Code: AE-20 **Subject: MICROWAVE THEORY & TECHNIQUES**

JUNE 2007

Time: 3 Hours **Max. Marks: 100**

NOTE: There are 9 Questions in all.

- **Question 1 is compulsory and carries 20 marks. Answer to Q. 1. must be written in the space provided for it in the answer book supplied and nowhere else.**
- **Out of the remaining EIGHT Questions answer any FIVE Questions. Each question carries 16 marks.**
- **Any required data not explicitly given, may be suitably assumed and stated.**

Q.1 Choose the correct or best alternative in the following: **(2x10)**

a. Repeller electrode is an essential building block of one of the following microwave tubes:

(A) TWT **(B)** Multicavity klystron
(C) Crossed field amplifier **(D)** Reflex klystron

b. A waveguide when terminated in a certain load has a reflection coefficient of $1/3$. Its VSWR is given by

(A) 3 **(B)** 2
(C) 1 **(D)** 4

c. The distance between adjacent minima and maxima of a standing wave on a slotted line is:

(A) λ **(B)** $\lambda/8$
(C) $\lambda/4$ **(D)** $\lambda/2$

d. A waveguide can be considered as

(A) High pass filter. **(B)** Low pass filter.
(C) Band pass filter. **(D)** Band elimination filter.

e. For measurement of high values of VSWR, we should use:

(A) Single minima method **(B)** Double minima method
(C) Single maxima method **(D)** Double maxima method

f. The main disadvantage of an IMPATT diode is its:

(A) Lower efficiency compared to other microwave diode.
(B) Low power handling capabilities.
(C) High noise.
(D) Inability to provide pulsed operation.

g. Which of the following microwave diodes is suitable for very low power and low noise application

(A) PIN diode. **(B)** TRAPATT diode.
(C) GUNN diode. **(D)** Tunnel diode.

h. The primary purpose of the helix structure in a Travelling Wave Tube (TWT) is to:

(A) Prevent the electron beam from spreading.
(B) Reduce the axial velocity of the RF field.
(C) Ensure broadband operation.
(D) Improve noise figure of the TWT.

i. Large microwave power may be measured with the help of:

(A) Calorimeter. **(B)** Bolometer.
(C) Baretter. **(D)** Thermistor.

j. When compared with stripline, the main disadvantage of microstrip line is:

(A) not amenable for printed circuit technique.
(B) more expensive and complex to manufacture.
(C) going to be more bulkier and voluminous.
(D) more likely to radiate.

Answer any FIVE Questions out of EIGHT Questions.
Each question carries 16 marks.

Q.2 a. Describe any two different methods of power measurement at microwave frequencies. Rank them in order of their performance and accuracy. **(6)**

b. Describe an experimental procedure for measurement of an unknown impedance using a typical microwave bench set up. **(6)**

c. A transmission line has a characteristic impedance of $50+j0.01\Omega$ and is terminated in a load impedance of $73-j42.5\Omega$. Calculate
(i) the reflection coefficient. (ii) the standing wave ratio. **(4)**

Q.3 a. A section of two wire parallel transmission line has a differential length dz. The voltage and current at the input are $v(z,t)$ and $i(z,t)$ respectively. Derive an expression for propagation

constant. Also show that the characteristic impedance of the line is given by $\left[\frac{R+j\omega L}{G+j\omega C}\right]^{1/2}$. **(6)**

b. (i) Calculate the impedance of a quarter wave length transformer if it is to be used for matching a 50Ω source to an 80Ω load impedance.

(ii) Also calculate the length of the transformer section if the circuit is operating at 1GHz and ϵ_r of the medium is 2.25. **(4)**

c. Explain the principle of microwave heating. Which one of the three common tube type devices is most suitable for heating application and why?
(6)

Q.4 a. Why are S-parameters used for microwave circuit measurement or circuit representation instead of conventional Y or Z parameters? Explain. **(4)**

b. What do you understand by a directional coupler? Explain a two hole directional coupler. Also write down its S-matrix. **(6)**

c. Using a neat diagram, explain, how can a four port circulator be realized using magic-tees. **(6)**

Q.5 a. For a reflex klystron oscillator, establish the relationship between the repeller voltage and mode number for a given beam voltage V_o. **(6)**

b. Explain with diagram, the construction and principle of working of a two cavity klystron amplifier. Explain the process of bunching using an "Applegate diagram". **(6)**

c. A helix travelling wave tube operates at 4 GHz under a beam voltage $V_o = 4KV$, and a beam current $I_o = 20mA$. If the helix impedance (Z_o) is 100Ω and the circuit length N = 30, find the output power gain. **(4)**

Q.6 a. Describe the negative resistance property of microwave devices. Show how a Gunn diode works as an amplifier. **(6)**

b. An IMPATT diode has a drift length of $2\mu m$ and drift velocity is of the order of 10^5 m/sec. Determine

(i) drift time of the carriers
(ii) operating frequency of IMPATT diode. **(4)**

c. Explain the operation of a PIN diode, when used as a switch. How can one generate a SPDT

switch using a PIN diode? Explain with the help of a neat diagram. **(6)**

Q.7 a. Why do conventional radars use microwave frequencies as compared to HF/VHF/UHF frequencies? Explain. **(6)**

b. Briefly explain the concept of Duct propagation. **(6)**

c. A microwave terrestrial link of 30 Km long is operating at 4GHz with radiated power of 100 W through a parabolic disk having maximum gain of 50 dB. The receiver uses a similar antenna. Find the
(i) free space loss. (ii) the received power. **(4)**

Q.8 a. Explain using a simple EM analysis that a TE_{10} mode is the dominant mode of propagation in rectangular waveguides. **(6)**

b. Using a neat diagram show how can
(i) a TE_{10} mode and (ii) TE_{01} mode can be excited in a rectangular waveguide. **(4)**

c. A rectangular air filled copper waveguide with dimension 0.9 inch $\times$ 0.4 inch cross-section and 12″ length is operated at 9.2 GHz with a dominant mode. Find
(i) Cut-off frequency (ii) Guide wavelength
(iii) Phase velocity (iv) Characteristic impedance **(6)**

Q.9 a. What do you understand by O-type and M-type tubes for microwave applications? Compare their performance with respect to their construction, bandwidth and operating power. **(6)**

b. Explain the construction of a cylindrical microwave resonator. How are its dimensions related to its resonant frequency of operation? Explain with the aid of a suitable analysis. **(6)**

c. Find the resonant frequencies of first two lowest modes of an air filled rectangular cavity of dimensions 5cm $\times$ 4 cm $\times$ 2.5 cm. **(4)**