GENERAL SIR JOHN KOTELAWALA DEFENCE UNIVERSITY

Faculty of Engineering
Department of Electrical, Electronic and Telecommunication Engineering

B. Sc. Engineering Degree
Semester 5 Examination - June 2021
Intake 36

ET3122 Antennas and Propagation

Time Allowed: 2 hours   April 23, 2021

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),   **[03 marks]**

    (ii) the beamwidth between first nulls (BWFN) and   **[03 marks]**

    (iii) the sideband suppression ratio (SSR) of an antenna.   **[03 marks]**

(b). An Internet of Things (IoT) sensor (S) requires a communication link to transmit its data to a nearby data aggregator node (Z). The antennas used by S and Z have gains of 2 dB and 3.4 dB respectively. The communication link is to use 2.4 GHz and the typical power transmitted is 10 dBm. If the required minimum received power is -90 dBm find the maximum range between S and Z. You may assume flat earth and optical line of sight propagation.   **[06 marks]**

(c). A large reflector antenna is used as a transmitter in a satellite link. It is made out of solid metal with an effective aperture 0.9 times that of the physical aperture. This antenna had to be replaced due to its support structure becoming weakened by wind stress. It was replaced by a mesh antenna of the same diameter of 3 m. The effective aperture of the mesh was found to be 0.65 times that of the physical aperture. If the link operates at 12 GHz and original transmitted power was 40 dBW find

    (i) the gain of the original solid metal antenna,   **[04 marks]**

    (ii) the gain of the new mesh antenna and   **[03 marks]**

    (iii) the additional power required for transmission if the remaining parameters of the link were unchanged.   **[03 marks]**

Question 2

A telecommunication base station requires a wideband antenna to handle a frequency range of 2.4-4.0 GHz. A $\lambda/4$ log periodic antenna is suggested for this purpose. The antenna has to be 30 cm long.

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

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

(c). Can the same antenna be realized as a discone antenna using the $f_{\max} = 1.5 f_{\min}$ design heuristic? Where $f_{\min}$ and $f_{\max}$ are the minimum and maximum frequencies respectively. Justify your answer.   **[06 marks]**

Question 3

(a). Briefly explain what is meant by

    (i) a broadside array, **[04 marks]**

    (ii) an endfire array and **[04 marks]**

    (iii) electronic beam steering. **[04 marks]**

(b). The earth is a main factor in determining the practical radiation pattern of a source.

    (i) Using first principles obtain the equation of the radiation pattern of an isotropic radiator at a height of h from the ground plane of reflectivity k. Take the wavelength of the source as λ. **[04 marks]**

    (ii) Using approximate diagrams show how radiation pattern of the isotropic radiator will vary for

        i. increasing k **[02 marks]**

        ii. increasing h **[02 marks]**

(c). Briefly explain the operating principle of a Yagi-Uda array. **[05 marks]**

Question 4

A terrestrial microwave link operating at 12 GHz has a transmitting antenna 14 m above mean sea level (MSL) and a receiving antenna 10 m above MSL. The two antennas are 10 km apart and the terrain profile between the two antennas is flat with an elevation at MSL. Two building construction projects X and Y have been proposed on the flat ground between the two antennas. The distances from the transmitter to sites X and Y are 2 km and 5 km respectively. The earth radius adjustment for normal atmospheric conditions (k) is taken as 1.33.

(a). Calculate the earth bulge at each location assuming normal atmospheric conditions.

[06 marks]

(b). Find the required first Fresnel zone clearance at each location. **[06 marks]**

(c). Hence calculate the maximum allowable MSL height of each building to ensure that the link will not fail under normal atmospheric conditions. The Fresnel clearance must be taken as 0.6 times the first Fresnel zone. **[10 marks]**

(d). What will be the benefit of increasing the frequency of the link with respect to the Fresnel zone? **[03 marks]**

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