ECE 713 - Spring Quarter 2006

Midterm Exam

April 28th, 2006

Write your name below and sign the honor pledge "No aid given, received, or observed" if it applies.

There are 3 problems on this exam. Exam is open book and notes.

Please box or underline your final answers, and remember to include units.

Be sure to show all work clearly if you wish to obtain any partial credit.

Try to keep your work within the provided space. Use the back of a previous sheet if necessary.

Name: ____

"The Pledge": No aid given, received, or observed.

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Problem 1 (3 parts, 30 points)

A plane wave $\underline{\overline{E}}^{inc} = (\hat{x} + \hat{y})e^{jk_1 z}$ (V/m) is normally incident from free space (region 1) onto a boundary with a medium having $\varepsilon = 9\varepsilon_0$, $\mu = \mu_0$, and $\sigma = 0.2$ S/m (region 2). The plane wave oscillates at a frequency of 5 GHz, and the boundary between regions 1 and 2 is the x-y plane (i.e. $z = 0$).

(a) Find k_1 and classify the polarization of this wave. Possible answers for the polarization are linear, circular, or elliptical; DO NOT specify the handedness if your choice is circular. (10 points)

(b) Write the transmitted electric field, including a numerical value for the transmission coefficient. (10 points)

(c) How many meters can the transmitted wave propagate into region 2 before its power density is reduced 10 dB from its power density at the interface ($z = 0$)? (10 points)

Problem 2 (3 parts, 40 points)

A communications system operates over a horizontal path at 30 GHz. The system uses vertical polarization, has a transmit antenna of gain 20 dBi, and the receiver 10 km away has a receive antenna of gain 6 dBi with a receiver noise figure of 6 dB. Assume the system is polarization and impedance matched. The system requires a signal-to-noise ratio of 20 (note not in dB) at the receiver in order to function properly. The system operates in a 290K external noise environment and has a bandwidth of 2 MHz. Neglect any Earth curvature or effects of the ground in your analysis.

(a) Estimate the attenuation on this path due to atmospheric gases. Note because a horizontal path is used, total attenuation should be estimated in terms of the number of dB/km times the number of km (i.e. not the total atmosphere result in Figure 5.4). (10 points)

(b) Find the transmitter power required under normal conditions (i.e. including atmospheric gas attenuation but neglecting rain attenuation) to ensure successful operation of the system. (15 points)

(c) Assuming a uniform rain rate over the entire path (i.e. total attenuation again dB/km times number of km) and using the Crane global rain rate distribution for locations near Columbus, OH, how much power should be transmitted to limit the failure of the system due to rain attenuation to 1.75 hours per year? (15 points)

Problem 3 (4 parts, 30 points)

It is known that the index of refraction at the Earth's surface is 3000 N-units, and that the appropriate effective Earth radius multiplier to describe the atmospheric state is 1.5.

(a) Find the true atmospheric index of refraction (not in N-units) at an altitude of 1 km. (10 points)

(b) Classify these conditions as sub-refractive, normal, super-refractive, or a trapping gradient. (5 points)

(c) Using the straight ray, effective Earth radius model, will the angle a ray makes with the local horizontal be increasing, constant, or decreasing as the ray propagates to higher altitudes? (5 points)

(d) Find $\frac{dM}{dh}$ in M-units/km for this atmosphere (10 points).