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M.E./M.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2023.

Second Semester

Communication Systems

CU 4201 – MICROWAVE INTEGRATED CIRCUITS

(Regulations 2021)

Time : Three hours Maximum : 100 marks

Approved ZY Smith Chart, Z Smith Chart, Chebyshev filter design table for 0.5dB.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Measurements using the slotted line for unmatched load show $V_{max} = 2.0$ and $V_{min} = 0.5V$. Compute the VSWR and magnitude of the reflection coefficient.

2. The S matrix for a coupler is given below. Justify whether the matrix is lossless and reciprocal.

$$[s] = \frac{-1}{\sqrt{2}} \begin{bmatrix} 0 & j & 1 & 0 \\ j & 0 & 0 & 1 \\ 1 & 0 & 0 & j \\ 0 & 1 & j & 0 \end{bmatrix}$$

3. Determine the transmission matrix for the network shown in Fig. 1.

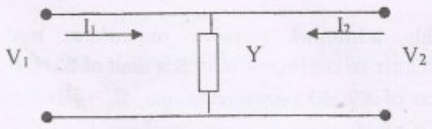

Figure 1

4. Sketch the RF equivalent circuit for resistor and capacitor.

5. Define unconditional stability with regards to microwave transistor amplifier.

6. Why are sustained oscillations produced in an oscillator?

7. Sketch the circuit for the double-balanced mixer.

8. Compare linear and non-linear mixer.

9. Why is alumina preferred as ceramic material over other materials in MIC fabrication?

10. List any four advantages of hybrid MIC technology.

PART B — (5 × 13 = 65 marks)

11. (a) (i) Consider a lossless two-port network

(1) If the network is reciprocal, show that $|S_{21}|^2 = 1 - |S_{11}|^2$

(2) If the network is non-reciprocal, it is impossible to have unidirectional transmission $S_{12} = 0$. (7)

(ii) A transmission line terminated with unknown load impedance exhibits a Voltage Standing Wave Ratio of 12. and the line's characteristic impedance is 75 ohms. Determine the unknown load impedance. Assume the signal propagates with a wavelength of 3 cm with free space velocity, length of the line is 100 cm. (6)

Or

(b) (i) Derive the S matrix for a Power divider. (5)

(ii) Apply unitary, symmetry and matched properties to a four-port directional coupler and conclude its scattering parameters as $[S] = \begin{bmatrix} 0 & \alpha & j\beta & 0 \\ \alpha & 0 & 0 & j\beta \\ j\beta & 0 & 0 & \alpha \\ 0 & j\beta & \alpha & 0 \end{bmatrix}$, where α and β are constants. (8)

12. (a) Design any two possible 2-lumped element impedance matching circuits(L-type) using ZY-chart to conjugate match a load of 25+j50 ohms with a source impedance of 60-j40 ohms. Assume $Z_0 = 50$ ohms and frequency of operation as 2.4 GHz.

Or

(b) Draw the equivalent circuit of an Inductor when operated at RF frequencies and interpret the design formulae for all its components.

13. (a) Draw the input stability circles for the following specifications and conditions:

(i) For $|S_{22}| < 1$, and $|C_{in}| > |r_{in}|$

(ii) For $|S_{22}| < 1$, and $|C_{in}| < |r_{in}|$

(iii) For $|S_{22}| > 1$, and $|C_{in}| > |r_{in}|$

(iv) For $|S_{22}| > 1$, and $|C_{in}| < |r_{in}|$

Mark the stability regions in respective conditions. Mention your assumptions.

Or

(b) (i) Design a transistor-based Hartley oscillator with a center frequency of 1.5 GHz and a transistor gain of 40. (6)

(ii) Summarize the design procedure for the RF oscillator that meets the stability requirements. (7)

14. (a) Choose at least three pairs of RF and Image frequencies when the local oscillator frequency is 5 GHz, and the intermediate frequency is 70 MHz. Assume the LO frequency is higher than the RF frequency. Determine the cut-off frequencies for an RF BPF that needs to be inserted to avoid the image frequencies for the frequency pairs chosen by you.

Or

(b) (i) Sketch and explain in detail the operation of single-ended and balanced mixers. State their relative merits and demerits. (7)

(ii) Discuss the operation of the image-reject mixer in detail and explain how it can reject image frequencies. (6)

15. (a) (i) How do materials play a significant role in the fabrication of MIC components? (4)

(ii) Compare Hybrid and Monolithic MICs in detail. (3)

(iii) Compare and analyze the test fixture, probe station and thermal and cryogenic measurements. (6)

Or

(b) Discuss the process flow of fabricating a hybrid Monolithic integrated circuit in detail. Highlight the features specifically.

PART C — (1 × 15 = 15 marks)

16. (a) The S parameter for the HP HBJFET GaAs FET at 2.45 GHz with a bias voltage $V_{gs} = 0$ characteristic impedance = 50 ohms are given as follows:

$S_{11} = 0.894 \angle -60.6^9$, $S_{12} = 0.020 \angle 63.4^9$,

$S_{21} = 3.122 \angle 123.6^9$ and $S_{22} = 0.781 \angle -27.6^9$

Determine the stability of this transistor using $k - \Delta$ the test and the μ test. Comment on the plot.

Or

(b) It is required to design a high pass filter to reject specific unwanted image frequencies in a satellite receiver. The cut-off frequency of the filter is 5 GHz. It should provide attenuation of 15 dB at 4.5 GHz. Up to 3 dB ripple in the pass band is permitted. The source attenuation is 75 Ω. Design the above Chebyshev filter and draw the circuit diagram.