ECT401	MICROWAVES AND ANTENNAS	CATEGORY	L	T	P	CREDIT
		PCC	2	1	0	3

Preamble: This course aims to impart knowledge on the basic parameters of antenna, design and workingofvariousbroad band antennas,arraysand itsradiationpatterns.It also introduces various microwave sources, their principle of operation and study of various microwave hybrid circuits and microwave semiconductor devices.

Prerequisite: ECT 302 ELECTROMAGNETICS

Course Out Comes: After the completion of the course the student will be able to:

CO1-K2	Understand the basic conceptofantennas anditsparameters.
CO2-K3	Analyzethe far filed pattern of Short dipole and Half wave dipole antenna.
CO3-K3	Design of various broad band antennas, arrays and its radiation patterns.
CO4-K2	Illustratethe principle of operation of cavity resonators and various microwave sources.
CO5-K2	Explain various microwave hybrid circuits and microwave semiconductor devices.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3		1								2
CO2	3	3	3	1	2							2
CO3	3	3	3	1	3							2
CO4	3	3	2	1								2
CO5	3	3	2	1								2

Assessment Pattern:

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember			
Understand K2	20	20	40
Apply K3	30	30	60
Analyse			
Evaluate			
Create			

Mark distribution:

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 Hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern

Maximum Marks: 100 **Time: 3 hours**

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define isotropic radiator and derive the expression for its electric field strength.
2. Explain the terms
   i) Antenna temperature ii) Antenna efficiency iii) Beam efficiency
   iv) Radiation pattern v) Antenna Polarization
3. Show that the directivity of a half wave dipole is 4 (from the expression for average power).
4. Find the radiation intensity of a current element with corresponding field strength in the direction of maximum radiation of $E_m = \frac{60}{r\sqrt{80}}\ V/m$

Course Outcome 2 (CO2):

1. Show that the directivity of a half wave dipole is 4 (from the expression for average power).
2. Derive expressions for the Far Field components and Radiation Resistance and Directivity of a short dipole antenna.
3. State and Prove Reciprocity Theorem.

Course Outcome 3 (CO3):

1. Derive the relation for normalized electrical field in the case of ‘n’ isotropic array sources $En = (AF)_n$.
2. Explain the working of a horn antenna. Write down the expression for gain, HPBW and BWFN.
3. Design an Endfire Array and plot its radiation pattern.
4. Design a LPDA with τ = 0.85, σ = 0.03 for the frequency range 15-45 MHz.

Course Outcome 4 (CO4):

1. Determine the resonant frequency of an air filled rectangular cavity operating in the dominant mode with dimensions as,a=4cm, b=5cm and d=6cm.
2. Derive power output and efficiency of a reflex klystron.
3. What is the significance of slow wave structures used in microwave circuits?Explain different slow wave structures with neat sketches.
4. With neat diagram explain the operation of a travelling wave tube.
5. With the help of figures explain the bunching process of an 8-cavity cylindrical magnetron.

Course Outcome 5 (CO5):

1. Explain S-parameters and its properties.
2. With a schematic describe the operation of a four port circulator. Obtain the simplified S matrix of a perfectly matched, lossless four port circulator.
3. Explain RWH theory of Gunn Oscillation.
4. Define Gunn Effect and with the help of figures explain different modes of operation of Gunn diode.

Syllabus

Module	Course contents	Hours
I	**Basic antenna parameters:** gain, directivity, beam width and effective aperture calculations, effective height, wave polarization, radiation resistance, radiation efficiency, antenna field zones. Duality and Principles of reciprocity, Helmholtz theorem (derivation required), Field, directivity and radiation resistance of a short dipole and half wave dipole (far field derivation).	7
II	**Broad band antenna:** Principle of Log periodic antenna array and design, Helical antenna: types and design. Designof Microstrip RectangularPatchantennas and feeding methods. Principles of Horn, Parabolic dish antenna (expression for E, H and Gain without derivation), Mobile phone antenna – Inverted F antenna.	6
III	**Arrays of point sources**, field of two isotropic point sources, principle of pattern multiplication, linear arrays of 'n' isotropic point sources. Array factor, Grating lobes.DesignofBroadside,End fire andDolph Chebyshevarrays. Concept of Phase array.	8
IV	**Microwaves:**Introduction, advantages, Cavity Resonators- Derivation of resonance frequency of Rectangular cavity. **Single cavity klystron- Reflex Klystron** Oscillators: Derivation of Power output, efficiency and admittance. **Magnetron oscillators:** Cylindrical magnetron, Cyclotron angular frequency, Power output and efficiency.**Travelling Wave Tube:** Slow wave structures, Helix TWT,Amplification process, Derivation of convection current, axialelectric field, wave modes and gain.	8

V	**Microwave Hybrid circuits**: Scattering parameters, Waveguide Tees- Magic tees, Hybrid rings.Formulation of S-matrix.Directional couplers: Two hole directional couplers, S-matrix. Circulators and Isolators. Phase Shifter. **Microwave Semiconductor Devices**: Amplifiers using MESFET. Principle of Gunn diodes: Different modes, Principle of operation Gunn Diode Oscillators.	6

Text Books:

1. Balanis, Antenna Theory and Design, 3/e, Wiley Publications.
2. John D. Krauss, Antennas for all Applications, 3/e, TMH.
3. K D Prasad, Antenna and Wave Propagation, Satyaprakash Publications
4. Samuel Y. Liao, Microwave Devices and Circuits, 3/e, Pearson Education, 2003.
5. Robert E. Collin, Foundation of Microwave Engineering, 2/e, Wiley India, 2012.

References:

1. Collin R.E, Antennas & Radio Wave Propagation, McGraw Hill. 1985.
2. Jordan E.C. & K. G. Balmain, Electromagnetic Waves & Radiating Systems, 2/e, PHI.
3. Raju G.S.N., Antenna and Wave Propagation, Pearson, 2013.
4. Sisir K.Das& Annapurna Das, Antenna and Wave Propagation, McGraw Hill,2012
5. Thomas A.Milligan, Modern Antenna Design, IEEE PRESS, 2/e, Wiley Inter science.
6. Das, Microwave Engineering, 3/e, McGraw Hill Education India Education , 2014
7. David M. Pozar, Microwave Engineering,4/e, Wiley India, 2012.

Course Contents and Lecture Schedule.

No	Topic	No.of. Lectures
	Module I	
1.1	Basicantennaparameters (all parameters and related simple problems), Relation between parameters (derivation required)	**2**
1.2	Principlesofreciprocity (proof required), Duality. Conceptofretardedpotential	**1**
1.3	Helmholtz theorem (derivation required)	
1.4	Derivation of Field, directivity and radiation resistance of a short dipole	**2**
1.5	Derivation of Field, directivity and radiation resistance of a half wave dipole.	**2**
	Module II	
2.1	Principle of Log periodic antenna array and design, Helical antenna: types and design	**2**
2.2	Design of Rectangular Patch antennas and feeding techniques	**2**
2.3	Principles of Horn,Parabolic dish antenna, (expression for E, H, G without derivation).	**1**
2.4	Mobile phone antenna – Inverted F antenna.	**1**
	Module III	

3.1	Arrays of point sources, field of two isotropic point sources, principle of pattern multiplication	**2**
3.2	Linear arrays of 'n' isotropic point sources. Grating lobes. Array factor (derivation)	**2**
3.3	Design of Broadside, End fire and Dolph Chebyshev arrays.	**3**
3.4	Concept of Phase array.	**1**
	Module IV	
4.1	**Microwaves:**Introduction, advantages, Cavity Resonators-Types, Derivation of resonance frequency of Rectangular cavity (problems required)	**1**
4.2	**Single cavity klystron- Reflex Klystron** Oscillators: Derivation of Power output, efficiency and admittance.(problems required)	**2**
4.3	**Magnetron oscillators:** Cylindrical magnetron, Cyclotron angular frequency, Power output and efficiency.(problems required)	**2**
4.4	**Travelling Wave Tube:** Slow wave structures, Helix TWT,Amplification process, Derivation of convection current, axialelectric field, wave modes and gain. (problems required)	**3**
	Module V	
5.1	**Microwave Hybrid circuits**: Scattering parameters, Waveguide Tees- Magic tees, Hybrid rings.Formulation of S-matrix.	**1**
5.2	Directional couplers: Two hole directional couplers, S-matrix. Circulators and Isolators. Phase Shifter.	**2**
5.3	**Microwave Semiconductor Devices**: Amplifiers using MESFET.	**1**
5.4	Principle of Gunn diodes: Different modes, Principle of operation Gunn Diode Oscillators.	**2**

Simulation Assignments (ECT 401)

The following simulation assignments can be done with MATLAB/HFSS/CST Microwave Studioor any Open software.

- Simulation of radiation pattern of
    a) Microstrip patch antenna
    b) Arrays
    c) Helical antenna

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B. TECH DEGREE EXAMINATION

Course Code: ECT401

Course Name: MICROWAVES AND ANTENNAS

Max. Marks:100 Duration: 3 Hours

PART A

(*Answer All Questions*)

1	Derive an expression for aperture area of an antenna.	(3)
2	(i) Obtain the radiation resistance of a thin dipole antenna of length λ/15.	(3)
	(ii) Find HPBW of an antenna which has a field given by: $E(\theta) = Cos^2\theta, for\ 0 \le \theta \le 90^0$.	
3	Why Log Periodic antenna is called as Frequency Independent antenna, explain?	(3)
4	Briefly explain about Inverted F antenna.	(3)
5	Explain (i) Pattern Multiplication (ii) Grating lobes	(3)
6	Demonstrate the working principle of Phase Arrays.	(3)
7	Derive the resonant frequency of a rectangular cavity resonator.	(3)
8	What are re-entrant cavities? Show that they support infinite number of resonant frequencies.	(3)
9	Explain with figure a ferrite isolator can support only forward direction waves.	(3)
10	Write a short note on Phase shifter.	(3)

PART B

(*Answer one question from each module. Each question carries 14 marks*)

MODULE I

11 a)	Define the terms (i) Retarded potential (ii) Antenna field zones	(4)
b)	Derive expressions for the Far Field components and Radiation Resistance and Directivity of a short dipole antenna.	(10)

OR

12a)	State and prove Helmholtz theorem	(7)
b)	(i) Compute the radiation resistance, power radiated and efficiency of an antenna having total resistance of 50Ω and effective height of 69.96m and a current of 50A (rms) at 0.480MHz. (ii) Calculate the effective aperture of a short dipole antenna operating at 100 MHz.	(7)

MODULE II

13 a) Explain the working of a parabolic dish antenna. Write down the expression for gain, HPBW and BWFN. (6)

b) Design a rectangular microstrip antenna using a dielectric substrate with dielectric constant of 2.2, h = 0.1588 cm so as to resonate at 10 GHz. (8)

OR

14 a) Explain the working of a Log periodic dipole array and explain its design steps. (7)

b) Explain axial mode helical antenna. Write down the expression for gain, HPBW,BWFN and radiation resistance of axial mode helical antenna. (7)

MODULE III

15 Derive expression for array factor of N isotropic sources for end-fire array and also the expression for major lobe, minor lobes and Nulls of the array. (14)

OR

16 a) Explain Chebyshev array and write down the expression for array factor. (7)

b) Design a Broadside Array and plot its radiation pattern. (7)

MODULE IV

17a) A reflex klystron operates under the following conditions: Vo=500V, Rsh =10KΩ, fr= 8 GHz, L=1 mm, e/m = l.759 x 1011 (MKS system) The tube is oscillating at fr at the peak of the n = 2 or mode. Assume that the transit time through the gap and beam loading to be neglected. Determine: - (7)

(a) The value of the repeller voltage Vr.
(b) The direct current necessary to give a microwave gap voltage of 200V.
(c) The electronic efficiency under this condition.

b) Assuming pi mode of oscillations explain how a magnetron can sustain its oscillations using the cross field. (7)

OR

18 a) Show that the axial electric field of TWT varies with convection current. (7)

b) Explain the electronic admittance of the gap in the case of reflex klystron. With admittance diagram explain the condition required for oscillation in a reflex Klystron. (7)

MODULE V

19 a) Explain the working of a microwave amplifiers using MESFET (8)

b) Explain the constructional features of two-hole directional coupler and derive the S Matrix. (6)

OR

20 a) Draw the J-E characteristics of Gunn diode and explain its operation. (10)

b) Discuss the constructional features of magic tees and derive its S Matrix. Why are they called so? (4)