

ORDRE DES INGÉNIEURS DU QUÉBEC

MAY 2018 SESSION

Open-book examination
Calculators : only authorized models
Duration : 3 hours

14-PH-A3 Electromagnetics - Propagation

1) A perfectly conducting metal wire containing a small $100\ \Omega$ resistor is formed into a square with 1m sides. The loop is located in the x-y plane and surrounded by a magnetic field density given by (12 pts):

$$\vec{B} = 0.3\cos(120\pi t)\hat{z}\ T$$

- Calculate the value of the current in the wire.
- Determine the direction of the current in the x-y plane at $t = 0^+$ (clockwise or anti-clockwise).

2) A nonmagnetic material has the following properties:

- Relative permittivity = 3.2**
- Conductivity = $1.5 \times 10^{-4}\ \text{S/m}$**

Calculate the following values at 3 MHz. (25 pts)

- Loss tangent
- Attenuation constant
- Phase constant
- Impedance
- Propagation velocity

3) A 10m long coaxial cable is terminated by a charge composed of a 1 nH inductance in series with a $10\ \Omega$ resistance. The cable is lossless and has an inductance per length of $L' = 240\ \text{nH/m}$ and a capacity per length of $C' = 110\ \text{pF/m}$. The cable is used at 1 GHz. (25 pts)

- Calculate the impedance of the cable.
- Calculate the propagation constant of the cable.
- Calculate the reflection coefficient at the end of the cable (at the charge).
- Calculate the impedance at the input of the coaxial cable.
- Calculate the standing wave ratio in the cable.

4) A perpendicular polarized wave travelling in free space is incident on a lossless material having a relative permittivity $\epsilon_r = 6$. The angle of incidence is 20° . (25 pts)

- a) Calculate the angle of the reflected wave
- b) Calculate the angle of the transmitted wave.
- c) Calculate the reflection coefficient.
- d) Calculate the transmission coefficient.
- e) Calculate the value of the transmitted power if the incident power is 10W.

5) The minimal signal power that a specific wireless Wi-Fi router working at 2.4 GHz can detect is 3×10^{-10} W. The typical output power of a Wi-Fi device is 0.1 W. (13 pts)

- a) Calculate the maximum range between a device and the router you can achieve assuming 0 dBi gain antenna on both sides.
- b) What is the required antenna gain on the router if you want to double that range (the antenna gain on the device stays at 0 dBi).