Roll No											

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING
END TERM EXAMINATION - JUN 2023

Semester : Semester IV - 2021
Course Code : ECE3009
Course Name : Sem IV - ECE3009 - Transmission Lines and Waveguides
Program : ECE

Date : 12-JUN-2023
Time : 9.30AM - 12.30PM
Max Marks : 100
Weightage : 50%

Instructions:
(i) Read all questions carefully and answer accordingly.
(ii) Question paper consists of 3 parts.
(iii) Scientific and non-programmable calculator are permitted.
(iv) Do not write any information on the question paper other than Roll Number.

PART A

ANSWER ALL THE QUESTIONS **(15 X 2 = 30M)**

1. What is the value of Z_0 for a lossless transmission line where $L = 4\ mH/m$ and $C = 10\,\mu F/m$?
(CO5) [Knowledge]

2. If z is a complex number such that $z = 3 + j4$, what is $|z|$?
(CO5) [Knowledge]

3. When does γ become purely imaginary for a transmission line?
(CO4) [Knowledge]

4. How many conductors does a transmission line have?
(CO3) [Knowledge]

5. What kind of a filter is a waveguide?
(CO4) [Knowledge]

6. What is the SI unit of G of a transmission line?
(CO1) [Knowledge]

7. What is the reflection coefficient when $Z_0 = Z_L$?
(CO2) [Knowledge]

8. What is the relationship between two adjacent voltage minima ($V_{\min}$) and wavelength λ for a transmission line?
(CO3) [Knowledge]

9. What are the SI units of G and L in a transmission line?
(CO1) [Knowledge]

10. Which of these modes have the lowest cut-off frequency - $TE_{10}, TE_{21}, TE_{31}$?

(CO5) [Knowledge]

11. The phase velocity of a signal whose frequency is $100\,\mathrm{MHz}$ on a transmission line is $v_p = 2 * 10^4\ km/s$. Find its wave-length.

(CO3) [Knowledge]

12. Which of the parameters - R, L, G and C should be zero for an ideal conductor of a transmission line?

(CO4) [Knowledge]

13. Which of these constants (R, L, G and C) do not apppear in β of a distortion-less transmission line?

(CO2) [Knowledge]

14. How many walls does a rectangular waveguide have?

(CO1) [Knowledge]

15. What is normally contained in the hollow region of a waveguide?

(CO2) [Knowledge]

PART B

ANSWER ALL THE QUESTIONS **(2 X 15 = 30M)**

16. Suppose you are asked to design a transmission line where all frequency components of a signal will travel at the same velocity (i.e. the line should be distortion-less). One approach will be to ensure a loss-less line where $R = G = 0$. However, since this is not practically feasible, suggest an alternative method. With all the necessary steps,

a. Arrive at the expressions of α and β for such a transmission line from the expression of γ.

b. Write down the expression for phase velocity v_p for this line.

c. Suppose the primary constants of this line are - $R = 0.01\,\Omega/km$, $L = 225\,mH/km$, $G = 0.008\,\mu\mho/km$, and $C = 900\,nF/km$ and the length of the line is $100\,km$. Use this data to determine the input impedances Z_{SC} and Z_{OC} when the load end of the line is - (i) short circuited and (ii) open circuited at $f = \frac{10^4}{2\pi}\,\mathrm{Hz}$

You may find the binomial expansion $(1+x)^n = 1 + nx + \frac{n(n-1)}{2!}x^2 + \frac{n(n-1)(n-2)}{3!}x^3 + \cdots$ useful for your solution.

(CO1) [Comprehension]

17. The constant VSWR circle on the Smith chart is very useful in finding the impedance at any point on a transmission line. For example, if the load impedance is known, the position of $V_{\max}$ or $V_{\min}$ can be found very easily without any laborious calculations. Consider such a transmission line where $Z_L = 100 + j150\,\Omega$ and $Z_0 = 75\,\Omega$. If the length of this transmission line is 1.2λ, determine the following ***using a Smith chart***

a. normalised load impedance z_L

b. standing wave ratio

c. reflection coefficient (both magnitude and phase-angle)

d. distance of the load from the first voltage minimum

e. distance of the load from the first voltage maximum

(CO2) [Comprehension]

PART C

ANSWER ALL THE QUESTIONS **(2 X 20 = 40M)**

18. Slotted lines are used for microwave measurements and consist of a movable probe inserted into a slot in a transmission line and can measure standing waves, wavelength, and a number of other parameters including reflection coefficient and electrical impedance using a Smith chart. Consider a slotted air line having an unknown load impedance with $\mathrm{VSWR} = 2$ whose minima are found at $11\,\mathrm{cm}$, $19\,\mathrm{cm}$, … , on the scale. When the load is replaced by a short circuit, the minima are at $16\,\mathrm{cm}$, $24\,\mathrm{cm}$, … , . If $Z_0 = 50\,\Omega$, calculate λ , f , z_L and Z_L ***using a Smith chart***. Assume $v_p = c$ for this case.

(CO2) [Application]

19. In general, a waveguide should only propagate a single mode rather than the higher order modes as power conversion to the latter reduces transmission efficiency. However, beyond its cut-off frequency, a higher order mode might be transmitted through a waveguide. Consider a rectangular waveguide with dimensions $a = 2.5\,\mathrm{cm}$ and $b = 1.0\,\mathrm{cm}$ is to operate below $15.1\,\mathrm{GHz}$.

(a) How many TE and TM modes can the waveguide transmit if the guide is filled with a medium characterized by $\varepsilon_r = 2$ and $\mu_r = 2$?

(b) Calculate the cutoff frequencies of the modes.

(CO3) [Application]