

**ECE 6345
Spring 2015****Class Project**

Please check periodically to make sure that you have the latest version of the project (from the date at the top of this page). The project will be updated as corrections or changes are made.

The purpose of this project is to design and analyze a dual-band rectangular microstrip antenna shown in Fig. 1 below. The design will be done using CAD formulas, and then various methods will be used to plot the input impedance of the antenna.

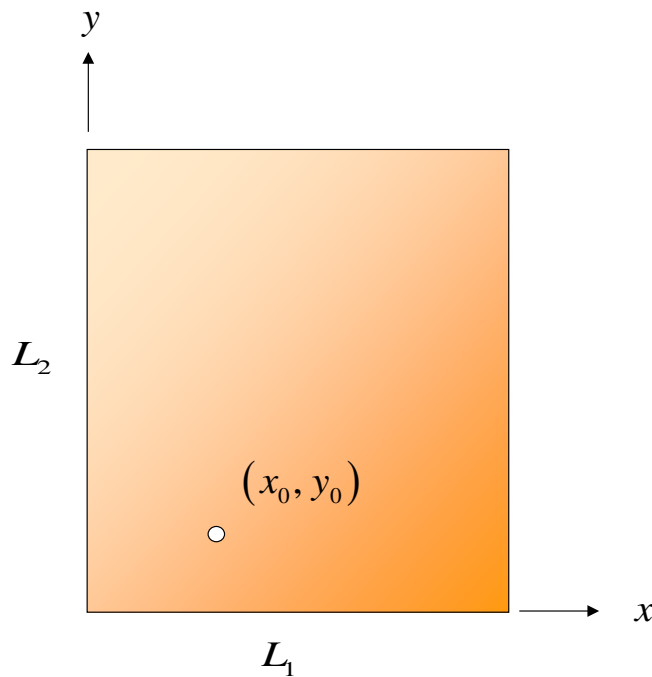


Fig. 1. Top view of dual-band microstrip antenna.

The antenna is a rectangular patch that is on a substrate of relative permittivity $\epsilon_r = 2.2$ with a thickness of $h = 0.1524$ cm (60 mils) and a loss tangent of 0.001. Assume that the conductivity of the patch and ground plane metal is 3.0×10^7 S/m. The antenna is to operate with horizontal (x -

directed) polarization at 1.575 GHz (the L1 GPS band) and vertical (y-directed) polarization at 1.227 GHz (the L2 GPS band).

The feed position (x_0, y_0) is chosen so that there is a 50Ω match at each frequency (the same feed is used for both frequencies), and the antenna input impedance has zero reactance at each frequency. Therefore, at each frequency, the input impedance should be $50 + j0 \Omega$. The antenna is fed by an SMA connector having a probe radius of 0.635 mm, which has a reactance that you should not ignore.

PROJECT TASKS

Task 1

Design the dimensions L_1 and L_2 and the feed position (x_0, y_0) for the antenna. In your design, use the CAD formulas that were given in the short-course notes. In the formulas for the Q factors, take all dimensions to be effective dimensions, and use the Hammerstad formula to calculate the fringing extension on all sides in order to get the effective dimensions. For example, if you see a term L in a CAD formula, take this to mean the effective length L_e . Your design should account for the probe inductance. (As part of your design process you should calculate the probe reactance at each of the two frequencies.)

Note that the dimension L_1 is the resonant dimension for the L_1 frequency band, while the dimension L_2 is the resonant dimension for the L_2 frequency band. Also, note that Q is different for the (1,0) mode and the (0,1) mode.

Task 2

Using the CAD formulas, calculate the following properties:

- The percent bandwidth at each of the two frequencies, based on an $SWR < 2$ definition.
- The radiation efficiency at each frequency.
- The directivity and gain (in dB) at each frequency.

Task 3

Using the CAD circuit model together with the CAD formulas for the relevant parameters (Q , f_0 , R , L_p), plot the input impedance (real and imaginary parts) vs. frequency, plotting from 1.0 GHz to 1.75 GHz. Note that the circuit model will consist of two RLC circuits in series, with a single series probe inductance in front. Each RLC circuit will have different parameters. The probe inductance L_p may be calculated at the average of the two specified frequencies, and then assumed to be constant.

Task 4

Using the cavity model with the mode matching method, plot the input impedance (real and imaginary parts) vs. frequency, plotting from 1.0 GHz to 1.75 GHz. The cavity model should use the effective dimensions and an effective loss tangent that comes from the total Q . The total Q should come from the CAD formulas. Take the Q to be frequency dependent, according to the formula

$$Q = Q_1 \left(\frac{f - f_2}{f_1 - f_2} \right) + Q_2 \left(\frac{f - f_1}{f_2 - f_1} \right).$$

This is a linear interpolation formula that forces Q to have the correct values of Q_1 and Q_2 at the frequencies f_1 and f_2 , respectively.

Task 5

Using the spectral-domain method, plot the input impedance (real and imaginary parts) vs. frequency, plotting from 1.0 GHz to 1.75 GHz. Use the physical patch dimensions (no fringing extension) in the calculation. Use an effective loss tangent that accounts for both dielectric and conductor loss (i.e., Q_d and Q_c). The effective loss tangent should not account for space-wave power or surface-wave power, since the spectral-domain method is already accounting for this. Note that $Q_d = 1 / \tan \delta$ does not depend on frequency, while Q_c does. You will need to use two basis functions in the formulation, since both the (1,0) and (0,1) modes are important here (see Notes 25 for the formulation with two basis functions).

Extra Credit

Use a full-wave simulator of your choice (HFSS, Designer, FEKO, IE3D, Microwave Studio, etc.) to plot the input impedance (real and imaginary parts) vs. frequency, plotting from 1.0 GHz to 1.75 GHz.

Format

It is recommended that you use the same type of format to write your project as is used for this project description. You can use this project description as your template.