**ECE 6345**

**Spring 2015**

**Homework 5**

1. A rectangular microstrip antenna is printed on a lossless substrate having a substrate relative permittivity *εr* = 2.2. The aspect ratio of the patch is . The antenna is operated at the resonant frequency (assume that fringing may be ignored, so the length of the patch is one-half of a wavelength in the dielectric). Plot the exact *Qsp* versus the normalized substrate thickness *h* / *λ*0 over the range 0 < *h* / *λ*0 < 0.1. On the same graph, add a plot of the CAD result for *Qsp* (which involves the CAD formula for *p*). The exact *Qsp* is based on the exact *Psp*, which comes from the exact power radiated by the equivalent dipole (which involves a single integration in *θ*) and the exact *p* factor (which must be found from a double integration in *θ* and *φ*.
2. Redo the above problem for a substrate relative permittivity of 10.8.
3. Consider the rectangular patch of Prob. 1. Plot the exact directivity (dB) versus the normalized substrate thickness *h* / *λ*0 over the range 0 < *h* / *λ*0 < 0.1. On the same graph, add a plot of the CAD results for the directivity (from a closed-form expression, which uses the CAD formula for *p*).
4. Redo the previous problem for a substrate relative permittivity of 10.8.
5. A circular microstrip antenna is printed on a lossless substrate having a substrate relative permittivity *εr* = 2.2. The antenna is operated at the resonance frequency of the TM011 mode. Ignore fringing, so that

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Plot the exact *Qsp* versus the normalized substrate thickness *h* / *λ*0 over the range 0 < *h* / *λ*0 < 0.1. On the same graph, add a plot of the CAD result for *Qsp* (which uses the CAD formulas for *p* and *I*0). The exact *Qsp* must be found from a numerical integration in *θ*.

1. Redo the previous problem for a substrate relative permittivity of 10.8.
2. Consider the circular patch of Prob. 4. Plot the exact directivity (dB) versus the normalized substrate thickness *h* / *λ*0 over the range 0 < *h* / *λ*0 < 0.1. On the same graph, add a plot of the CAD result for the directivity (from a closed-form expression, which uses the CAD formula for *p*).
3. Repeat the previous problem using a substrate permittivity of 10.8.