GENERAL SIR JOHN KOTELAWALA DEFENCE UNIVERSITY
Faculty of Engineering
Department of Electrical, Electronic and Telecommunication Engineering

B.Sc. Engineering Degree
Semester 5 Examination – May 2024
(Intake 39 – ET)

ET 3122 – Antennas and Propagation

Time allowed: 2 Hours | 13 May 2024

ADDITIONAL MATERIAL PROVIDED

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

INSTRUCTIONS TO CANDIDATES

This paper contains 4 questions on 5 pages.

Answer all 4 questions.

This is a limited open book examination. Handwritten notes, printed notes and textbooks are permitted. No mobile phones, tablets, electronic notes or media are allowed.

This examination accounts for 70% of the module assessment.

The total marks attainable for this examination is 100. The marks assigned for each question and sections thereof are included in square brackets.

All questions carry equal marks.

All symbols, notations and abbreviations not defined have their usual meanings.

Illustrate your answer with clear sketches when appropriate.

Clearly state any assumptions and approximations made when applicable.

DETAILS OF ASSESSMENT

Learning Outcome (LO)	Questions that assess LO	Marks allocated (Total 100%)
LO1	Q1, Q3	28
LO2	Q1, Q2	21
LO3	Q2, Q4	28
LO4	Q4	7
LO5	Q3	14

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Question 1

(a) A 50 Ω transmission line is connected to a $\lambda/4$ dipole antenna with an impedance of 60+j20 Ω. If the power fed to the antenna by the transmission line is 0.5 W, calculate.

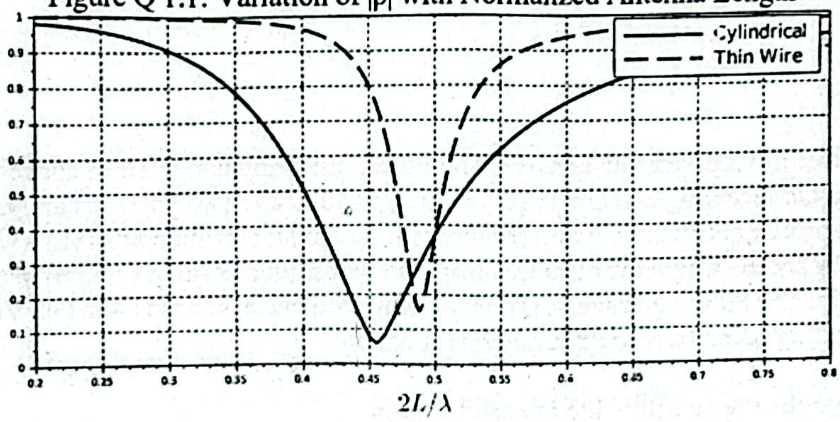
i. the reflection coefficient between the transmission line and antenna, [03 marks]
ii. the Voltage Standing Wave Ratio (VSWR) of the antenna, [03 marks]
iii. the power radiated from the antenna, and, [03 marks]
iv. the power reflected back into the transmission line. [01 marks]

(b) What will happen to the power of (a) that is reflected back into the transmission line? How can this be minimized? [03 marks]

(c) Figure Q1.1 shows the variation of the reflection coefficient $|\rho|$ with respect to the normalized antenna length of a thin wire dipole and a cylindrical dipole. It is required to realize a dipole antenna with an element length of $L = \lambda/4$, (where $\lambda = 1$m), and maximum VSWR of 2.7 dB. Based on the data of Figure Q1.1 calculate the bandwidth of

i. the thin wire dipole, and, [06 marks]
ii. the cylindrical dipole. [06 marks]

Figure Q 1.1: Variation of $|\rho|$ with Normalized Antenna Length



Question 2

(a) A wideband antenna is required for an agricultural sensor to communicate with the network. The required frequency range is 2.5 - 4 GHz. A $\lambda/4$ log periodic antenna with a maximum length of 10 cm is required by the client.

i. Obtain an expression for the unknown parameter N (i.e., the number of elements) in terms of the minimum spacing between two elements, δ, [09 marks]

ii. If the minimum spacing between two elements has to be above 4 mm, verify if the design will be feasible for 5, 7 and 9 elements. [06 marks]

(b) A large reflector antenna has a radius of 1.7 m and is made out of mesh instead of solid metal. This reduces the effective aperture of the antenna to 0.7 times that of the physical aperture.

i. Calculate the gain of the antenna at 12 GHz, [04 marks]

ii. Had solid metal been used, the antenna would have had a much higher gain. If so what are the three main benefits of using mesh instead of solid metal sheet for a reflector antenna? [06 marks]

Question 3

A microwave link operates at 12 GHz. The transmitting antenna is 10 m above mean sea level (MSL) and the receiving antenna is 10.5 m above MSL. The two antennas are 9.5 km apart and the terrain profile between the two antennas is flat with an elevation at MSL. Two buildings are located at A and B, where the distances from the transmitter to sites A and B are 2 km and 3 km respectively. The building at site A is 6 m tall while the one at site B is 4 m tall. You may assume that no bending occurs due to atmospheric refraction.

(a) Calculate the earth bulge at each location, [04 marks]

(b) Verify that the link is feasible in terms of line of sight, [05 marks]

(c) Find the required first Fresnel zone clearance (F1) at each location, [06 marks]

(d) Determine if there is sufficient clearance for the link for:

i. a rural setting of 0.4F1, and, [05 marks]

ii. an urban setting of 0.2F1. [05 marks]

Question 4

(a) For the radiation pattern of a given antenna, what is meant by

i. the half power beamwidth (HPBW), [02 marks]

ii. the beamwidth between first nulls (BWFN) and [02 marks]

iii. the sidelobe suppression ratio (SSR)? [03 marks]

(b) Figure Q4.1 shows the approximate result of a pattern multiplication of the electric field of an anisotropic array element (Figure Q4.1a) with an isotropic four element array (Figure Q4.1b). Based on the definitions of (a) determine the following

i. the HPBW of each radiation pattern of Figure Q4.1, [03 marks]

ii. the BWFN of each radiation pattern of Figure Q4.1 and [03 marks]

iii. the improvement of the SSR of Figure Q4.1c) compared to Figure Q4.1b). [03 marks]

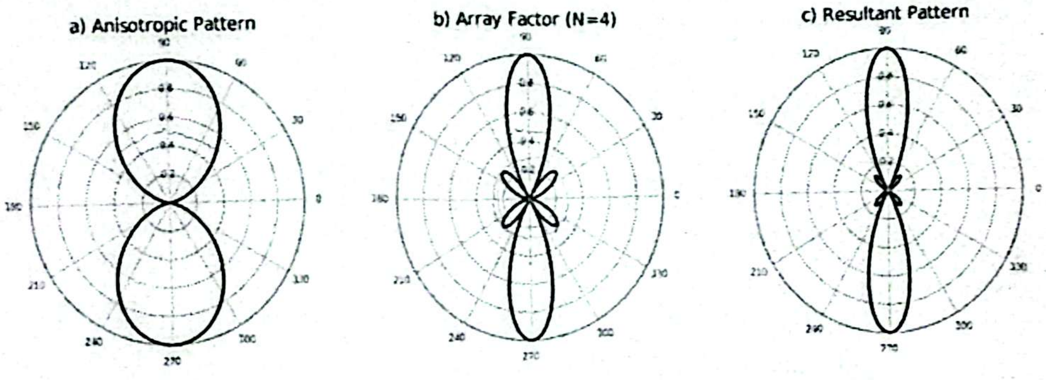
(c) Briefly explain the following

i. Broadside arrays [03 marks]

ii. Endfire arrays [03 marks]

iii. Electronic beam steering [03 marks]

Figure Q 4.1: Principle of Pattern Multiplication



End of question paper