UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2015/2016

COURSE NAME	:	ANTENNA THEORY AND DESIGN
COURSE CODE	:	BEB 41003
PROGRAMME	:	BEJ
EXAMINATION DATE	:	JUNE/JULY 2016
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

Q1 (a) Develop a basic formulation condition that is required in order to achieve Maximum Power Transfer (MPT).

(4 marks)

(b) A basic equivalent circuit can be used to represent a transmission line of length y cm with characteristic impedance, Z_0 given by $a \leq Z_0 \leq b$.

(i) Formulate the radiation resistance of the transmission line by taking into consideration dissipated power and radiated power of the line.

(3 marks)

(ii) If a half-wave dipole antenna is designed at $4\ GHz$ with slots embedded in the dipole element, analyze the radiation pattern of the antenna considering the important values of a and b.

(3 marks)

(iii) Discuss the impact caused by the introduction of slots on surface currents.

(3 marks)

(c) Consider an ideal transmit antenna, where the values of the radiation resistance $R_{rad} = 78.5\ \Omega$, the effective antenna resistance, $R_e = 18\ \Omega$, the directive gain, $G_d = 15$ and an input power $P_{in} = 100\ W$;

(i) Calculate the radiation/antenna efficiency.

(4 marks)

(ii) Determine the antenna gain, G_p (absolute and dB).

(2 marks)

(iii) Calculate the radiated power and the Effective Isotropic Power (EIRP) in dB.

(2 marks)

(iv) Based on the results obtained in **Q1(c)(i)-(iii)**, evaluate the performance of the antenna.

(4 marks)

Q2 (a) Radiation patterns of an antenna can be used as a reference to determine the half beamwidth of the antenna.

(i) With the aid of relevant mathematical equations and diagrams, explain radiation patterns of antenna in both polar and rectangular coordinates.

(7 marks)

(ii) A centre fed Hertzian dipole is excited by a current $I_0 = 20\ A$ with $\lambda/50$ in length. Determine the maximum radiated power density a distance of $2\ km$ by sketching surface current distribution of the dipole.

(5 marks)

(b) A $2\ m$ diameter parabolic reflector is required to be designed at the Control Tower of Subang International Airport with $10\ W$ of power radiated by the fed mechanism operating at $6\ GHz$. Given the transmit antenna efficiency is 65%, determine

(i) Beamwidth

(2 marks)

(ii) Transmit power gain and receive power gain (dB)

(2 marks)

(iii) EIRP

(3 marks)

(c) Predict the performance of the parabolic antenna in **Q2(b)** if the transmit efficiency is increased to 75%.

(6 marks)

Q3. (a) Discuss the advantages and disadvantages of microstrip antenna.

(10 marks)

(b) Cellular and mobile telephony, using earth-based repeaters has received wide acceptance and has become an essential means of communication. Cellular telephony by satellites is the wave of the future and communication systems are being designed for that purpose. The present allocated frequency band for satellites is at L-band. Various antennas are being examined for that purpose. One candidate is the microstrip patch antenna. Design a rectangular microstrip patch antenna based on dominant mode that can be mounted on the roof of a car for satellite cellular telephone. The center frequency is $1.6\ GHz$, the dielectric constant of the substrate is 10.2, and the thickness of the substrate is $0.127\ cm$.

(i) Determine the dimension of the rectangular patch antenna (in cm)

(7 marks)

(ii) Choose suitable feeding method for the designed antenna and justify your choice.

(4 marks)

(iii) If two rectangular patches are used in the design, suggest the most suitable configuration for the array. (refer to **Figure Q3(b)**)

(4 marks)

Q4. (a) Define broadband antenna.

(2 marks)

(b) A stub helix antenna in the cellular telephone band 883 MHz has 4 turns, $h = 5.7\ cm$, $D = 0.5\ cm$, and $S = 3.43x10^{-9} W/m^2$.

(i) Calculate the axial ratio.

(3 marks)

(ii) Calculate the radiation resistance.

(2 marks)

(iii) Determine the type of polarization.

(2 marks)

(c) A horn antenna with $28.85\ cm$ by $21.39\ cm$ aperture, and $HP_E = 12°$ and $HP_H = 13°$, and $G = 22.1\ dB$ at 6 GHz.

(i) Compute the horn antenna aperture efficiency.

(4 marks)

(ii) Estimate the gain from the measured half power beamwidth.

(2 marks)

(d) Anechoic chamber is a noise-canceling room designed to absorb sound or electromagnetic waves. First developed during World War II to test for aircraft's absorption and scattering properties, RF anechoic chamber is still in used today for a variety of different purposes. RF anechoic chamber provides a space where no incident energy waves are present, allowing for devices to be tested without interference. Presently there are two basic types on anechoic chamber design, the rectangular chamber and tapered chamber. Differentiate between rectangular chamber and tapered chamber.

(10 marks)

- END OF QUESTION -

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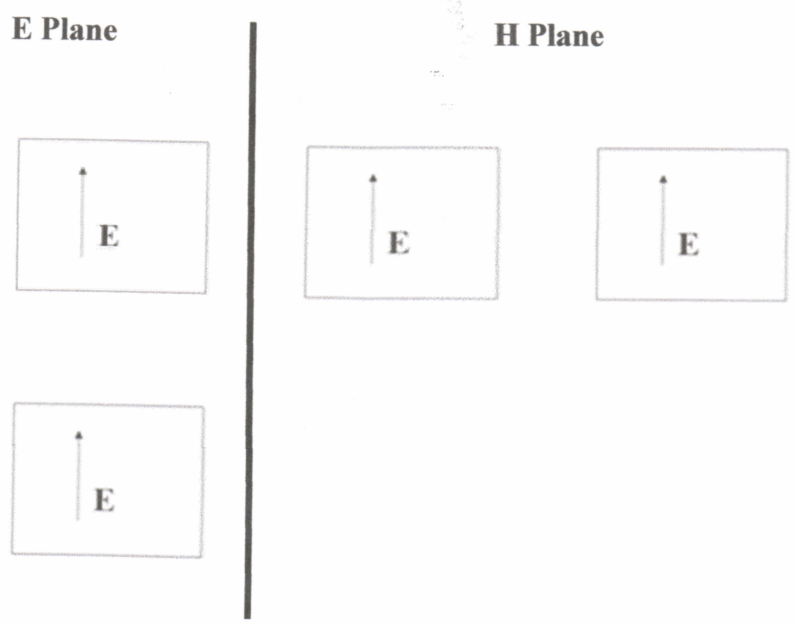

FIGURE Q3 (b)

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Helical antenna

$$E_D = j\omega\mu IS\frac{e^{-j\beta r}}{4\pi r}sin\theta\hat{\theta}$$

$$E_L = \eta\beta^2\frac{\pi}{4}D^2I\frac{e^{-j\beta r}}{4\pi r}sin\theta\hat{\theta}$$

$$S = spacing\ between\ helical\ turn$$

$$\frac{\pi}{4}D^2 = area\ of\ the\ loop$$

$$\frac{|E_\theta|}{|E_\phi|} = \frac{2S\lambda}{\pi^2 D^2} = \frac{2\frac{S}{\lambda}}{\left(C/_\lambda\right)^2}$$

$$C = \pi D$$

$$\alpha_{CP} = \sin^{-1}\left[\frac{-1+\sqrt{1+L/_{\lambda^2}}}{C/_\lambda}\right]$$

$$L = \sqrt{C^2+S^2}$$

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Aperture Antenna

$$R_r = 40\pi^2 \left(\frac{h}{\lambda}\right)^2$$

$$D_\pi = \frac{4\pi}{\lambda^2} L_x L_y$$

$$A_P = L_x L_y$$

$$D = \frac{4\pi}{\lambda^2} A_{em}$$

$$G = \frac{26000}{HP_E HP_H}$$

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Antenna parameters

$$D = \frac{4\pi}{\Omega_p}$$

$$P_{rad} = 40\pi^2 I_0^{\ 2} \left(\frac{l}{\lambda}\right)^2$$

$$\xi = \frac{P_{rad}}{P_t}$$

$$S = \frac{P}{4\pi r^2}$$

$$VSWR = \frac{1 + |\rho|}{1 - |\rho|}$$

$$P_r = A_e S$$

$$G = \frac{4\pi}{\lambda^2} A_e$$

$$S = \frac{P_t G_a}{4\pi r^2}$$

$$P_r = \frac{P_t G_t A_e}{4\pi r^2}$$

$$P_r = P_t G_t G_r \left(\frac{\lambda}{4\pi r}\right)^2$$

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Microstrip Patch Antenna

$$W = \frac{v_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

$$L = \frac{v_0}{2f_r\sqrt{\varepsilon_{eff}}} - 2\Delta L$$

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2}$$

$$\Delta L = 01.12h\frac{\left(\varepsilon_{eff} + 0.3\right)\left(\frac{W}{h} + 0.264\right)}{\left(\varepsilon_{eff} - 0.258\right)\left(\frac{W}{h} + 0.8\right)}$$