

How To Model Ferrite Beads in EMI Analyst Using Manufacturer Impedance Curves

Ferrite beads have complex impedance; part resistive, part reactive. Depending on the blend of materials, the manufacturing process, and the physical dimensions of the bead, the resistive and reactive components vary widely as a function of frequency. EMI Analyst provides a simple means to precisely model ferrite bead complex impedance over frequency to assure accurate circuit representation.

In the example below, a component model is created for a ferrite bead manufactured by Fair-Rite Products Corp., part number 2944776101. The data sheet for the modeled bead can be found at: <http://fair-rite.com>. The procedure outlined is applicable to any ferrite bead from any manufacturer.

The Fair-Rite 2944776101 ferrite bead is a multi-turn design made from Fair-Rite #44 material, which has an initial relative permeability, $\mu_i = 500$. Modeling this ferrite using an equivalent circuit would be difficult and would likely result in significant errors at some frequencies.

The impedance curve for the ferrite bead, taken from the data sheet, is shown in Figure 1. It has a resistive component R_s and a reactive component X_L . The vector summation of these components is the impedance Z .

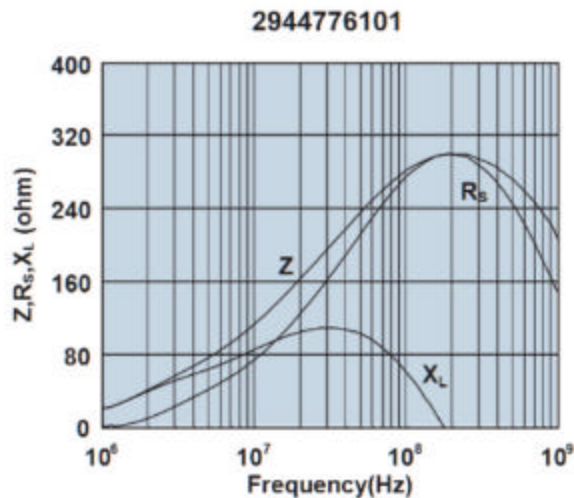
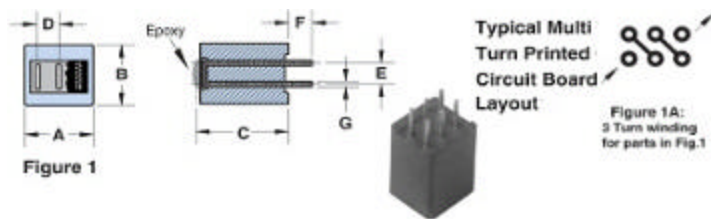


Figure 1 Mfg Ferrite Bead Impedance Curve

A circuit component that has the impedance characteristics equivalent to the ferrite bead can be easily created in EMI Analyst. Once created, this component can be saved to the Component Library for use in any filter or load circuit schematic in the future.

Follow the steps outlined below to create a ferrite bead component in EMI Analyst.

Step 1 Open Component Library

Start EMI Analyst

Open a filter or load circuit schematic

Click the Filter, Load, Left, or Right button on the EMI Analyst main screen

Open the Component Library

Double-click a component on the schematic or select a component, and then click the Edit button at the bottom of the Schematic form.

Step 2 Select 1-Port Component

Select the S-Parameter tab on the Component Library form

Select the 1-Port radio button if not already selected

Select Z-Parameters from the Parameter drop down box

Select Real/Imaginary from the Data Type drop down box

Default frequencies are displayed in the scroll box at the bottom left of the form

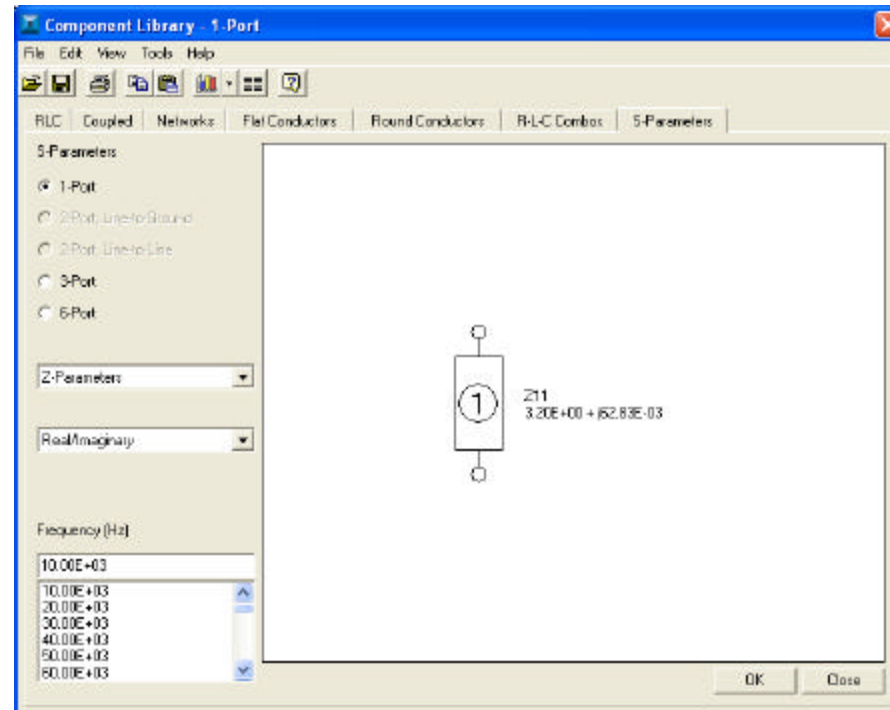


Figure 2 1-Port Component on Component Library Form

Step 3 Open 1-Port Data Table

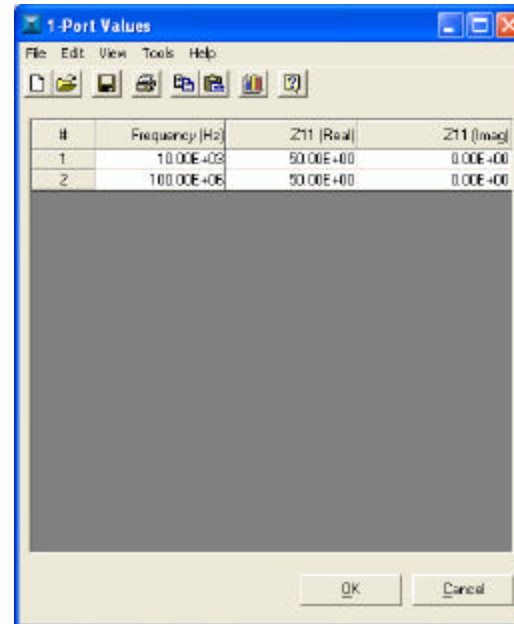
Display the Data Table

Click the Tabulate Values toolbar button on the Component Library form, or select Data Values from the View menu

Clear the Data Table

Click the New toolbar button on the Data Table form, or select New from the File menu

All but two lines of the Data Table will be deleted



The screenshot shows a dialog box titled "1-Port Values" with a menu bar (File, Edit, View, Tools, Help) and a toolbar. The main area contains a table with the following data:

#	Frequency (Hz)	Z11 (Real)	Z11 (mag)
1	1.000E+03	50.00E+00	0.00E+00
2	1.000E+06	50.00E+00	0.00E+00

At the bottom of the dialog box are "OK" and "Cancel" buttons.

Figure 3 1-Port Data Table

Step 4 Enter Ferrite Bead Impedance Values

Fill in the Data Table cells with the values shown in the figure to the right.

These values are estimated from the manufacturer’s impedance curve shown in Figure 1

The screenshot shows a dialog box titled "1-Port Values" with a menu bar (File, Edit, View, Tools, Help) and a toolbar. It contains a table with the following data:

#	Frequency [Hz]	Z11 (Real)	Z11 (Imag)
1	1.00E+06	0.00E+00	20.00E+00
2	2.00E+06	11.00E+00	40.00E+00
3	3.00E+06	23.00E+00	51.00E+00
4	5.00E+06	41.00E+00	65.00E+00
5	7.00E+06	55.00E+00	72.00E+00
6	10.00E+06	75.00E+00	85.00E+00
7	20.00E+06	125.00E+00	105.00E+00
8	30.00E+06	162.00E+00	110.00E+00
9	50.00E+06	210.00E+00	105.00E+00
10	70.00E+06	244.00E+00	90.00E+00
11	100.00E+06	275.00E+00	60.00E+00
12	130.00E+06	298.00E+00	30.00E+00
13	170.00E+06	297.00E+00	0.00E+00
14	200.00E+06	300.00E+00	0.00E+00
15	250.00E+06	294.00E+00	0.00E+00
16	300.00E+06	284.00E+00	0.00E+00
17	500.00E+06	243.00E+00	0.00E+00
18	700.00E+06	200.00E+00	0.00E+00
19	1.00E+09	150.00E+00	0.00E+00

At the bottom of the dialog box are "OK" and "Cancel" buttons.

Figure 4 Ferrite Bead Complex Impedance Values

Step 5 Plot Ferrite Bead Impedance

Click the Graph button on the Data Table toolbar or select Graph from the Tools menu

Select the Z11 checkbox and the Both radio button from the 1-Port Graphs form, and then click the Graph button

A plot of the component impedance will display as shown in Figure 5

Adjust graph appearance by right-clicking anywhere on the graph and then setting the chart control properties

When the graph has the desired appearance, it can be printed, saved to file, or copied to the clipboard

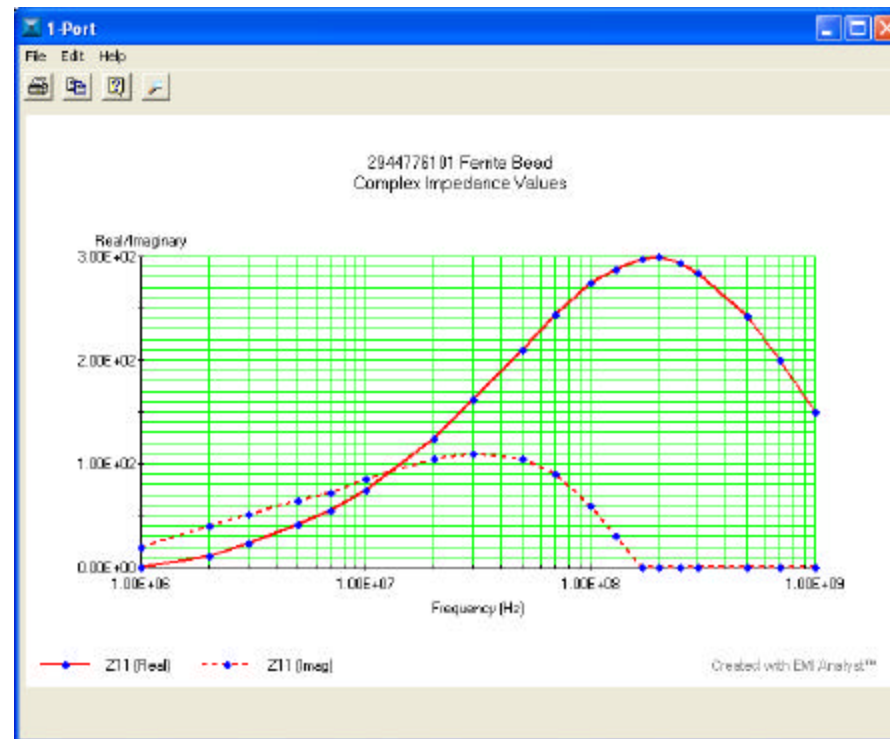


Figure 5 EMI Analyst Ferrite Bead Impedance Curve - Complex