Assignment 2. Patch

Assigned: Tuesday, 14 November 2023
Due: Tuesday, 28 November 2023 at class start

Type: **individual**
Software: Matlab™ (suggested)

Rev#: 1

Please note that a Matlab function is provided for computing Grad

Problem no. 1

a) Design a rectangular patch antenna at the (resonance) frequency f_0 =5.8 GHz with $Z_{in}(f_0) = R_0 \le 120\Omega$ input impedance, i.e. find the necessary length *L,* width *W*. The substrate is an FR4 material, from Eurocircuits: ε_r = 3.8, *h* = 1.55mm; the width W should be "as small as possible" (within reason…)[1]. Use of the provided script for Grad is recommended.

b) To have an idea of the bandwidth of the antenna just designed, calculate the input impedance in the band ±10% around the center frequency f_0 ; use the TL model and consider a constant $G_{edge} = ½ G_{rad}(f_0)$ in the whole band:

b1) plot real and imaginary parts of $Z_{in}(f)$ on the same graph;

b2) calculate and plot the return loss with respect to $Z_0 = R_0 = 120\Omega$ (the input impedance at resonance) in the same band.
What is the absolute (MHz) and relative (± %) bandwidth for VSWR ≤ 2 ?

b3) In order to appreciate the difference from the approximation $L \approx 0.5\frac{\lambda_0}{\sqrt{\varepsilon_r}}$ and the value you found,

repeat b1) adding (on the same plot) the response for the same *W* but for $L = 0.5\frac{\lambda_0}{\sqrt{\varepsilon_r}}$

Note: for performing this task you need the formulas that give the characteristic impedance of a microstrip line (in addition to those for the effective epsilon, already used in the design).

c) Modify now the designed antenna to work with probe feeding, with recessed probe position so as to achieve 50 Ohm impedance at centerband. Find the position of the feed point, and make a precise drawing of your antenna (top view only).

Problem no. 2
Design a patch with probe feeding to have 50 Ohm input impedance at 5.8 GHz using *air* as a dielectric at height h=1/10 of the wavelength at centerband frequency.

[1] Note that edge impedance monotonously decreases with increasing W, so in practice you try to "hit" the bound (120 Ohm, here)

a) Design the patch as square; in general, one has to specify a tolerance δW , i.e. $L = W \pm \frac{1}{2}\delta W$; for the present purposes, you can take anything below $\delta W / W$ =5%.
b) Find the (approximate) position of the probe to get a 50 Ohm input.
c) Estimate the (max) gain (directivity) of this antenna (from the handouts graphs). Optional: if you want to get a better estimate, recall that the max directivity is obtained from the integral of the radiated power density, which gives also the radiation conductance or resistance (see Assignment n.1); as you have the value of Grad, you can then find the corresponding max gain.
d) Determine the E and H planes of the antenna, using the expression for the far field approximation in the handouts. (Please note that just listing what are the planes is not what requested; you must carry out all necessary calculations)

Materials:
Course handouts
Provided matlab function for Grad