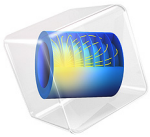


Busbar Assembly Geometry — with Group Nodes

Introduction

Group nodes in the Model Tree can help with the organization of models by grouping feature nodes that belong together, for example, nodes that belong to a particular part of the geometry, in a folder-like structure.

You can collapse group nodes, drag the group nodes to rearrange them, or drag other nodes to or from the group nodes. Actions like hiding can be applied to all members of a group node, making it more efficient to work with more complex geometries.

Follow this tutorial to create the busbar geometry used in the model *Electrical Heating in a Busbar Assembly* while learning more about how to:

- Collect geometry feature nodes into group nodes
- Set up work planes with user defined local coordinate systems
- Position geometry objects in various ways

Busbar Assembly Geometry — with Geometry Parts, the first part of this tutorial series, describes how to built a geometry that consists of several components by using geometry parts. The two tutorials in this series complement each other, and show methods to structure more complex geometry sequences.

Model Definition

This example contains the detailed steps to create the parameterized geometry used for the model *Electrical Heating in a Busbar Assembly*. The geometry for this model, displayed

in Figure 1, includes the coupling components for one cell, and a section of the intercell busbar that is connected to a cell grid.

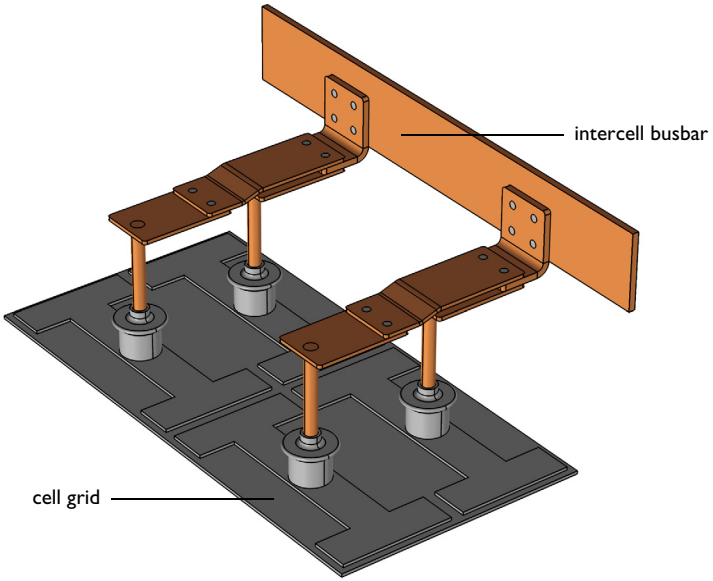


Figure 1: The busbar assembly.

When creating the geometry, you will collect feature nodes that build the components of the busbar into separate group nodes. Another approach to organize the geometry sequence could be to group the feature nodes based on, for example, the material properties.

This example describes only the process of creating the geometry sequence. For the physics setup, follow the instructions in *Electrical Heating in a Busbar Assembly*.

Application Library path: `COMSOL_Multiphysics/Geometry_Tutorials/busbar_assembly_groups_geometry`

Modeling Instructions

From the **File** menu, choose **New**.

NEW

In the **New** window, click **Blank Model**.

Load the parameters that define the geometry

GLOBAL DEFINITIONS

Parameters 1

1. In the **Model Builder** window, under **Global Definitions** click **Parameters 1**.
2. In the **Settings** window for **Parameters**, locate the **Parameters** section.
3. Click **Load from File**.
4. Browse to the model's Application Libraries folder and double-click the file `busbar_assembly_groups_geom_parameters.txt`.

ADD COMPONENT

In the **Home** toolbar, click **Add Component** and choose **3D**.

GEOMETRY 1

1. In the **Settings** window for **Geometry**, locate the **Units** section.
2. From the **Length unit** list, choose **mm**.

Cell grid top

1. In the **Geometry** toolbar, click **Block**.
2. In the **Settings** window for **Block**, type `Cell grid top` in the **Label** text field.
3. Locate the **Size and Shape** section. In the **Width** text field, type `c_g_w`.
4. In the **Depth** text field, type `c_g_l`.
5. In the **Height** text field, type `c_g_h`.
6. Locate the **Position** section. From the **Base** list, choose **Center**.
7. In the **z** text field, type `c_g_h/2`.
8. Locate the **Selections of Resulting Entities** section. Find the **Cumulative selection** subsection. Click **New**.
9. In the **New Cumulative Selection** dialog box, type `Titanium` in the **Name** text field.
10. Click **OK**.
11. In the **Settings** window for **Block**, click **Build Selected**.

Work Plane 1 (wp1)

1. In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane type** list, choose **Face parallel**.

4 On the object **blk1**, select Boundary 4 only.

5 Click to expand the **Local Coordinate System** section. In the **xw-displacement** text field, type `-c_g_w/2+s_di`.

6 In the **yw-displacement** text field, type `-c_g_l/2+s_di`.

By specifying the origin of the local coordinate system we can make sure that the objects drawn on the work plane are appropriately positioned without the need to move them later.

Work Plane 1 (wp1)>Plane Geometry

In the **Model Builder** window, click **Plane Geometry**.

Work Plane 1 (wp1)>Polygon 1 (pol1)

1 In the **Work Plane** toolbar, click **Polygon**.

2 In the **Settings** window for **Polygon**, locate the **Coordinates** section.

3 In the table, enter the following settings:

xw (mm)	yw (mm)
0	0
0	s_c_l
s_w/2-s_c_w/2	s_c_l
s_w/2-s_c_w/2	s_l-s_c_l
0	s_l-s_c_l
0	s_l
s_w	s_l
s_w	s_l-s_c_l
s_w/2+s_c_w/2	s_l-s_c_l
s_w/2+s_c_w/2	s_c_l
s_w	s_c_l
s_w	0

4 Click **Build Selected**.

Extrude 1 (ext1)

1 In the **Model Builder** window, under **Component 1 (comp1)>Geometry 1** right-click **Work Plane 1 (wp1)** and choose **Extrude**.

2 In the **Settings** window for **Extrude**, locate the **Distances** section.

3 In the table, enter the following settings:

Distances (mm)
s_h

4 Locate the **Selections of Resulting Entities** section. Find the **Cumulative selection** subsection. From the **Contribute to** list, choose **Titanium**.

5 Click **Build Selected**.

Extrude 1 (ext1), Work Plane 1 (wp1)

The **Work Plane 1** and **Extrude 1** create the object for the spine part of the busbar and can be grouped together in the sequence.

1 In the **Model Builder** window, under **Component 1 (comp1)>Geometry 1**, Ctrl-click to select **Work Plane 1 (wp1)** and **Extrude 1 (ext1)**.

2 Right-click and choose **Group**.

Spine

In the **Settings** window for **Group**, type `Spine` in the **Label** text field.

Work Plane 2 (wp2)

1 In the **Geometry** toolbar, click **Work Plane**.

Work Plane 2 is inserted after **Extrude 1** within the **Spine** group node, but you can move it outside the group, as it will be used to create the central column part of the busbar.

2 Right-click **Work Plane 2 (wp2)** and choose **Move Out**.

3 In the **Model Builder** window, click **Work Plane 2 (wp2)**.

4 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

5 From the **Plane** list, choose **zx-plane**.

6 In the **y-coordinate** text field, type `c_g_l/4`.

7 Locate the **Local Coordinate System** section. In the **xw-displacement** text field, type `c_g_h+s_h`.

8 In the **yw-displacement** text field, type `c_g_w/4`.

Work Plane 2 (wp2)>Plane Geometry

In the **Model Builder** window, expand the **Work Plane 2 (wp2)** node, then click **Plane Geometry**.

Work Plane 2 (wp2)>Polygon 1 (pol1)

1 In the **Work Plane** toolbar, click **Polygon**.

2 In the **Settings** window for **Polygon**, locate the **Coordinates** section.

3 In the table, enter the following settings:

xw (mm)	yw (mm)
0	0
c_c_h-c_c_d	0
c_c_h-c_c_d	r_d/2
c_c_h	r_d/2
c_c_h	0.7*r_d
c_c_h-0.8*r_d	0.7*r_d
c_c_h-0.8*r_d	c_c_r
c_c_h-1.1*r_d	c_c_r
c_c_h-1.1*r_d	c_c_r-r_d/2
0	c_c_r-r_d/2

Work Plane 2 (wp2)>Fillet 1 (fil1)

1 In the **Work Plane** toolbar, click **Fillet**.

2 In the **Settings** window for **Fillet**, locate the **Radius** section.

3 In the **Radius** text field, type `0.3*r_d`.

4 On the object **pol1**, select Points 6 and 9 only.

Work Plane 2 (wp2)>Fillet 2 (fil2)

1 In the **Work Plane** toolbar, click **Fillet**.

2 In the **Settings** window for **Fillet**, locate the **Radius** section.

3 In the **Radius** text field, type `0.15*r_d`.

4 On the object **fil1**, select Points 7 and 9 only.

5 Click **Build Selected**.

Revolve 1 (rev1)

1 In the **Model Builder** window, under **Component 1 (comp1)>Geometry 1** right-click **Work Plane 2 (wp2)** and choose **Revolve**.

2 In the **Settings** window for **Revolve**, locate the **Revolution Axis** section.

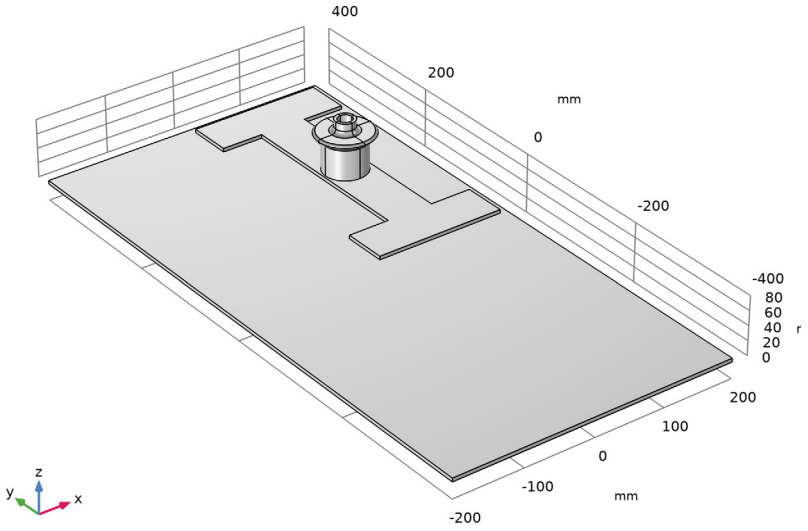
3 Find the **Direction of revolution axis** subsection. In the **xw** text field, type `1`.

4 In the **yw** text field, type `0`.

5 Locate the **Revolution Angles** section. Clear the **Keep original faces** check box.

6 Locate the **Selections of Resulting Entities** section. Find the **Cumulative selection** subsection. From the **Contribute to** list, choose **Titanium**.

7 Click **Build Selected**.



Select the features that form the central column and create a new group.

Revolve 1 (rev1), Work Plane 2 (wp2)

1 In the **Model Builder** window, under **Component 1 (comp1)>Geometry 1**, Ctrl-click to select **Work Plane 2 (wp2)** and **Revolve 1 (rev1)**.

2 Right-click and choose **Group**.

Central column

In the **Settings** window for **Group**, type `Central column` in the **Label** text field.

Rod

1 In the **Geometry** toolbar, click **Cylinder**.

2 In the **Settings** window for **Cylinder**, type `Rod` in the **Label** text field.

3 Locate the **Size and Shape** section. In the **Radius** text field, type `r_d/2`.

4 In the **Height** text field, type `r_l`.

5 Locate the **Coordinate System** section. From the **Work plane** list, choose **Work Plane 2 (wp2)**.

6 Locate the **Axis** section. From the **Axis type** list, choose **xw-axis**.

7 Locate the **Position** section. In the **xw** text field, type `c_c_h-c_c_d`.

8 Right-click **Rod** and choose **Move Out**.

You can also add an empty group node, and the next geometry operation you will be automatically added to the group.

Rod connector

1 In the **Model Builder** window, right-click **Geometry 1** and choose **Node Group**.

2 In the **Settings** window for **Group**, type `Rod connector` in the **Label** text field.

Work Plane 3 (wp3)

1 In the **Geometry** toolbar, click  **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane type** list, choose **Face parallel**.

4 Locate the **Local Coordinate System** section. In the **yw-displacement** text field, type `r_c_w/2-2*s_di`.

5 On the object **cyl1**, select Boundary 4 only.

Work Plane 3 (wp3)>Plane Geometry

In the **Model Builder** window, click **Plane Geometry**.

Work Plane 3 (wp3)>Cross Section 1 (cro1)

1 In the **Work Plane** toolbar, click  **Cross Section**.

2 In the **Settings** window for **Cross Section**, locate the **Cross Section** section.

3 From the **Intersect** list, choose **Selected objects**.

4 Find the **Objects to intersect** subsection. Click to select the  **Activate Selection** toggle button.

5 Select the object **cyl1** only.

Work Plane 3 (wp3)>Rectangle 1 (r1)

1 In the **Work Plane** toolbar, click  **Rectangle**.

2 In the **Settings** window for **Rectangle**, locate the **Size and Shape** section.

3 In the **Width** text field, type `a_c_w`.

4 In the **Height** text field, type `r_c_w`.

5 Locate the **Position** section. From the **Base** list, choose **Center**.

Work Plane 3 (wp3)>Fillet 1 (fil1)

1 In the **Work Plane** toolbar, click **Fillet**.

2 In the **Settings** window for **Fillet**, locate the **Radius** section.

3 In the **Radius** text field, type `5[mm]`.

4 On the object **r1**, select Points 1–4 only.

5 Click **Build Selected**.

Work Plane 3 (wp3)>Difference 1 (dif1)

1 In the **Work Plane** toolbar, click **Booleans and Partitions** and choose **Difference**.

2 Select the object **fil1** only.

3 In the **Settings** window for **Difference**, locate the **Difference** section.

4 Find the **Objects to subtract** subsection. Click to select the **Activate Selection** toggle button.

5 Select the object **cro1** only.

6 Click **Build Selected**.

Extrude 2 (ext2)

1 In the **Model Builder** window, under **Component 1 (comp1)>Geometry 1>Rod connector** right-click **Work Plane 3 (wp3)** and choose **Extrude**.

2 In the **Settings** window for **Extrude**, locate the **Distances** section.

3 In the table, enter the following settings:

Distances (mm)
`r_c_h`

4 Select the **Reverse direction** check box.

5 Click **Build Selected**.

To leave the group node, click **Geometry 1**

Array 1 (arr1)

1 In the **Geometry** toolbar, click **Transforms** and choose **Array**.

2 Select the objects **cyl1**, **ext1**, **ext2**, and **rev1** only.

3 In the **Settings** window for **Array**, locate the **Size** section.

4 In the **x size** text field, type `2`.

5 In the **y size** text field, type `2`.

6 Locate the **Displacement** section. In the **x** text field, type `-c_g_w/2`.

7 In the **y** text field, type `-c_g_l/2`.

Work Plane 4 (wp4)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 In the **z-coordinate** text field, type `c_g_h+s_h+c_c_h-c_c_d+r_l`.

4 Locate the **Local Coordinate System** section. In the **xw-displacement** text field, type `c_g_w/4-3*b_di+r_c_w`.

5 In the **yw-displacement** text field, type `c_g_l/4-a_c_w/2`.

Work Plane 4 (wp4)>Plane Geometry

In the **Model Builder** window, click **Plane Geometry**.

Work Plane 4 (wp4)>Rectangle 1 (r1)

1 In the **Work Plane** toolbar, click **Rectangle**.

2 In the **Settings** window for **Rectangle**, locate the **Size and Shape** section.

3 In the **Width** text field, type `e_c_lx`.

4 In the **Height** text field, type `a_c_w`.

Work Plane 4 (wp4)>Fillet 1 (fil1)

1 In the **Work Plane** toolbar, click **Fillet**.

2 On the object **r1**, select Points 1 and 4 only.

3 In the **Settings** window for **Fillet**, locate the **Radius** section.

4 In the **Radius** text field, type `5[mm]`.

5 Click **Build Selected**.

Extrude 3 (ext3)

1 In the **Model Builder** window, under **Component 1 (comp1)>Geometry 1** right-click **Work Plane 4 (wp4)** and choose **Extrude**.

2 In the **Settings** window for **Extrude**, locate the **Distances** section.

3 In the table, enter the following settings:

Distances (mm)
e_c_h

Work Plane 5 (wp5)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane** list, choose **yz-plane**.

4 In the **x-coordinate** text field, type `c_g_w/4-3*b_di+r_c_w+e_c_lx+2*e_c_h`.

5 Locate the **Local Coordinate System** section. In the **xw-displacement** text field, type `c_g_l/4-a_c_w/2`.

6 In the **yw-displacement** text field, type `c_g_h+s_h+c_c_h-c_c_d+r_l+2*e_c_h`.

Work Plane 5 (wp5)>Plane Geometry

In the **Model Builder** window, click **Plane Geometry**.

Work Plane 5 (wp5)>Rectangle 1 (r1)

1 In the **Work Plane** toolbar, click  **Rectangle**.

2 In the **Settings** window for **Rectangle**, locate the **Size and Shape** section.

3 In the **Width** text field, type `a_c_w`.

4 In the **Height** text field, type `e_c_lz`.

Work Plane 5 (wp5)>Fillet 1 (fil1)

1 In the **Work Plane** toolbar, click  **Fillet**.

2 On the object **r1**, select Points 3 and 4 only.

3 In the **Settings** window for **Fillet**, locate the **Radius** section.

4 In the **Radius** text field, type `5[mm]`.

5 Click  **Build Selected**.

Extrude 4 (ext4)

1 In the **Model Builder** window, under **Component 1 (comp1)>Geometry 1** right-click **Work Plane 5 (wp5)** and choose **Extrude**.

2 In the **Settings** window for **Extrude**, locate the **Distances** section.

3 In the table, enter the following settings:

Distances (mm)
e_c_h

4 Select the **Reverse direction** check box.

Work Plane 6 (wp6)

1 In the **Geometry** toolbar, click  **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane type** list, choose **Face parallel**.

4 On the object **ext3**, select Boundary 6 only.

5 Locate the **Local Coordinate System** section. From the **Origin** list, choose **Vertex projection**.

6 Find the **Vertex for origin** subsection. Click to select the **Activate Selection** toggle button.

7 On the object **ext3**, select Point 9 only.

8 In the **yw-displacement** text field, type `-2*e_c_h`.

9 In the **Rotation** text field, type `180`.

Work Plane 6 (wp6)>Plane Geometry

In the **Model Builder** window, click **Plane Geometry**.

Work Plane 6 (wp6)>Circle 1 (c1)

1 In the **Work Plane** toolbar, click **Circle**.

2 In the **Settings** window for **Circle**, locate the **Size and Shape** section.

3 In the **Radius** text field, type `e_c_h`.

4 In the **Sector angle** text field, type `90`.

5 Locate the **Rotation Angle** section. In the **Rotation** text field, type `270`.

Work Plane 6 (wp6)>Circle 2 (c2)

1 In the **Work Plane** toolbar, click **Circle**.

2 In the **Settings** window for **Circle**, locate the **Size and Shape** section.

3 In the **Radius** text field, type `2*e_c_h`.

4 In the **Sector angle** text field, type `90`.

5 Locate the **Rotation Angle** section. In the **Rotation** text field, type `270`.

Work Plane 6 (wp6)>Difference 1 (dif1)

1 In the **Work Plane** toolbar, click **Booleans and Partitions** and choose **Difference**.

2 Select the object **c2** only.

3 In the **Settings** window for **Difference**, locate the **Difference** section.

4 Find the **Objects to subtract** subsection. Click to select the **Activate Selection** toggle button.

5 Select the object **c1** only.

6 Click **Build Selected**.

Extrude 5 (ext5)

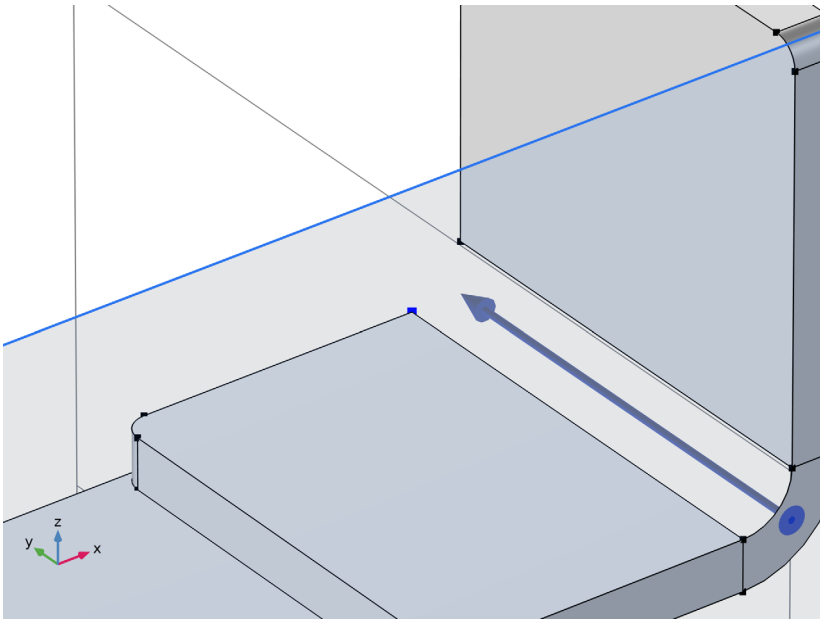
1 In the **Model Builder** window, under **Component 1 (comp1)>Geometry 1** right-click **Work Plane 6 (wp6)** and choose **Extrude**.

2 In the **Settings** window for **Extrude**, locate the **Distances** section.

3 From the **Specify** list, choose **Vertices to extrude to**.

4 On the object **ext3**, select Point 12 only.

5 Click the **Zoom to Selection** button in the **Graphics** toolbar.



Union 1 (uni1)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Union**.

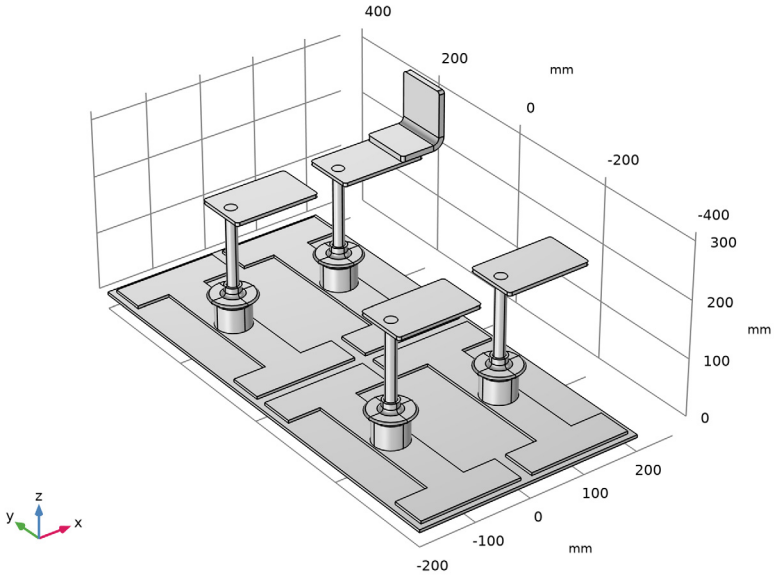
2 Select the objects **ext3**, **ext4**, and **ext5** only.

3 In the **Settings** window for **Union**, locate the **Union** section.

4 Clear the **Keep interior boundaries** check box.

5 Click **Build Selected**.

6 Click the **Zoom Extents** button in the **Graphics** toolbar.



Extrude 3 (ext3), Extrude 4 (ext4), Extrude 5 (ext5), Union 1 (uni1), Work Plane 4 (wp4), Work Plane 5 (wp5), Work Plane 6 (wp6)

1 In the **Model Builder** window, under **Component 1 (comp1)>Geometry 1**, Ctrl-click to select **Work Plane 4 (wp4)**, **Extrude 3 (ext3)**, **Work Plane 5 (wp5)**, **Extrude 4 (ext4)**, **Work Plane 6 (wp6)**, **Extrude 5 (ext5)**, and **Union 1 (uni1)**.

2 Right-click and choose **Group**.

Elbow connector

In the **Settings** window for **Group**, type `Elbow connector` in the **Label** text field.

Work Plane 7 (wp7)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane** list, choose **zx-plane**.

4 In the **y-coordinate** text field, type `c_g_l/4-a_c_w/2`.

5 Locate the **Local Coordinate System** section. In the **xw-displacement** text field, type `c_g_h+s_h+c_c_h-c_c_d+r_l`.

6 In the **yw-displacement** text field, type `-c_g_w/4-b_di*3+r_c_w`.

7 Right-click **Work Plane 7 (wp7)** and choose **Move Out**.

Work Plane 7 (wp7)>Plane Geometry

In the **Model Builder** window, expand the **Work Plane 7 (wp7)** node, then click **Plane Geometry**.

Work Plane 7 (wp7)>Polygon 1 (pol1)

1 In the **Work Plane** toolbar, click **Polygon**.

2 In the **Settings** window for **Polygon**, locate the **Coordinates** section.

3 In the table, enter the following settings:

xw (mm)	yw (mm)
0	0
0	60[mm]
e_c_h	90[mm]
e_c_h	c_g_w/2+b_di*2
e_c_h+a_c_h	c_g_w/2+b_di*2
e_c_h+a_c_h	90[mm]
a_c_h	60[mm]
a_c_h	0

Work Plane 7 (wp7)>Fillet 1 (fil1)

1 In the **Work Plane** toolbar, click **Fillet**.

2 On the object **pol1**, select Points 2 and 6 only.

3 In the **Settings** window for **Fillet**, locate the **Radius** section.

4 In the **Radius** text field, type `20[mm]`.

Work Plane 7 (wp7)>Fillet 2 (fil2)

1 In the **Work Plane** toolbar, click **Fillet**.

2 On the object **fil1**, select Points 5 and 6 only.

3 In the **Settings** window for **Fillet**, locate the **Radius** section.

4 In the **Radius** text field, type `20[mm]-a_c_h`.

5 Click **Build Selected**.

Extrude 6 (ext6)

1 In the **Model Builder** window, under **Component 1 (comp1)>Geometry 1** right-click **Work Plane 7 (wp7)** and choose **Extrude**.

2 In the **Settings** window for **Extrude**, locate the **Distances** section.

3 In the table, enter the following settings:

Distances (mm)
a_c_w

Work Plane 8 (wp8)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 In the **z-coordinate** text field, type `c_g_h+s_h+c_c_h-c_c_d+r_l`.

4 Locate the **Local Coordinate System** section. In the **xw-displacement** text field, type `-c_g_w/4-b_di*3+r_c_w`.

5 In the **yw-displacement** text field, type `c_g_w/2-a_c_w/2`.

Work Plane 8 (wp8)>Plane Geometry

In the **Model Builder** window, click **Plane Geometry**.

Work Plane 8 (wp8)>Rectangle 1 (r1)

1 In the **Work Plane** toolbar, click **Rectangle**.

2 In the **Settings** window for **Rectangle**, locate the **Size and Shape** section.

3 In the **Width** text field, type `c_g_w/2+b_di*2`.

4 In the **Height** text field, type `a_c_w`.

Work Plane 8 (wp8)>Fillet 1 (fil1)

1 In the **Work Plane** toolbar, click **Fillet**.

2 In the **Settings** window for **Fillet**, locate the **Radius** section.

3 In the **Radius** text field, type `5[mm]`.

4 On the object **r1**, select Points 1–4 only.

5 Click **Build Selected**.

Extrude 7 (ext7)

1 In the **Model Builder** window, under **Component 1 (comp1)>Geometry 1** right-click **Work Plane 8 (wp8)** and choose **Extrude**.

2 In the **Settings** window for **Extrude**, locate the **Distances** section.

3 In the table, enter the following settings:

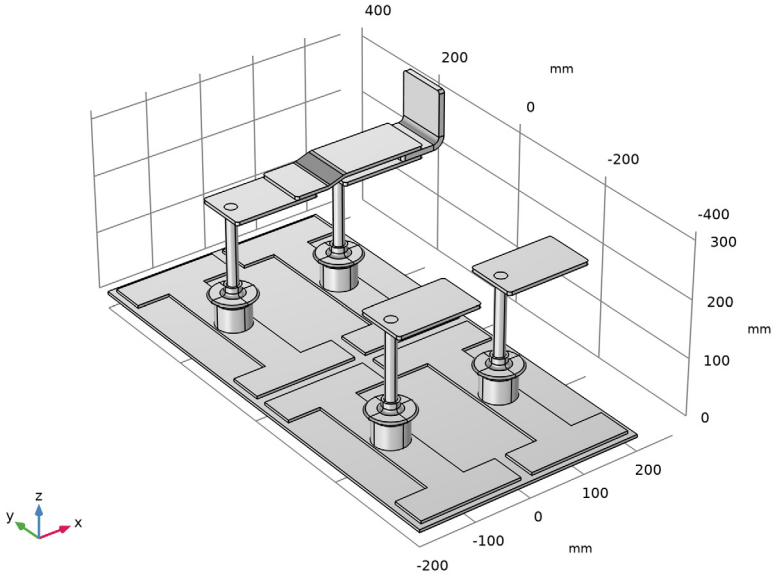
Distances (mm)
2*e_c_h

Intersection 1 (int1)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Intersection**.

2 Select the objects **ext6** and **ext7** only.

3 In the **Settings** window for **Intersection**, click **Build Selected**.



Extrude 6 (ext6), Extrude 7 (ext7), Intersection 1 (int1), Work Plane 7 (wp7), Work Plane 8 (wp8)

1 In the **Model Builder** window, under **Component 1 (comp1)>Geometry 1**, Ctrl-click to select **Work Plane 7 (wp7)**, **Extrude 6 (ext6)**, **Work Plane 8 (wp8)**, **Extrude 7 (ext7)**, and **Intersection 1 (int1)**.

2 Right-click and choose **Group**.

Angle connector

In the **Settings** window for **Group**, type `Angle connector` in the **Label** text field.

Intercell busbar

1 In the **Geometry** toolbar, click **Block**.

2 In the **Settings** window for **Block**, type `Intercell busbar` in the **Label** text field.

3 Locate the **Size and Shape** section. In the **Width** text field, type `i_b_h`.

4 In the **Depth** text field, type `i_b_l`.

5 In the **Height** text field, type `i_b_w`.

6 Locate the **Position** section. From the **Base** list, choose **Center**.

7 Locate the **Coordinate System** section. From the **Work plane** list, choose **Work Plane 5 (wp5)**.

8 Locate the **Axis** section. From the **Axis type** list, choose **yw-axis**.

9 Locate the **Position** section. In the **xw** text field, type `-c_g_l/4+a_c_w/2`.

10 In the **yw** text field, type `i_b_w/2`.

11 In the **zw** text field, type `i_b_h/2`.

12 Right-click **Intercell busbar** and choose **Move Out**.

Bolt short

1 In the **Geometry** toolbar, click **Cylinder**.

2 In the **Settings** window for **Cylinder**, type `Bolt short` in the **Label** text field.

3 Locate the **Size and Shape** section. In the **Radius** text field, type `b_r`.

4 In the **Height** text field, type `r_c_h+a_c_h`.

5 Locate the **Coordinate System** section. From the **Work plane** list, choose **Work Plane 8 (wp8)**. By selecting a work plane, the position of the cylinder can be defined from the origin of this work plane.

6 Locate the **Position** section. In the **xw** text field, type `b_di`.

7 In the **yw** text field, type `a_c_w/4`.

8 In the **zw** text field, type `-r_c_h`.

9 Locate the **Selections of Resulting Entities** section. Find the **Cumulative selection** subsection. From the **Contribute to** list, choose **Titanium**.

Bolt long

1 In the **Geometry** toolbar, click **Cylinder**.

2 In the **Settings** window for **Cylinder**, type `Bolt long` in the **Label** text field.

3 Locate the **Size and Shape** section. In the **Radius** text field, type `b_r`.

4 In the **Height** text field, type `r_c_h+a_c_h+e_c_h`.

5 Locate the **Coordinate System** section. From the **Work plane** list, choose **Work Plane 4 (wp4)**.

6 Locate the **Position** section. In the **xw** text field, type `b_di`.

7 In the **yw** text field, type `a_c_w/4`.

8 In the **zw** text field, type `-r_c_h`.

9 Locate the **Selections of Resulting Entities** section. Find the **Cumulative selection** subsection. From the **Contribute to** list, choose **Titanium**.

Bolt medium

1 In the **Geometry** toolbar, click **Cylinder**.

2 In the **Settings** window for **Cylinder**, type `Bolt medium` in the **Label** text field.

3 Locate the **Size and Shape** section. In the **Radius** text field, type `b_r`.

4 In the **Height** text field, type `e_c_h+i_b_h`.

5 Locate the **Coordinate System** section. From the **Work plane** list, choose **Work Plane 5 (wp5)**.

6 Locate the **Position** section. In the **xw** text field, type `a_c_w/4`.

7 In the **yw** text field, type `b_di`.

8 In the **zw** text field, type `-e_c_h`.

9 Locate the **Selections of Resulting Entities** section. Find the **Cumulative selection** subsection. From the **Contribute to** list, choose **Titanium**.

Move 1 (mov1)

1 In the **Geometry** toolbar, click **Transforms** and choose **Move**.

2 Select the object **cyl4** only.

3 In the **Settings** window for **Move**, locate the **Input** section.

4 Select the **Keep input objects** check box.

5 Locate the **Displacement** section. In the **z** text field, type `40[mm]`.

Mirror 1 (mir1)

1 In the **Geometry** toolbar, click **Transforms** and choose **Mirror**.

2 Select the objects **cyl2**, **cyl3**, **cyl4**, and **mov1** only.

3 In the **Settings** window for **Mirror**, locate the **Input** section.

4 Select the **Keep input objects** check box.

5 Locate the **Normal Vector to Plane of Reflection** section. In the **y** text field, type `1`.

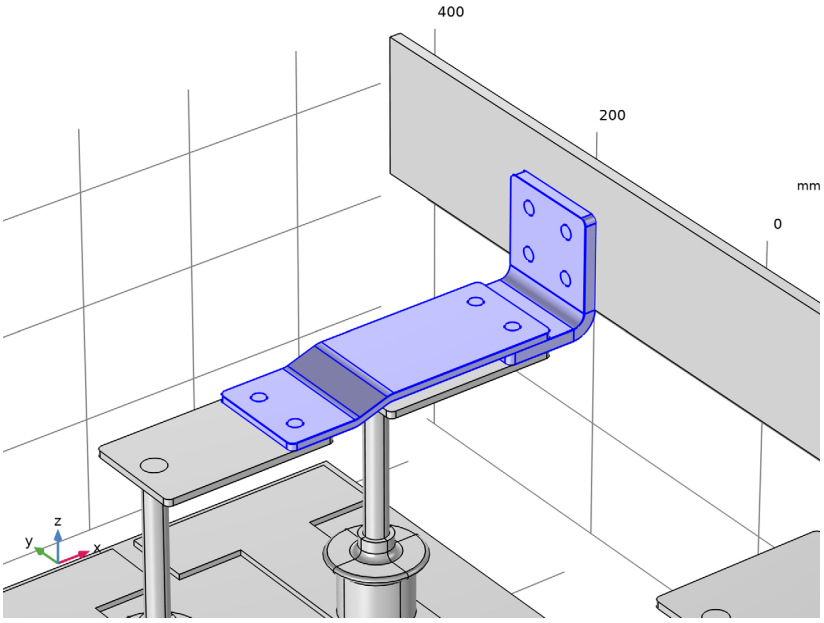
6 In the **z** text field, type `0`.

7 Locate the **Point on Plane of Reflection** section. In the **y** text field, type `c_g_l/4`.

Move 2 (mov2)

1 In the **Geometry** toolbar, click **Transforms** and choose **Move**.

2 Select the objects **cyl2**, **cyl3**, **cyl4**, **int1**, **mir1(1)**, **mir1(2)**, **mir1(3)**, **mir1(4)**, **mov1**, and **uni1** only.



3 In the **Settings** window for **Move**, locate the **Input** section.

4 Select the **Keep input objects** check box.

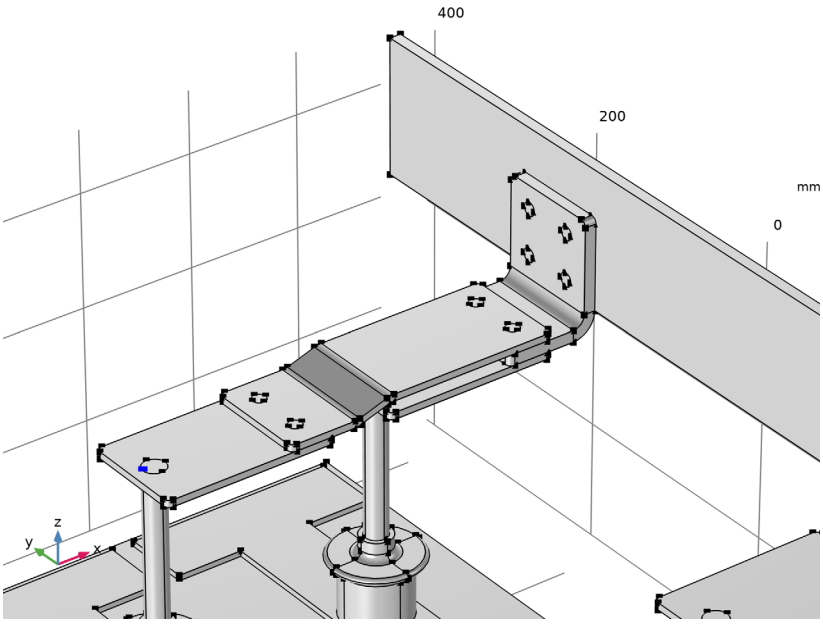
A displacement can also be defined by vertices. The starting point and destination point(s) do not have to be located inside the object to be moved.

5 Locate the **Displacement** section. From the **Specify** list, choose **Positions**.

6 Find the **Vertex to move** subsection. Click to select the **Activate Selection** toggle button.

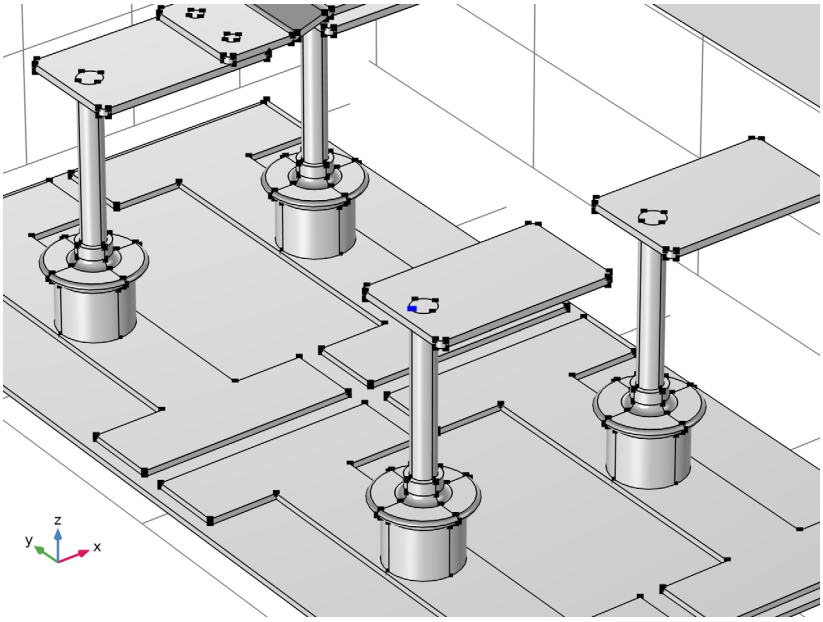
Select one vertex on the rod

7 On the object ***arr1(2,1,1,3)***, select Point 10 only.



8 Find the **Vertices to move to** subsection. Click to select the **Activate Selection** toggle button.

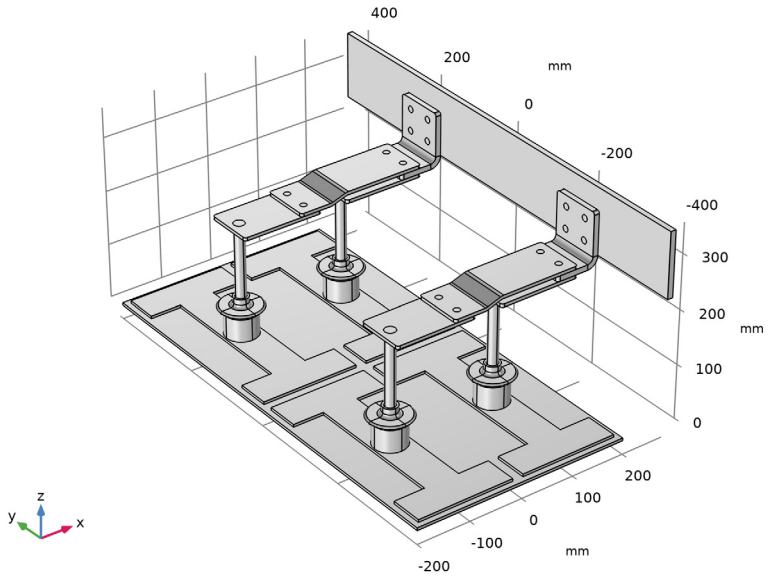
9 On the object **arr1(2,2,1,3)**, select Point 10 only.



Form Union (fin)

1 In the **Model Builder** window, click **Form Union (fin)**.

2 In the **Settings** window for **Form Union/Assembly**, click **Build Selected**.



Copper

1 In the **Geometry** toolbar, click **Selections** and choose **Complement Selection**.

2 In the **Settings** window for **Complement Selection**, locate the **Input Entities** section.

3 Click **Add**.

4 In the **Add** dialog box, select **Titanium** in the **Selections to invert** list.

5 Click **OK**.

6 In the **Settings** window for **Complement Selection**, type `Copper` in the **Label** text field.

Adjacent Selection 1 (adjsel1)

1 In the **Geometry** toolbar, click **Selections** and choose **Adjacent Selection**.

2 In the **Settings** window for **Adjacent Selection**, locate the **Input Entities** section.

3 Click **Add**.

4 In the **Add** dialog box, in the **Input selections** list, choose **Titanium** and **Copper**.

5 Click **OK**.

6 In the **Settings** window for **Adjacent Selection**, locate the **Resulting Selection** section.

7 From the **Show in physics** list, choose **Off**.

Electrolyte boundary

1 In the **Geometry** toolbar, click **Selections** and choose **Explicit Selection**.

2 In the **Settings** window for **Explicit Selection**, type `Electrolyte boundary` in the **Label** text field.

3 Locate the **Entities to Select** section. From the **Geometric entity level** list, choose **Boundary**.

4 On the object **fin**, select Boundary 3 only.

Grounded boundaries

1 In the **Geometry** toolbar, click **Selections** and choose **Explicit Selection**.

2 In the **Settings** window for **Explicit Selection**, type `Grounded boundaries` in the **Label** text field.

3 Locate the **Entities to Select** section. From the **Geometric entity level** list, choose **Boundary**.

4 On the object **fin**, select Boundaries 556 and 601 only.

Heat flux boundaries

1 In the **Geometry** toolbar, click **Selections** and choose **Difference Selection**.

2 In the **Settings** window for **Difference Selection**, type `Heat flux boundaries` in the **Label** text field.

3 Locate the **Geometric Entity Level** section. From the **Level** list, choose **Boundary**.

4 Locate the **Input Entities** section. Click **Add**.

5 In the **Add** dialog box, select **Adjacent Selection 1** in the **Selections to add** list.

6 Click **OK**.

7 In the **Settings** window for **Difference Selection**, locate the **Input Entities** section.

8 Click **Add**.

9 In the **Add** dialog box, in the **Selections to subtract** list, choose **Electrolyte boundary** and **Grounded boundaries**.

10 Click **OK**.