# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER I
## SESSION 2019/2020

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|---|---|---|
| COURSE NAME | : | ANTENNA THEORY AND DESIGN |
| COURSE CODE | : | BEB 41003 |
| PROGRAMME CODE | : | BEJ |
| EXAMINATION DATE | : | DECEMBER 2019/JANUARY 2020 |
| DURATION | : | 3 HOURS |
| INSTRUCTION | : | ANSWER **ALL** QUESTIONS |



THIS QUESTION PAPER CONSISTS OF FOURTEEN (14) PAGES

**Q1** (a) Briefly explain radiation pattern of an antenna.

(5 marks)

(b) Important design considerations are required to design a half-wave dipole. With the aid of relevant diagrams and mathematical equations:

(i) Distinguish the comparison between near field and far field regions.

(5 marks)

(ii) A magnetic field strength of 5μA/m is required at a point on $\theta = \Pi/2$, which is 2 km from an antenna. If ohmic loss is neglected, compute the power that should be transmitted for a hertzian dipole of length $\lambda/25$ and a half wave dipole.

(7 marks)

(c) As a communications engineer you are required to design a microstrip line for a multi-band system. It composes of zero thickness copper conductors on a substrate having $\varepsilon r = 8.4$ $\tan \delta = 0.0005$ and thickness 2.4 mm. If the line width is 1 mm, and operated at 10 GHz, develop a multi-band microstrip antenna with these specifications which takes into account the characteristics impedance and the attenuation due to the conductor loss and dielectric loss.

(8 marks)

**Q2** (a) Explain briefly the main advantages of a parabolic antenna.

(5 marks)

(b) Distinguish the comparison between directive gain ($G_d$) and power gain ($G_p$).

(6 marks)

(c) A parabolic reflector with a diameter of 1.8 m is used at 6 GHz.

(i) Calculate beamwidth between the nulls.

(4 marks)

(ii) Calculate the gain (dB).

(4 marks)

(iii) If the diameter of the parabolic is reduced to 20 cm with 5 cm deep, compute the focus coordinate of the parabolic reflector.

(6 marks)

**Q3** (a) With the aid of relevant diagrams, describe the concept of antenna arrays.
(4 marks)

(b) A helical antenna consists of 10 turns with a spacing of 10 cm and a diameter of 12.7 cm.

(i) Calculate the frequency of the antenna.
(4 marks)

(ii) Determine the gain in dBi at the frequency found in part (a).

(4 marks)

(iii) Compute the beamwidth at the frequency found in part (a).

(4 marks)

(c) A half wave dipole is designed at 1GHz with a radiation resistance of 68 Ω, a gain of 2.14 dBi and a total feed point resistance of 75 Ω.

(i) Calculate the antenna efficiency,

(3 marks)

(ii) Determine the electric field strength at a distance of 10 km in free space in the direction of maximum radiation from the half wave dipole by means of lossless and amached line by a 15W transmitter.

(3 marks)

(iii) If the half wave dipole is now replaced with a quarter wave monopole antenna at 900 MHz, compute the length of the antenna.

(3 marks)

**Q4** As a researcher at a consulting agency, you are required to design an array of 4 x 4 square patch antenna to be placed at an anechoic chamber for radiation pattern measurements.

(a) Briefly explain the principle of pattern multiplication and end-fire array.
(4 marks)

(b) Predict possible effects on the array performance if the element spacing between adjacent elements is greater than λ/2 and proposed some solutions to reduce the effects.
(4 marks)

(c) Three half-wave dipoles are aligned parallel to the z-axis, but have their centers located at $x = -\lambda\ \lambda\ 2, 0,\ 2$ on the x-axis. The dipoles are driven in phase, with equal amplitudes.

(i) Sketch the element pattern in the x-y plane.

(3 marks)

(ii) Determine the array factor (AF) and sketch the polar plot of the AF and the total pattern in the x-y plane.

(5 marks)

(iii) Four short dipoles with a field pattern $E_{dipole} = \cos(\varphi)$ are now arranged in a linear array along the x-axis. If the dipoles are spaced $d=\lambda/2$ and fed in phase, derive an expression of array factor for the linear array.

(5 marks)

(iv) Determine the expression for the total field pattern, $E(\varphi)$ of the four dipole array.

(4 marks)



- END OF QUESTIONS -

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## USEFUL EQUATIONS

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}\left[(1 + 12h/W)^{-1/2} + 0.04(1 - W/h)^2\right]$$

$$\alpha_d = 27.3\left(\frac{\epsilon_{eff} - 1}{\epsilon_r + 1}\right)\frac{\epsilon_r}{\epsilon_{eff}}\frac{\tan\delta}{\lambda_g}$$

$$Z_0 = 60/\left(\sqrt{\epsilon_{eff}}\right) ln\left[\frac{8h}{W} + \frac{W}{4h}\right]$$

$$|H_\phi| = \frac{I_o \beta dl \sin\theta}{4\pi r}$$

$$|H_\phi| = \frac{I_o \cos(\pi/2\cos\theta)}{2\pi r \sin\theta}$$

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