UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3. Examination in Engineering: July 2017

Module Number: EE3302

Module Name: Engineering Electromagnetism

[Three Hours]

[Answer **all questions**, each question carries ten marks]

(Permittivity of free space $\xi_0 = 10^{-9}/(36\pi)$ F/m and Permeability of free space $\mu_0 = 4\pi\times10^{-7}$ H/m)

Q1. Calculate the following of the signal in air $(z \geq 0)$ with the electric field component

$$\overline{E} = 10\sin(\omega t + 3z)\overline{a}_x \; V/m$$

a) Angular velocity ω. [2 Marks]

b) The wave length of the signal in air. [2 Marks]

c) The loss tangent and intrinsic impedance of the ocean. [3 Marks]

d) The reflection and transmitted $\overline{E}$ field. [3 Marks]

Q2. a) What is electromagnetic compatibility? [2 Marks]

b) What is electromagnetic interference? [2 Marks]

c) Discuss that what are the critical factors to be considered during the maintenance procedures and expansion stage of a systems. [2 Marks]

d) With the rapid rollout of the telecommunication networks in the recent past the Telecommunications Regulatory Commission of Sri Lanka (TRCSL) has realized the necessity to address health, safety, economic, environmental and other impacts due to antenna structures and installations of these networks.
The Telecommunications Regulatory Commission of Sri Lanka was established under the Sri Lanka Telecommunications (Amendment) Act No. 27 of 1996, to be the National Regulatory Agency for

Telecommunications in Sri Lanka. TRCSL, while promoting the sustained development in the telecommunication industry by shaping the regulatory process, will protect the public interests and be responsive to challenges in an increasingly competitive market. TRCSL will ensure that competition in the market is open, fair and effective.

Table no Q2 describe recommendations to prevent harmful effect in human beings exposed to electromagnetic field in the frequency range from 3 kHz to 300 GHz.

i) Explain that why do we need such regulation commission in our country?

[2 Marks]

ii) Write a short note by referring the table no Q2.regarding the reference levels for general exposure to time-varying electric and magnetic fields.

[2 Marks]

Q3. a) What do you meant by directive gain? [2 Marks]

b) What do you meant by effective area of the antenna? [2 Marks]

c) An antenna located at the origin has a far-zone electric field,

$$\bar{E}_s = \frac{\cos 2\theta}{r} e^{-j\beta r} \bar{u}_\theta \; V/m$$

i) Obtain the corresponding $\bar{H}_s$ field. [2 Marks]

ii) Determined the power radiated. [2 Marks]

iii) What is the fraction of the total power is radiated in the belt $60^0 < \theta < 120^0$? [2 Marks]

Q4. a) i) States the Biot-Sarvart's law. [2 Marks]

ii) Define the term, "Magnetic Field Intensity. [2 Marks]

iii) A disk of radius r_0 is charged with a uniform surface charge density $\rho_s C/m^2$. The disk is rotated at constant speed of N revolution per minute. Thus, we have circular loops of electric charges in motion that may be considered as loops of current. Using Biot-Sarvat's law, Determine the magnetic flux density at the center of the disk.

[2 Marks]

b) A toroid has a core of square cross section with 2500 mm^2 area while the mean diameter of the toroid is 250 mm. The core material has the relative permeability of 1000. Calculate the number of turns to be wound on the core to obtain an inductor.

[4 Marks]

Q5. Answer all MCQ given below and each question carries 1 mark.

a) What is the unit of magnetic charge
   i) Ampere-meter squired
   ii) Ampere
   iii) Coulomb
   iv) Ampere-meter

b) By saying that the electrostatic field is conservative, we do not meant that
   i) It is the gradient of a scalar potential.
   ii) Its curl is identically zero.
   iii) the work done in a closed path inside the field is zero.
   iv) potential difference between any two point is zero.

c) Stokes theorem relates the line integration to surface integration as
   i) $\oint_s \nabla . F . ds = \oint_c F . dl$
   ii) $\oint_s (\nabla . F) \times ds = \oint_c F \times dl$
   iii) $\oint_s (\nabla . F) \times d\bar{s} = \oint_c F . dl$
   iv) $\oint_s (\nabla . F) . ds = \oint_c F \times dl$

d) If $\nabla \bar{D} = \varepsilon \nabla . \bar{E}$ and $\nabla . \bar{J} = \sigma \nabla . \bar{E}$ in a given material, the material is said to be

   i) Isotropic
   ii) Linear and isotropic
   iii) Isotropic and homogeneous
   iv) Linear and homogeneous

e) Which of following is a mathematically incorrect expression?
   i) grad div
   ii) div curl
   iii) grad curl
   iv) curl grad

f) The thin parallel wires carry current along the same direction. The force experienced by one due to the other is
   i) Parallel to the line
   ii) Perpendicular to the lines and attractive
   iii) Perpendicular to the lines and repulsive
   iv) Zero

g) Which of these materials requires the least value of magnetic field strength to magnetized it?
   i) Nickel
   ii) Silver
   iii) Tungsten
   iv) Sodium chloride

h) If $\bar{E}_s = 10\, e^{j4x}$, which of these is not a correct representation of $\bar{E}$?
   i) $\mathrm{Re}(\bar{E}_s e^{j\omega t})$
   ii) $\mathrm{Re}(\bar{E}_s e^{-j\omega t})$
   iii) $\mathrm{Im}(\bar{E}_s e^{j\omega t})$
   iv) $10\cos(\omega t + j4x)\,\bar{a}_y$

i) The concept of displacement current was a major contribution attributed to
   i) Faraday
   ii) Lenz
   iii) Maxwell
   iv) Lorentz

j) Which one of these equations is not Maxwell's equation for a static electromagnetic field in a linear homogeneous medium?
   i) $\nabla . \bar{B} = 0$
   ii) $\int \bar{D} . d\bar{S} = Q$
   iii) $\nabla \times \bar{D} = 0$
   iv) $\nabla^2 \bar{A} = \mu_0 \bar{J}$

Table no Q2.:IEEE C95.1-1991 Reference levels for general exposure to time-varying electric and magnetic fields

Frequency range	E-field strength (Vm^{-1})	H-field strength (Am^{-1})	B-field (μT)	Equivalent plane wave power density s_{eq} ($W\ m^{-2}$)
Up to 1 Hz	-	3.2×10^4	4×10^4	
1-8 Hz	10,000	$3.2 \times 10^4/f^2$	$4 \times 10^4/f^2$	
8-25 Hz	10,000	4,000/f	5,000/f	
0.025-0.8KHz	250/f	4/f	5/f	
0.8-3KHz	250/f	5	6.25	
3-150 KHz	87	5	6.25	
0.15-1 MHz	87	0.73/f	0.92/f	
1-10 MHz	$87/f^{1/2}$	0.73/f	0.92/f	
10-400MHz	28	0.073	0.092	2
400-2,000MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	$0.0046/f^{1/2}$	f/200
2-300GHz	61	0.16	0.20	10