May 2013

National Exams May 2012

07-Elec-B9, Electromagnetic Field, Transmission Lines, Antenna,

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 exam. A Casio or Sharp approved 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.

5. Aids: $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m, $\mu_0 = 4\pi \times 10^{-7}$ H/m

1. A 50 ohm, 3×10^8 m/s transmission line drives a load consisting of parallel combination of a 20cm long open-circuited, a 20cm long short-circuited sections of the line and a 50 ohm resistor.

    What are three lowest frequencies such that:

    (i)   for two of these the driving line will be short-circuited and,
    (ii)   for the third one the line will be terminated in 50 ohm resistance?

2. A single frequency signal propagates along a transmission line of characteristic impedance Z_o. terminated in impedance $Z=Z_o.(0.5+j2.0)$.

    How far away (in terms of signal wavelength) from the termination will the real part of input admittance be equal to characteristic admittance $Y_o=^1/z_0$?

3. Internal impedance of a generator is 377 ohms, its EMF is a 1μs long pulse of 10GH signal of 1KWs total energy. The generator drives an infinitely long transmission line of 377 ohm characteristic impedance and 3×10^8 m/s propogation velocity. Two 377 ohm resistors 300m apart are connected across the line approximately 10 km away from the generator.

    What are:

    (i)   energy contents of first two return pulses arriving at the generator terminals and,
    (ii)   time interval between their arrivals?

4. Inside dimensions of a rectangular waveguide cavity are 1 cm x 2 cm x 3 cm.

    List all resonant frequencies below 20 GHz which the cavity can support.

5. A north-south horizontal array of five identical, vertical current elements separated by 40 cm radiates a 1GHz signal. Current amplitudes of the elements are same. Phase of the current of each element lags that of its northern neighbour by120^0.

    What is the direction of main beam of the array?

6. A vertical current element 50cm long located on a conducting horizontal ground plane radiates a 10MHz signal. 1km away on the ground plane the electric field intensity is 100 µV/m RMS. The current element is moved vertically up 1km and its frequency is changed to 15 MH, its length reduced to 25 cm and its total power radiated doubled.

   What is the RMS electric field intensity at the original point of observation?

   Aid: radiation resistance = $(2\pi/3)Z_0(l/\lambda)^2$.

7. A 1m diameter aperture of a paraboloidal antenna of a 10GH, 1MW radar transmitter is uniformely illuminated by its feed. The transmitter illuminates at normal incidence a 1m diameter flat metallic circular plate 10km away.

   (i)   What is the level of reflected power received by the transmitted antenna?
   (ii)   State whether approximations employed by you provide smaller or larger estimate of received power.

   Aid: θ_o= 1.2λ/d for circular appenture.

8. A plane wave of vacuum wavelength 0.6µm propagating in a medium of relative permittivity 2.25 (i.e. index of refraction 1.5) is incident at an 60° angle of incidence on a plane interface of the medium and vacuum. Electric field of the wave is polarized parallel to the interface.

   What is the relative phase of the incident and reflected waves at the interface?

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