GENERAL SIR JOHN KOTELAWALA DEFENCE UNIVERSITY

Faculty of Engineering
Department of Electrical, Electronic and Telecommunication Engineering

B. Sc. Engineering Degree
Semester 5 Examination - June 2020
Intake 35

ET3122 Antennas and Propagation

Time Allowed: 2 hours June 29, 2020

ADDITIONAL DATA

- Speed of light, $c = 3 \times 10^8$ m/s

INSTRUCTIONS TO CANDIDATES

1. This paper contains 4 questions on 4 pages.
2. Answer all 4 questions.
3. This is a limited open book examination. A single A4 sheet containing equations and diagrams is allowed. Model answers for specific questions, electronic documents and media are not permitted.
4. This examination accounts for 70% of the module assessment.
5. The total marks attainable for this examination is 100. The marks assigned for each question and sections thereof are included in square brackets.
6. All questions carry equal marks.
7. All symbols, notations and abbreviations not defined have their usual meanings.
8. Illustrate your answer with clear sketches when appropriate.
9. Clearly state any assumptions and approximations made when applicable.

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Question 1

(a). With the aid of clear diagrams briefly explain what is meant by

(i) the half power beamwidth (HPBW) and **[03 marks]**

(ii) the beamwidth between first nulls (BWFN) of the main lobe of an antenna. **[03 marks]**

(b). Out of the parameters of (a) which parameter is most suitable when selecting a feed antenna for a paraboloid reflector used

(i) only for transmission? **[03 marks]**

(ii) for both transmission and reception? **[03 marks]**

Justify your answer.

(c). Two reflector antennas X and Y have diameters of 0.9 m and 1.3 m respectively. Antenna X is made out of solid metal and has an effective aperture that is 0.95 times that of its physical aperture. Antenna Y is made out of mesh and has a low effective aperture that is only 0.61 times its physical aperture. They are placed 40 km apart and operate at a frequency of 10.2 GHz.

(i) Calculate the gain of each antenna. **[06 marks]**

(ii) Find the free space loss. **[02 marks]**

(iii) If X transmits 10 dBm what is the received power at Y? **[02 marks]**

(iv) Despite the low effective aperture compared to X, what are the three main benefits of using mesh instead of solid metal sheet for a reflector antenna? **[03 marks]**

Question 2

A safety critical industrial sensor node requires a wideband antenna to handle a frequency range of 2.4 - 3.8 GHz for redundancy. A $\lambda/4$ log periodic antenna is suggested for this purpose.

(a). Briefly explain how wideband operation is achieved in a log periodic antenna. **[04 marks]**

(b). Why is it preferable to maximize the number of elements in a log periodic antenna? **[04 marks]**

(c). Obtain the lengths of the widest and narrowest elements of the antenna. **[02 marks]**

(d). If the antenna has to be 20 cm long and the minimum spacing between two elements has to be above 5 mm, verify if the design will be feasible for 5, 10 and 15 elements. **[15 marks]**

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Question 3

(a). Why is the radiation pattern of a dipole or monopole antenna that is longer than 1.5 times the wavelength considered "useless"? **[05 marks]**

(b). Show how the apparently useless radiation pattern of (a) can be converted into

(i) The directive radiation pattern of a V-antenna **[04 marks]**

(ii) The omni-directional radiation pattern of a discone antenna **[04 marks]**

(c). The heuristic design procedure where $f_{\max} = 1.5 f_{\min}$ can be used to design discone antennas. Assume you are required to design a wideband discone antenna for a frequency range of 2.4 to 3 GHz.

(i) With the aid of clear diagrams briefly explain the rationale of this design process. Note: mathematical derivations are not required. **[04 marks]**

(ii) Using the requirement given above highlight the main drawback of the above mentioned design process. You may additionally use the example range of 2.4 to 4 GHz to illustrate your answer. **[05 marks]**

(iii) Determine the length of the discone antenna for the range of 2.4 to 3 GHz. **[03 marks]**

Question 4

(a). Why is the polarization of electromagnetic waves important in mobile communication? Illustrate your answer with the example of the fixed base station and mobile station both using monopole antennas. **[05 marks]**

(b). An axial mode helix operates at a frequency of 2.4 GHz. Using the established empirical relationships for achieving circularly polarized radiation obtain

(i) The diameter (D) and pitch (h) of the helix **[04 marks]**

(ii) The pitch angle of the helix **[02 marks]**

(iii) The length of wire required for a single turn **[02 marks]**

(c). Briefly explain

(i) Broadside arrays **[03 marks]**

(ii) Endfire arrays **[03 marks]**

(iii) Electronic beam steering **[03 marks]**

(iv) The principle of radiation pattern multiplication **[03 marks]**

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