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RF and Antenna Engineering (CT 425)

1st In-Semester Examination

Closed Books and Closed Notes Examination

Date: 14 September 2022 **Time: 8:30am to 10:30 am**

Answer all questions.

1. (a) What RF stands for? Define RF in terms of type of waves and frequency range. (3 marks)

   (b) Why uniform plane wave is called transverse electromagnetic (TEM) wave? Define Poynting vector in terms and electric field intensity (E) and magnetic field intensity (H). What is represented by magnitude and direction of Poynting vector? (3 marks)

   (c) An electromagnetic wave of frequency 300 MHz travels in the +z direction in an infinite, lossless medium having ε_R (relative permittivity) = 9 and μ_R (relative permeability) =1. The value of electric field is 100 volts/meter. Calculate phase constant (β), intrinsic impedance (η) and average power density (p_z). (4 marks)

   (d) Define polarization of an electromagnetic wave. Define and explain (by using equations and figures) linear polarizations (horizontal and vertical) and circular polarizations (left-hand and right-hand) of electromagnetic waves. Use IEEE notations to explain clockwise or counterclockwise rotation of the circular polarizations. (8 mark)

   (e) What is the frequency ranges of UHF and SHF bands? (2 marks)

2. (a) What is guiding surface waves in ground wave propagation? What is the highest frequency for ground wave propagation? (3 mark)

(b) What is the frequency range of sky wave propagation? State the layer of ionosphere which gives day time as well night time coverage. (4 marks)

(c) For radio wave propagation, derive the fundamental equation for free-space transmission (Friis equation) relating transmitted power (P_T), received power (P_R), transmitting antenna gain (G_T), receiving antenna gain (G_R), distance (d) and wavelength (λ). (6 marks)

(d) Why radio horizon is greater than optical horizon in line-of-sight (space) radio propagation system? (3 marks)

(e) In a satellite communication system, free-space conditions are assumed. The satellite is at a height of 36000 km and the frequency used is 6000 MHz. Calculate free-space transmission loss. (4 marks)

3. (a) State relationships of Z, Y, h and ABCD parameters in terms on V_1, V_2, I_1 and I_2 for two-port networks. At RF frequencies, why Z, Y, h and ABCD parameters are difficult to measure? (8 marks)

(b) State relationship between scattered wave amplitudes (b_1 and b_2) and incident wave amplitudes (a_1 and a_2) in a two-port RF network. Define all 4 S-parameters in terms of scattered and incident amplitudes with termination conditions at input and output. (8 marks)

(c) For dissipationless networks of 3-port network, what conditions must be satisfied? (4 marks)

4. (a) In a transmission line, what is the relationship between SWR and magnitude of reflection coefficient ($|\Gamma|$)? (4 marks)

(b) Define SWR in terms of voltage maximum (V_{max}) and voltage minimum (V_{min}) of standing wave pattern in a transmission line. (3 marks)

(c) What are the advantages of using Smith chart as compared to calculations in transmission line theory? (4 marks)

(d) For transmission line parameters (R', L', G' and C'), assume ω is the radian frequency. State condition for low-loss lines in terms of transmission line parameters and ω. (2 marks)

(e) In Smith chart, there are two scales wavelength towards generator (wtg) and wavelength towards load (wtl). These scales show distances on transmission line in terms of wavelengths. Why these scales are from 0 to 0.5 wavelength?

(3 marks)

(f) In Smith chart, draw sketches of polar chart of reflection constant values in terms of normalized impedances, constant resistance circles and constant reactance lines in Smith chart.

(3 marks)

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RF and Antenna Engineering (CT 425)

2nd In-Semester Examination

Closed Books and Closed Notes Examination

Date: 20 October 2022 **Time: 8:30 to 10:30 am**

Answer all questions.

1. (a) Define noise factor (F) in terms of the signal-to-noise ratio at the input and signal-to-noise ratio at the output of an amplifier. If the gain of the amplifier is G and the bandwidth is B_n and the noise factor is F, what is the available output noise power? What is the relationship between noise factor F and noise figure of an amplifier? Where k is Boltzmann's constant. (5 marks)

   (b) For amplifiers in cascade, G_i and Fi are gain and noise factor of i_{th} amplifier, respectively. Define Friis's formula for overall noise factor F. Where i vary from 1 to n. To maintain the overall noise figure as low as possible, what are the requirements regarding F_1 and G_1? (5 marks)

   (c) A mixer stage has a noise figure of 20 dB, and this is preceded by an amplifier that has a noise figure of 9 dB and an available power gain of 15 dB. Calculate the overall noise figure referred to input. (4 marks)

   (d) What is the relationship between noise factor F and equivalent input noise temperature T_e of an amplifier? (3 marks)

   (e) For a lossy network, what is the relationship between F and L? Where L is the loss factor. (3 marks)

2. (a) What are the two types of impedance matching in transmission line theory? Z_G and Z_L are complex impedances of source and load. For conjucate matching, what is relationship between Z_G and Z_L? (4 mark)

$20 \times \frac{9(19)}{15}$

$F_1 = 20$
F

(b) For a transmission line of characteristic impedance (Z_o) and length l, Z_G as well as Z_L are not equal to Z_o. To get matched transmission line system, draw a suitable figure to show locations of matching networks. (5 marks)

(c) For matching of load of a transmission line with a quarter-wave transformer, what are the two parameters which are calculated by the Smith chart? (4 marks)

(d) For matching of load of a transmission line with a short-circuited stub, what are the two parameters which are calculated by the Smith chart? (4 marks)

(e) In solving matching problems using Smith chart, it may be required to find load admittance from load impedance. If load impedance is plotted on Smith chart used as impedance chart, give steps to find load admittance on the Smith chart? λ is the wavelength. (3 marks)

3. (a) Briefly describe all types of antennas with the aid of figures. (10 marks)

(b) Define radiation pattern, directive gain (dBi), directive gain (dBd), HPBW, FNBW, bandwidth and polarization of an antenna. (10 marks)

4. (a) Define 3 field regions of an antenna with the aid of a figure. If D is the largest dimension of an antenna, what are R_1 and R_2 which are boundaries of different regions. λ is the wavelength. (8 marks)

(b) Define omnidirectional antenna, isotropic antenna, directive antenna, E-plane pattern of antenna and H-plane pattern of an antenna. (7 marks)

(c) In radiation pattern of an antenna, define radiation lobe, major lobe, minor lobe, side lobe and back lobe (5 marks)

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RF and Antenna Engineering (CT 425)

End-Semester Examination

Closed Books and Closed Notes Examination

Date: 8 December 2022 **Time: 2 to 4 pm**

Answer all questions.

1. (a) Antenna field regions are divided into reactive near-field, radiation near-field and far-field. Electric and magnetic fields are functions which vary as electrostatic field component (varies as $1/r^3$), inductive field component (varies as $1/r^2$) and radiation field component (varies as $1/r$). What are ranges of kr in these regions? Where k is a wave number and r is the distance from center of the antenna. From observation of field components in the antenna regions of infinitesimal dipole, state components dominating three antenna regions. (6 marks)

   (b) As length varies from infinitesimal to one wavelength, what is the range of 3-dB beamwidths of wire dipoles having sinusoidal current distribution? (3 marks)

   (c) What are resonant and nonresonant wire antennas? What is the difference between resonant and nonresonant wire antennas regarding radiation patterns? What are dBi gains of infinitesimal antenna (Hertzian Dipole), half-wave dipole (length = $\lambda/2$) and eight-wave dipole (length = 8λ)? (8 marks)

   (d) What are assumed current distributions and radiation patterns of infinitesimal, half-wave dipole and eight-wave dipole? (3 marks)

2. (a) Explain Yagi-Uda array with the aid of a figure? What are advantages of this antenna in receiving VHF broadcast television? (7 mark)

   (b) Calculate gain (dBi) and gain (dBd) at 6 GHz for parabolic reflector antenna of diameter 2 meters. Also, calculate half-power beamwidth. (6 marks)

(c) What are five variables for control of radiation pattern of array antenna of identical elements? (5 marks)

(d) Define array factor of an array antenna with identical elements. (2 marks)

3. (a) Define directivity and maximum directivity of an antenna. Radiation intensity is U watts per unit solid angle. U_{max} and U_o are maximum radiation intensity and radiation intensity due to isotropic source. (6 marks)

(b) Define overall efficiency of antenna in terms of reflection, conduction and dielectric efficiencies. Also, define reflection, conduction and dielectric efficiencies (7 marks)

(c) Briefly describe three basic propagation mechanisms for propagation of space waves. What is their relation to wavelength? (7 marks)

4. (a) *Describe block diagram for measurement of radiation pattern of antenna with the aid of figure.* (7 marks)

(b) For measurement of absolute gain of an antenna using two-antenna method, two identical antennas are separated by distance R. Describe procedure to measure gain using Friis transmission formula with aid of equations. (7 marks)

(c) In the two-antenna method, calculate the gain of a horn antenna at 10 GHz. If the separation between two identical antennas is 60 cm and the ratio of power received to power transmitted (P_r / P_t) is -15 dB. (6 marks)

$2 \times \pi \times (\frac{6}{3})^2 \times 100$

400π

λ

$\frac{0.0083}{4 \times \pi \times 0.6}$

2