



MACHAKOS UNIVERSITY

University Examinations 2017/2018

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

FIFTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

EEE 547: MICROWAVE ENGINEERING

DATE: 19/12/2017

TIME: 8.30-10.30 AM

INSTRUCTIONS:

Answer question one and any other two

QUESTION ONE (COMPULSORY) (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) Explain two reasons why the MOSFETs are often preferred as microwave power amplifiers over MESFETs and JFETs (6 marks)

QUESTION TWO (20 MARKS)

- (a) Explain the biological effects and safety of exposure to microwave radiation (6 marks)
- (b) Using suitable illustrations, explain how the following affect propagation of microwaves
 - (i) Atmosphere
 - (ii) Ground (8 marks)
- (c) Explain how microwave oven works (4 marks)

QUESTION THREE (20 MARKS)

A cylindrical resonator has a radius of 5cm which is used to measure frequency from 8GHz to 12GHz at TE_{11} mode. What is the required length, d for tuning those frequencies in that particular mode? (20 marks)

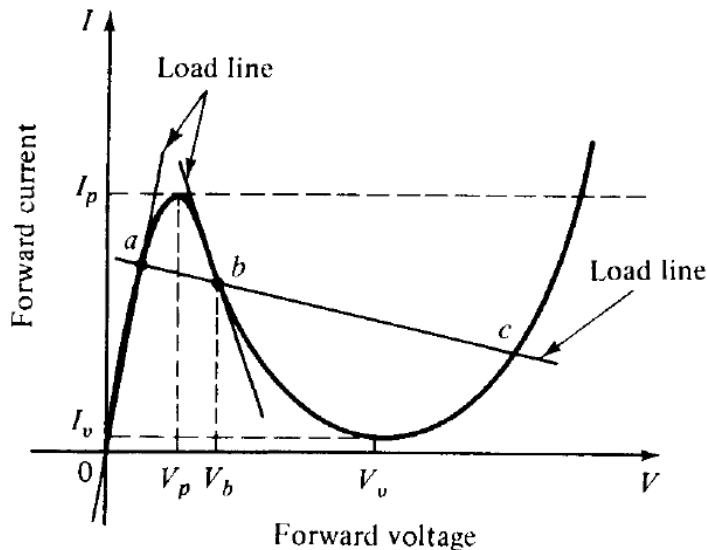
QUESTION FOUR (20 MARKS)

- (a) Explain why for high-frequency applications, the n-p-n structure of a BJT is preferred (3 marks)
- (b) Discuss tree limitation that affect the performance of a BJT at microwave frequencies (9 marks)
- (c) A certain silicon microwave transistor has the following parameters: (4 marks)
 - Reactance: $X_C=1\Omega$
 - Transit-time cutoff frequency: $f_r= 4\text{ GHz}$
 - 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.

- (d) Differentiate between Microwave Linear-Beam Tubes and Microwave Crossed-Field Tubes (4 marks)

QUESTION FIVE (20 MARKS)

- (a) With reference to the below IV characteristics, explain the operation modes of a tunnel diode at microwave frequencies (10 marks)



- (b) An X-band pulsed conventional magnetron has the following operating parameters: (10 marks)

Anode voltage:	$V_0 = 5.5 \text{ kV}$
Beam current:	$I_0 = 4.5 \text{ A}$
Operating frequency:	$f = 9 \times 10^9 \text{ Hz}$
Resonator conductance:	$G_r = 2 \times 10^{-4} \text{ mho}$
Loaded conductance:	$G_\ell = 2.5 \times 10^{-5} \text{ mho}$
Vane capacitance:	$C = 2.5 \text{ pF}$
Duty cycle:	$DC = 0.002$
Power loss:	$P_{\text{loss}} = 18.50 \text{ kW}$

Determine

- The angular resonant frequency
- The unloaded quality factor
- The loaded quality factor
- The external quality factor