



UNIVERSITY OF SURREY©

Department of Electronic Engineering

MSc EXAMINATION

EEM.Ant

Antennas and Propagation

Duration: 2 Hours

Spring 2002/03

READ THESE INSTRUCTIONS

Answer **FOUR** questions from six.

USE A SEPARATE ANSWER BOOK FOR EACH SECTION

On the front sheet of EACH answer book, complete the list of questions attempted **in that book** in the order they appear. Then draw a line below this list and add the question numbers you have attempted in the *other* answer book.

SECTION A

A1 (a) Define, and write notes on, the following antenna properties.

- (i) Radiation pattern
- (ii) Boresight
- (iii) Sidelobe
- (iv) Inverse square law
- (v) Polarisation
- (vi) Radiation resistance
- (vii) Directivity
- (viii) Efficiency

[30%]

(b) Sketch the azimuth and elevation patterns for a vertically polarised half-wave dipole. State the gain (in dBi) of such an ideal half wave dipole in the azimuth plane. **[15%]**

(c) Sketch the azimuth pattern for two such dipoles, spaced a quarter wavelength apart and fed with equal amplitudes but in phase quadrature. Carefully identify the boresight direction with respect to the relative phase of the drive signals. What should the front-to-back ratio of such an arrangement be (numerical estimate as a ratio) **[25%]**

(d) A short monopole is erected above a perfectly conducting ground plane. State, giving reasons, how the radiation resistance varies with the length of the monopole. Sketch the elevation radiation pattern, illustrating where the null lies. Describe the polarisation direction at a radiation angle 45 degrees to the length of the monopole. **[30%]**

- A2** (a) Write down a formula which relates the gain of a reflector antenna to its effective area for radiation capture. **[10%]**
- (b) Two antennas operate at 8GHz and point towards each other at a range of 100 km in free space. There are no scattering objects. If they have perfect feeds and parabolic reflector dishes of diameter 3 metres, estimate the transmitter power needed to establish a link with 20dB signal to noise ratio in a bandwidth of 100 MHz. **[30%]**
- (c) Critically discuss the antenna engineering factors which can lead to more signal power needed, and estimate for each of your factors the percentage increase in power needed. Ignore loss due to propagation effects. **[30%]**
- (d) If the receive antenna were to be replaced by a half-wave dipole, estimate the increase in transmitter power that would be needed. **[15%]**
- (e) Explain how circular polarisation may be generated and detected on such a link. **[15%]**

A3 The pattern and input impedance of an antenna above a Perfectly Electrically Conducting (PEC) ground is modified by ground reflections.

- (a) For (a) a vertical dipole and (b) a horizontal dipole, sketch the antenna and its image showing their relative positions and the phase relationship of the voltages and charges on each. **[20%]**
- (b) Sketch the vertical pattern of a half-wave ($\lambda/2$) vertical dipole, with its centre $\lambda/2$ above ground. Give an approximate expression for the pattern. **[15%]**
- (c) Sketch (a) the E plane pattern and (b) the H plane pattern of a horizontal $\lambda/2$ dipole at a height of $\lambda/4$ above ground. Give approximate expressions for the patterns. **[20%]**
- (d) A horizontal dipole (very) close to ground is found to have an input impedance of 25 ohms at resonance. Explain how this antenna may be matched to a 50 ohm transmission line using a single capacitor. Determine the value of the capacitor by graphical means or by calculation. **[30%]**
- (e) Assuming the dipole approximates a (lossy) 400 ohm transmission line, estimate any change in length of the dipole required. **[15%]**

SECTION B

- B4** (a) Explain how the ionosphere may be used for long distance HF radio communication to the opposite side of the world. **[25%]**
- (b) Sketch three types of long distance ionospheric path:
- (i) Conventional multi-hop
 - (ii) Chordal hop
 - (iii) Multi-layer hop **[25%]**
- (c) State where the critical frequencies should be measured to find the MUF (Maximum Usable Frequency) for a long ionospheric path. Give reasons for your choices. **[20%]**
- (d) State the secant law that relates critical frequency f_c to MUF, f_h and define the meaning of the angle ϕ . **[15%]**
- (e) State or derive the formula that relates 'virtual height' 'h' of an ionospheric layer to maximum hop length, $2D$. **[15%]**

- B5** (a) Describe and compare FDMA/FDD, TDMA/FDD and CDMA. [25%]
- (b) How can we classify a material as a conductor or a dielectric? Explain why it is crucial to have an understanding of the variation of constitutive parameters with frequency and material type. [20%]
- (c) Explain how you would expect transmission loss to vary in a single layer, low loss dielectric, with increasing frequency or material thickness? [35%]
- (d) When does scattering occur? How can we account for the reduction in amplitude of the specular component? [20%]
- B6** (a) Compare empirical and deterministic models. [20%]
- (b) Explain the concept of Fresnel zone. [15%]
- (c) Briefly describe the different cell types used in Mobile communications. [15%]
- (d) Discuss what would be the effect if we vary the antenna height in microcells. [15%]
- (e) Describe the propagation mechanisms involved, in the case of radio wave propagation between floors. [15%]
- (f) Describe the different radio wave propagation effects and attenuation mechanisms in satellite links. [20%]

Examiners: D.Jefferies
M.Underhill
S.Stavrou

External Examiner: J.Gardiner