



MACHAKOS UNIVERSITY

University Examinations for 2019/2020 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FIFTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING

EEE 547 MICROWAVE ENGINEERING

DATE: 21/10/2020

TIME: 2.00-4.00 PM

INSTRUCTIONS

Answer Question One and Any Other Two Questions

QUESTION ONE (30 MARKS)

- a) Explain two reasons why transmission lines are not suitable as microwave devices (4 marks)
- b) Given the table of some standard rectangular waveguides below, calculate the cutoff frequency for the first four modes of WR284 waveguide. (14 marks)

Some Standard Rectangular Waveguides

Waveguide designation	a (in)	b (in)	t (in)	$f_{c_{10}}$ (GHz)	Frequency range (GHz)
WR975	9.750	4.875	0.125	0.605	0.75–1.12
WR650	6.500	3.250	0.080	0.908	1.12–1.70
WR430	4.300	2.150	0.080	1.375	1.70–2.60
WR284	2.840	1.340	0.080	2.08	2.60–3.95
WR187	1.872	0.872	0.064	3.16	3.95–5.85
WR137	1.372	0.622	0.064	4.29	5.85–8.20
WR90	0.900	0.450	0.050	6.56	8.2–12.4
WR62	0.622	0.311	0.040	9.49	12.4–18

- c) A certain GaAs MESFET has the following parameters: (6 marks)
- $R_g=3\Omega$, $R_i=2.5\Omega$, $g_m=50\text{mS}$, $R_d=450\Omega$, $R_s=2.5\Omega$, $C_{gs}=0.60\text{pF}$
- i. Determine the cutoff frequency.

- ii. Find the maximum operating frequency.
- d) An air-filled rectangular waveguide of inside dimensions 7 x 3.5 cm operates in the dominant TE₁₀ mode as shown in Fig find frequency, wavelength, group velocity
(6 marks)

QUESTION TWO (20 MARKS)

- a) Explain two reasons why the MOSFETs are often preferred as microwave power amplifiers over MESFETs and JFETs (4 marks)
- b) Given a 50 Ω copper stripline conductor, with $b = 0.32$ cm and $\epsilon_r = 2.20$, dielectric loss tangent ($\tan \delta$) is 0.001 and the operating frequency is 10 GHz. (8 marks)
- i. Determine the width of the stripline
- ii. Calculate the attenuation in dB/ λ .
Assume the conductor thickness of $t = 0.01$ mm and surface resistance, R_s of 0.026 Ω
- c) A two-port network is known to have the following scattering parameters: (8 marks)
- $$[S] = \begin{bmatrix} 0.15 \angle 0^\circ & 0.85 \angle -45^\circ \\ 0.85 \angle 45^\circ & 0.2 \angle 0^\circ \end{bmatrix}$$
- i. Determine if the network is reciprocal and lossless:
- ii. If port 2 is terminated with a matched load, what is the return loss seen at port 1?
- iii. If port 2 is terminated with a short circuit, what is the return loss seen in port 1?

QUESTION THREE (20 MARKS)

Identify 4 types of waveguide junctions and using suitable diagram, explain their construction and their operation

QUESTION FOUR (20 MARKS)

- a) Explain why for high-frequency applications, the n-p-n structure is preferred (3 marks)
- b) Discuss three limitations that affect the performance of a BJT at microwave frequencies (9 marks)
- c) A certain silicon microwave transistor has the following parameters: (8 marks)
- Reactance: $X_C = 1 \Omega$

Transit-time cutoff frequency: $f_t = 4 \text{ GHz}$
Maximum electric field: $E_m = 1.6 \times 10^5 \text{ V/cm}$
Saturation drift velocity: $V_s = 4 \times 10^5 \text{ cm/s}$

Determine the maximum allowable power that the transistor can carry.

QUESTION FIVE (20 MARKS)

- a) Draw a well labelled diagram of the IV characteristics of a tunnel diode and explain the operation of a tunnel diode at microwave frequencies (10 marks)
- b) An X-band pulsed conventional magnetron has the following operating parameters: (10 marks)

Determine

- i. The angular resonant frequency
- ii. The unloaded quality factor
- iii. The loaded quality factor
- iv. The external quality factor