Laboratory Assignment:
EM Numerical Modeling of a Monopole

Names: ____________________ ____________________

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Objective

This laboratory experiment provides a hands-on tutorial for drafting an antenna (simple monopole) and simulating radiation in the ANSYS HFSS modeling tool.

Preparation

Before coming to the laboratory to perform this assignment, the students should prepare the following:

- Identify a workstation in our school (or remote log-in portal) with an installation and/or license for running ANSYS HFSS electromagnetic modeling software.

Write-Up

The students performing this laboratory do *not* need to prepare a stand-alone laboratory report for this assignment. All work may be neatly shown on this document, with any supplemental answers to questions attached. Be sure to include all group member names on this sheet.

Equipment Guide

ANSYS HFSS software

Procedure

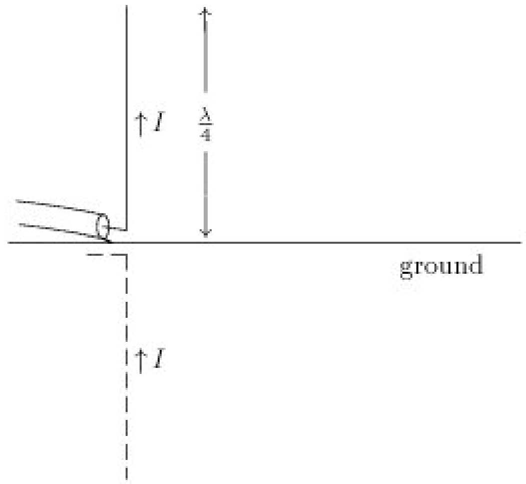
1. Starting HFSS

Follow instructions from the HFSS Stripline laboratory/tutorial for any pop ups that may occur.

2. Basic understanding of the Antenna

We will model one of the most basic antennas so that we can simulate a load, and design a matching network.

a. A quarter wavelength monopole is one of the easiest antennas to model. Essentially, it is a thin conductor standing up vertically at a quarter wavelength of the operational frequency. At the base, is a ground plane that theoretically extends to infinity, but in practice just needs to be moderately large.



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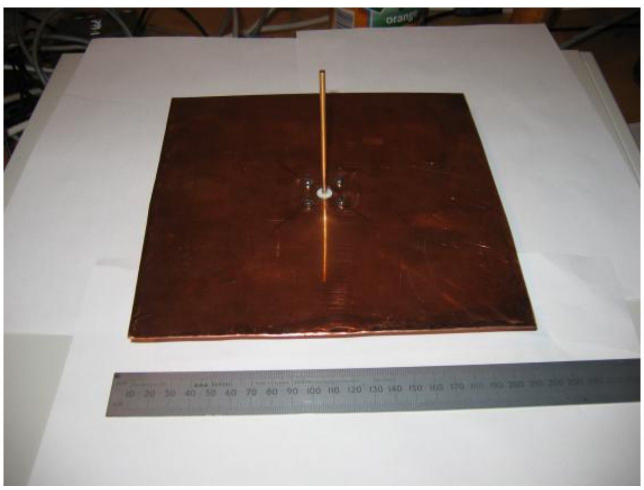


b. We will first build the antenna, and then you will design the matching network. For 2.4 GHz, the quarter wavelength is 31.3 mm.

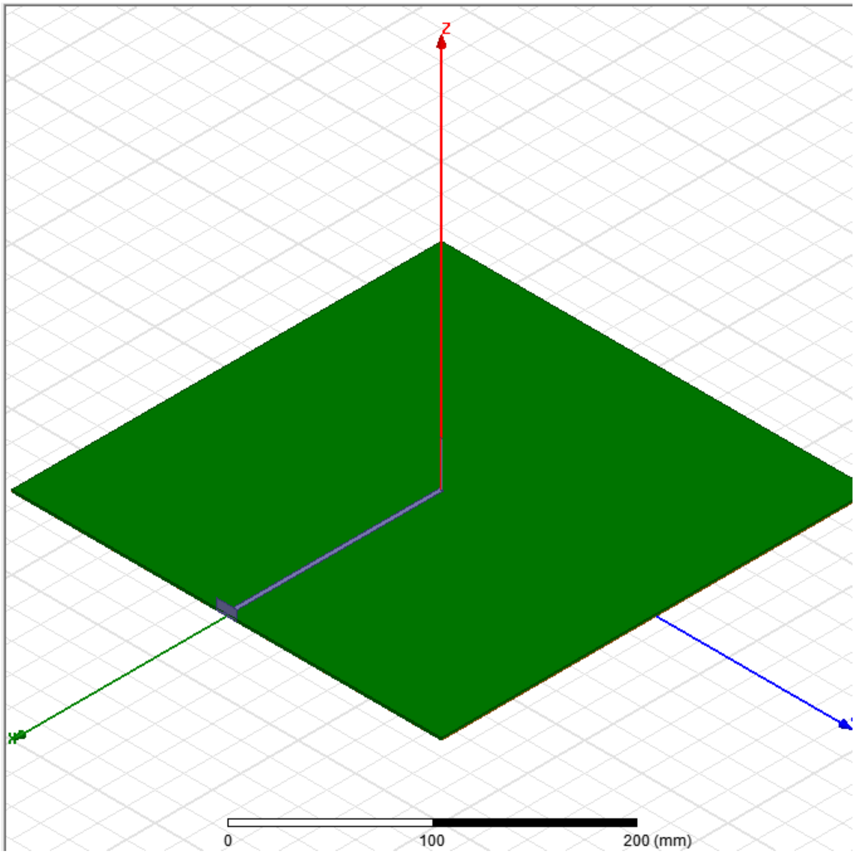
3. Setting up the Antenna

a. We will edit our previous model of a strip line now to include an antenna. First let's open our previous project. Select File-> Save As… and save it as MonopoleAntenna.hfss.

b. Now, as described previously, the antenna theoretically should have an infinite ground plane. Edit the "W" and "L" variable so that they are both "30cm". This should make a copper ground and FR4 layer of a 30cm square. The length of the micro stripline should have also increased due to its reliance on "L".

c. The antenna should be in the center of this ground plane, so we will remove half the length of the stripline. A quick way to do this is to change the X size from "L" to "L/2".

d. Verify which Waveport touches the edge of the stripline remaining. Delete the other port. The model should look as follows:



e. Now we will add a cylinder for the radiating element. Use the Draw Cylinder function, and align it by typing in the X,Y,Z coordinates. It should be in the center (x=0,y=0), **and start at the height of the FR4 + the copper sheet thickness of the bottom**. Use a length of 31.3mm, and a radius of .5mm. The two objects (**microstrip and cylinder**) should intersect. Make sure that the cylinder is copper. If you see an error related to FR4 being intersected, you probably did not setup your height correctly.

f. Select both the newly created cylinder and the microstrip layer, right click on the selection and select Edit -> Boolean -> Unite. This combines the microstrip and radiating element into one part.

g. Now that we have our antenna design, and we have removed one of the wave ports, we should be ready to simulate. We almost are. Edit the radiating boundary. In general, the further away it is from the radiating elements, the more accurate it is. A good rule of thumb is half the wavelength of the operational frequency. Edit it so the Z Size of the axis is 120mm, but centered around 0.

h. Go to HFSS->Radiation-> Insert Far Field Setup -> Infinite Sphere. Hit OK.

i. Right click on the sweep, and select disable sweep. Double click on Setup1 and adjust the max passes to 20.

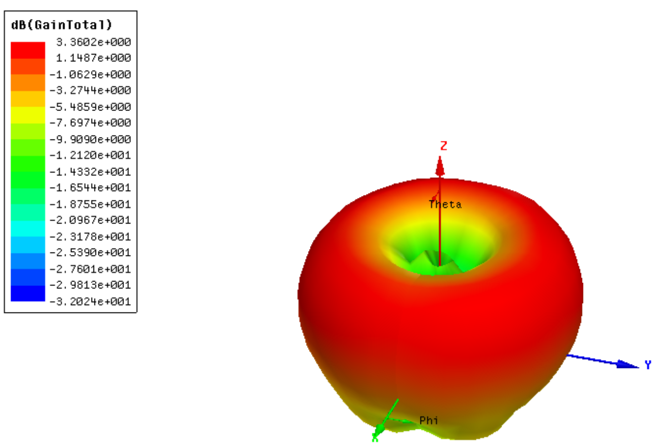
j. Let us setup the results. Right click on results and add a Far Fields report, and select 3D polar plot. Select Gain, gain total, and dB. Do another 3D polar plot with Realized Gain in dB.

k. Create a smith chart with the S11, as done in the previous lab. If you have only S22 edit the excitation on the left side so that the 2 is renamed to 1.

l. Create a Modal data solution report (similar to s11), and a rectangular plot of Port Z0, with both re and img selected (control click both of them, hit new report, and it will create one graph with both sets of data.)

m. Right click on Setup1, and select Analyze. Give it some time.

n. Double click the 3d polar plot labeled Gain. You should get the following result. The areas in red correspond where you would get the most signal with this antenna, but overall it seems omnidirectional.



o. Now look at the square plot of Port Z_o. The real and imaginary parts represent your Z_{in}. As we had the microstrip line matched to 50 ohms, this represents the load. You may notice some of your graphs are not showing up. Double click on the function that is supposed to be on the graph (such as $dB(s_{11})$) and it will bring up the menu for the graph. Edit the box in the top left so that it says “Solution:LastAdaptive”

p. Now that you know the load, we can design a matching network. Use the same width transmission lines (MS_W) and use the distance and length of transmission lines to match the load better. If you need to make a short stub, you will have to Boolean subtract it from the FR4. Use the short as a tool, and tell it to duplicate the item within the Boolean subtract.

Analysis

1. Report the gain, impedance, and half-power beamwidth of your monopole design.

Acknowledgment

This laboratory experiment was designed by Ryan Bahr.