Created in COMSOL Multiphysics 6.1

Parameterized Circulator Geometry

Introduction

This is a template MPH-file containing the physics interfaces and the parameterized geometry for the model Impedance Matching of a Lossy Ferrite 3-port Circulator. For a description of that application, see the book *Introduction to the RF Module* or the application documentation *Impedance Matching of a Lossy Ferrite 3-Port Circulator*.

Application Library path: `RF_Module/Ferrimagnetic_Devices/lossy_circulator_3d_geom`

Modeling Instructions

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

NEW

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

MODEL WIZARD

1 In the **Model Wizard** window, click **3D**.

2 In the **Select Physics** tree, select **Radio Frequency>Electromagnetic Waves, Frequency Domain (emw)**.

3 Click **Add**.

4 Click **Study**.

5 In the **Select Study** tree, select **General Studies>Frequency Domain**.

6 Click **Done**.

GLOBAL DEFINITIONS

The geometry is set up using a parameterized approach. This allows you to match the input impedance to that of the connecting waveguide sections by variation of two geometric design parameters. Before starting to build the geometry the geometric design parameters need to be entered. These are two dimensionless numbers used to scale selected geometric building blocks.

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 In the table, enter the following settings:

Name	Expression	Value	Description
`sc_chamfer`	`3`	3	`Geometry scale factor`
`sc_ferrite`	`0.5`	0.5	`Geometry scale factor`

The lossy ferrite material model is set up by referring to global variables. For convenience the definitions are stored in an external text file that is imported into the model. The external text file also contains comments.

Variables 1

1 In the **Home** toolbar, click **Variables** and choose **Global Variables**.
2 In the **Settings** window for **Variables**, locate the **Variables** section.
3 Click **Load from File**.
4 Browse to the model's Application Libraries folder and double-click the file `lossy_circulator_3d_parameters.txt`.

The geometry is built by first defining a 2D cross section of the 3D geometry in a work plane. The 2D geometry is then extruded into 3D.

GEOMETRY 1

Work Plane 1 (wp1)

1 In the **Geometry** toolbar, click **Work Plane**.
2 In the **Settings** window for **Work Plane**, click **Show Work Plane**.

Work Plane 1 (wp1)>Plane Geometry

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

Start by defining one arm of the circulator, then twice copy and rotate it to build all three arms.

Work Plane 1 (wp1)>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 `0.2-0.1/(3*sqrt(3))`.
4 In the **Height** text field, type `0.2/3`.
5 Locate the **Position** section. In the **xw** text field, type `-0.2`.
6 In the **yw** text field, type `-0.1/3`.

7 Click **Build Selected**.

Work Plane 1 (wp1)>Copy 1 (copy1)

1 In the **Work Plane** toolbar, click **Transforms** and choose **Copy**.

2 Select the object **r1** only.

Work Plane 1 (wp1)>Rotate 1 (rot1)

1 In the **Work Plane** toolbar, click **Transforms** and choose **Rotate**.

2 Select the object **copy1** only.

3 In the **Settings** window for **Rotate**, locate the **Rotation** section.

4 In the **Angle** text field, type 120.

5 Click **Build Selected**.

Work Plane 1 (wp1)>Copy 2 (copy2)

1 In the **Work Plane** toolbar, click **Transforms** and choose **Copy**.

2 Select the object **r1** only.

Work Plane 1 (wp1)>Rotate 2 (rot2)

1 In the **Work Plane** toolbar, click **Transforms** and choose **Rotate**.

2 Select the object **copy2** only.

3 In the **Settings** window for **Rotate**, locate the **Rotation** section.

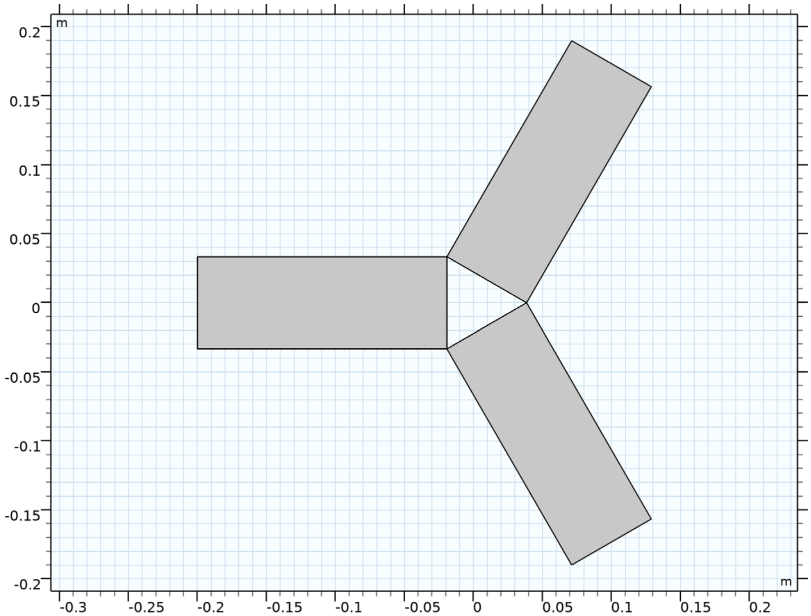
4 In the **Angle** text field, type -120.

5 Click **Build Selected**.

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

Work Plane 1 (wp1)>Plane Geometry

The geometry should now look as in the figure below.



Unite the three arms to one object.

Work Plane 1 (wp1)>Union 1 (uni1)

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

2 Click in the **Graphics** window and then press Ctrl+A to select all objects.

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

Work Plane 1 (wp1)>Plane Geometry

Next build the central connecting region and add the ferrite domain. During these stages, the geometric design parameters will be used. First build/add a triangle connecting the arms by subtracting a copy of what has already been drawn from a circle of proper radius.

Work Plane 1 (wp1)>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 `0.2/(3*sqrt(3))`.

4 Click **Build Selected**.

Work Plane 1 (wp1)>Copy 3 (copy3)

1 In the **Work Plane** toolbar, click **Transforms** and choose **Copy**.

2 Select the object **uni1** only.

Work Plane 1 (wp1)>Difference 1 (dif1)

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

2 Select the object **c1** only.

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

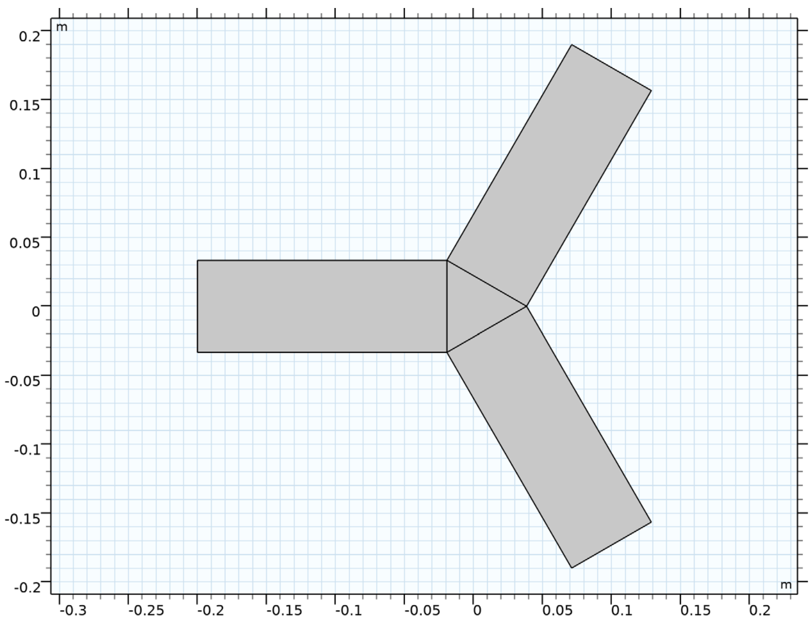
4 Find the **Objects to subtract** subsection. Click to select the **Activate Selection** toggle button.

5 Select the object **copy3** only.

6 Click **Build Selected**.

Work Plane 1 (wp1)>Plane Geometry

The geometry should now look as in the figure below.



Rotate the newly created triangle 180 degrees and use one scaled copy of it to create linear fillets for impedance matching. Use another scaled copy to define the ferrite.

Work Plane 1 (wp1)>Rotate 3 (rot3)

1 In the **Work Plane** toolbar, click **Transforms** and choose **Rotate**.

2 Select the object **dif1** only.

3 In the **Settings** window for **Rotate**, locate the **Rotation** section.

4 In the **Angle** text field, type `180`.

5 Click **Build Selected**.

Work Plane 1 (wp1)>Copy 4 (copy4)

1 In the **Work Plane** toolbar, click **Transforms** and choose **Copy**.

2 Select the object **rot3** only.

Work Plane 1 (wp1)>Plane Geometry

Apply the scaling for the impedance matching.

Work Plane 1 (wp1)>Scale 1 (sca1)

1 In the **Work Plane** toolbar, click **Transforms** and choose **Scale**.

2 In the **Settings** window for **Scale**, locate the **Scale Factor** section.

3 In the **Factor** text field, type `sc_chamfer`.

4 Select the object **copy4** only.

5 Click **Build Selected**.

Work Plane 1 (wp1)>Union 2 (uni2)

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

2 Select the objects **sca1** and **uni1** only.

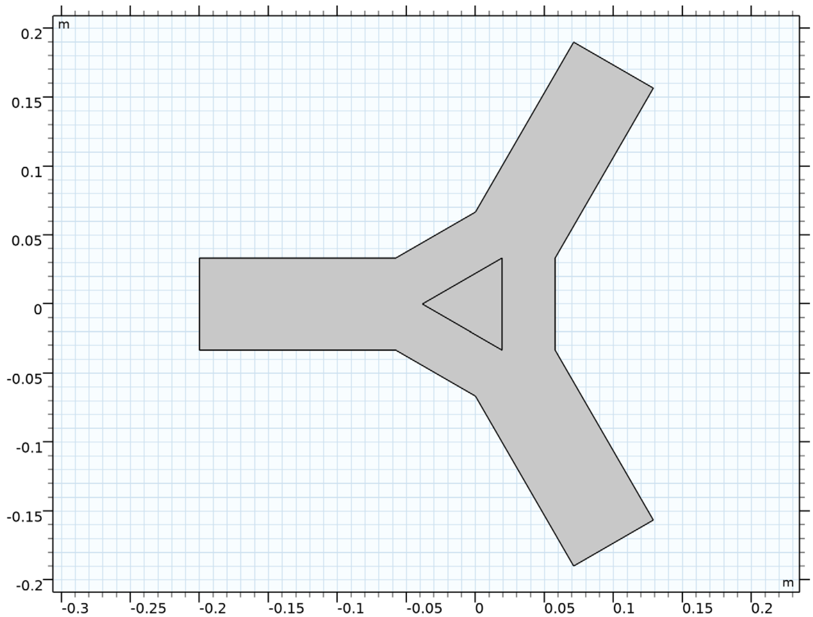
3 In the **Settings** window for **Union**, locate the **Union** section.

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

5 Click **Build Selected**.

Work Plane 1 (wp1)>Plane Geometry

The geometry should now look as in the figure below.



Apply the scaling for the ferrite region.

Work Plane 1 (wp1)>Scale 2 (sca2)

1 In the **Work Plane** toolbar, click **Transforms** and choose **Scale**.
2 Select the object **rot3** only.
3 In the **Settings** window for **Scale**, locate the **Scale Factor** section.
4 In the **Factor** text field, type `sc_ferrite`.
5 Click **Build Selected**.

Work Plane 1 (wp1)

Extruding the 2D cross section into a 3D solid geometry finalizes the geometry definition.

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 (m)
0.1/3

4 Click **Build Selected**.

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

Form Union (fin)

1 In the **Geometry** toolbar, click **Build All**.

The geometry should now look as in the figure below.