Model created in COMSOL Multiphysics 6.4

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 documentation for the model 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.

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
Ms	5.41e4[A/m]	54100 A/m	Saturation magnetization of ferrtie
H0	7.96e3[A/m]	7960 A/m	Bias magnetic field amplitude
dH	3.18e3[A/m]	3180 A/m	Line width
gamma	e_const/me_const	1.7588E11 C/kg	Gyromagnetic ratio
omega_0	mu0_const*gamma*H0	1.7593E9 1/s	Larmor frequency
omega_m	mu0_const*gamma*Ms	1.1957E10 1/s	Larmor frequency at saturation limit
aw	mu0_const*gamma*dH/2	3.5142E8 1/s	Product of dampening factor and angular frequency

Here, `e_const`, `me_const`, and `mu0_const` are predefined COMSOL constants for the elementary charge, the electron mass, and the permeability of vacuum, respectfully.

Except for `sc_chamfer` and `sc_ferrite`, the other parameters are not used for geometry construction here. However, the physics-based model directly imports this file, and those parameters are included for convenience in later use.

To create the geometry, the 2D cross-section of the circulator is built first. Then, it is 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 **Go to Plane Geometry**.

Work Plane 1 (wp1) > Plane Geometry

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

Start by defining one arm of the circulator 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) > Rotate 1 (rot1)

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

2 Select the object **r1** only.

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

4 Select the **Keep input objects** checkbox.

5 Locate the **Rotation** section. In the **Angle** text field, type `120 240`.

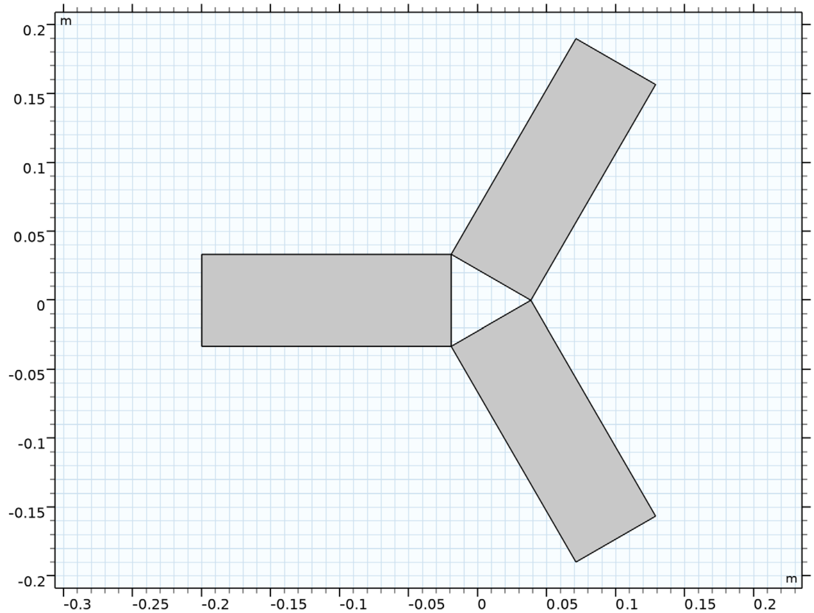
6 Click **Build Selected**.

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

Work Plane 1 (wp1) > Plane Geometry

At this stage, the geometry should appear as shown in the figure below.

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



Next, build the central connecting region.

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) > 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 Click to select the **Activate Selection** toggle button for **Objects to subtract**.

5 Select the objects **r1**, **rot1(1)**, and **rot1(2)** only.

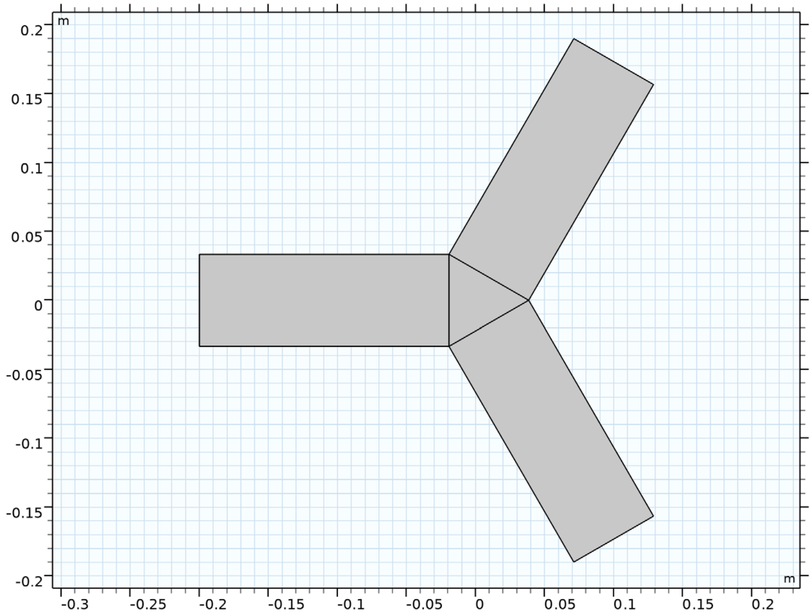
6 Select the **Keep objects to subtract** checkbox.

7 Click **Build Selected**.

Work Plane 1 (wp1) > Plane Geometry

The constructed geometry is expected to look like the figure presented below.

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



The remaining of the cross-section is generated using geometric parameters, along with rotation, scaling, and union operations.

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

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) > 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 Select the object **rot2** only.

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

4 Select the **Keep input objects** checkbox.

5 Locate the **Scale Factor** section. In the **Factor** text field, type `sc_chamfer`.

6 Click **Build Selected**.

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

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

2 Select the objects **r1**, **rot1(1)**, **rot1(2)**, and **sca1** only.

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

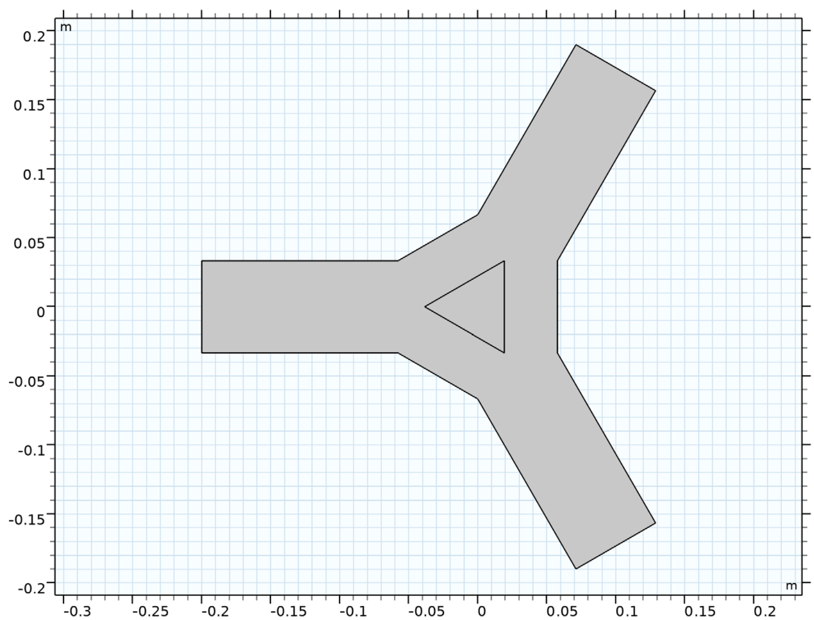
4 Clear the **Keep interior boundaries** checkbox.

5 Click **Build Selected**.

Work Plane 1 (wp1) > Plane Geometry

After completing these steps, the geometry should match the illustration below.

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



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 **rot2** 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 resulting geometry is displayed in the following figure.

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