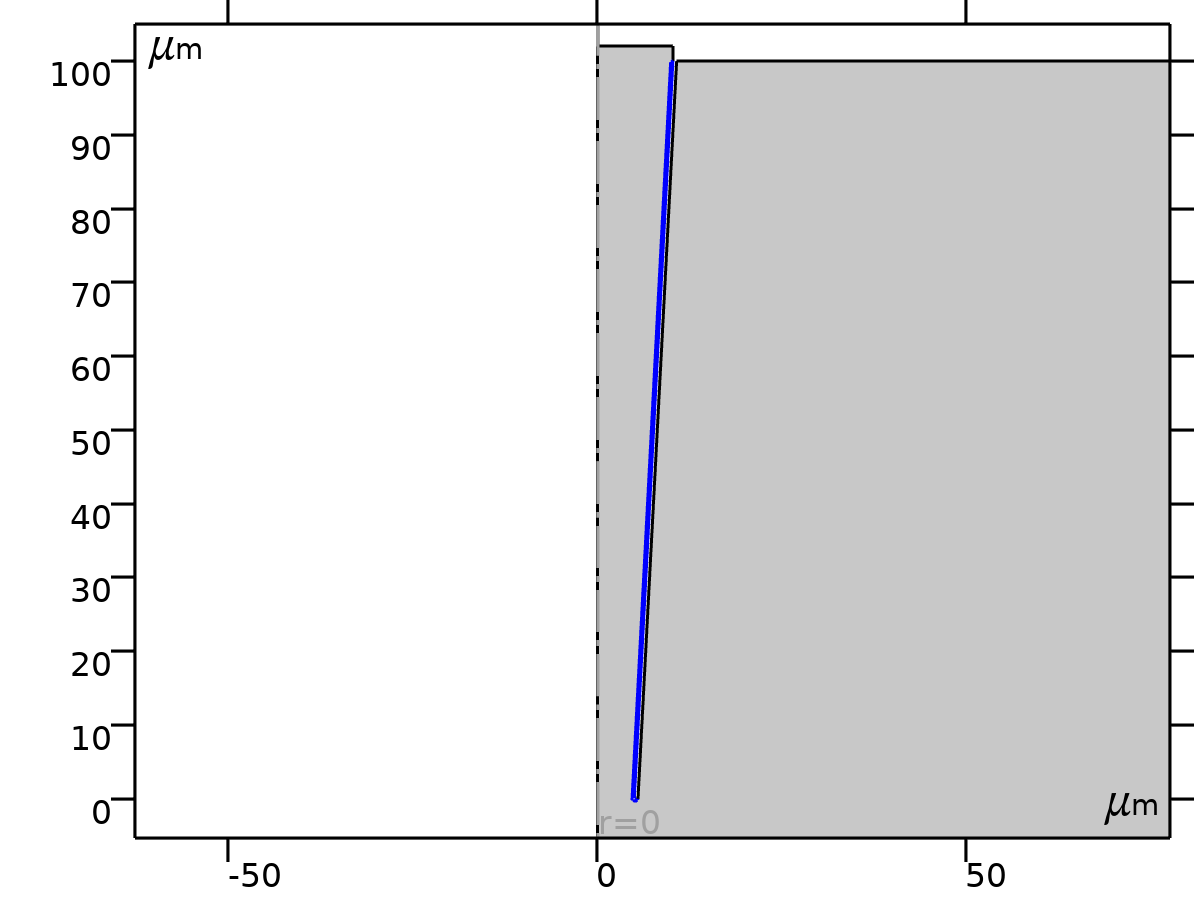
#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** | **Details** |
| --- | --- | --- | --- | --- | --- |
| es.rhoq | es.scd1.rhoq | C/m³ | Space charge density | Domains 1–2 | + operation |
| es.scd1.rhoq | F\_const\*(c-c2) | C/m³ | Space charge density | Domains 1–2 |  |

#### Weak Expressions

| **Weak expression** | **Integration order** | **Integration frame** | **Selection** |
| --- | --- | --- | --- |
| -2\*es.scd1.rhoq\*test(V)\*es.d\*pi\*r | 4 | Spatial | Domains 1–2 |

* + 1. Space Charge Density 2



Space Charge Density 2

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Geometry geom1: Dimension 2: Domain 2 |

Equations



#### Coordinate System Selection

Settings

| **Description** | **Value** |
| --- | --- |
| Coordinate system | Global coordinate system |

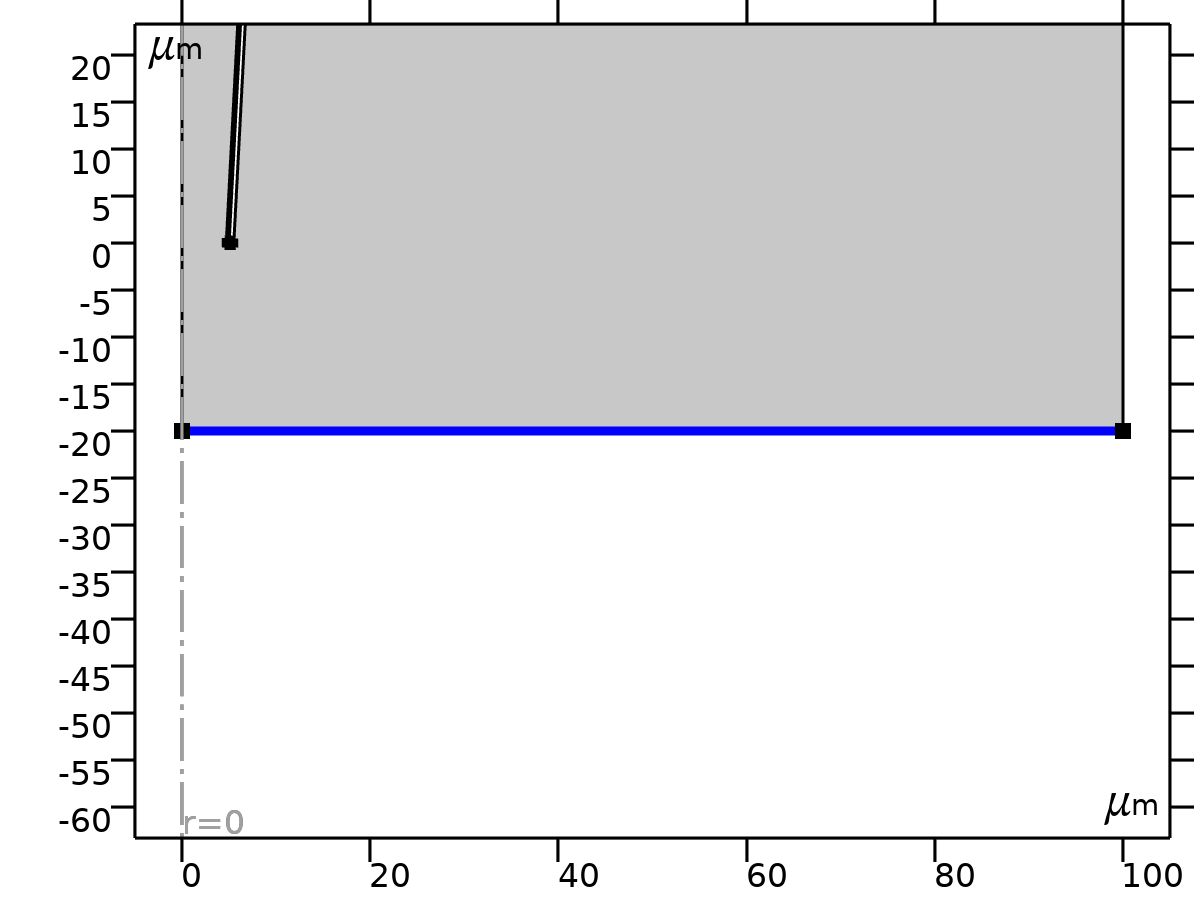
#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** | **Details** |
| --- | --- | --- | --- | --- | --- |
| es.rhoq | es.scd2.rhoq | C/m³ | Space charge density | Domain 2 | + operation |
| es.scd2.rhoq | 20000000[C/m^3]+F\_const\*(c-c2) | C/m³ | Space charge density | Domain 2 |  |

#### Weak Expressions

| **Weak expression** | **Integration order** | **Integration frame** | **Selection** |
| --- | --- | --- | --- |
| -2\*es.scd2.rhoq\*test(V)\*es.d\*pi\*r | 4 | Spatial | Domain 2 |

* + 1. Electric Potential



Electric Potential

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Geometry geom1: Dimension 1: Boundary 2 |

Equations



#### Electric Potential

Settings

| **Description** | **Value** |
| --- | --- |
| Electric potential | 0 |

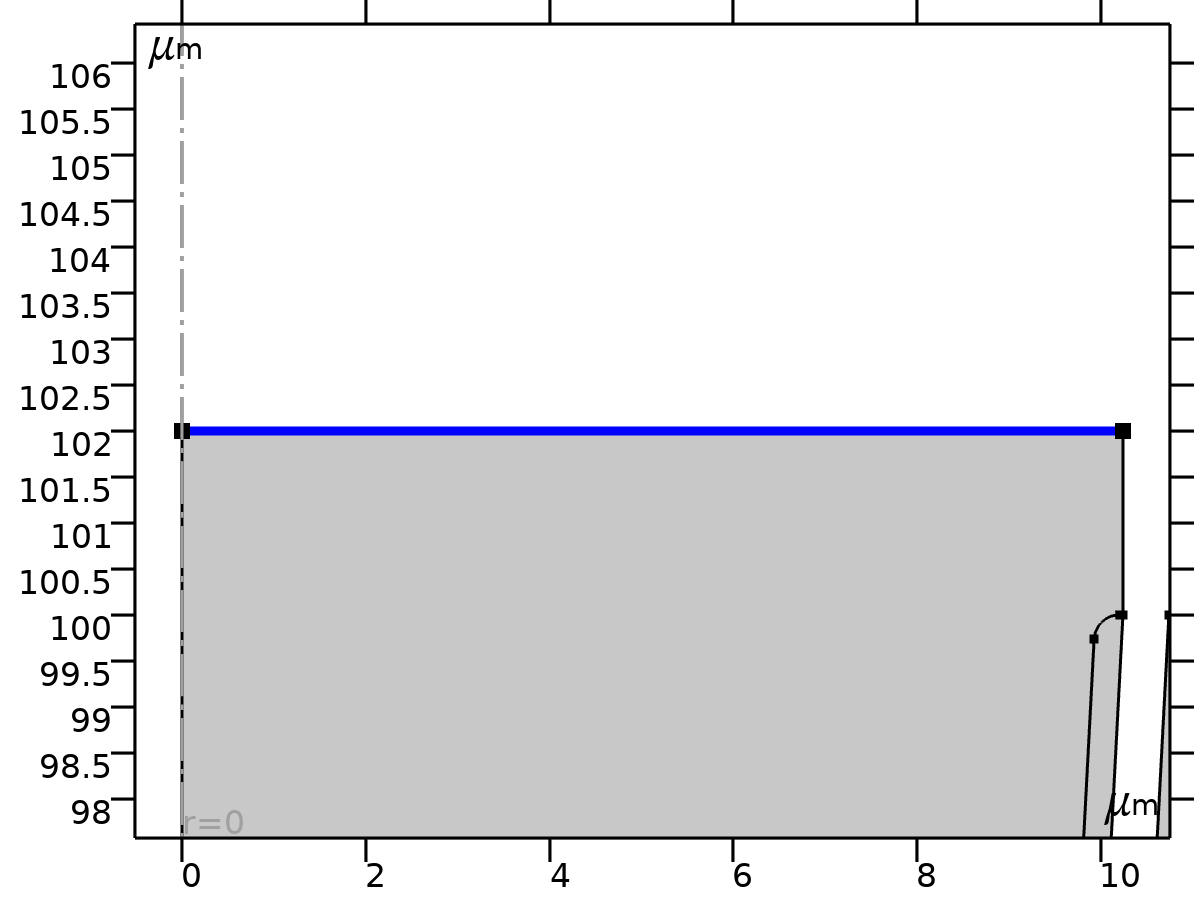
#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** | **Details** |
| --- | --- | --- | --- | --- | --- |
| es.nD | es.unr\*down(es.Dr)+es.unphi\*down(es.Dphi)+es.unz\*down(es.Dz) | C/m² | Surface charge density | Boundary 2 | + operation |
| es.V0 | 0 | V | Electric potential | Boundary 2 |  |

#### Constraints

| **Constraint** | **Constraint force** | **Shape function** | **Selection** | **Details** |
| --- | --- | --- | --- | --- |
| es.V0-V | test(es.V0-V) | Lagrange (Quadratic) | Boundary 2 | Elemental |

* + 1. Electric Potential 2



Electric Potential 2

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Geometry geom1: Dimension 1: Boundary 3 |

Equations



#### Electric Potential

Settings

| **Description** | **Value** |
| --- | --- |
| Electric potential | pw1(t) |

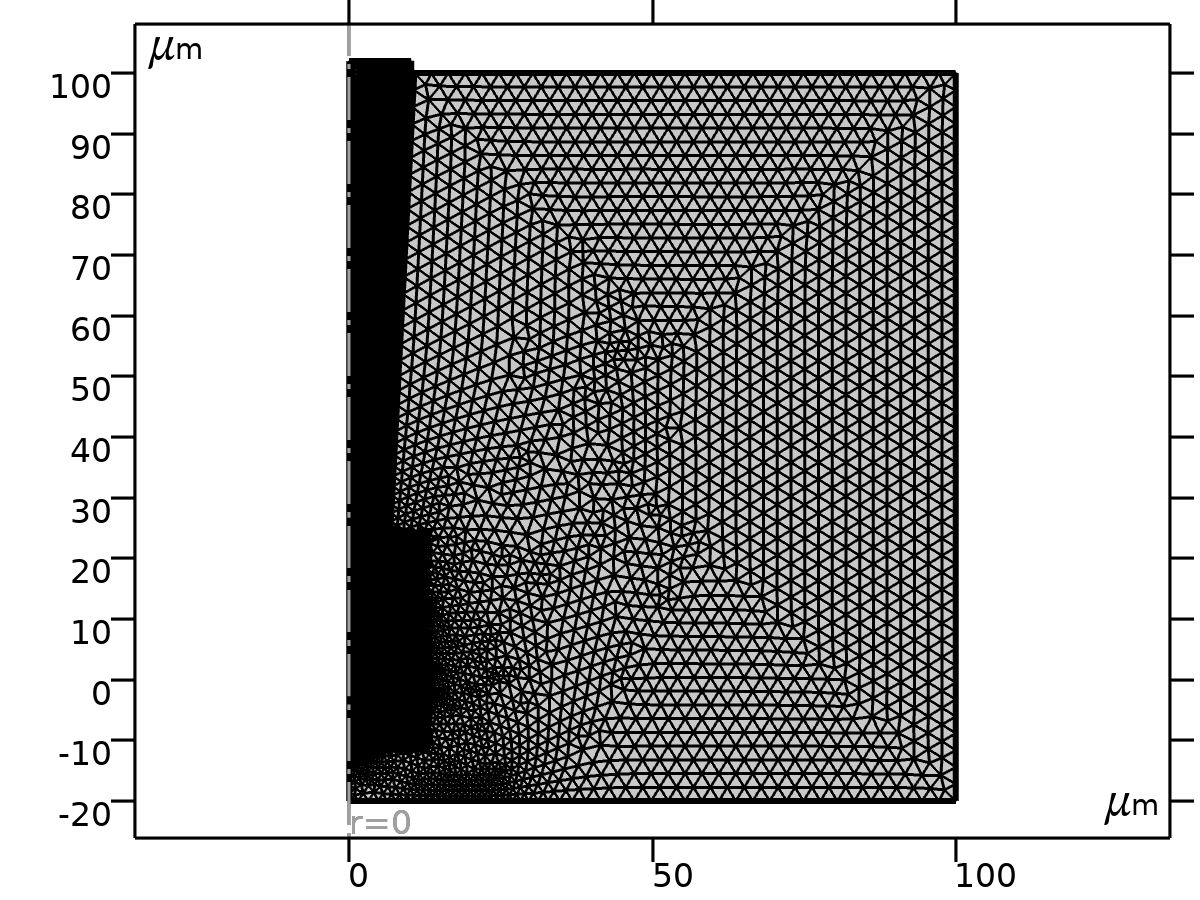
#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** | **Details** |
| --- | --- | --- | --- | --- | --- |
| es.nD | es.unr\*down(es.Dr)+es.unphi\*down(es.Dphi)+es.unz\*down(es.Dz) | C/m² | Surface charge density | Boundary 3 | + operation |
| es.V0 | pw1(t) | V | Electric potential | Boundary 3 |  |

#### Constraints

| **Constraint** | **Constraint force** | **Shape function** | **Selection** | **Details** |
| --- | --- | --- | --- | --- |
| es.V0-V | test(es.V0-V) | Lagrange (Quadratic) | Boundary 3 | Elemental |

* 1. Mesh



Mesh

* + 1. Size (size)

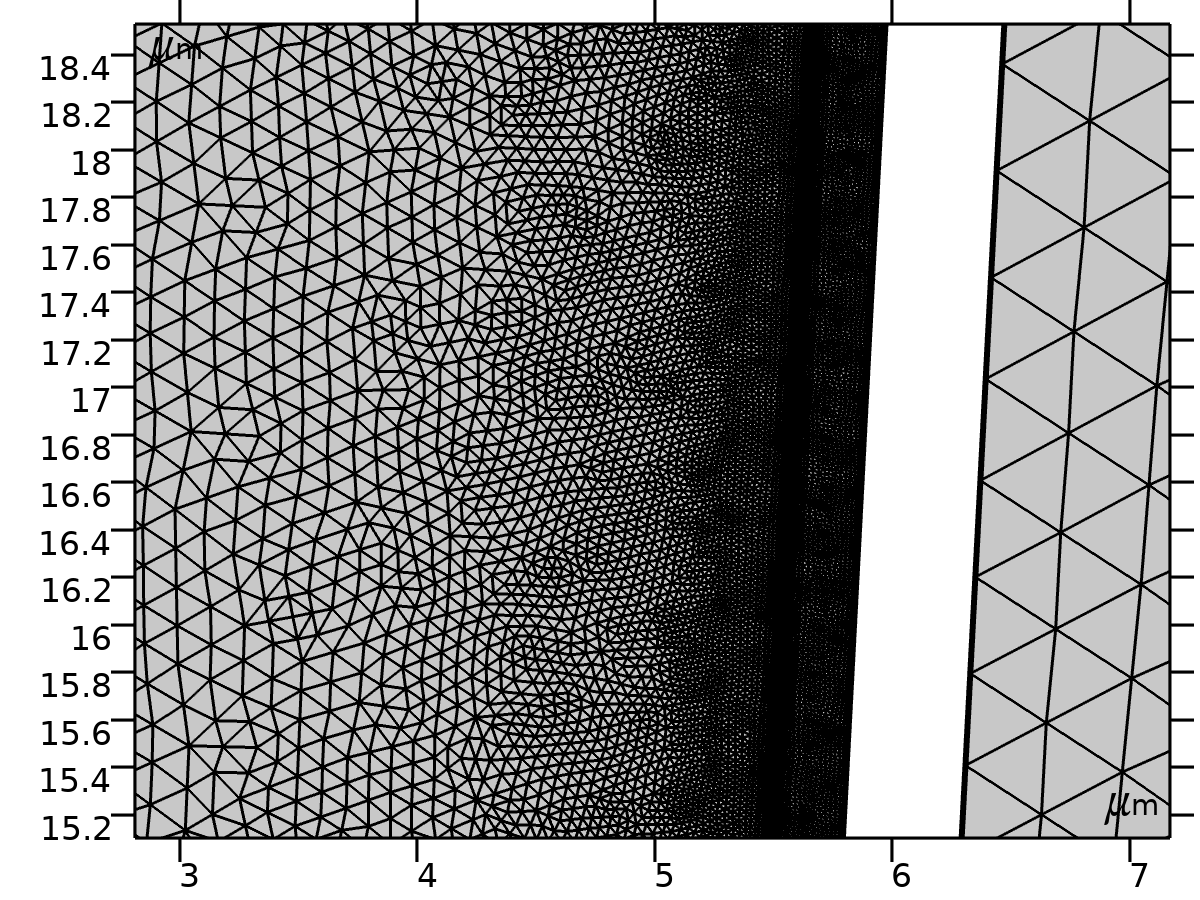
Settings

| **Description** | **Value** |
| --- | --- |
| Calibrate for | Fluid dynamics |
| Maximum element size | 0.67 |
| Minimum element size | 0.002 |
| Curvature factor | 0.2 |
| Maximum element growth rate | 1.05 |
| Predefined size | Extremely fine |

* + 1. Free Triangular (ftri1)

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Geometry geom1 |

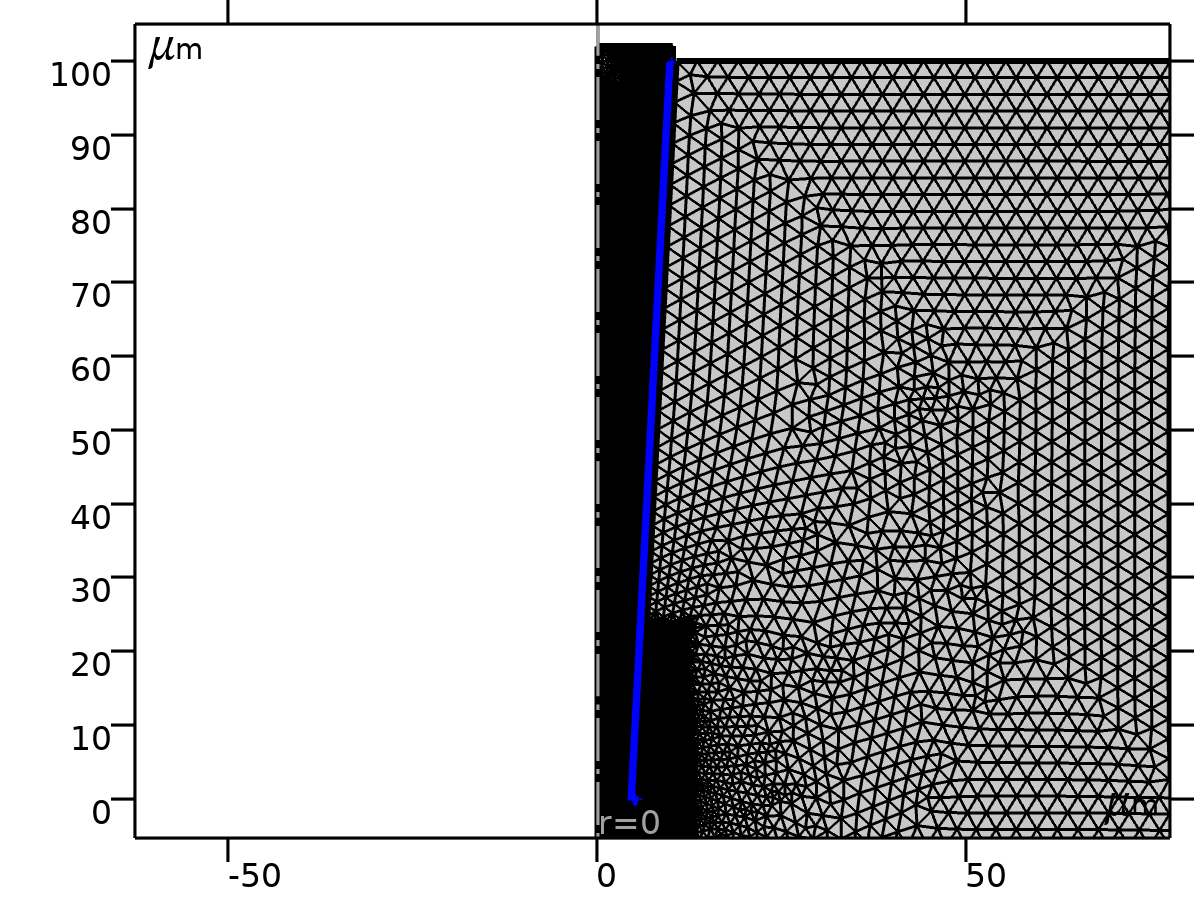


Free Triangular

#### Size\_Pim (size2)

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Geometry geom1: Dimension 2: Domain 2 |



Size\_Pim

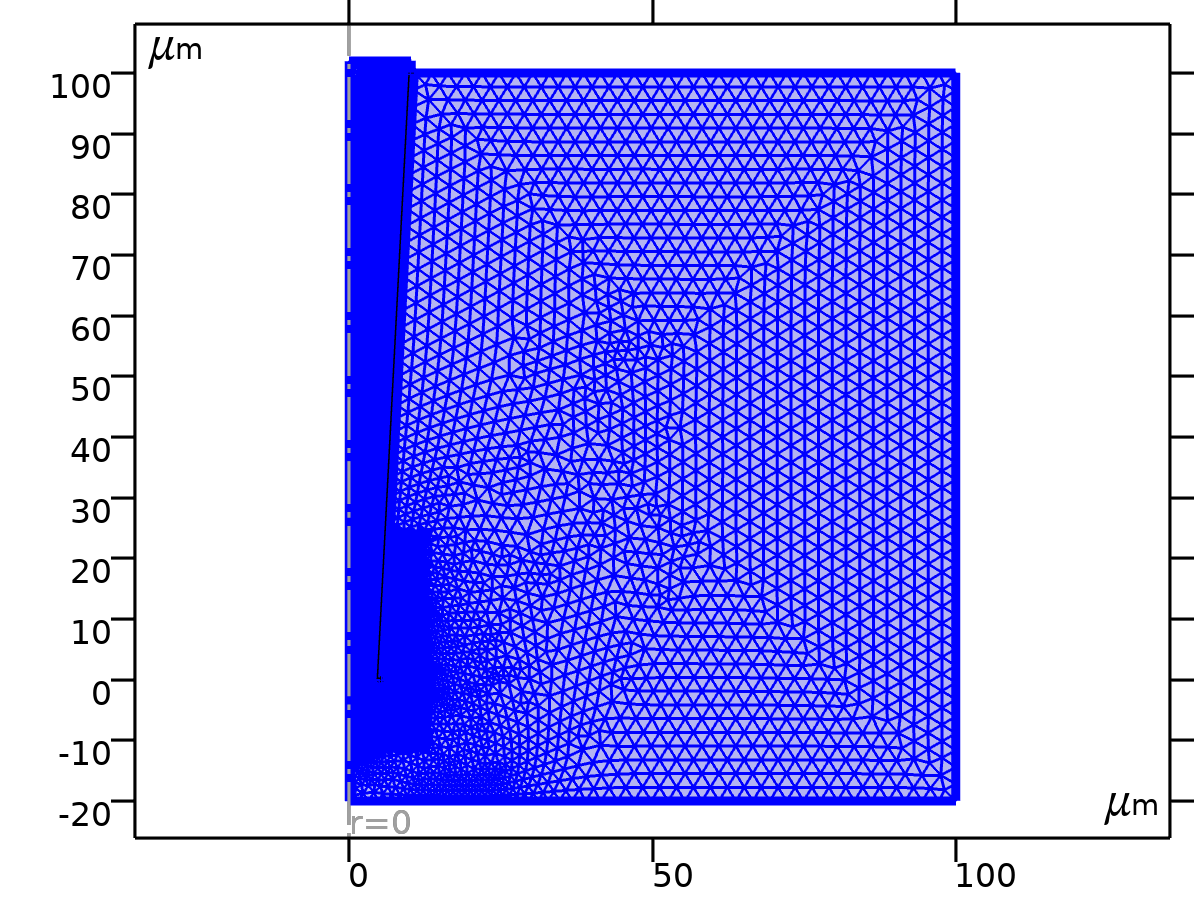
Settings

| **Description** | **Value** |
| --- | --- |
| Calibrate for | Fluid dynamics |
| Maximum element size | 0.05 |
| Minimum element size | 0.001 |
| Curvature factor | 0.2 |
| Curvature factor | Off |
| Resolution of narrow regions | Off |
| Maximum element growth rate | 1.05 |
| Predefined size | Extremely fine |
| Custom element size | Custom |

#### Size\_bulk (size1)

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Geometry geom1: Dimension 2: Domain 1 |



Size\_bulk

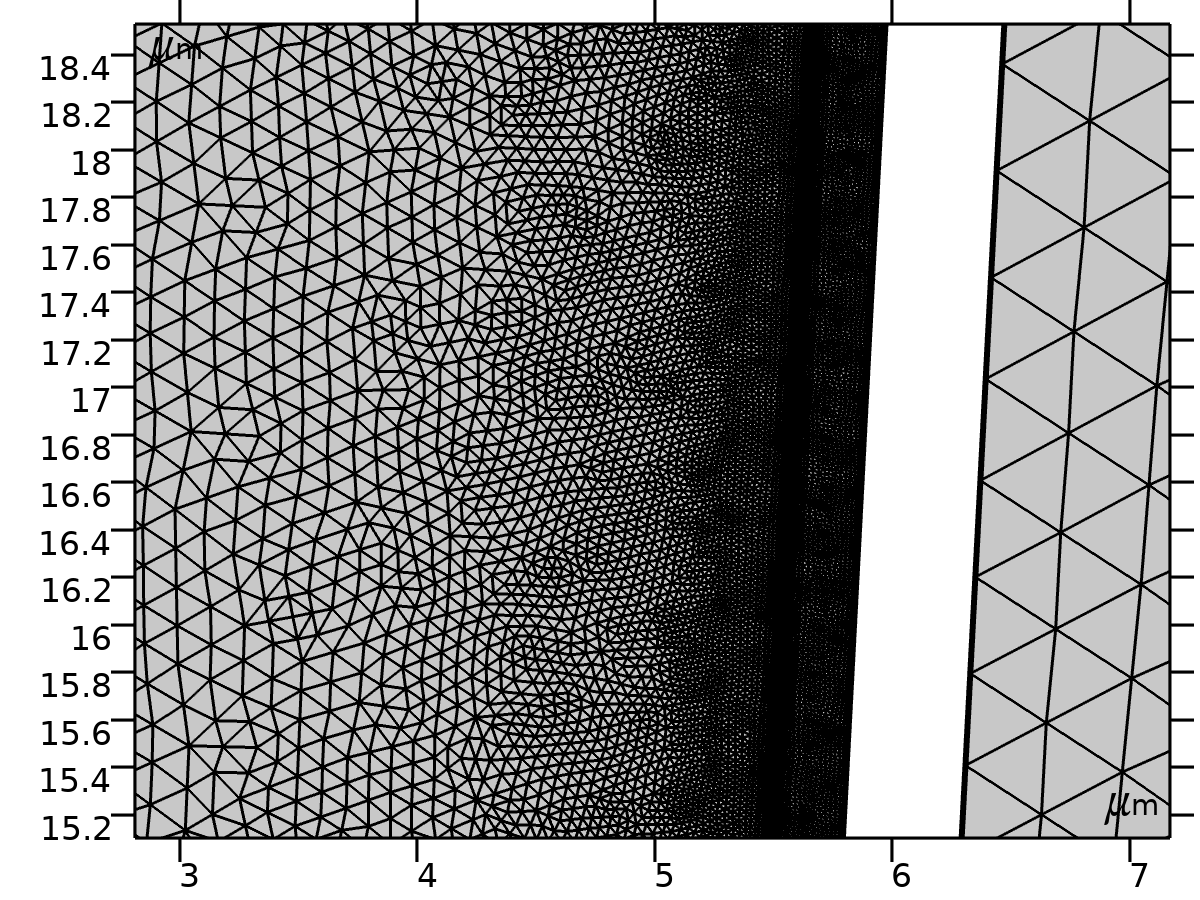
Settings

| **Description** | **Value** |
| --- | --- |
| Calibrate for | Fluid dynamics |
| Maximum element size | 2.8 |
| Minimum element size | 0.04 |
| Curvature factor | 0.25 |
| Predefined size | Finer |

* + 1. Boundary Layer (bl1)

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Geometry geom1 |

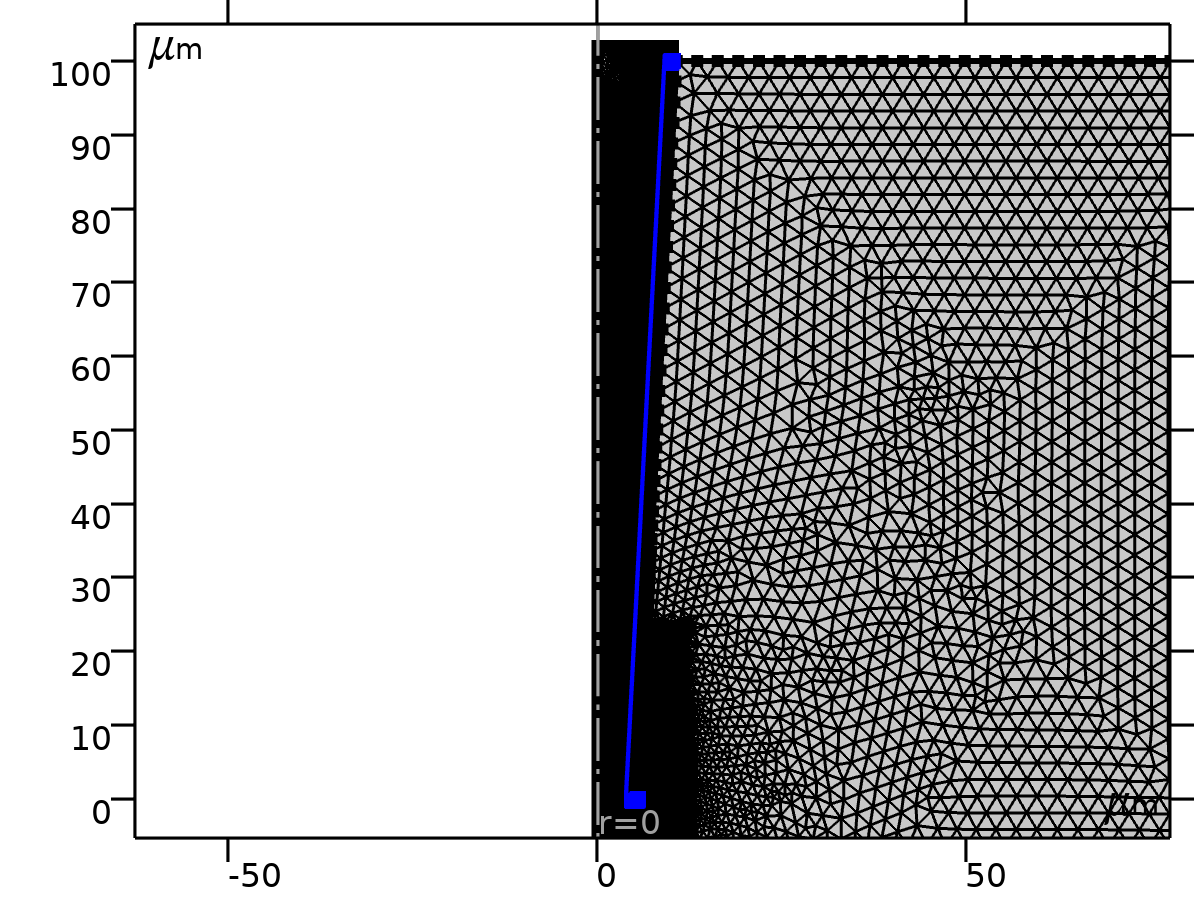


Boundary Layer

#### Boundary Layer Properties (blp)

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Geometry geom1: Dimension 1: Boundaries 4–6, 9, 11, 15–16, 18–19 |



Boundary Layer Properties

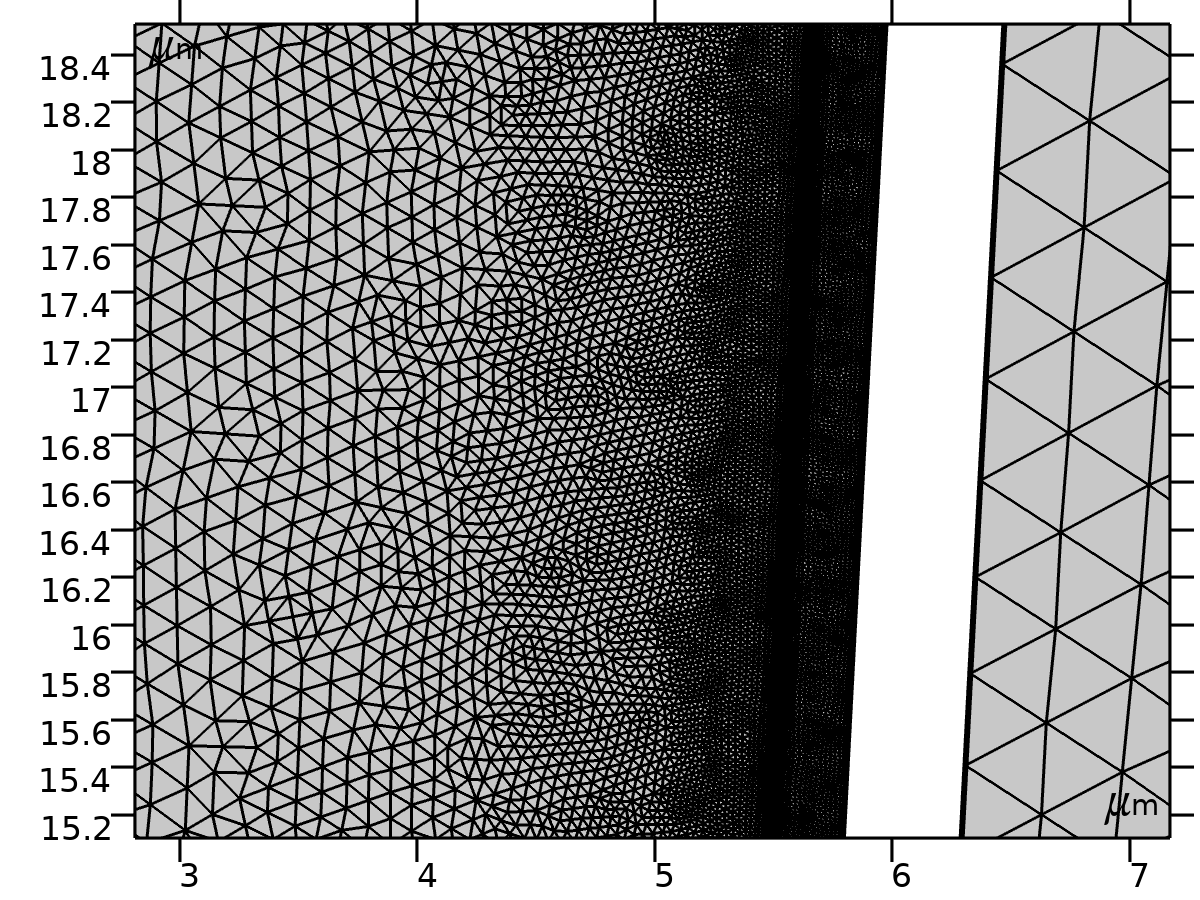
Settings

| **Description** | **Value** |
| --- | --- |
| Stretching factor | 1.1 |

* + 1. Refine (ref1)

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Geometry geom1 |



Refine

Settings

| **Description** | **Value** |
| --- | --- |
| Specify bounding box | Use bounding box |
| xmax | 13.5 |
| xmin | -2.67 |
| ymax | 25 |
| ymin | -12.1 |

1. Study\_1 no bias

Computation information

|  |  |
| --- | --- |
| Computation time | 3 min 13 s |

* 1. Steady state

Study settings

| **Description** | **Value** |
| --- | --- |
| Include geometric nonlinearity | Off |

Physics and variables selection

| **Physics interface** | **Discretization** |
| --- | --- |
| Transport of Diluted Species (tds) | physics |
| Electrostatics (es) | physics |

Mesh selection

| **Geometry** | **Mesh** |
| --- | --- |
| Geometry (geom1) | mesh1 |

* 1. Solver Configurations
     1. Solution 1

#### Compile Equations: Steady state (st1)

Study and step

| **Description** | **Value** |
| --- | --- |
| Use study | [Study\_1 no bias](#cs3755022) |
| Use study step | Steady state |

#### Dependent Variables 1 (v1)

General

| **Description** | **Value** |
| --- | --- |
| Defined by study step | [Steady state](#cs8835906) |

##### 浓度 (comp1.c) (comp1\_c)

General

| **Description** | **Value** |
| --- | --- |
| Field components | comp1.c |
| Internal variables | {comp1.uflux.c, comp1.dflux.c} |

##### 浓度 (comp1.c2) (comp1\_c2)

General

| **Description** | **Value** |
| --- | --- |
| Field components | comp1.c2 |
| Internal variables | {comp1.uflux.c2, comp1.dflux.c2} |

##### 电势 (comp1.V) (comp1\_V)

General

| **Description** | **Value** |
| --- | --- |
| Field components | comp1.V |

#### Stationary Solver (s1)

General

| **Description** | **Value** |
| --- | --- |
| Defined by study step | [Steady state](#cs8835906) |

##### Advanced Setting (aDef)

Assembly settings

| **Description** | **Value** |
| --- | --- |
| Reuse sparsity pattern | On |

##### 全耦合 1 (fc1)

General

| **Description** | **Value** |
| --- | --- |
| Linear solver | [直接 1](#cs4656108) |

Method and termination

| **Description** | **Value** |
| --- | --- |
| Initial damping factor | 0.01 |
| Minimum damping factor | 1.0E-6 |
| Maximum number of iterations | 50 |

1. Study\_2 PPF

Computation information

|  |  |
| --- | --- |
| Computation time | 1 h 33 min 55 s |

* 1. Time dependent

| **Times** | **Unit** |
| --- | --- |
| range(0,0.1,60) | ms |

Study settings

| **Description** | **Value** |
| --- | --- |
| Include geometric nonlinearity | Off |

Study settings

| **Description** | **Value** |
| --- | --- |
| Time unit | ms |
| Output times | {0, 0.1, 0.2, 0.30000000000000004, 0.4, 0.5, 0.6000000000000001, 0.7000000000000001, 0.8, 0.9, 1, 1.1, 1.2000000000000002, 1.3, 1.4000000000000001, 1.5, 1.6, 1.7000000000000002, 1.8, 1.9000000000000001, 2, 2.1, 2.2, 2.3000000000000003, 2.4000000000000004, 2.5, 2.6, 2.7, 2.8000000000000003, 2.9000000000000004, 3, 3.1, 3.2, 3.3000000000000003, 3.4000000000000004, 3.5, 3.6, 3.7, 3.8000000000000003, 3.9000000000000004, 4, 4.1000000000000005, 4.2, 4.3, 4.4, 4.5, 4.6000000000000005, 4.7, 4.800000000000001, 4.9, 5, 5.1000000000000005, 5.2, 5.300000000000001, 5.4, 5.5, 5.6000000000000005, 5.7, 5.800000000000001, 5.9, 6, 6.1000000000000005, 6.2, 6.300000000000001, 6.4, 6.5, 6.6000000000000005, 6.7, 6.800000000000001, 6.9, 7, 7.1000000000000005, 7.2, 7.300000000000001, 7.4, 7.5, 7.6000000000000005, 7.7, 7.800000000000001, 7.9, 8, 8.1, 8.200000000000001, 8.3, 8.4, 8.5, 8.6, 8.700000000000001, 8.8, 8.9, 9, 9.1, 9.200000000000001, 9.3, 9.4, 9.5, 9.600000000000001, 9.700000000000001, 9.8, 9.9, 10, 10.100000000000001, 10.200000000000001, 10.3, 10.4, 10.5, 10.600000000000001, 10.700000000000001, 10.8, 10.9, 11, 11.100000000000001, 11.200000000000001, 11.3, 11.4, 11.5, 11.600000000000001, 11.700000000000001, 11.8, 11.9, 12, 12.100000000000001, 12.200000000000001, 12.3, 12.4, 12.5, 12.600000000000001, 12.700000000000001, 12.8, 12.9, 13, 13.100000000000001, 13.200000000000001, 13.3, 13.4, 13.5, 13.600000000000001, 13.700000000000001, 13.8, 13.9, 14, 14.100000000000001, 14.200000000000001, 14.3, 14.4, 14.5, 14.600000000000001, 14.700000000000001, 14.8, 14.9, 15, 15.100000000000001, 15.200000000000001, 15.3, 15.4, 15.5, 15.600000000000001, 15.700000000000001, 15.8, 15.9, 16, 16.1, 16.2, 16.3, 16.400000000000002, 16.5, 16.6, 16.7, 16.8, 16.900000000000002, 17, 17.1, 17.2, 17.3, 17.400000000000002, 17.5, 17.6, 17.7, 17.8, 17.900000000000002, 18, 18.1, 18.2, 18.3, 18.400000000000002, 18.5, 18.6, 18.7, 18.8, 18.900000000000002, 19, 19.1, 19.200000000000003, 19.3, 19.400000000000002, 19.5, 19.6, 19.700000000000003, 19.8, 19.900000000000002, 20, 20.1, 20.200000000000003, 20.3, 20.400000000000002, 20.5, 20.6, 20.700000000000003, 20.8, 20.900000000000002, 21, 21.1, 21.200000000000003, 21.3, 21.400000000000002, 21.5, 21.6, 21.700000000000003, 21.8, 21.900000000000002, 22, 22.1, 22.200000000000003, 22.3, 22.400000000000002, 22.5, 22.6, 22.700000000000003, 22.8, 22.900000000000002, 23, 23.1, 23.200000000000003, 23.3, 23.400000000000002, 23.5, 23.6, 23.700000000000003, 23.8, 23.900000000000002, 24, 24.1, 24.200000000000003, 24.3, 24.400000000000002, 24.5, 24.6, 24.700000000000003, 24.8, 24.900000000000002, 25, 25.1, 25.200000000000003, 25.3, 25.400000000000002, 25.5, 25.6, 25.700000000000003, 25.8, 25.900000000000002, 26, 26.1, 26.200000000000003, 26.3, 26.400000000000002, 26.5, 26.6, 26.700000000000003, 26.8, 26.900000000000002, 27, 27.1, 27.200000000000003, 27.3, 27.400000000000002, 27.5, 27.6, 27.700000000000003, 27.8, 27.900000000000002, 28, 28.1, 28.200000000000003, 28.3, 28.400000000000002, 28.5, 28.6, 28.700000000000003, 28.8, 28.900000000000002, 29, 29.1, 29.200000000000003, 29.3, 29.400000000000002, 29.5, 29.6, 29.700000000000003, 29.8, 29.900000000000002, 30, 30.1, 30.200000000000003, 30.3, 30.400000000000002, 30.5, 30.6, 30.700000000000003, 30.8, 30.900000000000002, 31, 31.1, 31.200000000000003, 31.3, 31.400000000000002, 31.5, 31.6, 31.700000000000003, 31.8, 31.900000000000002, 32, 32.1, 32.2, 32.300000000000004, 32.4, 32.5, 32.6, 32.7, 32.800000000000004, 32.9, 33, 33.1, 33.2, 33.300000000000004, 33.4, 33.5, 33.6, 33.7, 33.800000000000004, 33.9, 34, 34.1, 34.2, 34.300000000000004, 34.4, 34.5, 34.6, 34.7, 34.800000000000004, 34.9, 35, 35.1, 35.2, 35.300000000000004, 35.4, 35.5, 35.6, 35.7, 35.800000000000004, 35.9, 36, 36.1, 36.2, 36.300000000000004, 36.4, 36.5, 36.6, 36.7, 36.800000000000004, 36.9, 37, 37.1, 37.2, 37.300000000000004, 37.4, 37.5, 37.6, 37.7, 37.800000000000004, 37.9, 38, 38.1, 38.2, 38.300000000000004, 38.400000000000006, 38.5, 38.6, 38.7, 38.800000000000004, 38.900000000000006, 39, 39.1, 39.2, 39.300000000000004, 39.400000000000006, 39.5, 39.6, 39.7, 39.800000000000004, 39.900000000000006, 40, 40.1, 40.2, 40.300000000000004, 40.400000000000006, 40.5, 40.6, 40.7, 40.800000000000004, 40.900000000000006, 41, 41.1, 41.2, 41.300000000000004, 41.400000000000006, 41.5, 41.6, 41.7, 41.800000000000004, 41.900000000000006, 42, 42.1, 42.2, 42.300000000000004, 42.400000000000006, 42.5, 42.6, 42.7, 42.800000000000004, 42.900000000000006, 43, 43.1, 43.2, 43.300000000000004, 43.400000000000006, 43.5, 43.6, 43.7, 43.800000000000004, 43.900000000000006, 44, 44.1, 44.2, 44.300000000000004, 44.400000000000006, 44.5, 44.6, 44.7, 44.800000000000004, 44.900000000000006, 45, 45.1, 45.2, 45.300000000000004, 45.400000000000006, 45.5, 45.6, 45.7, 45.800000000000004, 45.900000000000006, 46, 46.1, 46.2, 46.300000000000004, 46.400000000000006, 46.5, 46.6, 46.7, 46.800000000000004, 46.900000000000006, 47, 47.1, 47.2, 47.300000000000004, 47.400000000000006, 47.5, 47.6, 47.7, 47.800000000000004, 47.900000000000006, 48, 48.1, 48.2, 48.300000000000004, 48.400000000000006, 48.5, 48.6, 48.7, 48.800000000000004, 48.900000000000006, 49, 49.1, 49.2, 49.300000000000004, 49.400000000000006, 49.5, 49.6, 49.7, 49.800000000000004, 49.900000000000006, 50, 50.1, 50.2, 50.300000000000004, 50.400000000000006, 50.5, 50.6, 50.7, 50.800000000000004, 50.900000000000006, 51, 51.1, 51.2, 51.300000000000004, 51.400000000000006, 51.5, 51.6, 51.7, 51.800000000000004, 51.900000000000006, 52, 52.1, 52.2, 52.300000000000004, 52.400000000000006, 52.5, 52.6, 52.7, 52.800000000000004, 52.900000000000006, 53, 53.1, 53.2, 53.300000000000004, 53.400000000000006, 53.5, 53.6, 53.7, 53.800000000000004, 53.900000000000006, 54, 54.1, 54.2, 54.300000000000004, 54.400000000000006, 54.5, 54.6, 54.7, 54.800000000000004, 54.900000000000006, 55, 55.1, 55.2, 55.300000000000004, 55.400000000000006, 55.5, 55.6, 55.7, 55.800000000000004, 55.900000000000006, 56, 56.1, 56.2, 56.300000000000004, 56.400000000000006, 56.5, 56.6, 56.7, 56.800000000000004, 56.900000000000006, 57, 57.1, 57.2, 57.300000000000004, 57.400000000000006, 57.5, 57.6, 57.7, 57.800000000000004, 57.900000000000006, 58, 58.1, 58.2, 58.300000000000004, 58.400000000000006, 58.5, 58.6, 58.7, 58.800000000000004, 58.900000000000006, 59, 59.1, 59.2, 59.300000000000004, 59.400000000000006, 59.5, 59.6, 59.7, 59.800000000000004, 59.900000000000006, 60} |

Values of dependent variables

| **Description** | **Value** |
| --- | --- |
| Settings | User controlled |
| Method | Solution |
| Study | [Study\_1 no bias](#cs3755022) |

Physics and variables selection

| **Physics interface** | **Discretization** |
| --- | --- |
| Transport of Diluted Species (tds) | physics |
| Electrostatics (es) | physics |

Mesh selection

| **Geometry** | **Mesh** |
| --- | --- |
| Geometry (geom1) | mesh1 |

* 1. Solver Configurations
     1. Solution 2

#### Compile Equations: Time dependent (st1)

Study and step

| **Description** | **Value** |
| --- | --- |
| Use study | [Study\_2 -1 V](#cs2485359) |
| Use study step | Time dependent |

#### Dependent Variables 1 (v1)

General

| **Description** | **Value** |
| --- | --- |
| Defined by study step | [Time dependent](#cs8947553) |

Initial values of variables solved for

| **Description** | **Value** |
| --- | --- |
| Method | Solution |
| Solution | [Solution 1](#cs2175061) |

Residual scaling

| **Description** | **Value** |
| --- | --- |
| Method | Manual |

Initial value calculation constants

| **Constant name** | **Initial value source** |
| --- | --- |
| t | range(0,0.1,60) |
| timestep | 0.06[ms] |

##### Concentration (comp1.c) (comp1\_c)

General

| **Description** | **Value** |
| --- | --- |
| Field components | comp1.c |
| Internal variables | {comp1.uflux.c, comp1.dflux.c, comp1.tds.dt2Inv\_c} |

##### Concentration (comp1.c2) (comp1\_c2)

General

| **Description** | **Value** |
| --- | --- |
| Field components | comp1.c2 |
| Internal variables | {comp1.uflux.c2, comp1.dflux.c2, comp1.tds.dt2Inv\_c2} |

##### Electric potential (comp1.V) (comp1\_V)

General

| **Description** | **Value** |
| --- | --- |
| Field components | comp1.V |

#### Time-Dependent Solver 1 (t1)

General

| **Description** | **Value** |
| --- | --- |
| Defined by study step | [Time dependent](#cs8947553) |
| Time unit | ms |
| Output times | {0, 0.1, 0.2, 0.30000000000000004, 0.4, 0.5, 0.6000000000000001, 0.7000000000000001, 0.8, 0.9, 1, 1.1, 1.2000000000000002, 1.3, 1.4000000000000001, 1.5, 1.6, 1.7000000000000002, 1.8, 1.9000000000000001, 2, 2.1, 2.2, 2.3000000000000003, 2.4000000000000004, 2.5, 2.6, 2.7, 2.8000000000000003, 2.9000000000000004, 3, 3.1, 3.2, 3.3000000000000003, 3.4000000000000004, 3.5, 3.6, 3.7, 3.8000000000000003, 3.9000000000000004, 4, 4.1000000000000005, 4.2, 4.3, 4.4, 4.5, 4.6000000000000005, 4.7, 4.800000000000001, 4.9, 5, 5.1000000000000005, 5.2, 5.300000000000001, 5.4, 5.5, 5.6000000000000005, 5.7, 5.800000000000001, 5.9, 6, 6.1000000000000005, 6.2, 6.300000000000001, 6.4, 6.5, 6.6000000000000005, 6.7, 6.800000000000001, 6.9, 7, 7.1000000000000005, 7.2, 7.300000000000001, 7.4, 7.5, 7.6000000000000005, 7.7, 7.800000000000001, 7.9, 8, 8.1, 8.200000000000001, 8.3, 8.4, 8.5, 8.6, 8.700000000000001, 8.8, 8.9, 9, 9.1, 9.200000000000001, 9.3, 9.4, 9.5, 9.600000000000001, 9.700000000000001, 9.8, 9.9, 10, 10.100000000000001, 10.200000000000001, 10.3, 10.4, 10.5, 10.600000000000001, 10.700000000000001, 10.8, 10.9, 11, 11.100000000000001, 11.200000000000001, 11.3, 11.4, 11.5, 11.600000000000001, 11.700000000000001, 11.8, 11.9, 12, 12.100000000000001, 12.200000000000001, 12.3, 12.4, 12.5, 12.600000000000001, 12.700000000000001, 12.8, 12.9, 13, 13.100000000000001, 13.200000000000001, 13.3, 13.4, 13.5, 13.600000000000001, 13.700000000000001, 13.8, 13.9, 14, 14.100000000000001, 14.200000000000001, 14.3, 14.4, 14.5, 14.600000000000001, 14.700000000000001, 14.8, 14.9, 15, 15.100000000000001, 15.200000000000001, 15.3, 15.4, 15.5, 15.600000000000001, 15.700000000000001, 15.8, 15.9, 16, 16.1, 16.2, 16.3, 16.400000000000002, 16.5, 16.6, 16.7, 16.8, 16.900000000000002, 17, 17.1, 17.2, 17.3, 17.400000000000002, 17.5, 17.6, 17.7, 17.8, 17.900000000000002, 18, 18.1, 18.2, 18.3, 18.400000000000002, 18.5, 18.6, 18.7, 18.8, 18.900000000000002, 19, 19.1, 19.200000000000003, 19.3, 19.400000000000002, 19.5, 19.6, 19.700000000000003, 19.8, 19.900000000000002, 20, 20.1, 20.200000000000003, 20.3, 20.400000000000002, 20.5, 20.6, 20.700000000000003, 20.8, 20.900000000000002, 21, 21.1, 21.200000000000003, 21.3, 21.400000000000002, 21.5, 21.6, 21.700000000000003, 21.8, 21.900000000000002, 22, 22.1, 22.200000000000003, 22.3, 22.400000000000002, 22.5, 22.6, 22.700000000000003, 22.8, 22.900000000000002, 23, 23.1, 23.200000000000003, 23.3, 23.400000000000002, 23.5, 23.6, 23.700000000000003, 23.8, 23.900000000000002, 24, 24.1, 24.200000000000003, 24.3, 24.400000000000002, 24.5, 24.6, 24.700000000000003, 24.8, 24.900000000000002, 25, 25.1, 25.200000000000003, 25.3, 25.400000000000002, 25.5, 25.6, 25.700000000000003, 25.8, 25.900000000000002, 26, 26.1, 26.200000000000003, 26.3, 26.400000000000002, 26.5, 26.6, 26.700000000000003, 26.8, 26.900000000000002, 27, 27.1, 27.200000000000003, 27.3, 27.400000000000002, 27.5, 27.6, 27.700000000000003, 27.8, 27.900000000000002, 28, 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38.300000000000004, 38.400000000000006, 38.5, 38.6, 38.7, 38.800000000000004, 38.900000000000006, 39, 39.1, 39.2, 39.300000000000004, 39.400000000000006, 39.5, 39.6, 39.7, 39.800000000000004, 39.900000000000006, 40, 40.1, 40.2, 40.300000000000004, 40.400000000000006, 40.5, 40.6, 40.7, 40.800000000000004, 40.900000000000006, 41, 41.1, 41.2, 41.300000000000004, 41.400000000000006, 41.5, 41.6, 41.7, 41.800000000000004, 41.900000000000006, 42, 42.1, 42.2, 42.300000000000004, 42.400000000000006, 42.5, 42.6, 42.7, 42.800000000000004, 42.900000000000006, 43, 43.1, 43.2, 43.300000000000004, 43.400000000000006, 43.5, 43.6, 43.7, 43.800000000000004, 43.900000000000006, 44, 44.1, 44.2, 44.300000000000004, 44.400000000000006, 44.5, 44.6, 44.7, 44.800000000000004, 44.900000000000006, 45, 45.1, 45.2, 45.300000000000004, 45.400000000000006, 45.5, 45.6, 45.7, 45.800000000000004, 45.900000000000006, 46, 46.1, 46.2, 46.300000000000004, 46.400000000000006, 46.5, 46.6, 46.7, 46.800000000000004, 46.900000000000006, 47, 47.1, 47.2, 47.300000000000004, 47.400000000000006, 47.5, 47.6, 47.7, 47.800000000000004, 47.900000000000006, 48, 48.1, 48.2, 48.300000000000004, 48.400000000000006, 48.5, 48.6, 48.7, 48.800000000000004, 48.900000000000006, 49, 49.1, 49.2, 49.300000000000004, 49.400000000000006, 49.5, 49.6, 49.7, 49.800000000000004, 49.900000000000006, 50, 50.1, 50.2, 50.300000000000004, 50.400000000000006, 50.5, 50.6, 50.7, 50.800000000000004, 50.900000000000006, 51, 51.1, 51.2, 51.300000000000004, 51.400000000000006, 51.5, 51.6, 51.7, 51.800000000000004, 51.900000000000006, 52, 52.1, 52.2, 52.300000000000004, 52.400000000000006, 52.5, 52.6, 52.7, 52.800000000000004, 52.900000000000006, 53, 53.1, 53.2, 53.300000000000004, 53.400000000000006, 53.5, 53.6, 53.7, 53.800000000000004, 53.900000000000006, 54, 54.1, 54.2, 54.300000000000004, 54.400000000000006, 54.5, 54.6, 54.7, 54.800000000000004, 54.900000000000006, 55, 55.1, 55.2, 55.300000000000004, 55.400000000000006, 55.5, 55.6, 55.7, 55.800000000000004, 55.900000000000006, 56, 56.1, 56.2, 56.300000000000004, 56.400000000000006, 56.5, 56.6, 56.7, 56.800000000000004, 56.900000000000006, 57, 57.1, 57.2, 57.300000000000004, 57.400000000000006, 57.5, 57.6, 57.7, 57.800000000000004, 57.900000000000006, 58, 58.1, 58.2, 58.300000000000004, 58.400000000000006, 58.5, 58.6, 58.7, 58.800000000000004, 58.900000000000006, 59, 59.1, 59.2, 59.300000000000004, 59.400000000000006, 59.5, 59.6, 59.7, 59.800000000000004, 59.900000000000006, 60} |
| Relative tolerance | 0.005 |

Time stepping

| **Description** | **Value** |
| --- | --- |
| Maximum BDF order | 2 |
| Nonlinear controller | On |

##### Advanced (aDef)

Assembly settings

| **Description** | **Value** |
| --- | --- |
| Reuse sparsity pattern | On |

##### Fully Coupled 1 (fc1)

General

| **Description** | **Value** |
| --- | --- |
| Linear solver | [Direct 1](#cs9054074) |

Method and termination

| **Description** | **Value** |
| --- | --- |
| Damping factor | 0.9 |
| Jacobian update | Once per time step |
| Maximum number of iterations | 8 |
| Stabilization and acceleration | Anderson acceleration |
| Dimension of iteration space | 5 |
| Mixing parameter | 0.9 |

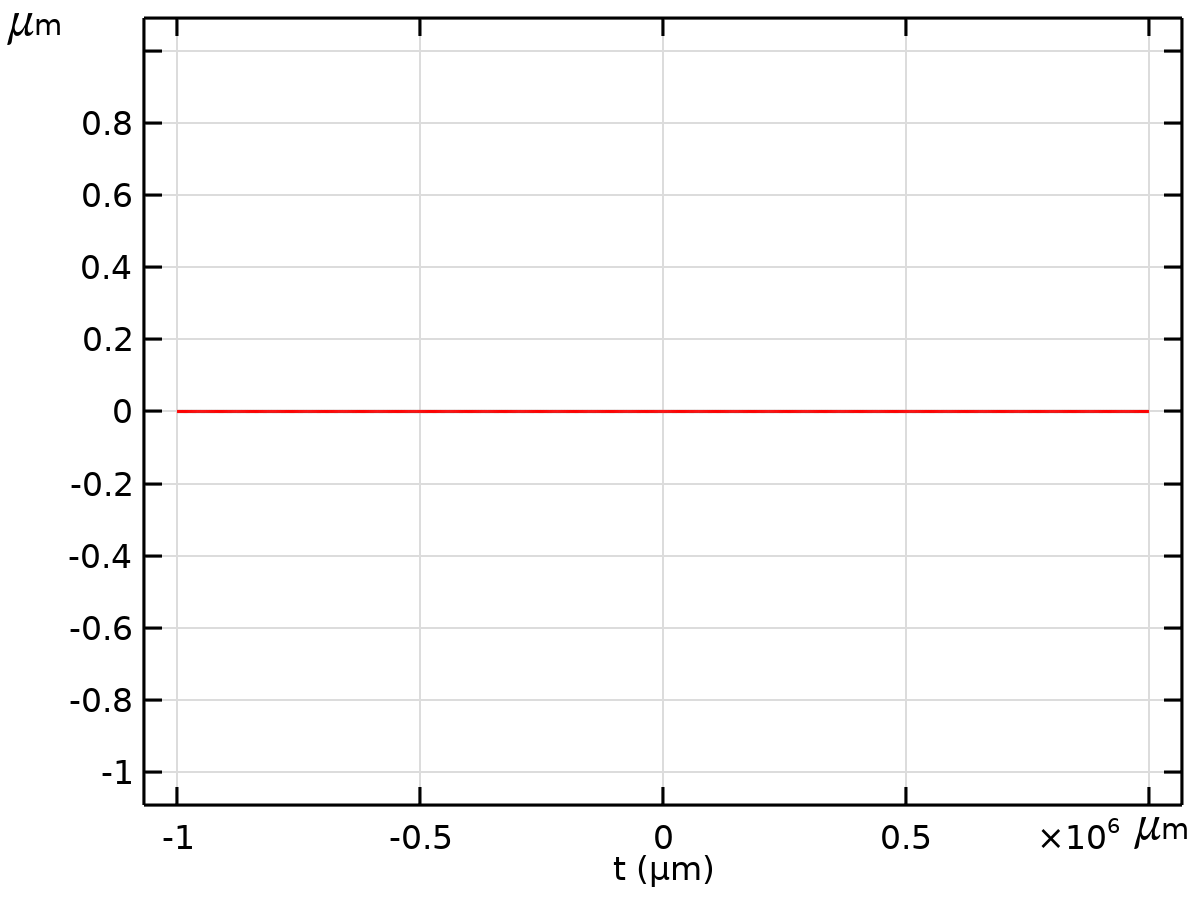
1. Results
   1. Dataset
      1. Grid 1D

Data

| **Description** | **Value** |
| --- | --- |
| Function | Triangle Wave 1 |
| Refresh |  |

Parameter bounds

| **Description** | **Value** |
| --- | --- |
| Name | t |
| Minimum | -1 |
| Maximum | 1 |

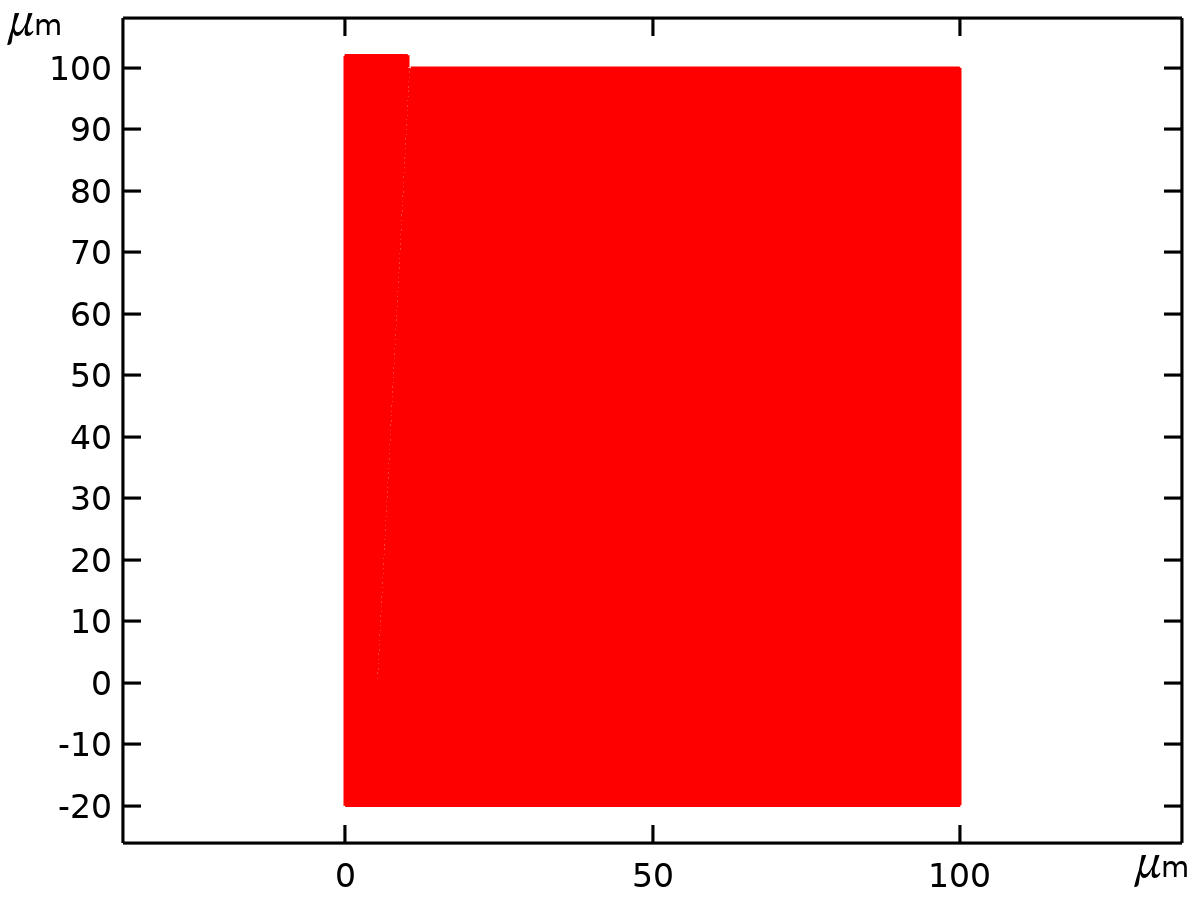


Dataset: Grid 1D

* + 1. Study\_1 no bias/Solution 1

Solution

| **Description** | **Value** |
| --- | --- |
| Solution | [Solution 1](#cs2175061) |
| Component | Compoment 1 (comp1) |



Dataset: Study\_1 no bias/Solution 1

* + 1. Revolution 2D

Data

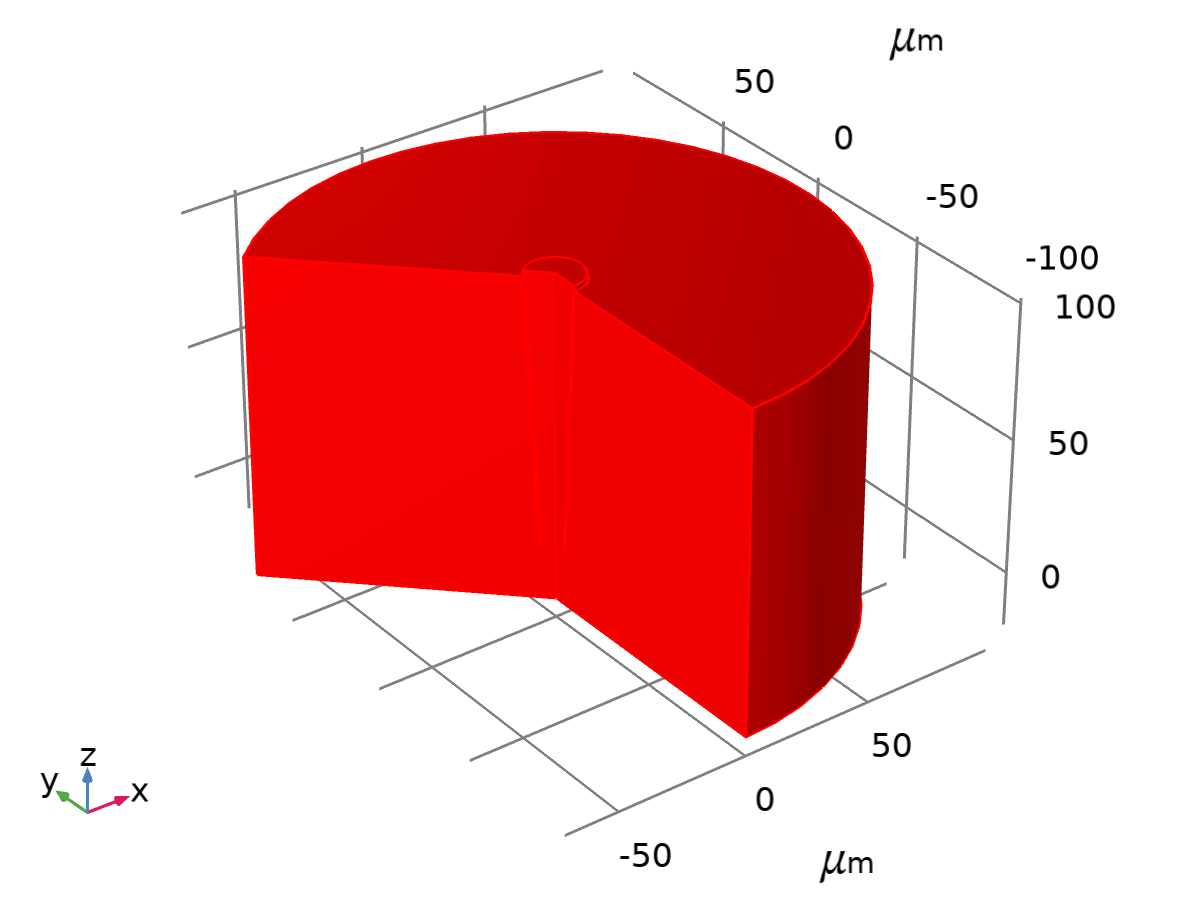
| **Description** | **Value** |
| --- | --- |
| Dataset | [Study\_1 no bias/Solution 1](#cs8794738) |

Axis data

| **Description** | **Value** |
| --- | --- |
| Axis entry method | Two points |
| Points | {{0, 0}, {0, 1}} |

Revolution layers

| **Description** | **Value** |
| --- | --- |
| Start angle | -90 |
| Revolution angle | 225 |



Dataset: Revolution 2D

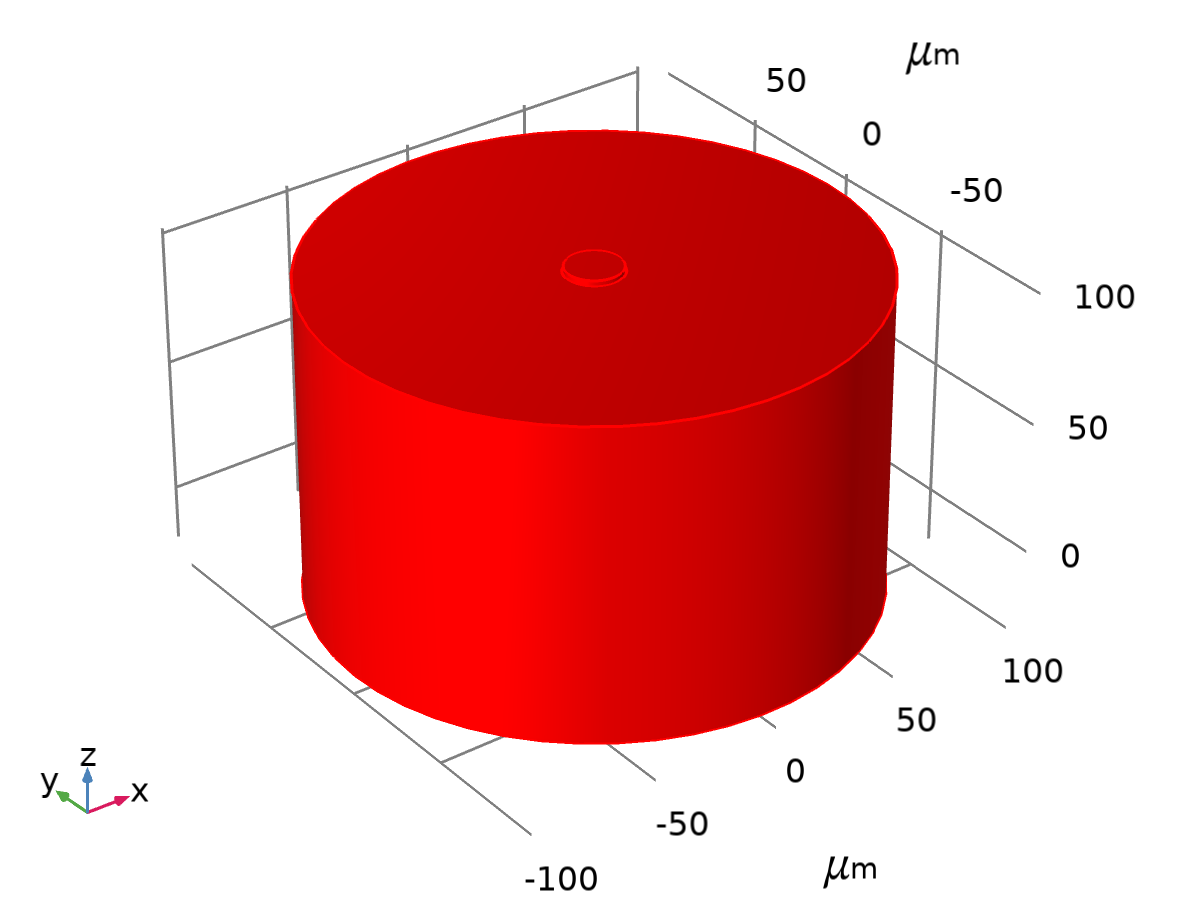
* + 1. Revolution 2D\_2

Data

| **Description** | **Value** |
| --- | --- |
| Dataset | [Study\_1 no bias/Solution 1](#cs8794738) |

Axis data

| **Description** | **Value** |
| --- | --- |
| Axis entry method | Two points |
| Points | {{0, 0}, {0, 1}} |

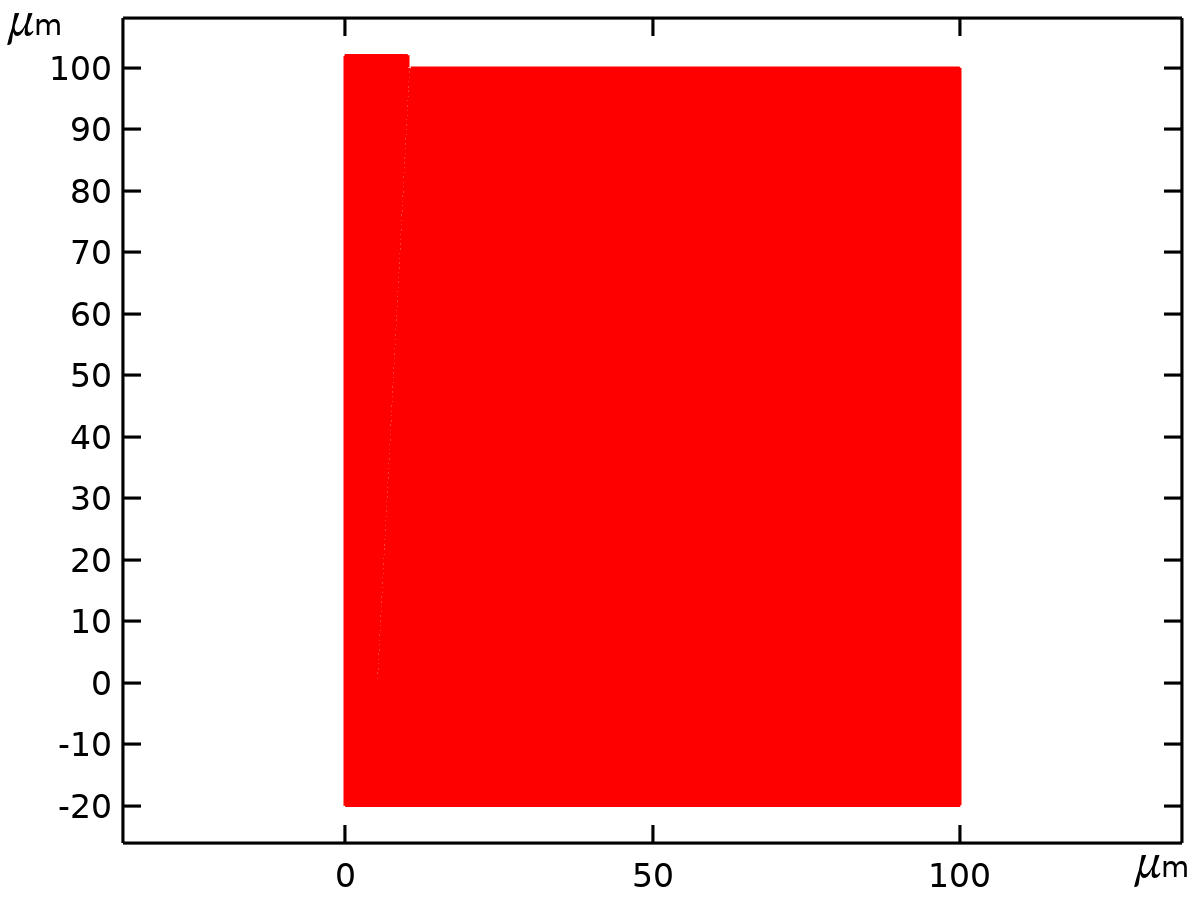


Dataset: Revolution 2D\_2

* + 1. Study\_2 1 V/Solve 2

Solution

| **Description** | **Value** |
| --- | --- |
| Solution | [Solution 2](#cs4942361) |
| Component | Component (comp1) |



Dataset: Study\_2 1 V/Solve 2

* + 1. Revolution 2D\_3

Data

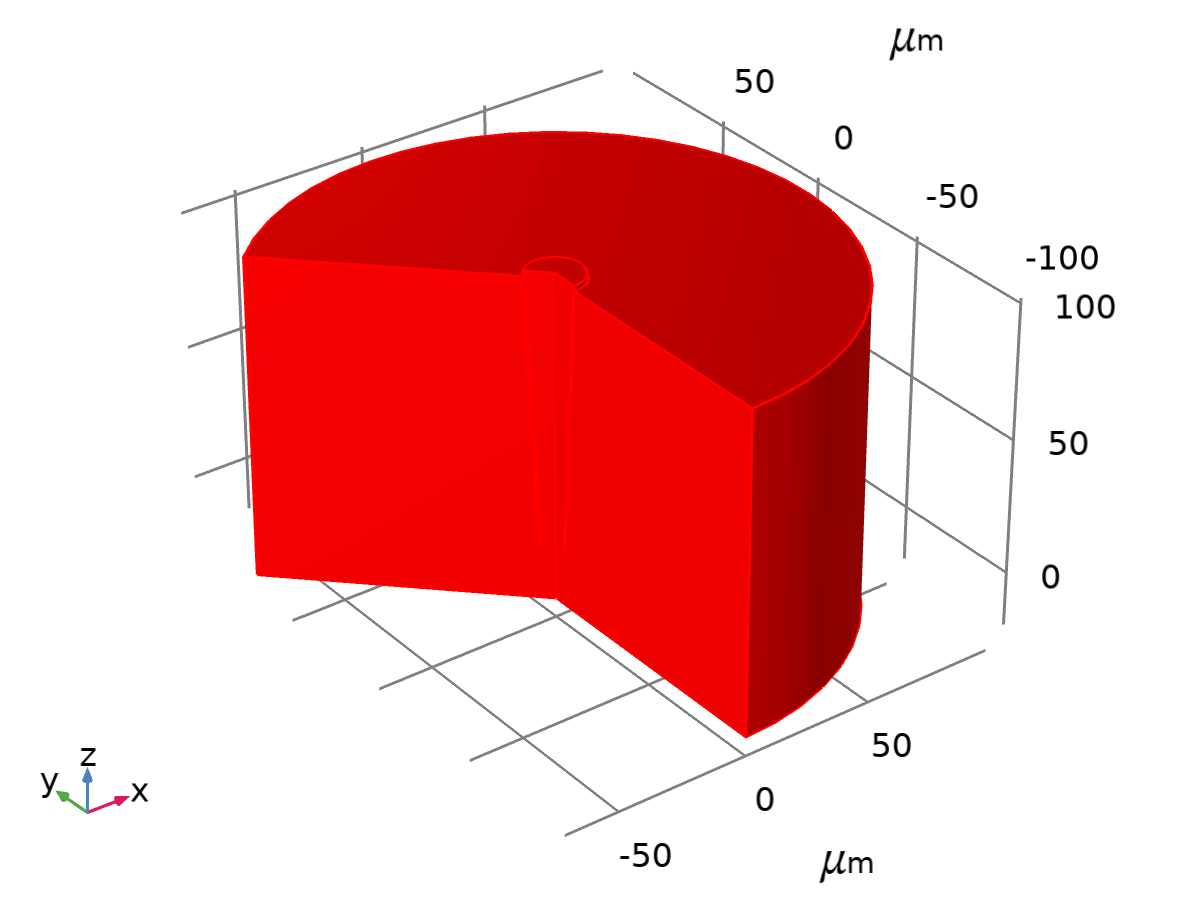
| **Description** | **Value** |
| --- | --- |
| Dataset | [Study\_2 1 V/Solve 2](#cs4212131) |

Axis data

| **Description** | **Value** |
| --- | --- |
| Axis entry method | Two points |
| Points | {{0, 0}, {0, 1}} |

Revolution layers

| **Description** | **Value** |
| --- | --- |
| Start angle | -90 |
| Revolution angle | 225 |



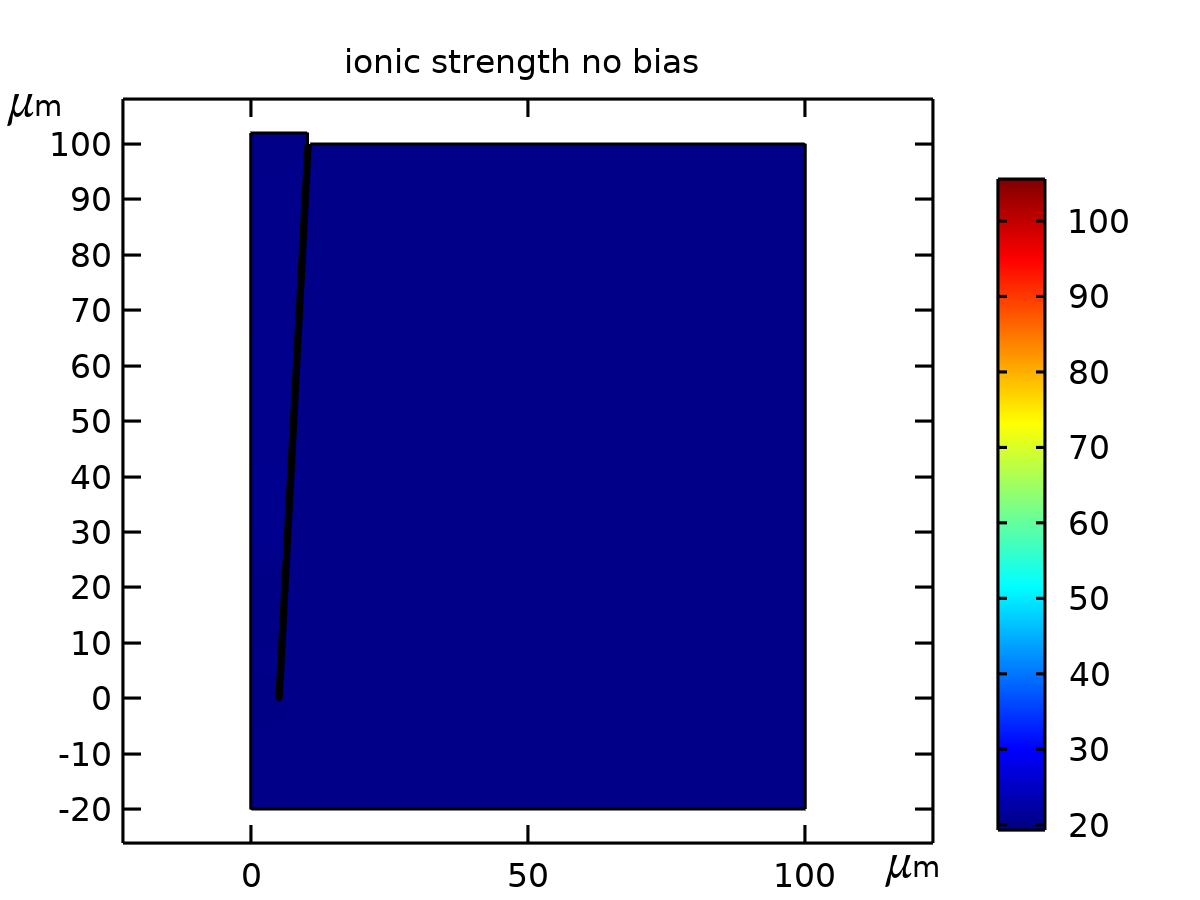
Dataset: Revolution 2D\_3

* 1. 表格
     1. Evaluation 2D

Interactive 2D values

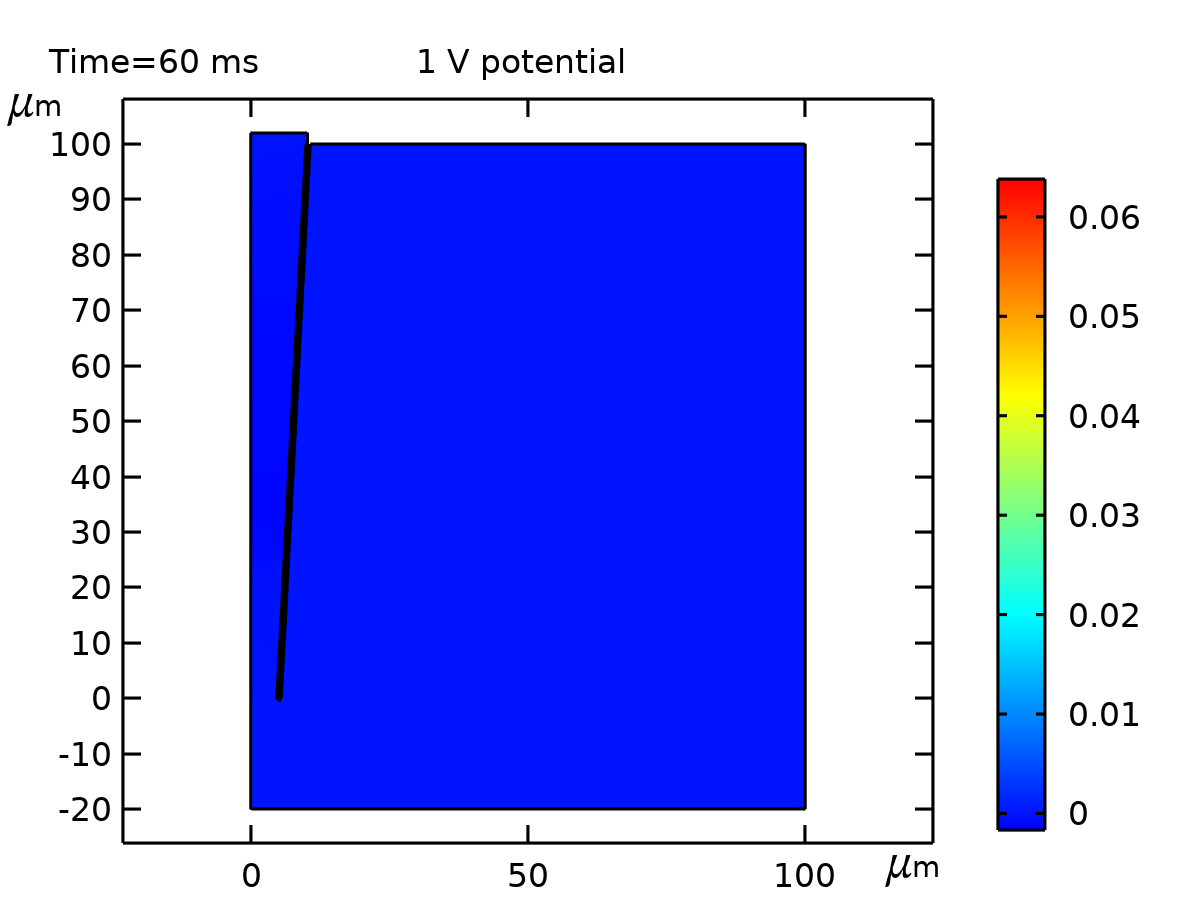
| **x** | **y** | **Value** |
| --- | --- | --- |
| 5.0299 | 18.616 | -0.28936 |

* 1. Plot Groups
     1. ionic strength no bias



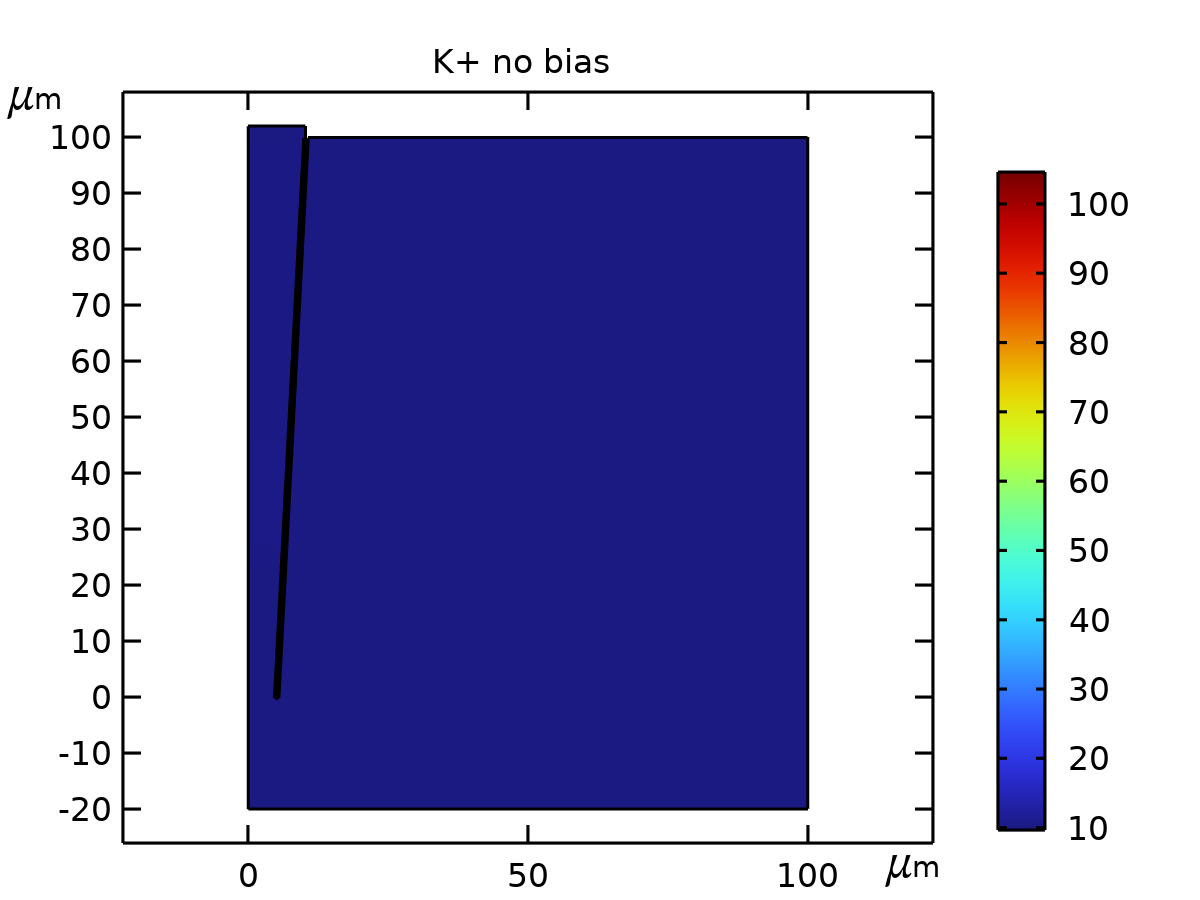
ionic strength no bias

* + 1. electrical potential (0 s)



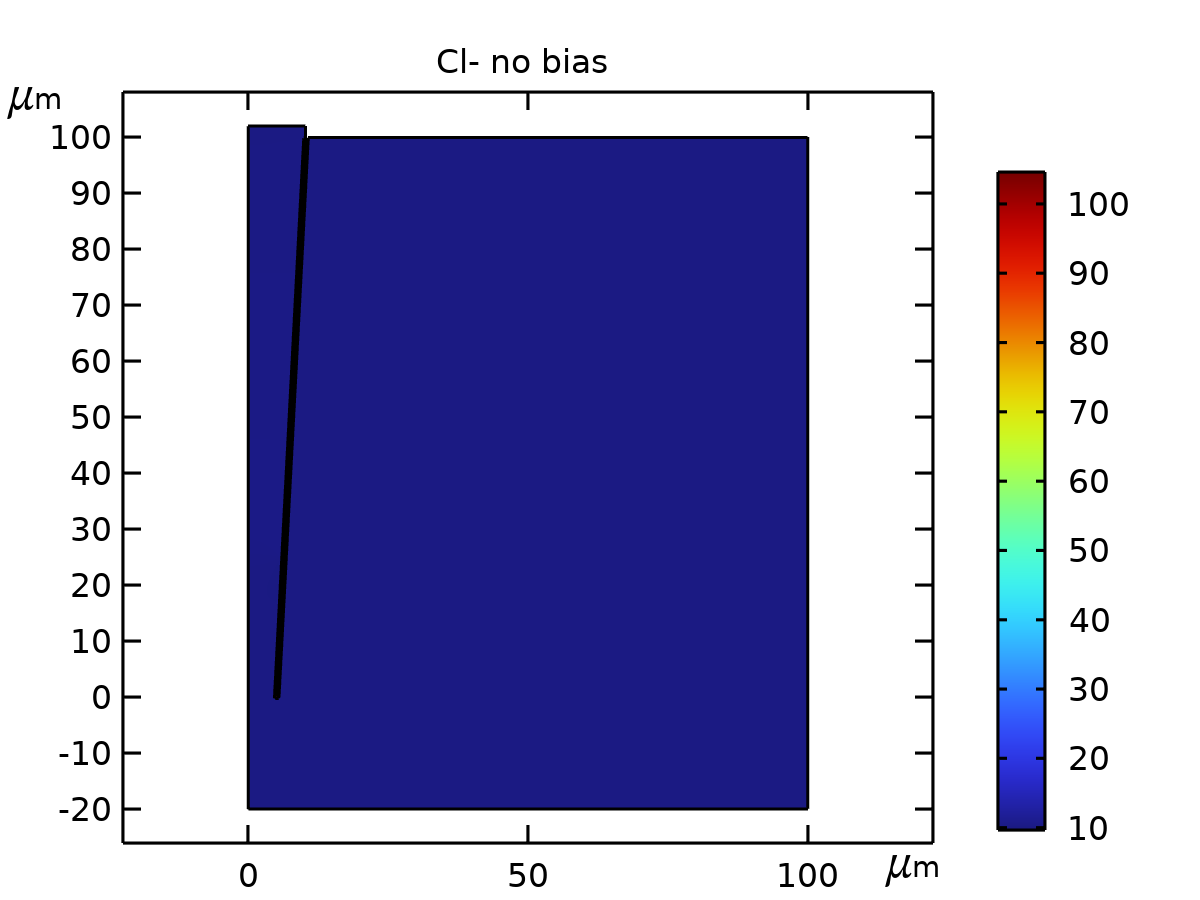
0 s potential

* + 1. K (no bias)



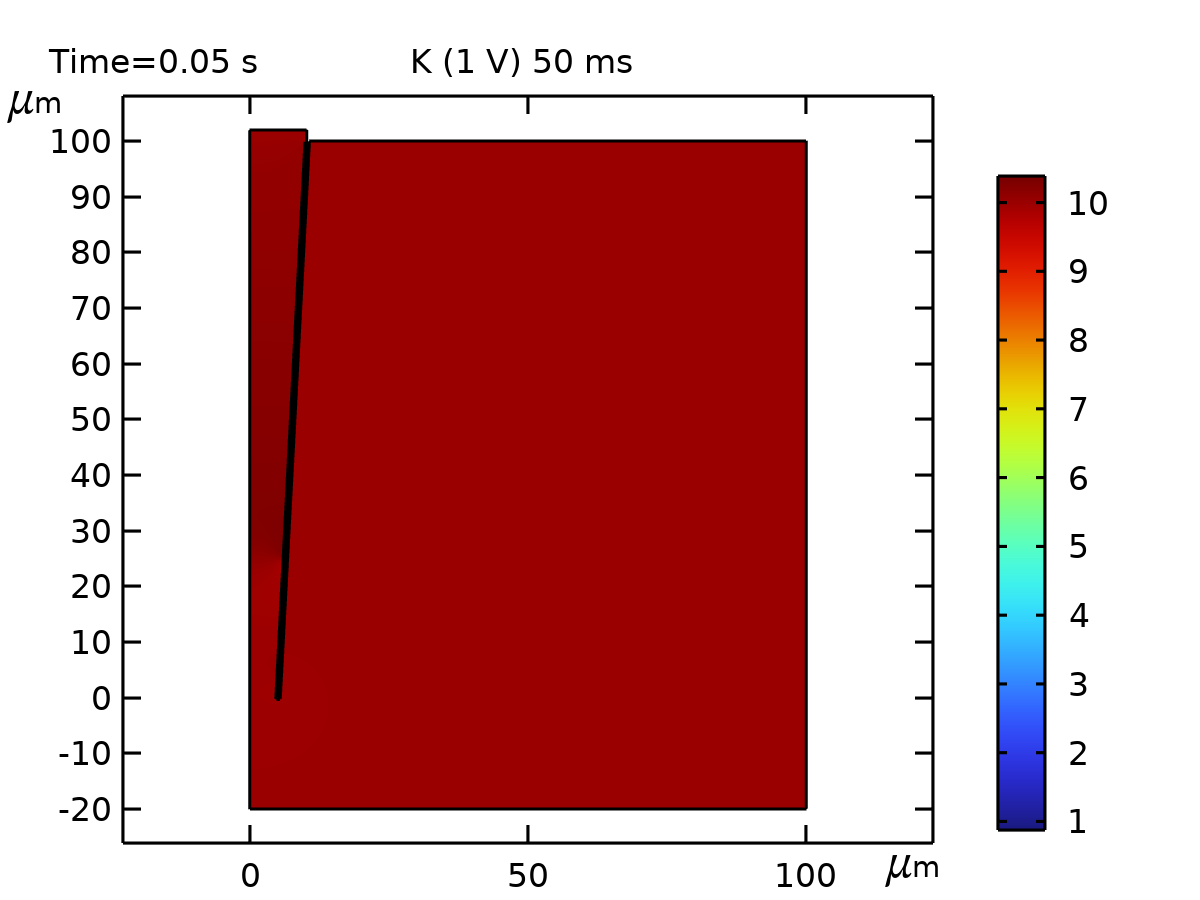
K+ no bias

* + 1. Cl (no bias)



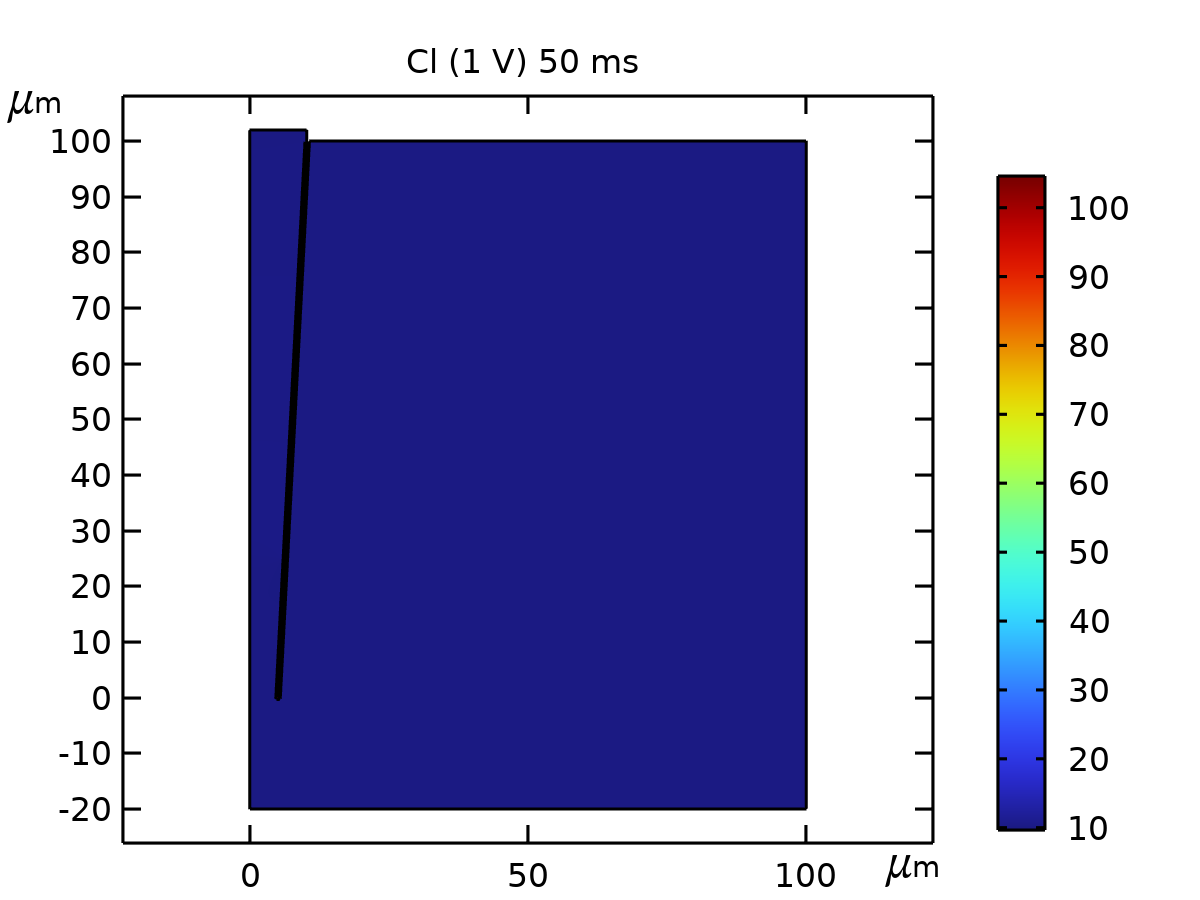
Cl- no bias

* + 1. K (0 s)



K 0 ms

* + 1. Cl (0 s)



Cl 0 ms