ECE4122: Advanced Electromagnetics

Assignment S2 2018

Q1. Plan wave (marks 75)

An $\boldsymbol{x}$ Hz ground penetration radar obliquely incidents a randomly polarized UPW at the Brewster's angle from air ($z < 0$) onto the soil. Assume the soil is lossless, nonmagnetic material with $\varepsilon_r = 20$ ($z > 0$). The wave can be decomposed into equal TE and TM parts, each with an incident electric field amplitude of A (V/m).

Calculate (i) the Brewster's angle; (5 marks) (ii) the phase constants β_1 and β_2 in (rad/m) for air and soil, respectively, (5 marks) (iii) the intrinsic wave impedances η_1 and η_2 for air and soil, respectively, (5 marks) (iv) the angle of transmission, θ_t in (deg), (5 marks) (v) the TE polarised reflection coefficient, Γ_{TE}; (5 marks) (vi) the time domain expressions of TE polarised incident, reflected ad transmitted electric fields in (V/m), (15 marks) (vii) the reflection coefficient for TM polarised oblique incidence fields, (5 marks) (viii) the incident, reflected and transmitted electric fields for TM polarisation, (15 marks) and finally, (ix) find the time domain expressions of the incident, reflected and transmitted randomly polarized electric fields. (15 marks)

Rule: $\boldsymbol{x} = your\ student\ number\ in\ Hz$;

$A = 1^{st}\ two\ digits\ of\ your\ student\ number,$

$if\ 1^{st}\ digit\ is\ zero\ then\ A = 2^{nd}\ two\ digits\ of\ your\ student\ number$

Hints: Calculate the Brewster's angle first. Then calculated incident, reflected and transmitted electric fields for both TE and TM. Finally combine the respective fields to get resultant field expressions.

Q2. Terminated transmission line and impedance matching (marks 75)

A microstrip patch is to be design at 2.2 GHz for PCS (personal **communications** service) digital cellular system for better mobility than conventional mobilephones. The input impedance of the patch antenna is $Z_A = R_A + jX_A(\Omega)$ at 2.2 GHz. The antenna needs to be matched to a 50 Ω impedance T-Line.

(a) Calculate the complex reflection coefficient of the antenna (15 marks)

(b) Design an open circuit stub matching network to match the antenna with the T-line on FR4 board with $\varepsilon_r = 4.2$. Choose the solutions that minimise: (i) the length of the through line and (ii) the length of the open circuited stub

(i) Through line length in (mm) and Open circuit stub length (mm) (30 marks)

(ii) Through line length in (mm) and Open circuit stub length (mm) (30 marks)

Rule: $R_A = 1^{st}3 - digit\ of\ your\ student\ number \div 2\ (\Omega)$; *if first digit is zero, select next 3-digit of your student number* (Ω);

$X_A = 1^{st}3 - digit\ of\ your\ student\ number \div 1.5\ (\Omega)$; *if first digit is zero, select next 3-digit of your student number* $\div 1.5\ (\Omega)$;