Mawlana Bhashani Science and Technology University

Department of Information and Communication Technology

3rd year 2nd Semester B. Sc. (Engg.) Final Examination 2023

Course Title: Microwave Engineering Course Code: ICT 3201

Full Marks: 70 Time: 3 hours

Answer any **five** from the following questions

1. (a) What is Microwave? Explain the microwave system using the proper generalized block diagram. 4

   (b) Discuss the importance and applications of microwave engineering in modern communication systems. How have microwave technologies contributed to the advancement of wireless communication? 5

   (c) Why do conventional electronic devices not behave satisfactorily at microwave frequencies? 2

   (d) In a microwave vacuum tube, electrons are accelerated by a potential difference of 50 V. How would the velocity of the electron change if the potential difference were increased to 200 V? 3

2. (a) What is a waveguide? Define the TE, TM, and TEM modes of the waveguide. 4

   (b) Using Maxwell's equations in the time domain, derive the wave equations for the electric and magnetic fields. 4

   (c) Considering wave propagation in the negative Z-direction in a Rectangular Coordinate system, solve the wave equations that are derived in 2(b). 6

3. (a) What are microwave cavities? Write down the properties of TEM modes in the lossless medium. 3

   (b) "The reciprocal of the quality factor of a loaded cavity resonator is equal to the sum of the reciprocals of its unloaded quality factor and the external quality factor" – Prove that statement mathematically. 7

   (c) Using the concepts and equations from 3(b), explain the coupling coefficients and illustrate the relationship between the coupling coefficient and the standing wave ratio with a graphical representation. 4

4. (a) What is klystron? Explain the principle of two cavity klystron by using a proper diagram. 5

   (b) Define Traveling Wave Tube (TWT). Write down the characteristics of TWT. 3

   (c) A reflex klystron operates under the following conditions: 6

   V_0 =600 V, L = 1 mm, R_{sh} =15 KΩ, $\frac{e}{m} = 1.759 \times 10^{11}\ C/kg$, f_r = 9 Hz

   The tube is oscillating at f_r at the peak of the n = 2 mode or $1\frac{3}{4}$ mode. Assume that the transit time through the gap and beam loading can be neglected.

   (i) Find the value of the repeller voltage, V_r.

   (ii) Find the direct current necessary to give a microwave gap voltage of 200 V.

   (iii) What is the electronic efficiency under this condition?

5. (a) Why conventional vacuum tubes less effective as are signal sources for microwave circuits, and how can this limitation be minimized? 4

(b) Find out the gain-bandwidth product limitation for the output-tuned circuit of ordinary vacuum tubes like pentode. 4

(c) A two-cavity klystron has the following parameters: 6
Beam voltage, V_0 = 20kV, Signal Voltage, V_1 = 10V (rms), Beam Current, I_0 = 2A, Operating frequency, f = 8GHz, Beam coupling coefficient = 1, DC electron beam current density = 10^{-6} C/m^3, Shunt resistance of the cavity, R_{sh} = 10 kΩ, Total Shunt resistance including load is 30kΩ. R = 0.5.

Calculate:
(i) The plasma frequency
(ii) The induced current and voltage in the output cavity
(iii) The power gain

6. (a) What is a micro-strip line? Derive the equation of characteristics impedance of the micro-strip line. 5

(b) Velocity modulation can mitigate the transit angle effect of conventional vacuum tubes. Briefly describe the process of velocity modulation, besides finding out the final velocity modulation equations in the time domain. 7

(c) A certain micro-strip line has the following parameters: 2
$\varepsilon_r = 5.23$, $h = 7$ mm, $t = 2.8$ mm, $w = 10$ mm, Calculate the characteristics impedance $Z0$ of the line by using final equation of 6(a).

7. (a) Describe the applications of Radar in several field. 4

(b) Define transmitter and radiators. Discuss about electronic navigation system. 6

(c) A shielded strip line has the following parameters: 4
Dielectric constant of the insulator
(polystyrene): ε_r, = 2.56; Strip width: w = 25 mils; Strip thickness: t = 14 mils;
Shield depth: d = 70 mils
Calculate:
a. The K factor
b. The fringe capacitance
c. The characteristic impedance of the line.

8. (a) What do you mean by antenna? Write down the applications of antenna. 4

(b) Discuss about reflector antenna. How does radiation occur in single wire antenna? 4

(c) Explain the design procedure and operating principle of a Yagi-Uda antenna array. 6