UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2012/2013

COURSE NAME : APPLIED ELECTROMAGNETICS

COURSE CODE : BEB 30603

PROGRAMME : BEB

EXAMINATION DATE : JUNE 2013

DURATION : 3 HOURS

INSTRUCTION : ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) You are given a task to set a high-speed secure communication network between two points. Explain the factors that lead to choosing the suitable transmission line for this purpose.

(5 marks)

(b) The general input impedance, Z_{in} formula for a transmission line is given by:

$$Z_{in} = Z_0 \left[\frac{Z_L + jZ_0 \tan \beta\ell}{Z_0 + jZ_L \tan \beta\ell} \right]$$

Formulate an expression for Z_{in} when:

(i) the load is a short,
(ii) the load is an open, and
(iii) the line is a half wavelength long line terminated by Z_L.

(7 marks)

(c) A 100 MHz FM broadcast station uses a 300 Ω transmission line between the transmitter and tower-mounted half-wave dipole antenna. The antenna impedance is 73 Ω. You are asked to design a single shunt stub to match the antenna to the line. Using the Smith Chart, determine the length and the position of the stub (both in meters) from the antenna.

(6 marks)

(d) An antenna with a purely real input impedance of 400 Ω needs to be impedance-matched (by using quarter wavelength transformer matching technique) to a transmission line having a characteristic impedance of 100 Ω at a frequency of 300 MHz. Design the intended quarter wavelength transformer. Next, calculate the SWR and the reflection coefficient for this transmission line.

(7 marks)

Q2 (a) Differentiate between waveguide and transmission line.

(6 marks)

(b) In an air filled rectangular waveguide, the cut off frequency for the dominant mode is 5 GHz. Determine the dimensions of this waveguide in order to allow single mode propagation. Then, validate that only single mode propagation occurs in this waveguide.

(10 marks)

(c) For TE_{30} mode, show all the field components in their simplest form.

(5 marks)

(d) Design an air-filled cubical cavity to have its dominant mode to resonate at 3 GHz.

(4 marks)

Q3 (a) With the help of suitable diagram(s), distinguish between reflection, refraction, and diffraction, related to the radio waves properties.

(6 marks)

(b) A transmitter and a receiver separated by 10 km operate at 400 MHz and are at the same height above the earth. A building with the height of 30 m is at the centre of the path between the transmitter and the receiver. Evaluate if diffraction loss can be neglected. If not, design a practical solution to overcome diffraction loss based on Fresnel zone clearance.

(8 marks)

(c) A point-to-point free space communication system at 1 GHz with the distance of 100 km has the same gain for both transmitting and receiving antennas, which is 20 dB each. Calculate the attenuation of the whole system. Next, compare the attenuation with a wireline system (for the same frequency and distance) using optical fiber (attenuation 0.5 dB/km). Interpret your finding.

(8 marks)

(d) "The critical frequency for an ionospheric propagation is normally lower during the night than during the day."

Using appropriate mathematical equation, predict what happens to the critical frequency during the night and day.

(3 marks)

Q4 (a) "A large computer system was installed in an office complex near a commercial airport. At random times, the system would lose or store incorrect data. The problem turned out to be synchronized with the sweep of the airport surveillance radar as it illuminated the office complex."

(i) Identify the source, the coupling path and the receptor.
(ii) Determine a method that can rectify this EMI problem.

(4 marks)

(b) With the help of appropriate diagrams, distinguish the FOUR (4) basic EMC sub-problems.

(6 marks)

(c) Differentiate between the EMC standards that are imposed on electronic systems of:

(i) those mandated by governmental agencies, and
(ii) those imposed by the product manufacturer.

(8 marks)

(d) Identify the importance of EMC testing. Then, prepare the procedure of semi anechoic chamber testing.

(7 marks)

Q5 (a) Assess the capability of a radar. Then, examine the basic operation of a radar system with the help of a diagram.

(9 marks)

(b) Generalise the principle of the Doppler radar based on the operation of the radar gun used by law enforcement office to detect the speed of a motor vehicle.

(6 marks)

(c) A radar system transmitting at 1 kW with a pulse length of 0.1 μs and operates at 10 GHz. Its gain is 30 dB and the system temperature is 1,500 K. The radar cross section of a car is 5 m^2. Determine the distance of a car so that it is still detectable by the radar with a minimum signal-to-noise ratio (SNR) of 13 dB. Then, calculate the minimum power of the receiver to still be detectable by the radar. Finally, propose how the detection probability is related to the noise level of a radar receiver.

(7 marks)

(d) A radar with the wavelength of 3 cm is located at the origin of an x-y coordinate system. A car located at $x = 100$ m and $y = 200$ m is heading east (x-direction). The radar measured the Doppler frequency of 993 Hz. Determine the speed of the car (in km/h).

(3 marks)

- END OF QUESTION -

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USEFUL EQUATIONS:

TM mode:

$$E_x = -\frac{\gamma}{h^2}\left(\frac{m\pi}{a}\right)E_0\cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma z} \qquad H_x = \frac{j\omega\varepsilon}{h^2}\left(\frac{n\pi}{b}\right)E_0\sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$$

$$E_y = -\frac{\gamma}{h^2}\left(\frac{n\pi}{b}\right)E_0\sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma z} \qquad H_y = -\frac{j\omega\varepsilon}{h^2}\left(\frac{m\pi}{a}\right)E_0\cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$$

$$E_z = E_0\sin\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma z} \qquad H_z = 0$$

$$\eta_{TM} = \frac{E_x}{H_y} = -\frac{E_y}{H_x}$$

TE mode:

$$E_x = \frac{j\omega\mu}{h^2}\left(\frac{n\pi}{b}\right)H_0\cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma z} \qquad H_x = \frac{\gamma}{h^2}\left(\frac{m\pi}{a}\right)H_0\sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$$

$$E_y = -\frac{j\omega\mu}{h^2}\left(\frac{m\pi}{a}\right)H_0\sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma z} \qquad H_y = \frac{\gamma}{h^2}\left(\frac{n\pi}{b}\right)H_0\cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$$

$$E_z = 0 \qquad H_z = H_0\cos\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$$

$$\eta_{TE} = \frac{E_x}{H_y} = -\frac{E_y}{H_x}$$

$$h^2 = \left[\frac{m\pi}{a}\right]^2 + \left[\frac{n\pi}{b}\right]^2 \qquad k^2 = \omega^2\mu\varepsilon \qquad \gamma = \sqrt{h^2 - k^2}$$