BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE EDUCATION

DEPARTMENT OF ENGINEERING AND PHYSICS

PROGRAMME: Bachelor of Science Honours Degree in Electronic Engineering

EEE5202/EEE4202(2): RF and MICROWAVE DEVICES and Circuits

Duration: 3 Hours Total Marks: 100

INSTRUCTIONS TO CANDIDATES
1. Answer any **five (5)** questions
2. The paper contains **SEVEN (7)** questions
3. Marks are shown in brackets

JUN 2025

INSTRUCTIONS TO CANDIDATES
1. Answer any **five (5)** questions
2. The paper contains **SEVEN (7)** questions
3. Each question carries twenty (20) marks
3. Marks are shown in brackets

Constants: $\mu_o = 4\pi\, x10^{-7}\ F/m, \varepsilon_o = 8.854\, x\, 10^{-12}\ H/m$

Question 1

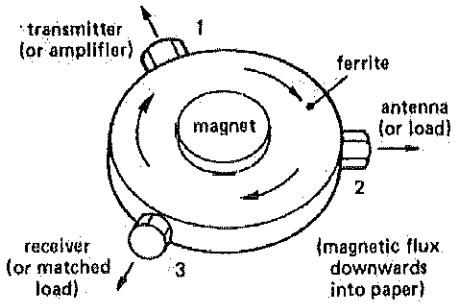
(a) Using examples, state four applications of microwaves. [4]
(b) Justify why microwaves are suitable for the applications above. [4]
(c) State any two disadvantages of microwaves. [2]
(d) In what way are Microwaves different from Low-Frequency Signals? [4]
(e) Giving examples of each, state three key components that are found in a microwave system. [6]

Question 2

(a) State two functions of IEEE commonly used microwave frequency bands. [3]
(b) With the aid of S-parameters or S-matrices, state any three properties of S-parameters. [6]
(c) Outline the significance of S-parameters in analysing microwave networks. [3]
(d) Draw the high-frequency equivalent circuit of an inductor. Account for C and R. [3]
(e) State two typical applications of a directional coupler. [2]
(f) A lossy cable with R = 2.5 Ω/m, L = 10 mH/m, C = 10 pF/m and G = 0 operates at f = 1GHz. Find the attenuation constant of the line. [3]

Question 3

(a) (i)Name the microwave passive component below and describe how it operates. [5]



(b) A plane wave of frequency 1 GHz frequency is travelling in a block of Teflon where $\varepsilon_r = 2.1, \mu_r = 1$ *and* $\sigma = 0$. Determine:

(i) Phase constant. [1]
(ii) Intrinsic impedance. [1]
(iii) Wavelength. [1]
(iv) Phase velocity. [1]

(c) A two-port network is known to have the following scattering matrix:

$$[S] = \begin{bmatrix} 0.15\angle 0^\circ & 0.85\angle -45^\circ \\ 0.85\angle 45^\circ & 0.2\angle 0^\circ \end{bmatrix}$$

(i) Determine if the network is reciprocal and lossless. For each case give a reason by calculation or otherwise. [3]

(i) If a port 2 is terminated with a matched load, what is the return loss seen at port 1? [3]

(d) Deduce the range of SWR and Γ of a transmission line? [4]

Question 4

(a) Briefly describe how a Microwave Oven Work? [2]

(b) Which component is represented by the scattering matrix $\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$? [2]

(c) Differentiate an isolator from a circulator [2]

(d) Write down the S-matrix of a three-port circulator. [3]

(e) In a two-way communication, the transmitter transmits an output power of 100W at 10 GHz. The transmitting antenna has a gain of 36 dB, and the receiving antenna has a gain of 30 dB. What is the received power level at a distance of 40 km (a) if there is no system loss and (b) if the system loss is 10 dB? [7]

(f) The incident power is 100 W for a directional coupler. It has a coupling factor of 25 dB and a directivity of 40 dB. Find coupled and isolated port powers. [4]

Question 5

(a) If **H** field is given by $H(z,t) = 48\cos(10^8 t + 40z)a_y$ A/m. Calculate or identify the following:

i. Amplitude. [1]
ii. Frequency. [1]
iii. Phase constant. [1]
iv. Wavelength. [1]

(b) Calculate the voltage reflection coefficient at the terminating end of a transmission line with a characteristic impedance of 50 Ω when it is terminated by:

(i) A 50 Ω termination. [1]
(ii) An open-circuit termination. [1]
(iii) A short circuit termination. [2]

(c) A 300 m long line has the following constants: R = 4.5 kΩ, L = 0.15 mH, G = 60 Siemens, C = 12 nF, operated at a frequency 6 MHz. Find the propagation constant, characteristic impedance and velocity of propagation. [6]
(d) Of the passive microwave devices you studied, state any two two-port devices? [2]
(e) State boundary conditions at the interface between free space and an antenna. [4]

Question 6

(a) **What** are the basic parameters used to measure the performance of a directional coupler? [4]
(b) A lossless 75 W transmission line is terminated by an impedance of 150 + j150 Ω. Using the Smith chart, find (a) VSWR, and (b) reflection coefficient. [5]
(c) Name some wave guide components used to change the direction of the guide through an arbitrary angle [3]
(d) Determine the S parameters for a reciprocal and lossless network, perfectly matched 2-port network. [4]
(e) Draw a well labelled diagram of a four-port directional coupler showing power flow [4]

Question 7

The S-parameters can be measured using commercial test sets such as the network analyzer.
(a) Draw a diagram that can be used to measure S_{11} and S_{22}. [6]
(b) What is Tee junction with reference to passive microwave components? Give two examples [3]
(c) The block diagram of a wireless receiver front-end is shown in Figure1 below. Compute the overall noise figure of this subsystem. If the input noise power from a feeding antenna is Ni = kT_AB, where T_A = 150 K, find the output noise power in dBm. If we require a minimum signal-to-noise ratio (SNR) of 20 dB at the output of the receiver, what is the minimum signal voltage that should be applied. [8]

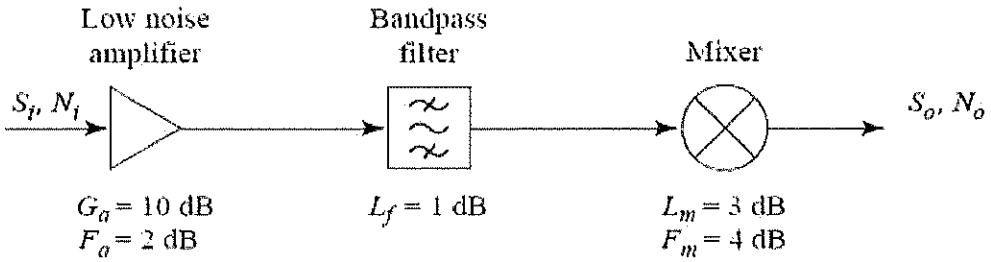


Figure 1Block diagram of a wireless receiver front-end

(d)Using examples of typical applications state what is meant by the term microwave engineering. [3]

END OF EXAMINATION

The Complete Smith Chart

Black Magic Design