EE5801 Tutorial 1

Q1

A team of scientists is designing a radar as a probe for measuring the depth of the ice layer over the Antarctic land mass. In order to measure a detectable echo due to the reflection by the ice-rock boundary, the thickness of the ice sheet should not exceed three skin depths. If $\varepsilon'_r = 3$, $\varepsilon''_r = 10^{-2}$ and $\mu_r = 1$ for ice and if the maximum anticipated ice thickness in the area under exploration is 1.2km, what frequency range is useable with the radar?

Q2

A 1-MHz plane wave propagates in a conductive medium characterized by a permittivity $\varepsilon' = 8\varepsilon_o$, a permeability $\mu = \mu_o$, and a conductivity $\sigma = 4.8 \times 10^{-2}$ S/m. Determine:

    i)   He ratio between the magnitudes of the conduction and displacement current densities.

    ii)   The skin depth.

Q3

A uniform plane wave propagates in seawater. The constitutive parameters of seawater are $\varepsilon_r = 72$, $\mu_r = 1$ and $\sigma = 4$ S/m. The frequency of the wave is at 5×10^6 Hz.

    i)   Calculate the attenuation constant, intrinsic impedance, phase velocity, wavelength and skin depth.

    ii)   Let the wave propagates in the +z direction and the average power density at z = 0 is equal to 1 W/m². Find the location (i.e., the value of z) at which the average power density is at 10^{-4} W/m².

Q4

A 100 MHz uniform plane wave propagates in a medium with the following constitutive parameters: $\varepsilon_r = $ 100, $\mu_r = 1$ and $\sigma = 0.4$ S/m and incident on a second medium of constitutive parameters: $\varepsilon_r = 2$, $\mu_r = 1$ and $\sigma = 100$ S/m.

    i)   If the incident electric field strength at the boundary is 1 V/m, what is the magnitude of the incident magnetic field strength at the boundary?

    ii)   What would be the reflected electric field and magnetic field strengths at the boundary? What would be the transmitted electric field and magnetic field strengths at the boundary?

    iii)   In (ii) above, what are the incident, reflected and transmitted power densities at the boundary respectively?