

ECE 6345
Spring 2015

Homework 4

A rectangular microstrip antenna is printed on a substrate having $\epsilon_r = 2.2$ and $h = 0.1524$ [cm] (60 mils), unless stated otherwise below. The substrate may be assumed to be lossless (and nonmagnetic). The antenna is resonant at 1.575 [GHz]. Assume that the antenna operates at the resonance frequency, unless it is stated otherwise in the problems below. The aspect ratio of the patch is $W/L = 1.5$. Ignore fringing in the calculations. Please make all plots in dB on a polar plot, normalizing so that the patterns are zero dB at the maximum, unless stated otherwise below. Plot on a scale that has zero dB at the maximum and -40 dB at the center of the chart, with a scale of 10 dB per division. Please use plotting software (of your choice) to make the plots, so that they look professional.

- 1) Plot the E-plane ($\phi = 0$) and H-plane ($\phi = \pi/2$) patterns of the antenna using the electric current model based on the (1,0) cavity mode current (neglect the probe current and higher-order modes). Assume an infinite substrate. Plot both patterns on the same graph for comparison.
- 2) Plot the E-plane and H-plane patterns of the antenna using the magnetic current model, based on the dominant (1,0) cavity mode. Assume an infinite substrate. Plot both patterns on the same plot for comparison. (Note that if the plots are correct, they should be exactly the same as the ones obtained in Prob. 1. Do not assume this however – please verify it!).
- 3) Repeat Prob. 1 for three different substrate thickness: $h = 0.1524$ [cm], $h = 0.01524$ [cm] (ten times thinner) and $h = 1.524$ [cm] (ten times thicker). Comment on how the shape of the patterns changes with increasing substrate thickness.
- 4) For the E-plane, plot the patterns from the electric and magnetic current models on the same graph, assuming an infinite substrate. Make a separate graph for three different frequencies: 1.0 GHz, 1.575 GHz (the resonance frequency) and 2.0 GHz. Comment on the comparison.
- 5) Using the magnetic current model, plot the E-plane patterns for the infinite substrate and the truncated substrate on the same graph. Repeat for the H-plane patterns. Comment on how the substrate truncation affects the shape of the patterns.
- 6) By examining the far-field expressions from the electric current model for an infinite substrate, give a proof of the following property about the far-field pattern for the infinite-substrate case: The E- and H-plane patterns of the microstrip antenna always tends to zero at the horizon ($\theta = \pi/2$). This is true for substrates with $\epsilon_r > 1$ and also air substrates (you should consider both cases).

- 7) By examining the far-field expressions from the magnetic current model for a truncated substrate, give a proof of the following property about the far-field pattern for the truncated-substrate case: The E-plane pattern of the truncated microstrip antenna remains nonzero at the horizon unless the substrate is air, in which case the patterns tends to zero at the horizon. The H-plane pattern always tends to zero at the horizon.
- 8) Consider the same antenna in the previous problems. Assume now that the antenna is probe fed at a $50 [\Omega]$ match point, which occurs at $x_0 / L = 0.20$. (Note that x_0 is measured from the center of the patch here.) Determine the ratio of the peak patch current to the probe current. That is, calculate the ratio I_{patch} / I_0 , where $I_{patch} = A_{10}' W$.
- 9) Assuming an infinite substrate and using the electric current model, plot the far-field E_θ from the probe on the same scale in which you also show E_ϕ from the patch in the H plane (from Prob. 1). Normalize the plots so that the pattern from the patch has a maximum amplitude of zero dB (just as it does in prob. 1). The maximum amplitude of the probe pattern should have the correct level relative to the maximum of the patch pattern (the probe pattern will be less than zero dB at its maximum). What is the cross-pol level in the H plane of the patch due to the probe radiation, as predicted by your patterns?
- 10) Assume now a circular patch on the same substrate, which is also resonant at 1.575 GHz (neglect fringing). Plot the E and H plane patterns of this patch. Plot both patterns on the same graph for comparison.