Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/M.TECH(ECE)/SEM-2/MCE-204D/2013

2013

MICROWAVE MEASUREMENT TECHNIQUES

Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

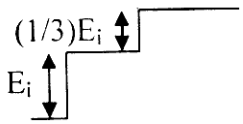
Smith Chart is provided.

Answer Q. No. **1** and any *four* from the rest. 5 × 14 = 70

1. Answer any *seven* of the following : 7 × 2 = 14

a) What are the merits of evaluating a transmission line and its load using Time Domain Reflectometry (TDR) over evaluating the same using a network analyser ?

b) In a TDR, the voltage wave as shown in the figure below was observed. What can you infer on the nature of the load at the end of a transmission line ?



E_i is the amplitude of the step voltage.

c) Write down the limitation of barretters and thermistors as power sensors.

d) How are microwave measurements different from low frequency measurements ?

e) In a microwave power measurement set up, the microwave pulse had an average power of 250 W and a duration of 5 μs. If the time intervals between pulses were measured at 2 ms, determine the value of the peak power.

f) A slotted line is used to measure the frequency and it was found that the distance between nulls is 1·85 cm. Given the guide dimensions as 3 × 1·5 cm, calculate the value of the frequency.

g) What is Thomson *emf* ?

h) Classify microwave power.

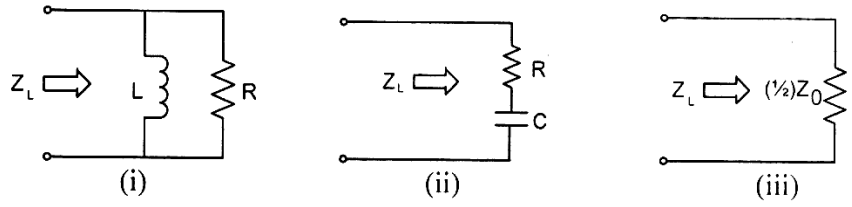
i) Why a coplanar transmission line structure is used for delivering microwave power to the thermocouple chip ?

j) Find the percentage reduction in a detector's sensitivity if the mismatch on the line produces a VSWR of 4 ?

k) What are the advantages of thermocouple power sensor over thermistor power sensor ?

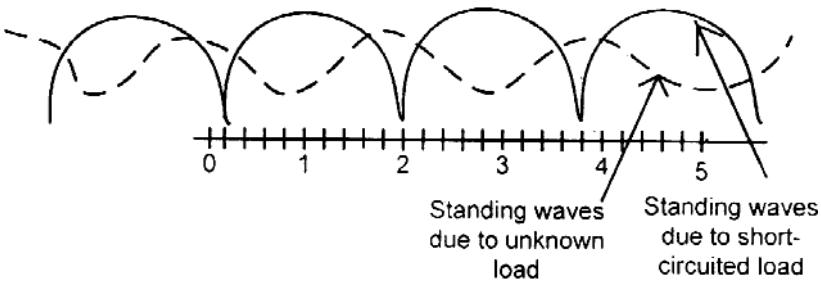
l) Define sensitivity of a thermocouple sensor. Give the typical value of sensitivity of a HP 8481A power sensor.

2. A transmission line of characteristic impedance Z_0 is terminated by (a) a resistive-inductive load; (b) a resistive-capacitive load, and (c) a pure resistive load as shown in the figure below. Explain the nature of the voltage wave obtained in a Time Domain Reflectrometry. 5 + 5 + 4



3. a) Describe a technique of measuring unknown impedance using a slotted line. Use analytical expressions only. 4

b) The experiment was carried out with a 50Ω coaxial slotted line to determine unknown load impedance. The short circuit was placed at the load plane and the voltage minima were recorded at z = 0·2 cm, 2·2 cm, 4·2 cm. The short circuit was then removed and replaced with the unknown load. The standing wave ratio was measured as 1·5 and voltage minima were recorded at z = 0·72 cm, 2·72 cm, 4·72 cm as shown in figure below. Find the load impedance using (a) Smith chart, (b) analytical expression. 5



c) Write down the steps for the measurement of high VSWR (> 10) using double minimum technique. Derive the formula used. 5

4. a) Draw and explain the cross sectional view of a typical thermocouple sensor. 4

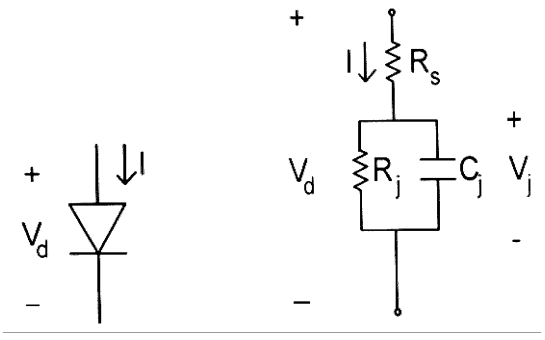
   b) Explain with the help of a schematic diagram, how two thermocouples of 8481A power sensor are electrically connected. Explain the choice of capacitors used. 4

   c) Prepare a short note on power meter for thermocouple sensor along with the proper block diagram. 6

5. a) Explain balanced bolometer bridge technique for the measurement of low microwave power. 7

   b) Explain the calorimetric method (flow type) of medium power measurement. 7

6. A diode used in a detector has the equivalent circuit model given in the figure below. Assuming the input signal is unmodulated, determine β_i (current sensitivity) and β_v (voltage sensitivity) assuming the diode is biased at (I_0, V_0). 14



7. a) An AM-modulated RF signal (modulated by an audio signal) is given by $V_{RF}(t) = v_m(1 + m\cos\omega_m t)\cos\omega_0 t$, where m is the modulation index, v_m the amplitude of the input signal, ω_m the angular frequency of an audio signal and ω_0 the angular frequency of the RF carrier wave. This signal is fed to a diode detector circuit. Explain how this diode detector is able to recover the audio signal. 5

b) Explain three types of detector losses. 3

c) Draw a typical diode detector's output characteristic curve and mark different regions. Mention the typical range of input signal power so that the diode detector operates in the square law region. 2

d) The VSWR in a guide feeding a detector is 4. What is the power loss due to this mismatch ? What is the return loss ? 2

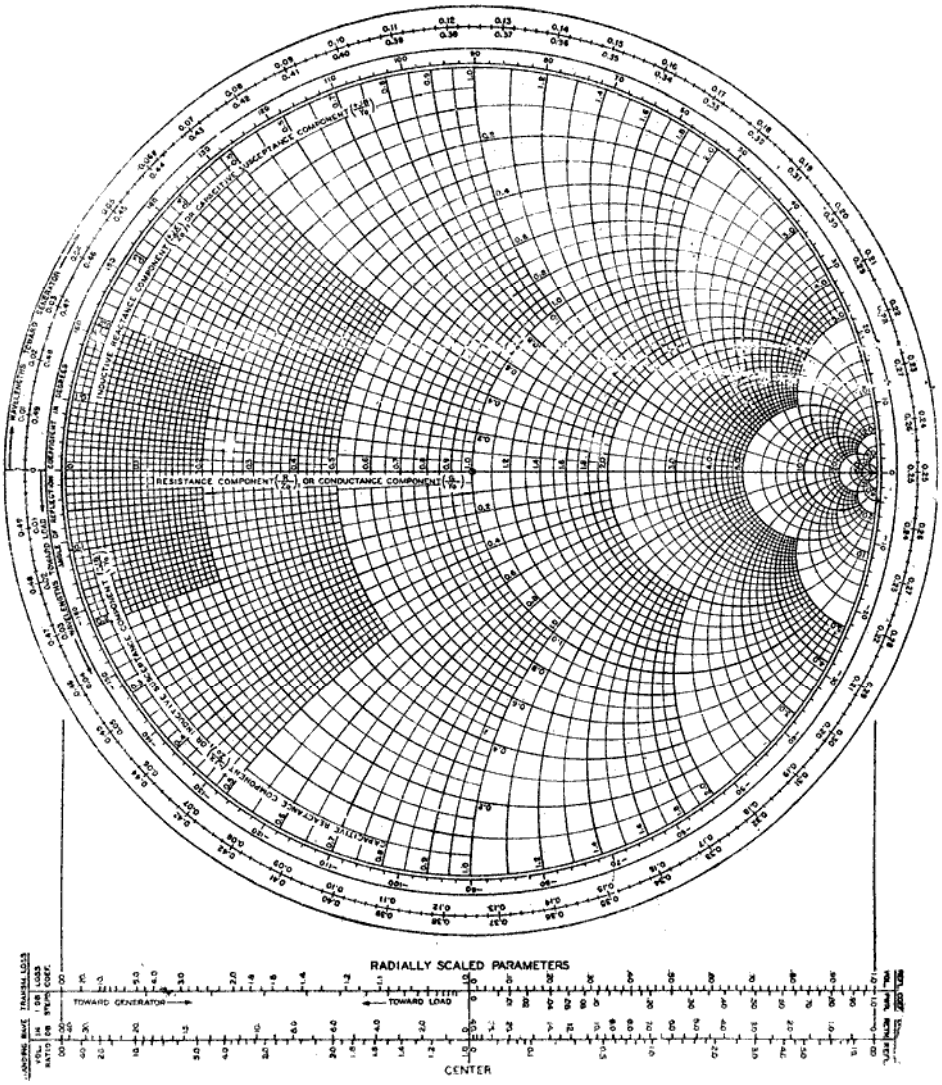
e) What are the advantages of using a Schottky diode detector over ordinary diode detector at microwave frequencies ? 2

8. a) Explain with the help of a functional block diagram, the basic operation of a spectrum analyser. 9

b) In a spectrum analyser, selectivity is the key in determining the resolution of unequal amplitude signals. Elucidate. 5

SMITH-CHART

IMPEDANCE OR ADMITTANCE COORDINATES



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