



UNIVERSITY OF SURREY

School of Electronics and Physical Sciences

ELECTRONIC ENGINEERING PROGRAMMES

For BEng, MEng, MRes and MSc Degrees

Level M Modular Examination

Module EEM.ant

ANTENNAS AND PROPAGATION

Duration: 2 hours

Spring 2005

READ THESE INSTRUCTIONS

Answer **ONE** question from **EACH** section.

If you attempt more than **THREE** questions, only your best **THREE** answers will be taken into account.

Boltzman's Constant $K = 1.38 \times 10^{-23}$ MKSU

SECTION A

- A1** (a) Write definitions of, and notes on, the terms:
- Gain of a receive antenna
 - Radiation resistance
 - Polarisation
 - Poynting vector
 - Half-power beamwidth **[25%]**
- (b) State the typical radiation resistance of the following antennas:
- (i) Half wave dipole
 - (ii) $1/20$ wavelength dipole
 - (iii) Half wave folded dipole
 - (iv) Full wave loop antenna
- Explain why the radiation resistance of the folded dipole and loop antennas differs from that of the half wave dipole. **[20%]**
- (c) An omnidirectional circularly polarised antenna is to be constructed from the combination of a short dipole and a small loop antenna. For this combination,
- (i) sketch the geometry you might use
 - (ii) suggest a suitable feed arrangement
 - (iii) draw the elevation and azimuth radiation patterns **[20%]**
- (d) Suggest a method of making an approximation to an isotropic antenna, using two polarisation states. Explain why a linearly-polarised antenna cannot be isotropic. **[20%]**
- (e) Estimate the electric field strength, on boresight, at a range of 10km from an antenna having gain 8dBi and having an accepted input power of 1 watt. **[15%]**

- A2**
- (a) Write down the formula relating the gain of an aperture antenna to its effective area for the capture of radiation, and to the wavelength of the radiation. **[15%]**
- (b) Estimate the diameter of a dish designed for a 30dBi gain antenna at a frequency of 6GHz. Suggest a tolerance limit for the dish profile accuracy. **[20%]**
- (c) Illustrate with a diagram the following methods of constructing a dual-reflector dish antenna
- (i) Axially-fed Cassegrain
 - (ii) Offset fed Cassegrain
 - (iii) Gregorian
- Give two advantages and disadvantages of each design. **[30%]**
- (d) A certain earth-to-satellite communications link at 6GHz is specified to work at a maximum range of 80,000 km with a bandwidth of 30MHz. The ground station dish has an effective diameter of 2m and the satellite antenna is a 2dBi gain omnidirectional monopole.
- Suggest a suitable rating for the HPA (high power amplifier) on this dish. **[35%]**

SECTION B

- B3** (a) For a transmitting antenna define:
- (i) Directivity
 - (ii) Gain
 - (iii) 3dB beam-widths in the E-plane and the H-plane
 - (iv) Efficiency **[40%]**
- (b) Give expressions for the following two parameters in terms of the other parameters in the above list
- (i) Gain
 - (ii) Directivity **[20%]**
- (c) Sketch the patterns of the following wire antennas, and wherever possible estimate the beam-width given that the first of these has a beam-width of 90 degrees:
- (i) A short centre-fed dipole with a directivity of 1.5
 - (ii) A half-wave centre-fed dipole with a directivity of 1.64
 - (iii) A full-wave centre-fed dipole with a directivity of 2.41
 - (iv) A $5/4$ -wavelength centre-fed dipole with a directivity of 3.28
 - (v) A two-wavelength centre-fed dipole **[40%]**
- B4** (a) Describe the main characteristics of those layers of the ionosphere that can affect radio propagation. Explain how the layers are formed and in general terms how they may vary with time. **[40%]**
- (b) Describe the various types of fading that may occur on HF radio signals. **[30%]**
- (c) For an ionospheric layer at a height of 400 km and with a critical frequency of 6MHz estimate the 'skip distance' for a transmission frequency of 12 MHz.. The radius of the earth is $20,000/\pi$ km. **[30%]**

SECTION C

- C5** (a) Define briefly what we mean by ionospheric, tropospheric and local radio wave propagation effects. **[15%]**
- (b) When does the reflected wave become scattered and what does the degree of scattering depends on? How can we account for the reduction in the amplitude of the specular component? **[20%]**
- (c) Explain briefly the cellular concept. In which way can the efficiency (capacity) of the system be increased? What is the limiting factor and on what does it depend? **[10%]**
- (d) What can we achieve with sectorisation? Explain graphically why in the case of sectorisation there are less interferers. What are the advantages and disadvantages of sectorisation? **[10%]**
- (e) What steps are involved when using geometrical optics to calculate the received field? What are the assumptions made and limitations when using this method? What other method can we use to overcome these limitations? **[25%]**
- (f) How you would expect the transmission loss to vary, as a function of increasing frequency or material thickness in:
- (i) a single layer, homogeneous, high loss dielectric wall/interface?
 - (ii) a single layer, homogeneous, low loss dielectric wall/interface? **[20%]**

- C6** (a) Define linear, circular, elliptical and random polarisation. [20%]
- (b) Explain the process of creating an empirical propagation model. What are the requirements and the assumptions made for the use of such a model? What are the main disadvantages of this modelling approach? [10%]
- (c) When can a material be classified as a conductor or a dielectric? Explain why it is crucial to have an understanding of the variation of the constitutive parameters with frequency and material type. [20%]
- (d) Describe the propagation mechanisms involved, when radio waves propagate between floors. [15%]
- (e) Explain the concept of Fresnel zones. [15%]
- (f) What are the steps for predicting propagation loss over terrestrial fixed links? [20%]

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