EEE (39)

MSc TE, 2nd Semester May 16, 2023

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Semester Final Examination — Summer Semester, A. Y. 2021-2022
Course No.: EEE 6297 — Time: 3 Hours
Course Title: Microwave Engineering — Full Marks: 150

There are **6 (six)** questions. Answer any **5 (five)** questions. The symbols have their usual meanings. Programmable calculators are not allowed. Marks of each question are written in the margin.

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1. a) Derive the following expressions for voltage $v(z,t)$ and current $i(z,t)$ on a transmission line with characteristic impedance Z_0 and phase velocity v_p. **15**

$$v(z,t) = f_1(t-\frac{z}{v_p}) + f_2(t+\frac{z}{v_p}) \quad \text{and} \quad i(z,t) = \frac{1}{Z_0}[f_1(t-\frac{z}{v_p}) - f_2(t+\frac{z}{v_p})].$$

   b) The load $Z_L = 25 + j50\ \Omega$ is connected to an ideal transmission line with characteristic impedance $Z_0 = 50\ \Omega$. The source is 0.5 cm away from the load. The incident voltage is $V_{+} = 15\angle 75^\circ$ and reflected voltage $V_{-} = 5\angle 10^\circ$ at the point of source. Calculate the reflection coefficient, return loss, transmission coefficient and insertion loss at the point of load. ($\beta = \pi/2$). **15**

2. a) Show that the propagation constant $\gamma = \sqrt{(R+j\omega L)(G+j\omega C)}$ where $V(z) = Ve^{-\gamma z}$ represents the voltage wave equation for lossy transmission line. **10**

   b) An ideal transmission line with characteristic impedance $Z_0 = 1/Y_0$ and phase constant, β is connected to the load impedance $Z_L = 1/Y_L$. Show that the input admittance Y_i at a distance l away from the load is given by, **10**

$$Y_i = Y_0 \frac{Y_L \cos\beta l + jY_0 \sin\beta l}{Y_0 \cos\beta l + jY_L \sin\beta l}.$$

   You may start off the derivation with the wave equations of ideal transmission line in terms of voltage and current in phasor form.

   c) Prove that the same Smith chart can be alternately used as either impedance Smith chart or admittance Smith chart by simply rotating halfway (180°) on SWR circle. **10**

3. a) Derive the filed equations for TM wave in parallel plate waveguide. Also write down the electric filed equations for TM_1 wave. **15**

   [For TM wave, $H_x = -\frac{j\omega\varepsilon}{k_c^2}\frac{\partial E_z}{\partial y}, H_y = -\frac{j\omega\varepsilon}{k_c^2}\frac{\partial E_z}{\partial x}, E_x = -\frac{j\beta}{k_c^2}\frac{\partial E_z}{\partial x}, E_y = -\frac{j\beta}{k_c^2}\frac{\partial E_z}{\partial y}$]

   b) Derive the filed equations for TE wave in rectangular waveguide. Also write down the electric filed equations for TE_{10} mode. **15**

   [For TE wave, $H_x = -\frac{j\beta}{k_c^2}\frac{\partial H_z}{\partial x}, H_y = -\frac{j\beta}{k_c^2}\frac{\partial H_z}{\partial y}, E_x = -\frac{j\omega\mu}{k_c^2}\frac{\partial H_z}{\partial y}, E_y = \frac{j\omega\mu}{k_c^2}\frac{\partial H_z}{\partial x}$]

4. a) Calculate the cut-off frequencies for TE_{10} and TE_{21} modes for a rectangular waveguide having width, a = 6 cm and heigh, b = 2 cm. **10**

b) Show that the characteristic impedance of the added transmission line in a quarter wave transformer, $Z_1 = \sqrt{Z_0 Z_l}$. **10**

c) Design a quarter wave transformer to match 100 + j65 Ω load on a transmission line at 3 GHz. **10**

5. a) For a load impedance Z_L = 60 − j80 Ω, design two single-stub (short circuit) shunt tuning networks to match this load to a 50 Ω line. **15**

b) Match a load impedance of Z_L = 100 + j80 to a 50 Ω line using a single series open-circuit stub. **15**

6. a) Design a double-stub shunt tuner to match a load impedance Z_L = 60 − j80 Ω to a 50 Ω line. The stubs are to be open-circuited stubs and are spaced λ/8 apart. **18**

b) Write down the advantages of double-stub matching as compared to single-stub matching. Show that a stub with open-circuit end has purely reactive input impedance. **12**