



**SCHOOL OF COMPUTING AND ENGINEERING SCIENCES**  
**BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING**  
**BEE 3202: TRANSMISSION LINES AND WAVEGUIDES**  
**END OF SEMESTER EXAM**

**Date: 4<sup>th</sup> December 2023**

**Time: 13:00-16:00 Hours**

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**Instructions:**

This Examination consists of **FOUR** questions.

Answer **Question ONE (COMPULSORY)** and any other **TWO** questions.

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***LIST OF CONSTANTS***

$$\mu_0 = 4\pi \times 10^{-7} \text{ H/M}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ F/M}$$

**Question one [20 Marks]**

- a) With aid of mathematical expression define the following
  - i. Phase velocity 2marks
  - ii. Group velocity 2marks
- b) Describe how a transmission line would be matched to a complex impedance load to allow for maximum power transfer. 2marks
- c) Describe any TWO types of wave guides giving diagrammatic sketches as used in microwave engineering. 2marks
- d) It is necessary to propagate 10 GHz in a waveguide whose wall separation is 6 cm. What is the greatest number of half-waves of electric intensity that will be possible to establish between the two walls? Also, calculate the guide wavelength for this mode of propagation. 4marks
- e) A load impedance of  $130 + j90\Omega$  terminates a  $50\Omega$  transmission line that is  $0.3\lambda$  long. Find
  - i. The reflection coefficient at the load, 2marks
  - ii. The reflection coefficient at the input to the line, 2marks
  - iii. The SWR on the line, 2marks

f) Describe any two methods of exciting wave guides

2marks

**Question two [20 marks]**

a) A rectangular wave guide is 5.1 cm by 2.4cm. Calculate the cutoff frequency of the dominant mode.

4marks

b) A rectangular  $TE_{10}$  mode waveguide measures 4 x 5.5 cm internally and has a 9 GHz signal propagated in it, Calculate.

i. Cutoff wave length,

2marks

ii. Group velocity for the wave

2marks

c) A transmission line has the following per unit length parameters:  $L=0.3\mu\text{H}/\text{m}$ ,  $C=450\text{pF}/\text{m}$ ,  $R=5\Omega/\text{m}$  and  $G=0.01\text{S}/\text{m}$ . calculate the complex propagation constant and characteristic impedance of this line at 880MHz.

6marks

d) A  $50\Omega$  load is being fed from a  $72\Omega$  transmission line as shown in the Fig. 1 below



Fig.1

i. Find the SWR resulting from the mismatch

2marks

ii. Determine the reflection coefficient

2marks

iii. What percentage of incident power is reflected

2marks

**Question three [20 Marks]**

- a) Write down the expression for cut off wavelength and cut off frequency for TE<sub>10</sub> modes  
4marks
- b) A rectangular wave guide measures 3x4.5cm internally and has signal of 10GHz propagated in it. Calculate the cutoff wavelength, the guide wavelength, the group velocity, phase velocities and the characteristic impedance for.
- i. The TE<sub>1,0</sub> 5marks
  - ii. The TM<sub>1,1</sub> 5marks
- c) A transmission line with characteristic impedance of 300Ω is terminated in a purely resistive load. If it is found by measurements that the minimum value of voltage upon it is 5μV and maximum is 7.5μV. what is the value of the load resistance. 6marks

**Question four [20 Marks]**

- a) Using the Smith Chart provided solve the following. A series RC combination having an impedance  $Z_L = (450 - j600) \Omega$  at 10 MHz is connected to a 300Ω line. Calculate the position and length of a short circuit stub designed to match this load to the line. Indicate all steps followed. 12marks  
ANS
- b) Derive the equation for reflection coefficient in transmission lines given the possibility of reflected voltage and incident voltage 4marks
- b) A wave guide has an internal width  $a$  of 3cm and carries the dominant mode of a signal of unknown frequency. If the characteristic impedance is 500Ω what is the frequency. 4marks

# The Complete Smith Chart

## Black Magic Design

