NATIONAL EXAMS, MAY 2016

07-ELEC-B9, ELECTROMAGNETIC FIELD,

TRANSMISSION LINES, ANTENNAS, AND RADIATION

3 HOURS DURATION

**NOTES** :

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is a closed book examination. Any non-communicating calculator is permitted.

3. FIVE (5) questions constitute a complete exam paper. The first five questions as they appear in the answer book will be marked.

4. Each question is of equal value.

1. Express Maxwell's equations in free space, in cartesian coordinates for the case of only one spatial variable and comment on the results obtained.

   Aid: curl $(X, Y, Z) = \left(\frac{\delta Z}{\delta y} - \frac{\delta Y}{\delta z}\ ,\ \frac{\delta X}{\delta z} - \frac{\delta Z}{\delta x}\ ,\ \frac{\delta Y}{\delta x} - \frac{\delta X}{\delta y}\right)$ .

2. The EMF of a generator of 377 ohm internal resistance is a one microsecond pulse of 100 kW power. The generator drives an infinitely long transmission line of 377 ohm characteristic impedance and $3\times10^{8}$ m/s propagation velocity. A 754 ohm resistance is connected across the line 10 km from the generator terminals. Another 754 ohm resistance is connected across the line 450 m further down the line.

   Plot the generator terminal voltage in the time interval 0 to 120 μs, with zero the time of launching the pulse on the line.

3. A 500 MHz generator of 50 ohm internal resistance and unknown EMF drives a load of unknown impedance through a 25 cm long section of transmission line of 50 ohm characteristic impedance and $2\times10^{8}$ m/s propagation velocity. Power delivered to the load is 10 W. Standing wave ratio on the line is 2 and voltage minimum occurs 15 cm from load terminals.

   Determine load impedance and generator EMF.

   Suggested aid : use Smith chart.

4. Inside dimensions of an air-filled waveguide are 2.25 cm×1 cm. Calculate the maximum 10 GHz power that can propagate in the waveguide with no reflections if the maximum allowed field in the waveguide is $10^{6}$ V/m peak.

5. A north-south 30 MHz array consists of three vertical current elements 20 m apart. The three currents are in phase.

   What is the width between nulls of the main beam pointing east?

6. An antenna receiving simultaneously 300 MHz and 200 MHz signals drives a 50 ohm load through a transmission line of 50 ohm characteristic impedance and $3\times10^8$ m/s propagation velocity. Two short-circuited sections of line identical to the driving line are connected in parallel to the load.

   What are the lengths of the sections if the 300 MHz signal is prevented from reaching the load while the 200 MHz signal is allowed to reach the load unobstructed?

7. A radar antenna of square aperture of 1 m side illuminated uniformly (amplitude, phase, polarization). The transmitter power is 1 MW. The signal in the main beam propagates horizontally and is normally reflected by a vertical square flat target of 10 m side at 10 km distance. The wavelength is 3 cm.

   Calculate reflected power intercepted by the radar antenna. Use following simplifying assumptions in your calculations: total transmitter power is confined to main beam (i.e. neglect power in side lobes) and is uniformly distributed therein.

8. A 10 MHz generator delivers 10 W power to a 1 m long vertical current element radiating into free space. At a point on a 10 km sphere surrounding the element power density is $9\times10^{-9}$ W/m$^2$.

   (i) What is the elevation angle of the point?

   (ii) What would be the power density at the point if the generator frequency was reduced to 5 MHz?

   Aid: On a sphere surrounding the radiating current element the ratio of maximum power density to average power densities is 1.5.

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## IMPEDANCE OR ADMITTANCE COORDINATES