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# VIT

Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)
CHENNAI

## Final Assessment Test(FAT) - NOV/DEC 2025

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|---|---|---|---|
| Programme | **B.Tech.** | Semester | **Fall Semester 2025-26** |
| Course Code | **BECE305L** | Faculty Name | **Prof. Usha Kiran Kommuri** |
| Course Title | **Antenna and Microwave Engineering** | Slot | **A1+TA1** |
| | | Class Nbr | **CH2025260101074** |
| Time | **3 hours** | Max. Marks | **100** |

**Instructions To Candidates**

- Write only your registration number in the designated box on the question paper. Writing anything elsewhere on the question paper will be considered a violation.
- Use Smith Chart where ever applicable. .

**Course Outcomes**

CO1: Examine the radiation mechanism of electromagnetic fields and identify the various antenna parameters.
CO2: Apply the design criteria to Linear, HF, UHF, microwave antenna and arrays.
CO3: Comprehend the performance of different microwave sources and ferrite devices.
CO4: Design and analyze the passive components at microwave frequencies.
CO5: Design and analyze the various passive circuits at microwave frequencies.
CO6: Infer the importance of high frequency transistors to design microwave amplifiers.

### Section - I

**Answer all Questions (5 × 5 Marks)**

01. Two spacecrafts are separated by 3000 km . Each has an antenna with directivity, D = 200 operating at 2 GHz. If craft A's receiver requires 20 dB over 1 pW, what transmitter power is required on craft B to achieve this signal level? [5] (CO1/K3)

02. Describe how a phased array antenna is used in radar and 5G communication systems. Mention the advantages over conventional antennas. [5] (CO2/K2)

03. Discuss the design considerations of the frequency independent spiral antennas . [5] (CO2/K2)

04. Explain the major applications of microwave devices circulator and directional coupler in the communication, industry and medicine. Discuss the advantages of using a microwave over conventional frequency range for this applications. [5] (CO4/K2)

05. Compare Wilkinson and T-junction power divider based on isolation, matching, insertion loss and bandwidth. If an application needs a high isolation requirement, which one would you suggest and why? [5] (CO5/K2)

### Section - II

**Answer all Questions (6 × 10 Marks)**

06. . If the normalized radiation intensity of an antenna is symmetric in φ direction, and it is represented by:

$$U = \begin{cases} 1 & 0^\circ \le \theta < 30^\circ \\ 0.5 & 30^\circ \le \theta < 60^\circ \\ 0.1 & 60^\circ \le \theta < 90^\circ \\ 0 & 90^\circ \le \theta \le 180^\circ \end{cases}$$

i) Find out the directivity of the antenna in dB. [7 Marks]
ii) Determine the maximum effective area (in $m^2$) of the antenna if the frequency of operation is 12 GHz. [3 Marks]

[10] (CO1/K4)

07. Determine the length and spacing for the 7 element Yagi-Uda antenna operating at 800MHz. Sketch the Yagi Uda antenna
i) Spacing between the elements [4 marks]
ii) Lengths of the elements [4 marks]
iii) Yagi Uda antenna Sketch [2 marks]

[10] (CO2/K3)

08. A uniform array of 3 elements is designed so that its maximum is directed toward broadside. The spacing between the elements is $\lambda/2$.
Determine
(i) all the angles (in degrees) where the nulls will occur. [3 marks]
(ii) all the angles (in degrees) where all the maxima will occur. [ 3 Marks]
(iii) the half-power beamwidth (in degrees). [2 Marks]
(iv) directivity (dimensionless and in dB). [2 Marks]

[10] (CO2/K3)

09. With the help of a neat diagram, explain the working principle of a two-cavity klystron amplifier. Elaborate on the process of velocity modulation in the input cavity and how this leads to bunch formation of electrons in the drift region.

[10] (CO3/K2)

10. For the given transistor, the scattering parameters are as follows.
$S_{11} = 0.385\angle-55°$ $\quad S_{12} = 0.385\angle 90°$
$S_{21} = 2.7\angle-78°$ $\quad S_{22} = 0.89\angle-26.5°$
Check if the case is stable or potentially unstable, with proper justification and draw the stability circles using smith chart.

[10] (CO6/K4)

11. Design a stepped-impedance low-pass filter having a maximally flat response and a cutoff frequency of 3.0 GHz. It is desired to have more than 20 dB insertion loss at 5.0 GHz. The filter impedance is 50 Ω; the highest practical line impedance is 150 Ω, and the lowest impedance is 30 Ω. Use the values given in Table 1 and Figure 1.

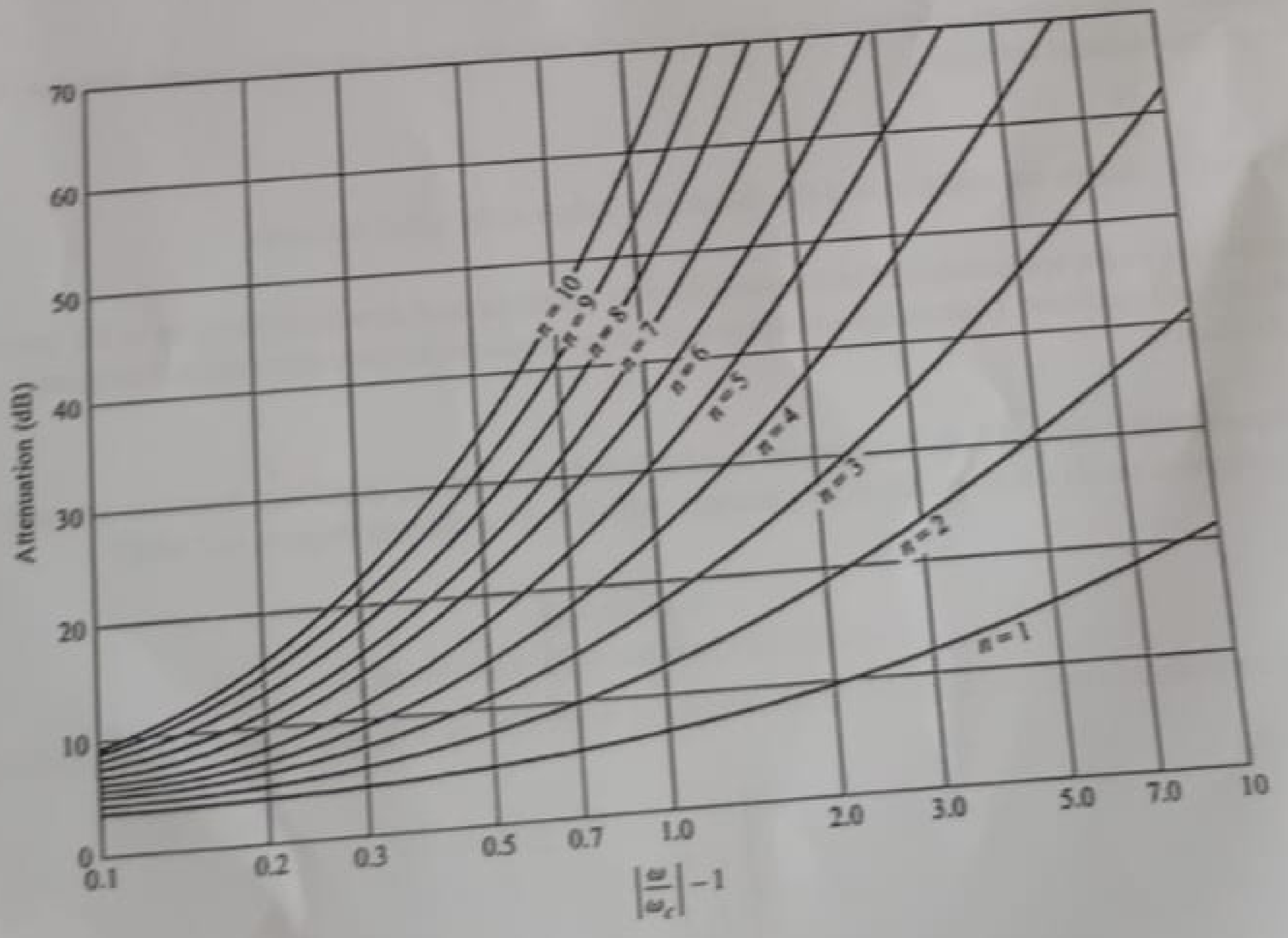


Figure 1

Table 1

TABLE Element Values for Maximally Flat Low-Pass Filter Prototypes ($g_0 = 1$, $\omega_c = 1$, $N = 1$ to 10)

| $N$ | $g_1$ | $g_2$ | $g_3$ | $g_4$ | $g_5$ | $g_6$ | $g_7$ | $g_8$ | $g_9$ | $g_{10}$ | $g_{11}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.0000 | 1.0000 | | | | | | | | | |
| 2 | 1.4142 | 1.4142 | 1.0000 | | | | | | | | |
| 3 | 1.0000 | 2.0000 | 1.0000 | 1.0000 | | | | | | | |
| 4 | 0.7654 | 1.8478 | 1.8478 | 0.7654 | 1.0000 | | | | | | |
| 5 | 0.6180 | 1.6180 | 2.0000 | 1.6180 | 0.6180 | 1.0000 | | | | | |
| 6 | 0.5176 | 1.4142 | 1.9318 | 1.9318 | 1.4142 | 0.5176 | 1.0000 | | | | |
| 7 | 0.4450 | 1.2470 | 1.8019 | 2.0000 | 1.8019 | 1.2470 | 0.4450 | 1.0000 | | | |
| 8 | 0.3902 | 1.1111 | 1.6629 | 1.9615 | 1.9615 | 1.6629 | 1.1111 | 0.3902 | 1.0000 | | |
| 9 | 0.3473 | 1.0000 | 1.5321 | 1.8794 | 2.0000 | 1.8794 | 1.5321 | 1.0000 | 0.3473 | 1.0000 | |
| 10 | 0.3129 | 0.9080 | 1.4142 | 1.7820 | 1.9754 | 1.9754 | 1.7820 | 1.4142 | 0.9080 | 0.3129 | 1.0000 |

*Source:* Reprinted from G. L. Matthaei, L. Young, and E. M. T. Jones, *Microwave Filters, Impedance-Matching Networks, and Coupling Structures*, Artech House, Dedham, Mass., 1980, with permission.

[10] (CO5/K4)

## Section - III

**Answer all Questions (1 × 15 Marks)**

12. a) A directional coupler has the following S-parameters. Calculate the coupling coefficient, insertion loss, isolation and directivity in dB. [8 marks]

$$S = \begin{bmatrix} 0 & 0.92\angle 0^\circ & 0.32\angle -90^\circ & 0.03\angle 180^\circ \\ 0.92\angle 0^\circ & 0 & 0.03\angle 170^\circ & 0.32\angle -90^\circ \\ 0.32\angle -90^\circ & 0.03\angle 170^\circ & 0 & 0.92\angle 0^\circ \\ 0.03\angle 180^\circ & 0.32\angle -90^\circ & 0.92\angle 0^\circ & 0 \end{bmatrix}$$

b) i) What modification is expected to convert circulator into isolator? [2 marks]
ii) Is an isolator a matched, reciprocal, and lossless device? Justify your answer using its S-parameters and mention a practical application.[5 marks].

Some formula:

$$C_L = \frac{(S_{22} - \Delta S_{11}^*)^*}{|S_{22}|^2 - |\Delta|^2}$$

$$R_L = \left| \frac{S_{12}S_{21}}{|S_{22}|^2 - |\Delta|^2} \right|$$

$$C_S = \frac{(S_{11} - \Delta S_{22}^*)^*}{|S_{11}|^2 - |\Delta|^2}$$

$$R_S = \left| \frac{S_{12}S_{21}}{|S_{11}|^2 - |\Delta|^2} \right|$$

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2|S_{12}S_{21}|}$$

$$|\Delta| = |S_{11}S_{22} - S_{12}S_{21}| < 1$$

[15] (CO4/K4)