Altair Feko 2022.3.1

Practical Guide to Ports and Sources

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About This Guide

The Feko Practical Guide to Ports and Sources is part of the Feko documentation and is a practical guide to using ports and sources in Feko.

If you are a beginner user, you are recommended to work through the Feko Getting Started Guide.

Purpose of This Guide

The Feko Practical Guide to Ports and Sources highlights essential information regarding ports and sources in Feko. It also shows practical examples of feeding typical structures such as waveguides, coaxial cables and microstrip structures.

The content is also available as stand-alone How-to's on https://community.altair.com/community.

Document Conventions

The Feko Practical Guide to Ports and Sources, makes use of a number of conventions to help you quickly learn about Feko.

- Hyperlinks are indicated in blue.
- Text cited from the GUI interface, are written in bold text, for example, the **Add** button.
- A combination of keystrokes are joined with the "+" sign, for example, Alt+0.
- To draw your attention to important information, the information is marked as a note, tip or warning, for example:

> **Note:** This is a note to draw your attention to critical information.

Feedback

We value your feedback regarding the Feko components and the documentation.

If you have comments or suggestions regarding the Feko component and the documentation, please send an email to support@altair.co.za or contact your local Altair representative.

Introduction to Ports and Sources in Feko

1

This chapter covers the following:

- 1.1 What is a Port in Feko (p. 11)
- 1.2 Ports per Solution Method (p. 13)

1.1 What is a Port in Feko

To cause current to flow in a model, you need to excite or illuminate a model. A port is a mathematical representation of where energy can enter (source) or leave a model (sink).

Define a port where you want to add a source to excite the model and also add discrete loads.

Types of Ports and their Associated Sources

The following types of ports are supported:

- wire port (voltage source)
- edge port (voltage source)
- microstrip port (voltage source)
- waveguide port (waveguide source)
- FEM line port (current source)
- FEM modal port (FEM modal source)

Construct a model as close to the physical model as possible by including the connector and use a waveguide port to excite the model.

If a connector is replaced with a simplified feed representation (usually computationally cheaper) such as a wire port or edge port, the results could be affected. The degree to which results could be affected is unpredictable. If a more accurate result is required than an approximation, de-embedding and calibration will be required.

Note: Select a port type based on the model construction and solution method.

Coupling Between Sources

Voltage sources added to wires, edges or FEM line ports will contribute to the radiation and couple to one another.

Waveguide and FEM modal sources will include a finite number of higher order modes in the mode expansion. It will not directly couple to each other or other types of sources.

Geometry and Mesh Ports

When a port is added to geometry, the port is listed (icon in green) in the model tree (**Construction** tab) under **Ports**.

Similarly, when a port is added to an imported or unlinked mesh, the port is listed (icon in blue) in the model tree.

Note:

- The icon indicates the geometry instance of the port.
- The icon indicates the mesh instance of the port.

When the simulation mesh is unlinked from either its geometry or model mesh, a mesh instance of each port in the model is created and listed in the model tree.

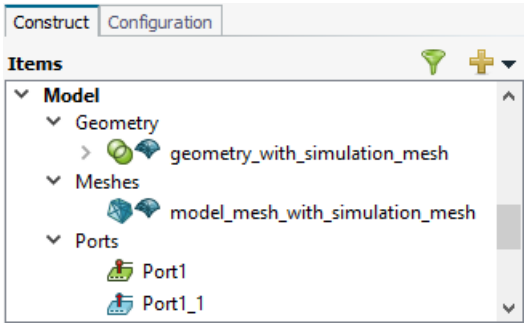

Figure 1: Example of (1) a geometry part that was meshed and its geometry port instance (port icon in green) and (2) a mesh part that has a simulation mesh with a mesh port instance (port icon in blue).

1.2 Ports per Solution Method

The model construction and the solution method dictate the port and it associated source that can be used to excite the model.

Table 1: The port types in Feko per supported solution method.

Solution Method	Wire Port	Edge Port	Microstrip Port	Waveguide Port	FEM Modal Port	FEM Line Port	Cable Port
MoM (SEP)	✅	✅	✅ (only with planar multilayer substrates)	✅	☒	☒	✅
MoM (VEP)	✅	✅	☒	✅	☒	☒	☒
MLFMM	✅	✅	☒	✅	☒	☒	✅
FEM	☒	☒	☒	✅	✅	✅	☒
FDTD	✅	✅	☒	☒	☒	☒	☒
PO & LE-PO	✅	✅	☒	✅	☒	☒	☒
RL-GO	✅	✅	☒	☒	☒	☒	☒
UTD & faceted UTD	✅	✅	☒	☒	☒	☒	☒

How to Excite a Model

2

This chapter covers the following:

- 2.1 How to Excite Waveguide Structures (p. 15)
- 2.2 How to Excite a Coaxial Cable (p. 22)
- 2.3 How to Excite Microstrip Structures (p. 24)
- 2.4 How to Add a Port to an Imported Mesh (p. 37)

2.1 How to Excite Waveguide Structures

Standard waveguide components include feed horns, horn antennas, waveguide filters, waveguide diplexers and waveguide couplers. These structures are typically connected with a flange with an SMA connector to a high-frequency coaxial cable.

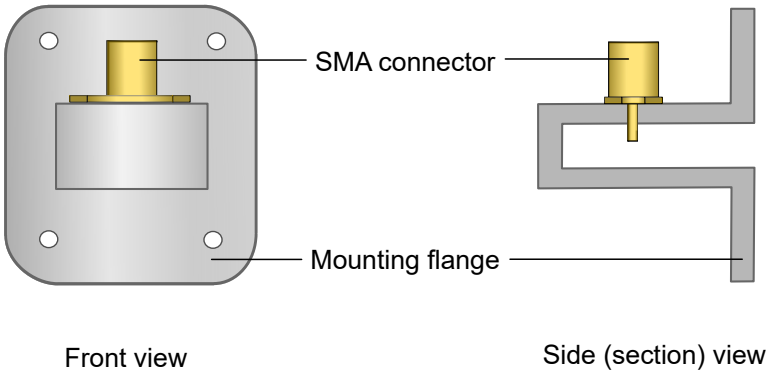

Figure 2: Example of a coaxial to waveguide adapter.

For further examples of how to excite waveguide structures, refer to the following examples:

- Feko Getting Started Guide
  - Example 6
- Feko Example Guide
  - Example A.11.2
  - Example A.12
  - Example E.2
  - Example H.3.1
  - Example H.4

2.1.1 Horn Feed for a Cassegrain Reflector

As an example, we will look at a Cassegrain reflector antenna with a multi-flare horn as feed, solved using the method of moments (MoM). All faces are set to PEC.

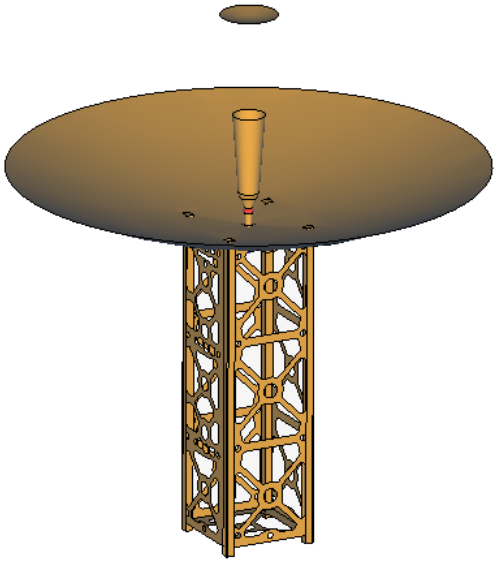

Figure 3: The model of a Cassegrain reflector with multi-flare horn feed.

Since the model is solved using SEP and the horn is a waveguide structure, a waveguide port will be used to excite the model.

A good approximation of the physical model is to place the waveguide port in the plane where the waveguide transitions into the coaxial adaptor. The waveguide port must cover the full cross-section of the face. Boundary edges forming the port shape must be set to PEC[1].

To excite the horn:

1. Select the bottom face of the horn where the waveguide would transition into the coaxial adaptor.

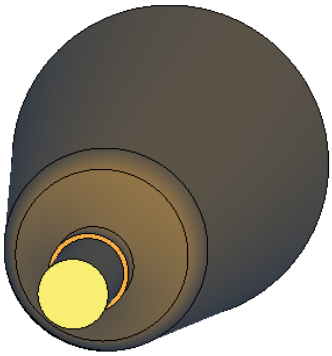

Figure 4: Select the bottom PEC face of the horn. The rest of the model is hidden.

1. Perfect electric conductor

2. Add a waveguide port to the selected face.

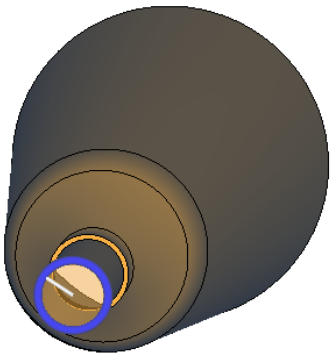

Figure 5: A waveguide port is added to the bottom PEC face of the horn.

3. Add a waveguide source to the waveguide port.

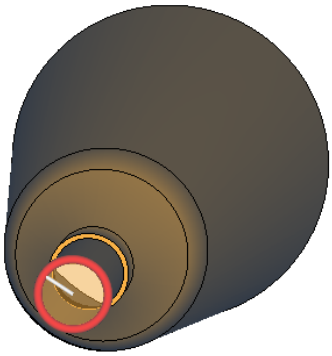

Figure 6: A waveguide source is added to the waveguide port to excite the model.

2.1.2 Waveguide Dielectric Resonator Filter

As an example, we will look at a waveguide filter with dielectric resonators solved using the finite element method (FEM). The outer waveguide faces are set to PEC.

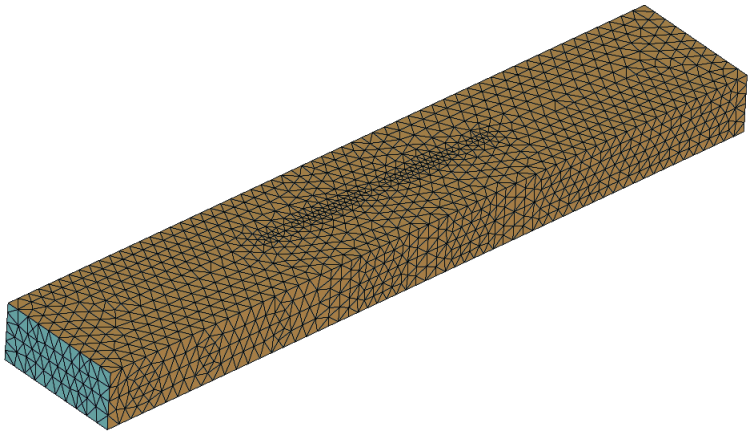

Figure 7: The dielectric resonator filter model.

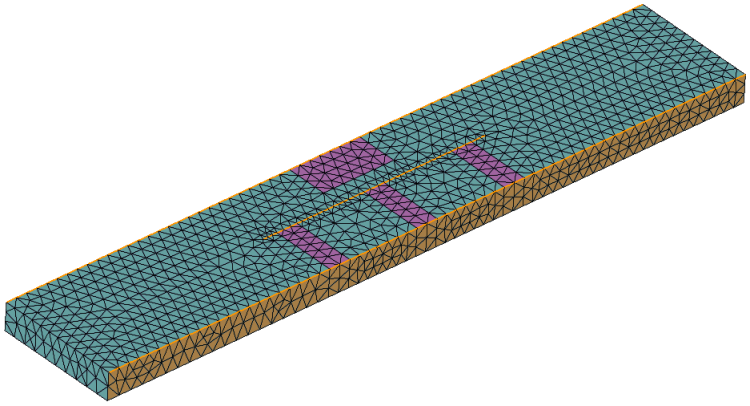

Figure 8: The dielectric resonator filter model with mesh with an active cutplane showing the FEM dielectric regions.

Since this shielded waveguide filter is a non-radiating microwave component containing dielectric regions, the example[2] is well suited to be solved using FEM. For this example, the waveguide structure will be excited using a waveguide port.

A good approximation of the physical model is to place the waveguide port in the plane where the waveguide transitions into the coaxial adaptor. The waveguide port must cover the full cross-section of the face. Boundary edges forming the port shape must be set to PEC[3].

To excite the filter:

2. Hiroshi Shigesawa et al., "Two-path cutoff waveguide dielectric resonator for filters", IEEE Trans. Microwave Theory and Techniques, vol. 7, pp.1105-1112, July 1989.
3. Perfect electric conductor

1. Select one of the two faces at either side of the filter where the waveguide would transition into the coaxial adaptor.

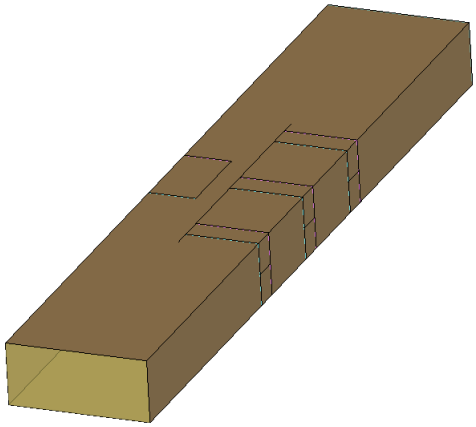

Figure 9: A face is selected on one side of the filter where the waveguide in the physical model would have transitioned into the coaxial adaptor.

2. Add a waveguide port to the first selected face.

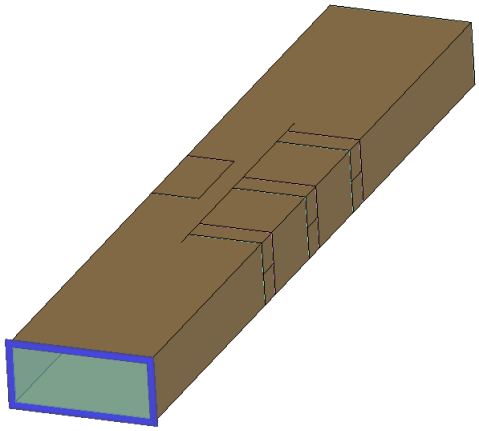

Figure 10: A waveguide port is added to the filter.

3. Select the second face at the side of the filter where the waveguide would transition into the coaxial adaptor.
4. Add a waveguide port to the second selected face.
5. Add an S-parameter configuration and make Port 1 active to calculate the S-parameters between the two ports.

2.1.3 Double-Ridged Horn

As an example, we will have a look at a double-ridged horn antenna consisting of a horn and a ridged waveguide solved using the FEM.

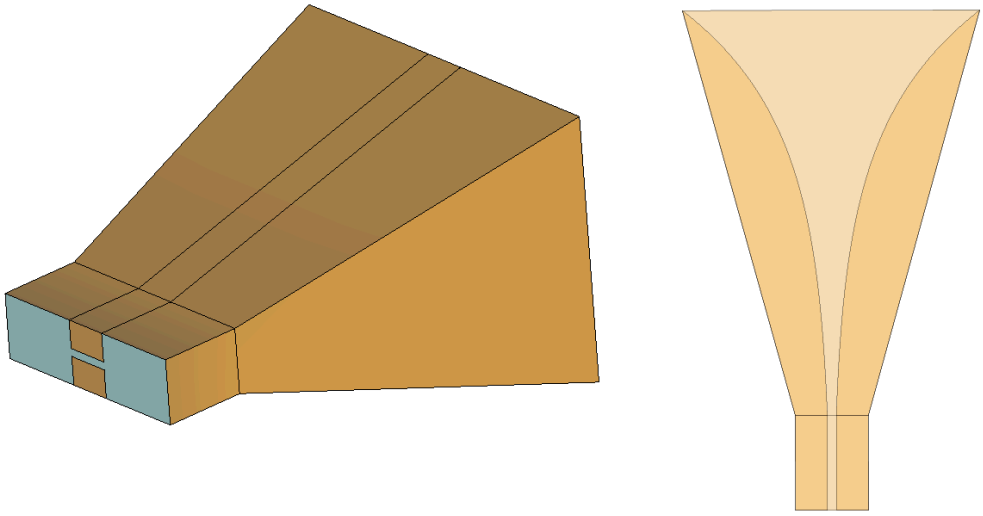

Figure 11: The double-ridged horn. Left: Isometric view; Right: Side view with opacity set to 20%.

Since the face that will be used to excite the model is on the boundary of a FEM region, a FEM modal port must be used.[4]

A good approximation of the physical model is to place the FEM modal port in the plane where the waveguide would transition into the coaxial adaptor in the physical model.

To excite the model:

- Select the face of the ridged waveguide where the waveguide would transition into the coaxial adaptor in the physical model.

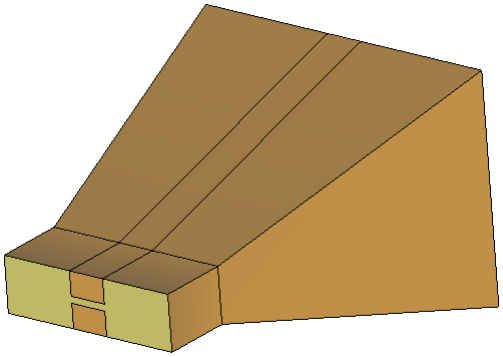

Figure 12: A face is selected.

4. A waveguide port can only be applied to a single flat face solved using the SEP or a single flat face on the boundary of a FEM region. Only three basic cross-sections are supported for waveguide ports: rectangular, circular and coaxial.

- Add a FEM modal port to the selected face.

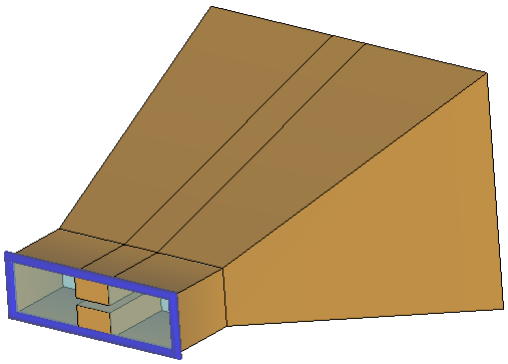

Figure 13: A FEM modal port is added to the face.

- Add a FEM modal source to the FEM modal port.

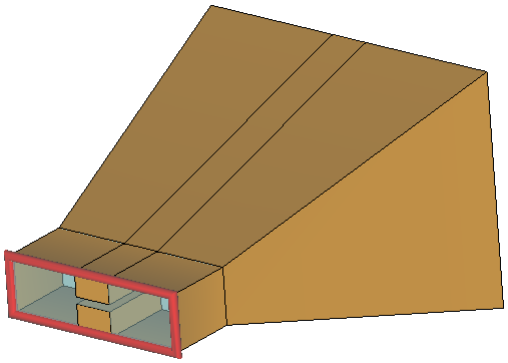

Figure 14: A FEM modal source is added to the FEM modal port.

2.2 How to Excite a Coaxial Cable

As an example, we will look at a patch antenna on a finite substrate fed by a coaxial cable connected to the ground plane.

For this example, the model is constructed as close to the physical model by including a short section of the coaxial cable. Since a coaxial cable is also a waveguide structure, a waveguide port will be used to excite the model.

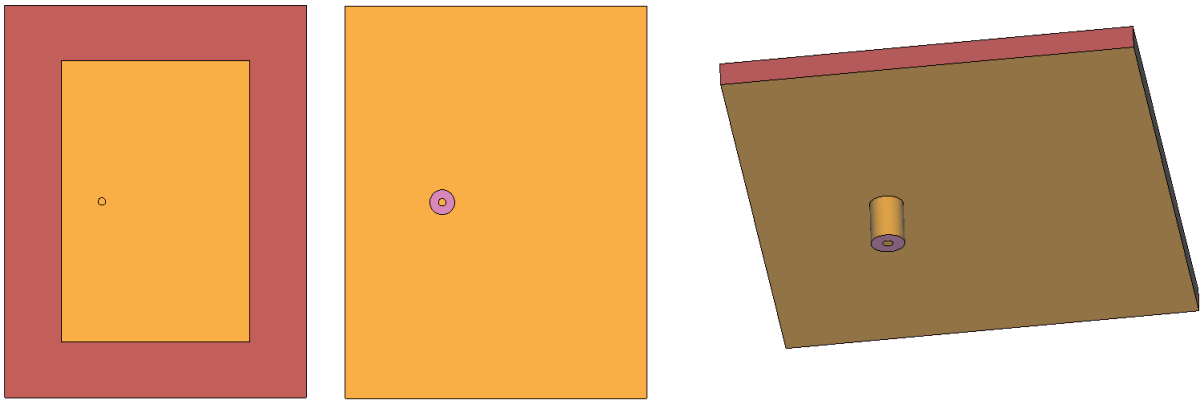

Figure 15: Patch antenna. Left: Top view; Centre: Bottom view; Right: Isometric view.

To excite the coaxial cable:

- Select the bottom face of the coaxial cable.

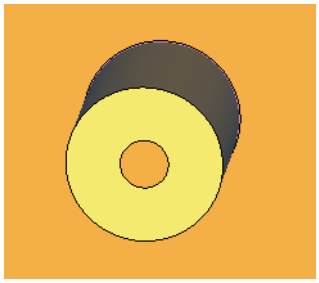

Figure 16: The face at the end of the coaxial cable section is selected.

- Add a waveguide port to the selected face.

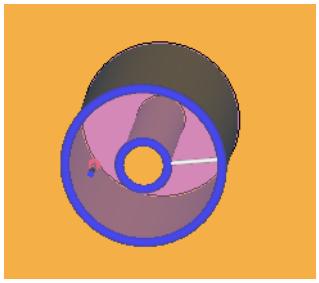

Figure 17: A waveguide port is added to the coaxial cable.

- Add a waveguide source to the waveguide port.

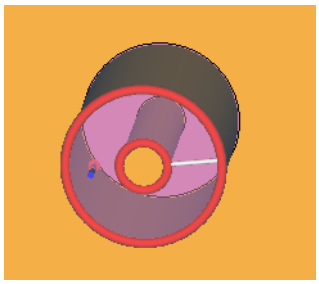

Figure 18: A waveguide source is added to the coaxial cable.

2.3 How to Excite Microstrip Structures

Microstrip structures are typically connected to a coaxial cable with a connector (for example, an SMA connector).

When you excite a Feko model, you can model the physical connector or use an approximation for the connector. Both options are accurate and the method to choose depend on the physical model you want to simulate, the model construction and solution method used.

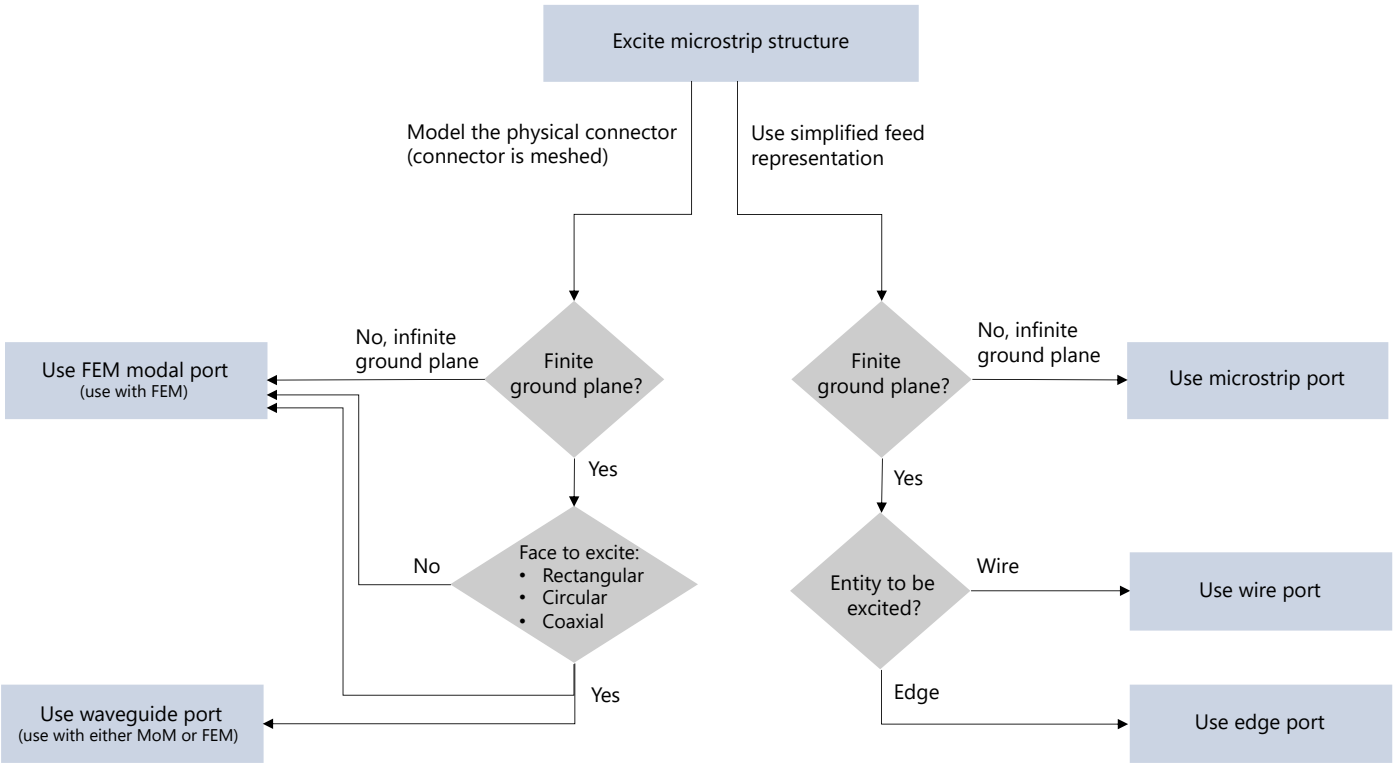

Figure 19: A decision flowchart showing the options when exciting a microstrip structure.

For further examples of how to excite microstrip structures, refer to the following examples:

- Feko Example Guide
  - Example A.8
  - Example A.9
  - Example A.10
  - Example E.1
  - Example E.5

2.3.1 Patch Antenna with Pin-Feed (Finite Ground)

As an example, we will look at a microstrip patch antenna fed by a coaxial cable via an SMA connector from below the patch.

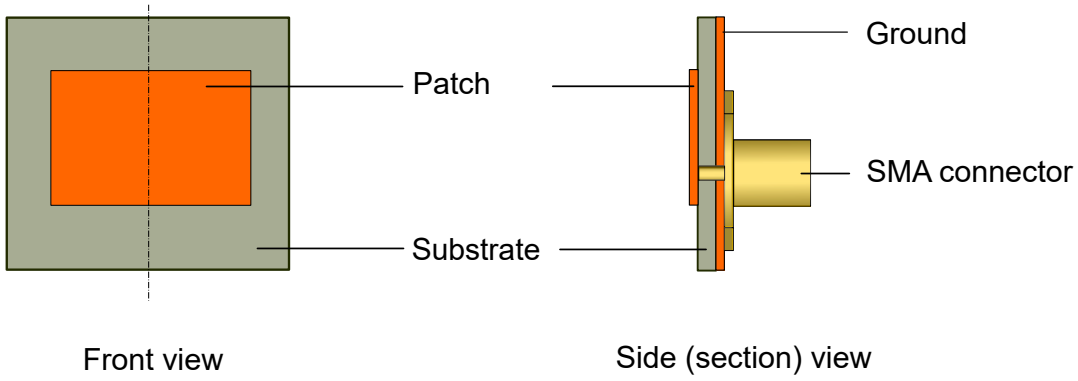

Figure 20: The front and side (section) view of the physical microstrip patch antenna for illustration purposes. Dimensions not to scale.

The patch antenna is modelled using a finite ground plane. A good approximation of a microstrip patch antenna (fed from below using an SMA connector) is to use a wire that connects the patch and the finite ground. A wire port and voltage source are added to the wire to excite the patch antenna.

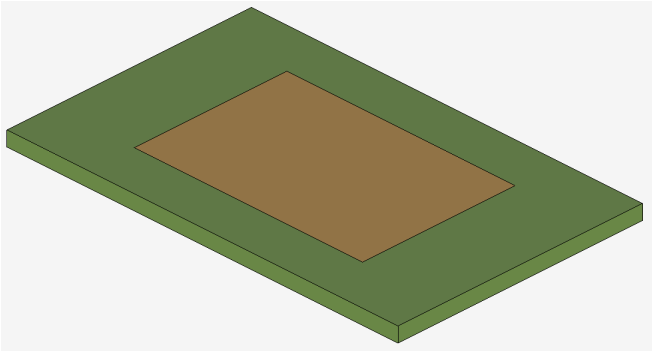

Figure 21: An example of a micostrip patch antenna on a finite substrate in CADFEKO.

To excite the microstrip antenna:

- To model the SMA connector, add a wire from the ground to the patch. The wire should be located where the SMA connector would have been connected.

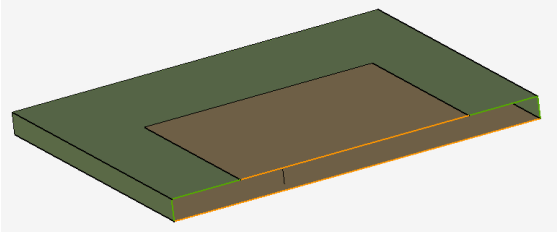

Figure 22: The microstrip patch antenna with a cut plane showing the wire.

- Select the wire and add a wire port to the start of the wire (on the side of the ground).

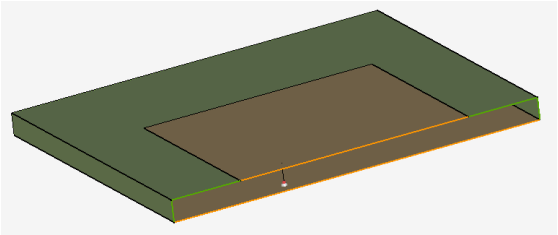

Figure 23: The microstrip patch antenna with a cut plane showing the location of the wire port on the wire.

- Add a voltage source to the wire port.

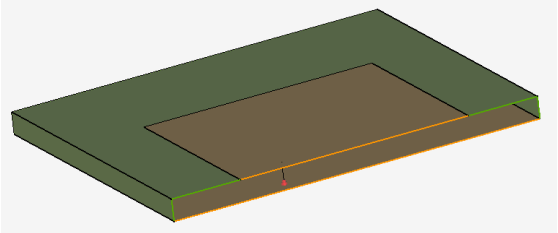

Figure 24: The microstrip patch antenna with a cut plane showing the voltage source added to the wire port.

Note: An alternative method to feed the model is to add the physical connector and excite the face of the connector, see Proximity-Fed Patch Antenna with SMA Connector (Finite Ground).

2.3.2 Patch Antenna with Edge-Feed (Infinite Ground)

As an example, we will have a look at a microstrip patch antenna fed by a coaxial cable via an SMA connector connected to a feed line.

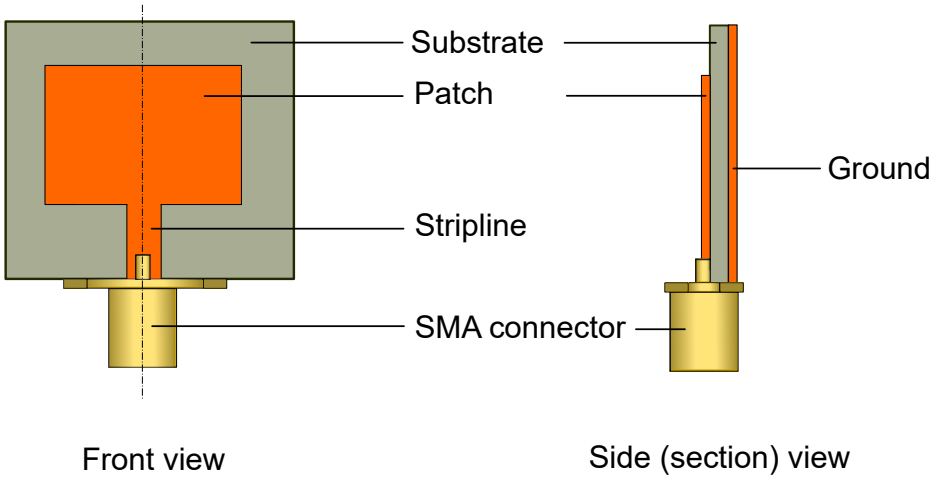

Figure 25: The front and side (section) view of the physical microstrip patch antenna for illustration purposes. Dimensions not to scale.

The patch antenna is modelled using an infinite ground plane. A good approximation of a microstrip patch antenna (fed using a feed line) is to use a microstrip port[5] where the connector would have been located. A voltage source is then added to the microstrip port to excite the patch antenna.

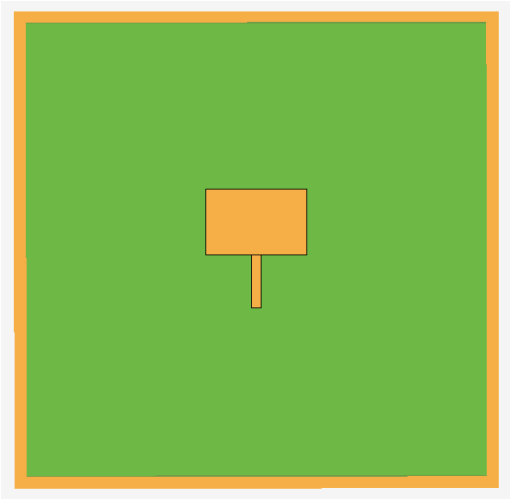

Figure 26: An example of a micostrip patch antenna on an infinite substrate in CADFEKO.

5. Since the substrate is modelled using an infinite ground plane, a microstrip port can be used. Microstrip ports are only supported with planar multilayer substrates, see Ports per Solution Method.

To excite the microstrip antenna:

- Select the edge at the end of the feed line.

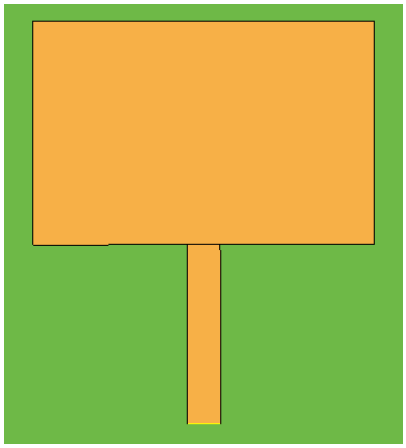

Figure 27: The edge at the end of the feed line is selected.

- Add a microstrip port to the selected edge.

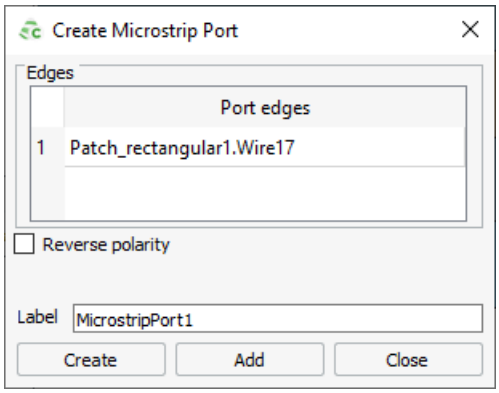

*Figure 28: The **Create Microstrip Port** dialog.*

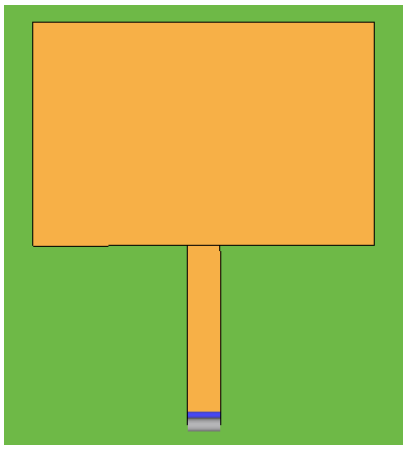

Figure 29: A microstrip port is added to the selected edge.

- Add a voltage source to the microstrip port.

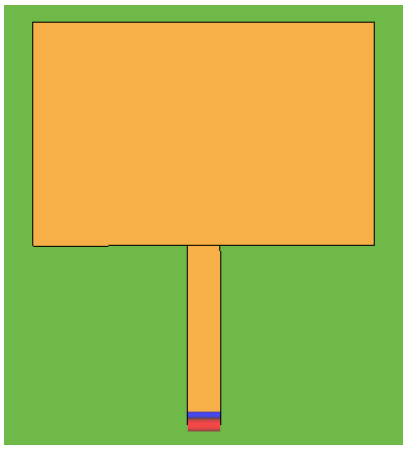

Figure 30: A voltage source is added to the microstrip port.

Note: An alternative method to feed the model is to add the physical connector and excite the face of the connector, see Proximity-Fed Patch Antenna with SMA Connector (Finite Ground).

2.3.3 Annular-Ring Slot Antenna with Edge Feed (Finite Ground)

As an example, we will have a look at a microstrip annular-ring slot antenna with a feed line that is connected by an SMA connector to a coaxial cable.

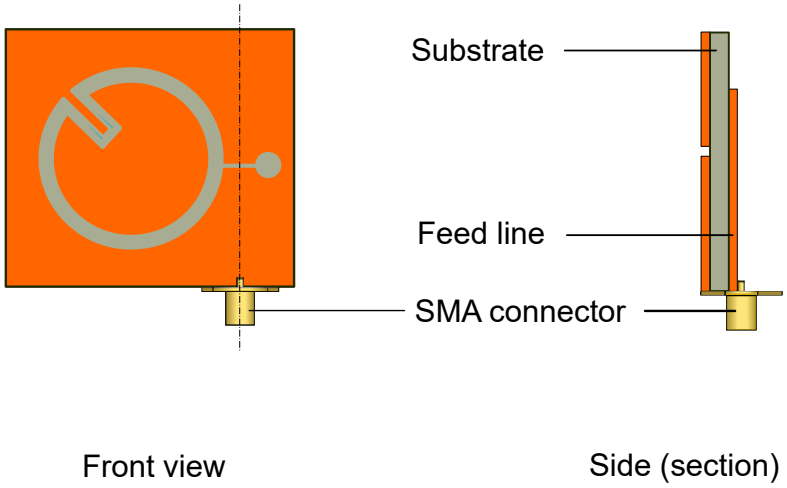

Figure 31: The front and side (section) view of the physical microstrip antenna for illustration purposes. Dimensions not to scale.

The annular-ring slot antenna is modelled using a finite ground plane. A good approximation of a microstrip annular ring antenna is to use an edge port[6]. A voltage source is then added to the edge port to excite the patch antenna.

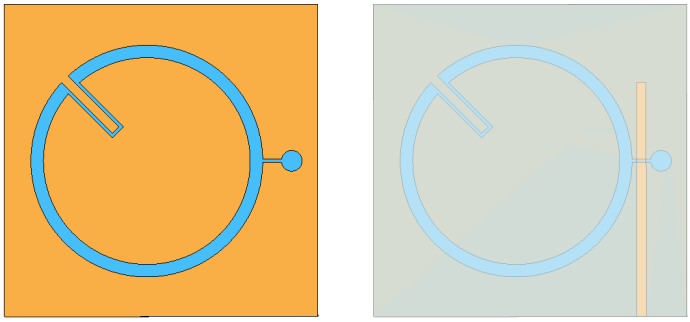

Figure 32: An annular-ring slot antenna on a finite substrate with a feedline at the bottom of the substrate. Left: 100% opacity; Right: 20% opacity.

> **Important:** A port cannot be placed on the boundary of a finite dielectric substrate when using the method of moments (MoM).

6. Since we are using a finite ground plane, we cannot use a microstrip port. Microstrip ports are only supported with planar multilayer substrates, see Ports per Solution Method.

Since there is the restriction that a port cannot be placed on the edge of a finite substrate when using MoM, the model is adjusted to have a separation gap. The edge port is to be placed on the face perpendicular to the feedline.

To adjust the model to allow placing an edge port:

- Subtract [7] a volume from the finite substrate where the edge port will be placed.

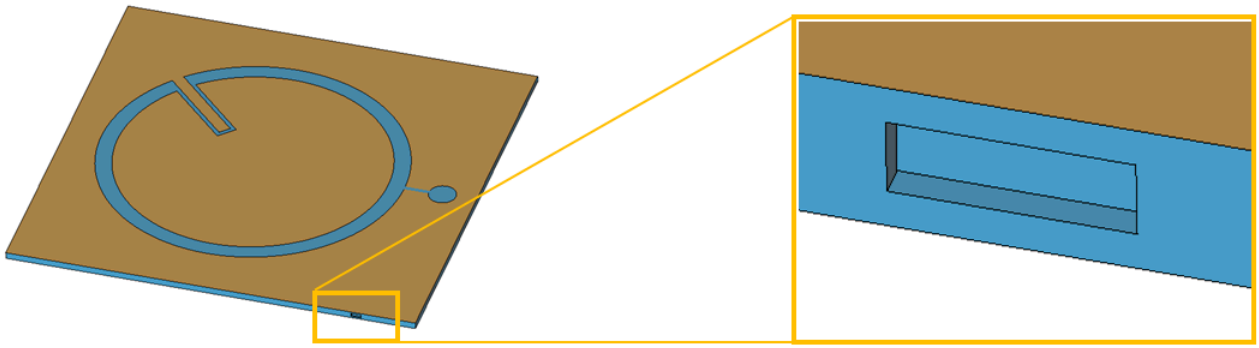

Figure 33: Subtract a volume from the finite substrate.

- Create two[8] polygons to connect the top PEC face and the feedline at the bottom. To keep the port edge smaller than $\frac{\lambda}{30}$, taper the face to the centre where the port will be located. The faces will be in the shape of a "bow tie".

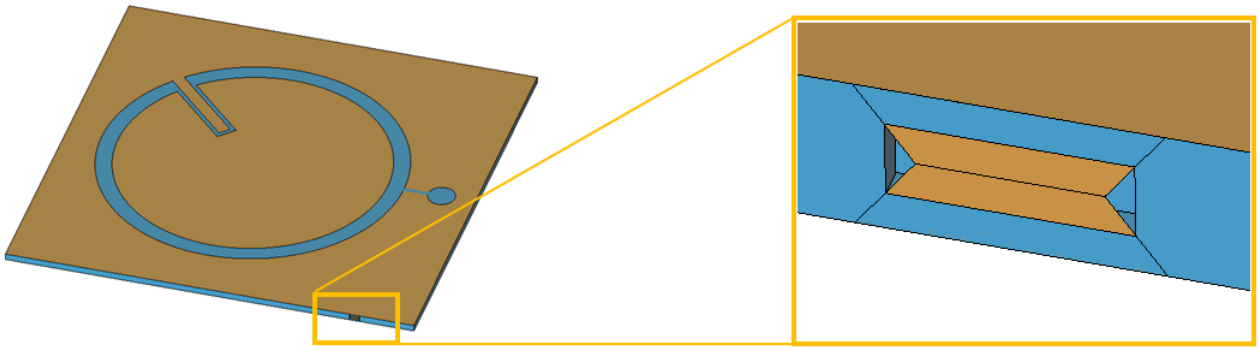

Figure 34: Two faces are created that taper to an edge length smaller than $\frac{\lambda}{30}$. The edge port will be placed on the faces on either side of the edge.

- Union the model to ensure mesh connectivity.
- Set the faces of the "bow tie" to PEC.

7. Create a rectangle and sweep to create a cuboid and subtract the cuboid from the substrate.
8. We will require two faces when defining an edge port .

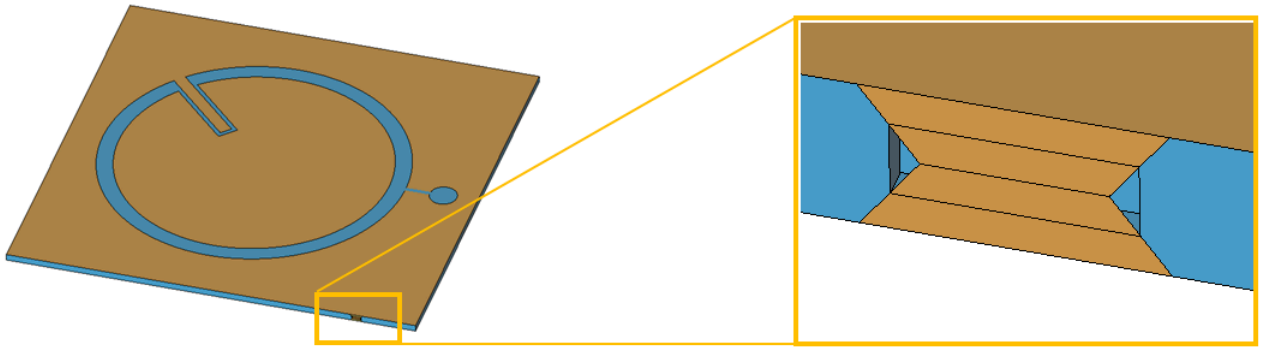

Figure 35: The "bowtie" faces are set to PEC.

To excite the patch antenna:

- Add an edge port on the edge smaller than $\frac{\lambda}{30}$.

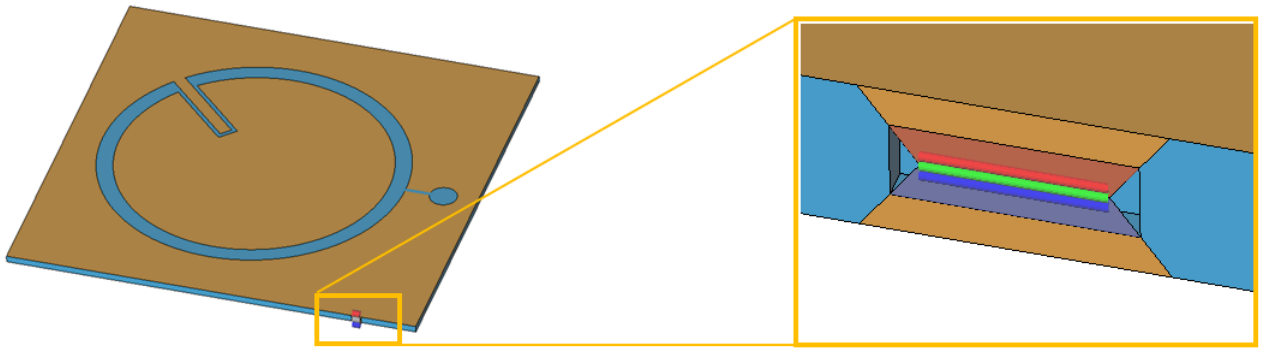

Figure 36: Add an edge port to the faces.

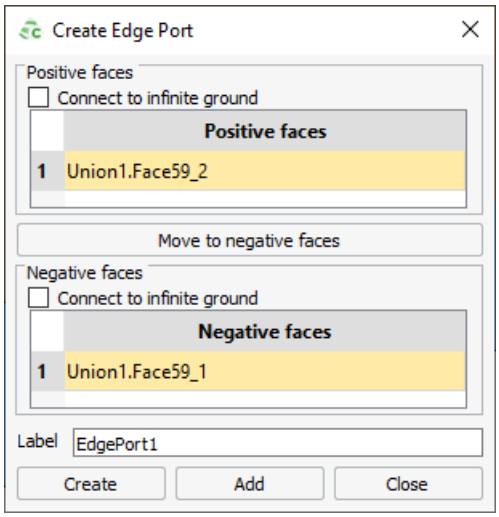

*Figure 37: The **Create Edge Port** dialog.*

- Add a voltage source to the edge port.

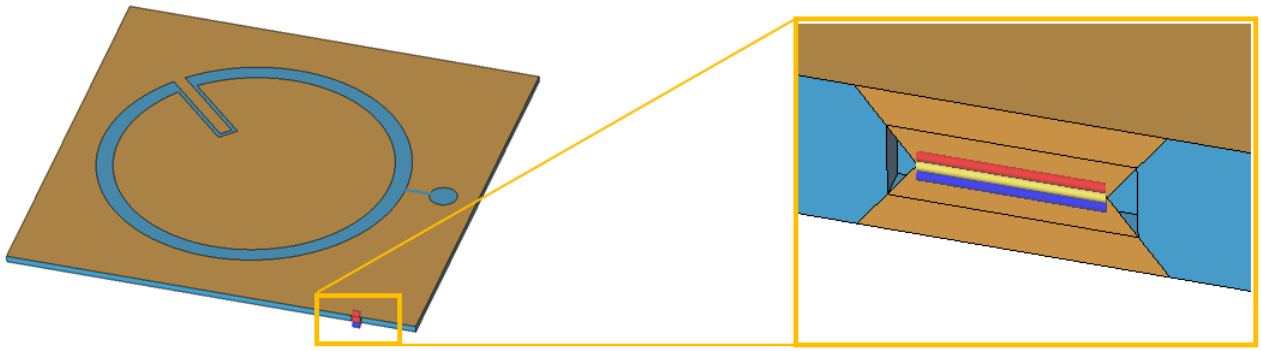

Figure 38: A voltage source is added to the edge port.

Note: An alternative method to feed the model is to add the physical connector and excite the face of the connector, see Proximity-Fed Patch Antenna with SMA Connector (Finite Ground).

2.3.4 Proximity-Fed Patch Antenna with SMA Connector (Finite Ground)

As an example, we will look at a microstrip circular patch antenna with a feed line connected by an SMA connector to a coaxial cable.

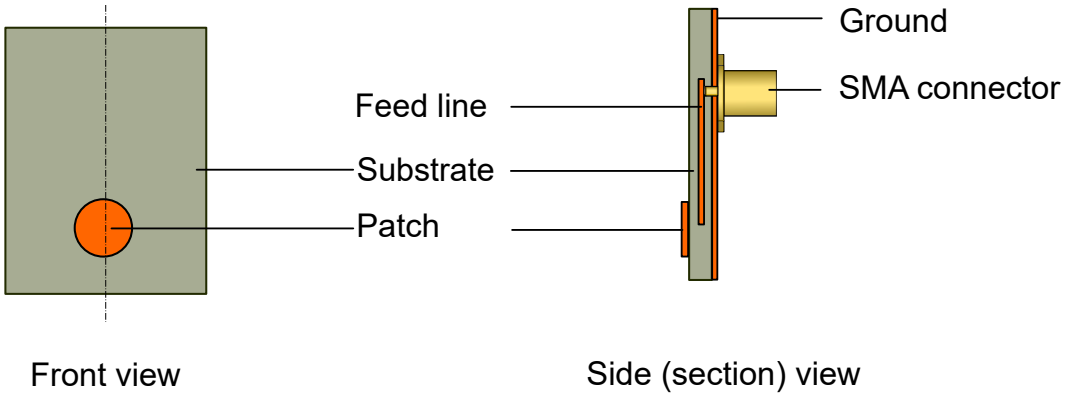

Figure 39: The front and side (section) view of the physical microstrip patch antenna for illustration purposes. Dimensions not to scale.

The circular patch antenna is modelled using a finite ground plane. Instead of using an approximation of the feeding mechanism (for example, a pin feed or edge feed), an SMA connector will be modelled as in the physical model. A waveguide port and waveguide source are added to the front face of the SMA connector to excite the patch antenna.

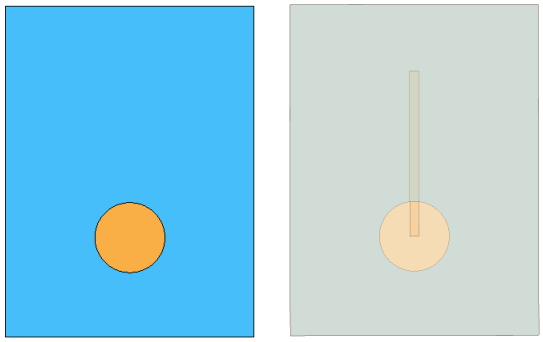

Figure 40: An example of a circular patch antenna on a finite substrate with a feed line at the bottom of the substrate in CADFEKO. Left: 100% opacity; Right: 20% opacity.

To model the SMA connector:

- Import a model of an SMA connector and place it near the end of the feed line.
- Adjust the height of the pin to ensure that the pin makes contact with the feed line.
- To ensure electrical connectivity, union the patch antenna and the SMA connector.

Note: Confirm that the regions and faces of the connector have the correct material properties after the union operation.

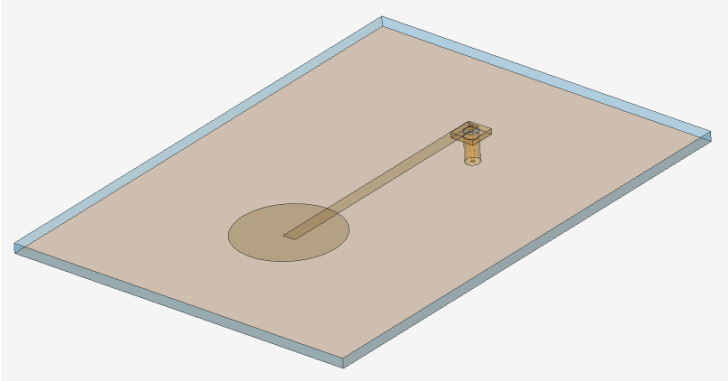

Figure 41: A model of a SMA connector was imported as a `.cfx` file and placed near the end of the feed line. Opacity set to 20%.

To excite the microstrip antenna:

- Select the front face of the SMA connector.

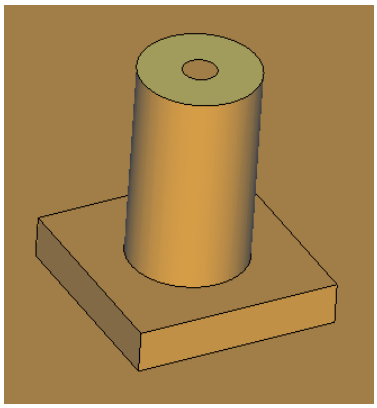

Figure 42: The face of the SMA connector is selected.

- Add a waveguide port to the selected face.

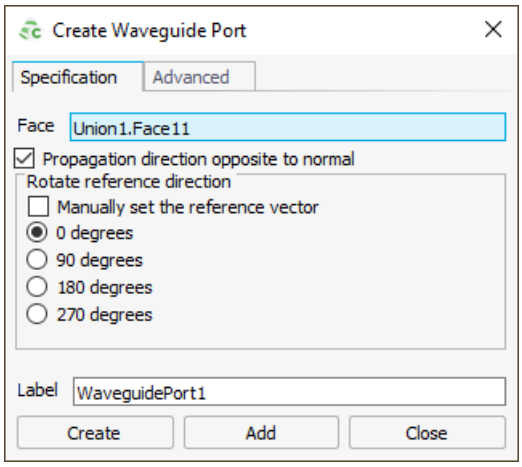

*Figure 43: The **Create Waveguide Port** dialog.*

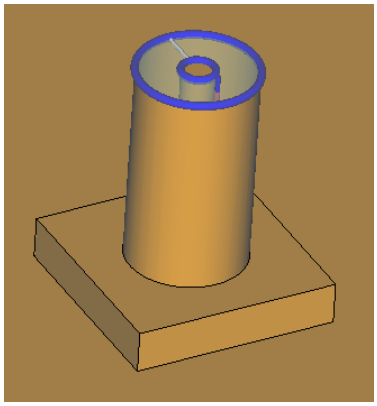

Figure 44: A waveguide port is added to the selected face.

- Add a waveguide source to the waveguide port.

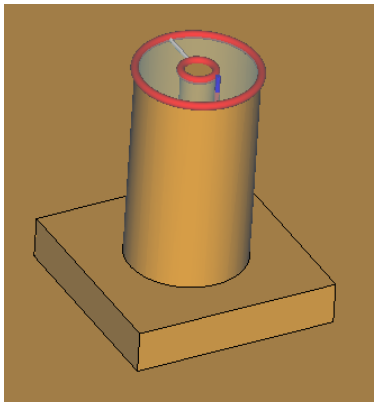

Figure 45: A waveguide source is added to the waveguide port.

2.4 How to Add a Port to an Imported Mesh

As an example, we will look at an imported mesh model of an automobile with a monopole attached to the roof.

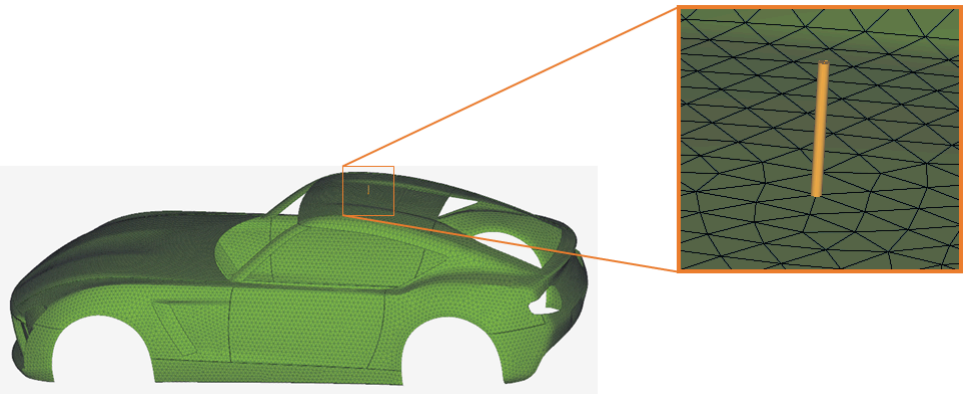

Figure 46: An imported automobile model (meshed using Altair HyperMesh) with a monopole antenna on the roof.

Since the antenna is a wire and meshed into segments, a wire port will be used to excite the monopole.

To excite the monopole:

- Select the mesh segment in the details tree.

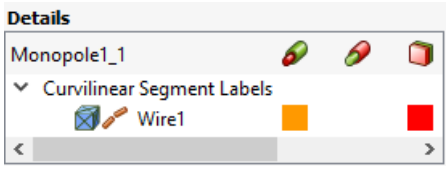

Figure 47: The mesh segment is selected.

- Add a wire mesh port to the selected wire segment:

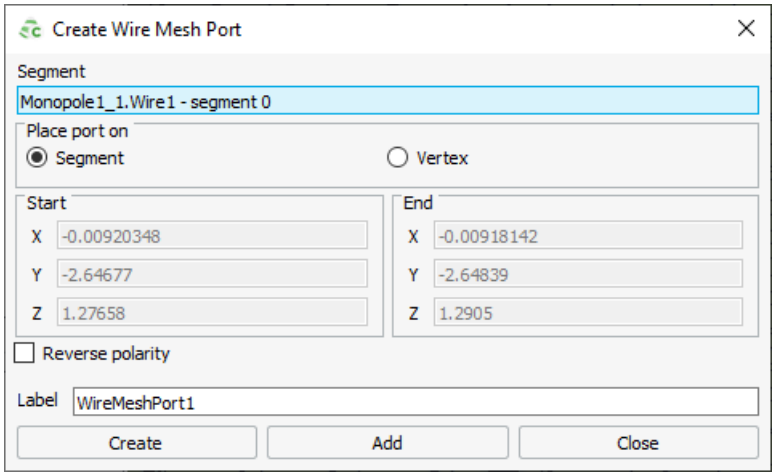

*Figure 48: The **Create Wire Mesh Port** dialog.*

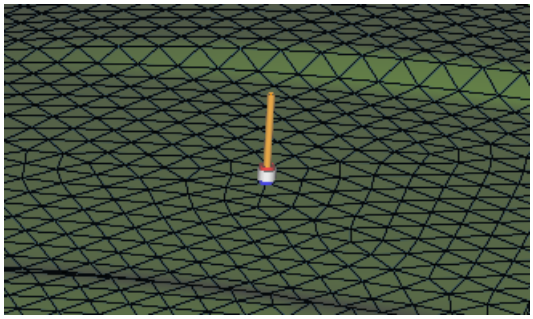

Figure 49: Added a wire mesh port to the segment.

- Add a voltage source to the wire mesh port.

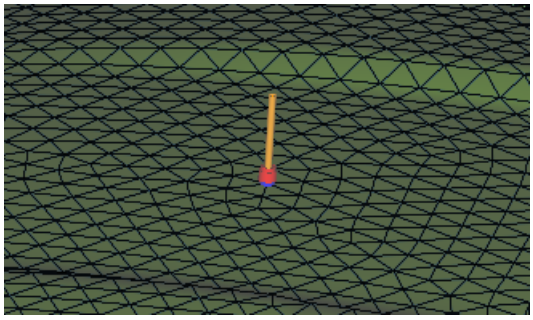

Figure 50: Added a voltage source to the wire mesh port.

Note: View Appendix *A-2.12 How to Connect an Antenna to a HyperMesh Generated Mesh* in the Feko User Guide for more information.

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