53 (EC 601) MWEN

2012C
2013
(May)

MICROWAVE ENGINEERING

Paper : EC 601

Full Marks : 100

Pass Marks : 30

Time : Three hours

The figures in the margin indicate full marks for the questions.

*Answer **any five** questions.*

1. *(a)* If a transmission line of characteristic impedance of $10+j7\Omega$ is terminated by a load of $5+j7\Omega$ then find the reflection coefficient, transmission coefficient and *SWR*. 6

   (b) An airfilled rectangular waveguide has demensions of $a=6\,cm$ and $b=4\,cm$. The signal frequency is *3GHz*. Compute the following for the $T\,E_{10}$ and $T\,M_{11}$ modes.

   (i) Cutoff frequency.

(ii) Wavelength in the waveguide.

(iii) Phase constant and Phase velocity.

(iv) Wave impedance. 10

(c) Show that TM_{01} mode in rectangular waveguide does not exit. 4

2. (a) Why TEM mode is impossible in circular waveguide ? 4

(b) An airfilled circular waveguide is to be operated at a frequency of 6 *GHz* and is to have dimensions such that $f_c = 0.8f$ for the dominant mode $\left(X_{np} = 1.841\right)$. Determine–

(i) The diameter of the guide.

(ii) The wavelength λ_g and phase velocity v_g in the guide.

(iii) Power transmitted if $H\phi = 3 + 4j$ *A/cm* and $H_r = r + 5j$ *A/cm*. 8

(c) What is cavity resonator? How it differs from waveguide ? Explain how standing wave ratio varies in cavity resonator with coupling. 8

3. *(a)* What is an S-matrix ? Why it is required in characterization of microwave hybrid circuits ? 5

(b) What are the different types of tee junctions? Write the S-matrix of each and simplify the S-matrices as much as possible. 15

4. *(a)* A hybrid waveguide is constructed of two identical rectangular waveguides across each other at the centre and works as a four port device. Make the simplified S-matrix for the device. 10

(b) Explain the function of different blocks in a microwave bench. 10

5. *(a)* Explain the velocity modulation process of a reflex Klystron. 10

(b) A two cavity Klystron amplifier has the following parameters :

Beam voltage $= 900V$

Beam current $= 30\ mA$

frequency $= 8GHz$

Gap spacing in both cavities $= 1\ mm$

distance between the centres of the two cavities $= 4\ cm$

Shunt resistance $= 40\ K\Omega$

Efficiency $= 95\%$, Determine –

(i) Initial electron velocity

(ii) Bunching parameter and buncher gap transit angle.

(iii) Optimum length of bunching

(iv) Output power 10

6. (a) A *TWT* operates under the following parameters:

Beam Current $= 50mA$

Beam Voltage $= 2 \cdot 5\ KV$

Characteristic impedance of helix $= 6.75\Omega$

Circuit length $= 45$ Frequency $= 8\,GHz$

Determine–

(i) The gain parameter C.

(ii) The output power gain Ap in dB

(iii) All four propagation constants

(iv) The wave equations for all four modes in expornential form. 12

(b) Derive the Hull cut off magnetic equation of a cylindrical magneticon. 8

7. *(a)* Explain the two valley model theory. 8

(b) A typical *n-type GaAs* Gunn diode has the following parameters :

Threshold field $= 2800\ V/cm$

Applied field $= 3200\ V/cm$

Device length $= 10\mu m$

Doping concentration $= 2 \times 10^{14}\ cm^{-3}$

Operating frequency $= 10\,GHz$. Determine

(i) Electron drift velocity

(ii) Current density

(iii) negative electron mobility. 6

(c) An *IMPATT* diode has the following parameters :

Carrier drift velocity $= 2 \times 10^{7}\ cm/s$

Drift region length $= 6\mu m$

Maximum operating voltage $= 100V$

Maximum operating current $= 200mA$

Efficiency $= 15\%$

Breakdown voltage $= 90V$. Calculate –

(i) The maximum CW output power

(ii) Resonant frequency 6
