Universiti Tun Hussein Onn Malaysia

# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER II
## SESSION 2017/2018

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|---|---|---|
| COURSE NAME | : | APPLIED ELECTROMAGNETICS |
| COURSE CODE | : | BEB 30603 |
| PROGRAMME CODE | : | BEJ |
| EXAMINATION DATE | : | JUNE/JULY 2018 |
| DURATION | : | 3 HOURS |
| INSTRUCTION | : | ANSWER **ALL** QUESTIONS |

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THIS QUESTION PAPER CONSISTS OF SIX **(6)** PAGES

**Q1** (a) Define lossless transmission lines together with the line parameters.
(2 marks)

(b) Explain the concept of skin depth with the help of a proper figure.
(2 marks)

(c) Illustrate the concept of matching network in a transmission line system. Relate the matching network with impedance matching techniques.
(3 marks)

(d) A lossless transmission line of length $0.434\lambda$ and characteristic impedance $100\ \Omega$ is terminated in an impedance $260 + j180\ \Omega$. Use the Smith Chart to determine:

(i) voltage reflection coefficient,

(ii) standing wave ratio,

(iii) input impedance, and

(iv) the location of a voltage maximum closest to the load.
(12 marks)

(e) The standing wave ratio on the line is now reduced to 2 by changing the terminating impedance to a resistive load, $R_L$. Determine:

(i) resistive load $R_L$, and

(ii) input impedance.
(6 marks)

**Q2** (a) Explain THREE (3) main roles of a metallic cavity in Microwave Engineering.
(4 marks)

(b) Briefly describe the Quality Factor, Q of the Cavity. Evaluate Q if the Cavity is lossless.
(4 marks)

(c) A rectangular air-filled copper waveguide with dimension 0.9 inch x 0.4 inch cross section and 12 inch length operates at 9.2 GHz with a dominant mode. Design a rectangular waveguide in a dominant mode of microwave operation

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by calculating cut-off frequency, guide wavelength, phase velocity, characteristic impedance and loss factor. (12 marks)

(d) Differentiate the field distribution of the waveguide for $TE_{10}$ and $TE_{20}$. With the help of relevant diagrams, explain important steps in order to avoid multi-mode operation in the waveguide. (5 marks)

Q3 (a) With the aid of relevant equations or diagrams, briefly explain the following terms:

(i) gain, $G_R$ for a receive antenna,

(ii) radiation efficiency, $\eta_r$,

(iii) polarisation, and

(iv) half-power beam width.

(2 marks)

(b) A dipole antenna of length 0.35λ operating at 3 GHz is constructed by using copper with 2.5 mm in diameter.

(i) Determine the radiation efficiency, $\eta_r$ of the antenna.

(2 marks)

(ii) Calculate the directivity, D of the antenna if maximum radiation intensity, $U_{max}$ of 0.75W/sr and input power, $P_{in}$ of 0.25W are employed respectively.

(8 marks)

(iii) Four half-wave dipoles are arranged in a square lattice, spaced in a straight line by a distance of one half wavelength along a line. Illustrate the element pattern in both E and H planes and predict the boresight gain in case that all elements are fed with equal amplitudes which are in phase.

(5 marks)

(c) Given transmit antenna efficiency, $\eta_r$ is 65%, design a parabolic reflector operating at 8.52 GHz with 15W of power radiated by the systems. In your consideration, plan the design of the reflector by taking into account the beam width, θ; transmit power, $P_T$; receive power, $P_R$; and Effective Isotropic Radiated Power, EIRP. (8 marks)

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Q4 (a) Differentiate between *Electromagnetic Compatibility* (EMC) and *Electromagnetic Interference* (EMI)

(2 marks)

(b) Describe the condition(s) when a system is considered as *Electromagnetically Compatible*.

(2 marks)

(c) Figure **Q4(c)** shows an electrical system that fails some EMC tests due to some EMI issues.

(i) Relate to the EMC tests involved

(ii) Propose and elaborate some methods that you can used to minimize the emissions as shown in the Figure **Q4(c)**.

(10 marks)

(d) In EMC measurement setups, many *environments* such as listed below are involved:

- Open Area Test Site (OATS)
- Screened Room (SR)
- GigaHertz Transverse Electromagnetic Cell (GTEM)
- Semi Anechoic Room (SAR)
- Reverberation Chamber (RC)

(i) Explain the term *environment* in the aspect of EMC testing. (2 marks)

(ii) From the environments listed above, compare these environments in terms of their advantages and disadvantages.

(9 marks)

**- END OF QUESTIONS -**

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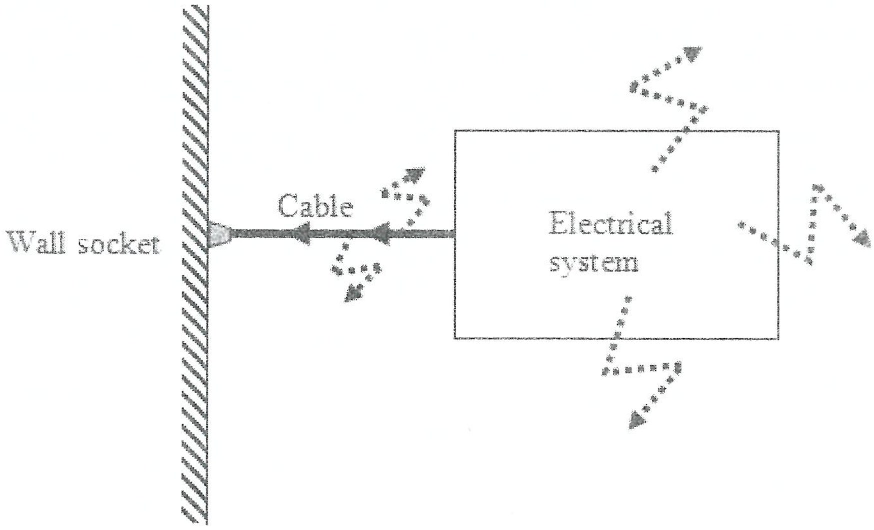


Figure Q4(c): Arrows show some types of emission

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| TM Modes | TE Modes |
| --- | --- |
| $E_{xs} = -\frac{j\beta}{h^2}\left(\frac{m\pi}{a}\right)E_o \cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$ | $E_{xs} = \frac{j\omega\mu}{h^2}\left(\frac{n\pi}{b}\right)H_o \cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$ |
| $E_{ys} = -\frac{j\beta}{h^2}\left(\frac{n\pi}{b}\right)E_o \sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$ | $E_{ys} = -\frac{j\omega\mu}{h^2}\left(\frac{m\pi}{a}\right)H_o \sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$ |
| $E_{zs} = E_o \sin\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$ | $E_{zs} = 0$ |
| $H_{xs} = \frac{j\omega\varepsilon}{h^2}\left(\frac{n\pi}{b}\right)E_o \sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$ | $H_{xs} = \frac{j\beta}{h^2}\left(\frac{m\pi}{a}\right)H_o \sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$ |
| $H_{ys} = -\frac{j\omega\varepsilon}{h^2}\left(\frac{m\pi}{a}\right)E_o \cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$ | $H_{ys} = \frac{j\beta}{h^2}\left(\frac{n\pi}{b}\right)H_o \cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$ |
| $H_{zs} = 0$ | $H_{zs} = H_o \cos\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$ |
| $\eta = \eta'\sqrt{1-\left(\frac{f_c}{f}\right)^2}$ | $\eta = \frac{\eta'}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}}$ |

These formulas below can be used for both TM and TE modes:

$$f_c = \frac{u'}{2}\sqrt{\left(\frac{m}{a}\right)^2+\left(\frac{n}{b}\right)^2}$$

$$\lambda_c = \frac{u'}{f_c}$$

$$\beta = \beta'\sqrt{1-\left(\frac{f_c}{f}\right)^2}$$

$$u_{ph} = \frac{\omega}{\beta} = f\lambda$$

Where: $h^2 = \left(\frac{m\pi}{a}\right)^2+\left(\frac{n\pi}{b}\right)^2$ , $u' = \frac{1}{\sqrt{\mu\varepsilon}}$ , $\beta' = \frac{\omega}{u'}$ , $\eta' = \sqrt{\frac{\mu}{\varepsilon}}$

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