KSIT BANGLORE

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

COURSE FILE

NAME OF THE STAFF : **Dr.B.SUREKHA**

SUBJECT CODE/NAME : **17EC71/MICROWAVES AND ANTENNAS**

SEMESTER/YEAR : **7th Sem/4th Year**

ACADEMIC YEAR : **2020 – 2021**

BRANCH : **ECE (A & B)**

COURSE IN-CHARGE	**MODULE COOORDINATOR**	**HOD**

K. S. INSTITUTE OF TECHNOLOGY

VISION

"To impart quality technical education with ethical values, employable skills and research to achieve excellence".

MISSION

- To attract and retain highly qualified, experienced & committed faculty.
- To create relevant infrastructure.
- Network with industry & premier institutions to encourage emergence of new ideas by providing research & development facilities to strive for academic excellence.
- To inculcate the professional & ethical values among young students with employable skills & knowledge acquired to transform the society.

DEPARTMENT OFELECTRONICS & COMMUNICATION ENGINEERING

VISION

"To achieve excellence in academics and research in Electronics & Communication Engineering to meet societal need".

MISSION

- To impart quality technical education with the relevant technologies to produce industry ready engineers with ethical values.
- To enrich experiential learning through active involvement in professional clubs & societies.
- To promote industry-institute collaborations for research & development.

K.S. INSTITUTE OF TECHNOLOGY

Department: Electronics and Communication Engg.

PROGRAM EDUCATIONAL OBJECTIVES (PEO'S)

- Excel in professional career by acquiring domain knowledge.
- Motivation to pursue higher Education & research by adopting technological innovations by continuous learning through professional bodies and clubs.
- To inculcate effective communication skills, team work, ethics and leadership qualities.

PROGRAM SPECIFIC OUTCOMES(PSO'S)

:Graduate should be able to understand the fundamentals in the field of Electronics & Communication and apply the same to various areas like Signal processing, embedded systems, Communication &Semiconductor technology.

Graduate will demonstrate the ability to design, develop solutions for Problems in Electronics & Communication Engineering using hardware and software tools with social concerns.

1) Graduates will be in a position to apply knowledge of mathematics, science & Engineering subjects as applicable to Electronics & Communication engineering.

2) In the fast changing scenario of technical & business ecosystem, the graduates will understand the necessity for quality , punctuality, continuous learning and adopt themselves accordingly.

3) Graduates will have ability to design & analyze high / low power electronic modules using discrete components and integrated circuits.

4) Graduates will have ability to design logic circuits using processors, controllers & hardware description languages.

5) Graduates will have ability to design & control multidisciplinary systems.

6) Graduates will have ability to design, construct & analyze high and low frequency communication devices.

7) Graduates will have ability to design and configure secured data communication networks for short &long haul applications.

8) Graduates will gain knowledge of professional, ethical and managerial aspects with effective communication skills.

9) Graduates will demonstrate the ability to design & develop algorithms by using different programming skills and EDA tools.

10) Graduates will acquire & understand the impact of engineering solutions on social, cultural, economic, global & environmental aspects.

11) Graduates will be able to address complex computational problems.

12)Graduates will to be aware of the dynamic landscapeof the technological field and adapt to changing scenarios.

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#14, Raghuvanahalli, Kanakapura Main Road, Bengaluru-5600109

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

Course: MICROWAVES AND ANTENNAS			
Course Incharge: Dr.B.Surekha			
Type: Core Academic Year: 2020-21		**Course Code:17EC71**	
No of Hours per week			
Theory (Lecture Class)	Practical/Field Work/Allied Activities	Total/Week	Total teaching hours
4	0	4	52
Marks			
Internal Assessment	Examination	Total	Credits
20	80	100	4

Aim/Objective of the Course:

This course enables students to:

- Describe the microwave properties and its transmission media
- Analyze various parameters related to microwave transmission lines and devices
- Identify microwave devices for several applications
- Analyze various antenna parameters necessary for building an RF system
- Recommend various antenna configurations according to the applications

Course Learning Outcomes:
After completing the course, the students will be able to

CO1	**Apply** Smith charts to find solutions to transmission line problems.	Applying (K3)
CO2	**Analyze** passive microwave devices using S-parameters	Analyzing (K4)
CO3	**Evaluate** various parameters and characteristics of the microwave strip lines and devices.	Evaluating (K5)
CO4	**Estimate** radiation patterns and performance parameters of n-isotropic antennas	Evaluating (K5)
CO5	**Recommend** various antenna configurations based on application	Evaluating (K5)

Syllabus Content:	
Module 1 **Microwave Tubes:** Introduction, Reflex Klystron Oscillator, Mechanism of Oscillations, Modes of Oscillations, Mode Curve **Microwave Transmission Lines:** Microwave Frequencies, Microwave devices, Microwave Systems, Transmission Line equations and solutions, Reflection Coefficient and Transmission Coefficient, Standing Wave and Standing Wave Ratio, Smith Chart, Single Stub matching. LO: At the end of this session the student will be able to, 1. Understand working of Reflex Klystron Oscillator 2. Explain the characteristics of microwave transmission lines 3. Apply Smith charts to find solutions to impedance matching problems.	**CO1, CO3 10 hrs** PO1-3 PO2-2 PO3-1 PO5-1 PO9-2 PO10-1 PSO1-3
Module 2: **Microwave Network theory:** Symmetrical Z and Y-Parameters for Reciprocal Networks, S matrix representation of Multi-Port Networks. **Microwave Passive Devices:** Coaxial Connectors and Adapters, Attenuators, Phase Shifters, Waveguide Tees, Magic tees. LO: At the end of this session the student will be able to, 1. Differentiate Z,Y and S parameters 2. Derive S Matrix for Attenuators, phase shifters and waveguide Tees 3. Compare different Coaxial connectors	**CO2 10hrs** PO1-3 PO2-2 PO3-1 PO5-1 PO9-2 PO10-1 PSO1-3
Module 3: **Strip Lines:** Introduction, Micro Strip lines, Parallel Strip lines, Coplanar Strip lines, Shielded Strip Lines. **Antenna Basics**: Introduction, Basic Antenna Parameters, Patterns, Beam Area, Radiation Intensity, Beam Efficiency, Directivity and Gain, Antenna Apertures, Effective Height, Bandwidth, Radio Communication Link, Antenna Field Zones & Polarization. LO: At the end of this session the student will be able to, 1. Understand the types and working of strip lines 2. Analyze various parameters related to microwave transmission lines 3. Understand antenna performance characteristics Analyze Radio communication Links, zones and polarization techniques	**CO3, CO4 10 hrs** PO1-3 PO2-2 PO3-1 PO5-1 PO9-2 PO10-1 PSO1-3
Module 4: **Point Sources and Arrays**: Introduction, Point Sources, Power Patterns, Power Theorem, Radiation Intensity, Field Patterns, Phase Patterns, Arrays of Two Isotropic Point Sources, Pattern Multiplication, Linear Arrays of n Isotropic Point Sources of equal Amplitude and Spacing **Electric Dipoles:** Introduction, Short Electric Dipole, Fields of a Short Dipole (General and Far Field Analyses), Radiation Resistance of a Short Dipole, Thin Linear Antenna (Field Analyses), Radiation Resistances of Lambda/2 Antenna. LO: At the end of this session the student will be able to, 1. Analyze radiation patterns of n isotropic point sources and dipoles 2. Analyze the parameters of antennas 3. Differentiate dipoles and point sources	**CO4, CO5 10 hrs** PO1-3 PO2-2 PO3-1 PO5-1 PO9-2 PO10-1 PSO1-3

Module 5: **Loop and Horn Antenna:** Introduction, Small loop, Comparison of Far fields of Small Loop and Short Dipole, The Loop Antenna General Case, Far field Patterns of Circular Loop Antenna with Uniform Current, Radiation Resistance of Loops, Directivity of Circular Loop Antennas with Uniform Current, Horn antennas Rectangular Horn Antennas.(Text 3: 7.1-7.8, 7.19, 7.20) **Antenna Types:** Helical Antenna, Helical Geometry, Practical Design Considerations of Helical Antenna, Yagi-Uda array, Parabola General Properties, Log Periodic Antenna. (Text 3: 8.3, 8.5, 8.8, 9.5, 11.7) LO: At the end of this session the student will be able to, 1. Analyze radiation patterns of variety of antennas 2. Analyze the parameters and applicability of antennas 3. Explain the importance of array antennas	**CO4, CO5** **10hrs** PO1-3 PO2-2 PO3-1 PO5-1 PO9-2 PO10-1 PSO1-3
Text Books: - 1. **Microwave Engineering** – Annapurna Das, Sisir K Das TMH Publication, 2nd, 2010. 2. **Microwave Devices and circuits**- Liao, Pearson Education. 3. **Antennas and Wave Propagation,** John D. Krauss, Ronald J Marhefka and Ahmad S Khan,4th Special Indian Edition , McGraw- Hill Education Pvt. Ltd., 2010.	
Reference Books: 1. **Microwave Engineering** – David M Pozar, John Wiley India Pvt. Ltd. 3rdEdn, 2008. 2. **Microwave Engineering** – Sushrut Das, Oxford Higher Education, 2ndEdn, 2015. 3. **Antennas and Wave Propagation** – Harish and Sachidananda: Oxford University Press, 2007.	
Useful Journals IET Microwaves, Antennas & Propagation International Journal of Microwave and Wireless Technologies International Journal of Antennas and Propagation Americal Journal of Electromagnetics and Applications.	
Teaching and Learning Methods: 1. Lecture class: 50 hrs. 2. Self-study: 5hrs. 3. Field visits/Group Discussions/Seminars: 3hrs.	
Assessment: Type of test/examination: Written examination **Continuous Internal Evaluation(CIE)** : 20 marks (Average of best two of total three tests will be considered) **Semester End Exam(SEE)** : 80 marks (students have to answer all main questions) Test duration: 1 :30 hr Examination duration: 3 hrs	

CO - PO MAPPING

PO1: Science and engineering Knowledge **PO2:** Problem Analysis **PO3:** Design & Development **PO4:** Investigations of Complex Problems **PO5:** Modern Tool Usage **PO6:** Engineer & Society	**PO7:** Environment and Sustainability **PO8:** Ethics **PO9:** Individual & Team Work **PO10:** Communication **PO11:** Project Mngmt & Finance **PO12:** Lifelong Learning

PSO1: Graduate should be able to understand the fundamentals in the field of Electronics & Communication and apply the same to various areas like Signal processing, embedded systems, Communication & Semiconductor technology.

PSO2: Graduate will demonstrate the ability to design, develop solutions for Problems in Electronics & Communication Engineering using hardware and software tools with social concerns.

CO 17EC71	Blooms Level	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	K3	3	2	1	–	1	–	–	–	2	1	–	–	3	–
CO2	K4	3	2	1	–	1	–	–	–	2	1	–	–	3	–
CO3	K5	3	2	1	–	1	–	–	–	2	1	–	–	3	–
CO4	K5	3	2	1	–	1	–	–	–	2	1	–	–	3	–
CO5	K5	3	2	1	–	1	–	–	–	2	1	–	–	3	–
Avg		3	2	1	–	1	–	–	–	2	1	–	–	3	–

Justification for CO-PO mapping

CO -Subject Code	Justification for PO mapping
CO1	PO1- Strongly maps as concepts involved gives engineering knowledge. PO2-Moderately maps as it is more of understanding and examining the smith charts PO3- Poorly maps as there is no complex design involved. PO5-Poorly maps as the Internet sources are used for explanation of smithcharts but not any modern tools PO9-Moderately maps as the students are assigned with pedagogy activity that requires the student to prepare individually and present on a topic.

	PO10- Poorly maps as the students are assigned with pedagogy activity that requires the student to prepare individually and make oral presentation on a topic. PSO1- strongly maps as the knowledge of smith charts are very much needed for communication.
CO2	PO1- Strongly maps as concepts involved gives engineering knowledge. PO2-Moderately maps as it is more of understanding and examining the function of passive devices PO3- Poorly maps as there is no complex design involved. PO5-Poorly maps as the Internet sources are used for explanation of S-Parameters but not any modern tools PO9-Moderately maps as the students are assigned with pedagogy activity that requires the student to prepare individually and present on a topic. PO10- Poorly maps as the students are assigned with pedagogy activity that requires the student to prepare individually and make oral presentation on a topic. PSO1- strongly maps as the knowledge of passive microwave devices are very much needed for communication.
CO3	PO1- Strongly maps as concepts involved gives engineering knowledge. PO2-Moderately maps as it is more of understanding and examining the function of microwave strip lines and devices. PO3- Poorly maps as there is no complex design involved. PO5-Poorly maps as the Internet sources are used for explanation of S-Parameters but not any modern tools PO9-Moderately maps as the students are assigned with pedagogy activity that requires the student to prepare individually and present on a topic. PO10- Poorly maps as the students are assigned with pedagogy activity that requires the student to prepare individually and make oral presentation on a topic. PSO1- strongly maps as the knowledge of microwave strip lines and devices are very much needed for communication
CO4	PO1- Strongly maps as concepts involved gives engineering knowledge. PO2-Moderately maps as it is more of understanding and examining the function of antennas PO3- Poorly maps as there is no complex design involved. PO5-Poorly maps as the Internet sources are used for explanation of antennas but not any modern tools PO9-Moderately maps as the students are assigned with pedagogy activity that requires the student to prepare individually and present on a topic.

	PO10- Poorly maps as the students are assigned with pedagogy activity that requires the student to prepare individually and make oral presentation on a topic. PSO1- strongly maps as the knowledge of radiation patterns and performance parameters of n-isotropic antennas are very much needed for communication.
CO5	PO1- Strongly maps as concepts involved gives engineering knowledge. PO2-Moderately maps as it is more of understanding and examining the function of variety of antennas PO3- Poorly maps as there is no complex design involved. PO5-Poorly maps as the Internet sources are used for explanation of antennas but not any modern tools PO9-Moderately maps as the students are assigned with pedagogy activity that requires the student to prepare individually and present on a topic. PO10- Poorly maps as the students are assigned with pedagogy activity that requires the student to prepare individually and make oral presentation on a topic. PSO1- strongly maps as the knowledge of radiation patterns and performance parameters of various antennas are very much needed for communication.

CO PO mapping for the events conducted after gap identification

Sl. No.	Gap Identification	CO	Relevant PO Mapping
1.	Modern Tool Usage Individual and Team Work	1-5	2 5, 9, 10

Signature of Course in-Charge　　Signature of Module Coordinator　　Signature of HOD

K. S INSTITUTE OF TECHNOLOGY, BENGALURU-560109

TENTATIVE CALENDAR OF EVENTS: ODD SEMESTER (2020-2021)

SESSION: SEP 2020 - JAN 2021

Week No.	Month	Day						Days	Activities
		Mon	Tue	Wed	Thu	Fri	Sat		
1	SEP		1*	2	3	4	5	5	1*-Commencement of Higher Semester
2	SEP	7	8	9	10	11	12	6	
3	SEP	14	15	16	17H	18	19	5	17- Mahalaya Amavasya
4	SEP	21	22	23	24	25	26TA	6	
5	SEP / OCT	28 T1	29 T1	30 T1	1	2H	3	5	2- Mahatma Gandhi Jayanthi
6	OCT	5	6BV	7ASD	8	9	10	6	5-10 First Feed Back
7	OCT	12	13	14	15	16	17DH	5	
8	OCT	19	20	21	22	23	24	6	24 - Monday Time Table
9	OCT	26H	27	28	29	30H	31H	3	26- Vijayadashami 30- Eid-Milad 31- Maharishi Valmiki Jayanti
10	NOV	2	3	4	5	6	7 TA	6	7 - Wednesday Time Table
11	NOV	9	10	11	12	13	14DH	5	
12	NOV	16H	17 T2	18 T2	19 T2	20	21	5	16 - Balipadyami Deepavalli 18 - 21 Second Feed Back 21 - Friday Time Table
13	NOV	23	24BV	25ASD	26	27	28DH	5	
14	NOV /DEC	30	1	2	3H	4	5	5	3- Kanakadasa Jayanti 5 - Monday Time Table
15	DEC	7	8	9	10	11	12DH	5	
16	DEC	14	15	16	17	18	19	6	19- Monday Time Table
17	DEC	21	22	23	24	25H	26DH	4	25-Christmas
18	DEC/ JAN	28	29	30	31	1 TA	2	6	2Thursday Time Table
19	JAN	4 LT	5 LT	6 LT	7 LT	8	9DH	5	
20	JAN	11 T3	12 T3	13 T3	14H	15	16 *	5	14- Makara sankaranthi 16* -Last Working Day

Total No of Working Days : 106

Total Number of working days (Excluding holidays and Tests)=87

H	Holiday
BV	Blue Book Verification
T1,T2, T3	Tests 1,2, 3
ASD	Attendance & Sessional Display
DH	Declared Holiday
LT	Lab Test
TA	Test attendance

Monday	16
Tuesday	16
Wednesday	16
Thursday	16
Friday	17
Saturday	6
Total	**87**

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

TENTATIVE CALENDAR OF EVENTS: ODD SEMESTER (2020-2021)

SESSION: SEP 2020 – JAN 2021

Week No.	Month	Mon	Tue	Wed	Thu	Fri	Sat	Days	Activities	Department Activities Tentative Dates
1	SEP		1*	2	3	4	5	5	1*-Commencement of Higher Semester	
2	SEP	7	8	9	10	11	12	6		10 - Technical Talk IEEE, ASH
3	SEP	14	15	16	17 H	18	19	5	17- Mahalaya Amavasya	15- Engineers Day IEEE 19 - Guest Lecture
4	SEP	21	22	23	24	25	26 TA	6		21 - Technical Talk 23 - Valedictory IEEE
5	SEP / OCT	28 T1	29 T1	30 T1	1	2 H	3	5	2- Mahatma Gandhi Jayanthi	
6	OCT	5	6 BV	7 ASD	8	9	10	6	5-10 First Feed Back	5 - IEEE Day , 10 - Guest Lecture
7	OCT	12	13	14	15	16	17 DH	5		15 - Tachnical Talk
8	OCT	19	20	21	22	23	24	6	24 Monday Time table	19 - Tachnical Talk 20 - Technical Talk
9	OCT	26 H	27	28	29	30 H	31 H	3	26- Vijayadashami 30- Eid-Milad 31- Maharishi Valmiki	
10	NOV	2	3	4	5	6	7TA	6	7-Wednesday Time Table	
11	NOV	9	10	11	12	13	14 DH	5		12 - Technical Talk
12	NOV	16H	17 T2	18 T2	19 T2	20	21	5	16 - Balipadyami Deepavalli 18-21 Second Feed Back 21- Friday Time Table	20 - Simulation
13	NOV	23	24 BV	25 ASD	26	27	28 DH	5		
14	NOV /DEC	30	1	2	3H	4	5	5	3- Kanakadasa Jayanti 5- Monday Time Table	
15	DEC	7	8	9	10	11	12 DH	5		
16	DEC	14	15	16	17	18	19	6	19- Monday Time Table	
17	DEC	21	22	23	24	25H	26DH	4	25- Christmas	
18	DEC/JAN	28	29	30	31	1TA	2	6	2- Tuesday Time Table	
19	JAN	4LT	5LT	6LT	7LT	8	9DH	5		
20	JAN	11T3	12T3	13T3	14H	15	16	5	14- Makara Sankranthi 16* -Last Working Day	

Total No of Working Days : 106

Total Number of working days (Excluding holidays and Tests)=87

H	Holiday
BV	Blue Book Verification
T1, T2, T3	Tests 1,2, 3
ASD	Attendance & Sessional Display
DH	Declared Holiday
LT	Lab Test
TA	Test attendance

Monday	16
Tuesday	16
Wednesday	16
Thursday	16
Friday	17
Saturday	6
Total	**87**

30/11/2020

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE -109

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

VII SEMESTER TIME TABLE FOR THE YEAR 2020 (ODD SEMESTER)

W.E.F. : 1/9/2020 **ONLINE TIME TABLE** **CLASS TEACHER : Mrs. VISHALINI DIVAKAR**

SEC : 'B'

PERIOD	1	2		3	4		5	6
TIME / DAY	9.00 AM 10.00 AM	10.00 AM 11.00 AM	11.00 AM 11.30 AM	11.30 AM 12.30 PM	12.30 PM 1.30 PM	1.30 PM 2.00 PM	2.00 PM 3.00 PM	3.00 PM 4.00 PM
MON	← PLACEMENT TRAINING →							
TUE	MWA (17EC71)	CRYPT (17EC744)	BREAK	DIP (17EC72)	PE (17EC73)	LUNCH BREAK	← VLSI Lab (17ECL77) →	
WED	CRYPT (17EC744)	IOT (17EC752) & SC (17EC755)		MWA (17EC71)	DIP (17EC72)		← ADC LAB(17ECL76) →	
THU	PE (17EC73)	CRYPT (17EC744)		IOT (17EC752) & SC (17EC755)	MWA (17EC71)		← PROJECT WORK PHASE -I (17ECP78) →	
FRI	CRYPT (17EC744)	PE (17EC73)		DIP (17EC72)	IOT (17EC752) & SC (17EC755)		PEDAGOGY DIP (17EC72)	PEDAGOGY PE (17EC73)
SAT	IOT (17EC752) & SC (17EC755)	DIP (17EC72)		MWA (17EC71)	PE (17EC73)		PEDAGOGY CRYPT (17EC744)	PEDAGOGY MWA (17EC71)

Sub-Code	Subject Name	Faculty Name
17EC71	Microwave and Antennas	Dr. B Surekha
17EC72	Digital Image Processing	Dr. P Joy Prabhakaran
17EC73	Power Electronics	Mrs. Vishalini Divakar
17EC744	Cryptography (Professional Elective-3)	Dr. P.N Sudha
17EC752	IOT and Wireless Sensor Networks (Professional Elective	Mr. Praveen.A
17EC755	Satellite Communication (Professional Elective-4)	Mr. Saleem S Tevaramani
17ECL76	Advanced Communication Lab	Mr. Sampath Kumar S , Mr. Saleem S Tevaramani
17ECL77	VLSI Lab	Mr. Praveen.A, Mrs. Aruna Rao B , Mrs. Pooja S
17ECP78	Project Work Phase–I + Project work Seminar	Dr. Sudarshan B , Mrs. Sahana Salagare

Time Table Co-ordinator

HOD

HEAD OF THE DEPARTMENT

1/9/2020

Principal

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

VII SEMESTER TIME TABLE FOR THE YEAR 2020 (ODD SEMESTER)

W.E.F. : 1/9/2020 | **ONLINE TIME TABLE** | **CLASS TEACHER : Mr. SALEEM S TEVARAMANI**

SEC : 'A'

PERIOD	1	2		3	4		5	6
TIME DAY	9.00 AM 10.00 AM	10.00 AM 11.00 AM	11.00 AM 11.30 AM	11.30 AM 12.30 PM	12.30 PM 1.30 PM	1.30 PM 2.00 PM	2.00 PM 3.00 PM	3.00 PM 4.00 PM
MON	← PLACEMENT TRAINING →							
TUE	CRYPT (17EC744)	PE (17EC73)	BREAK	DIP (17EC72)	MWA (17EC71)	LUNCH BREAK	← ADC LAB(17ECL76) →	
WED	MWA (17EC71)	IOT (17EC752) & SC (17EC755)	BREAK	CRYPT (17EC744)	DIP (17EC72)	LUNCH BREAK	← VLSI Lab (17ECL77) →	
THU	CRYPT (17EC744)	MWA (17EC71)	BREAK	IOT (17EC752) & SC (17EC755)	PE (17EC73)	LUNCH BREAK	← PROJECT WORK PHASE -I (17ECP78) →	
FRI	DIP (17EC72)	CRYPT (17EC744)	BREAK	PE (17EC73)	IOT (17EC752) & SC (17EC755)	LUNCH BREAK	PEDAGOGY DIP (17EC72)	PEDAGOGY PE (17EC73)
SAT	IOT (17EC752) & SC (17EC755)	PE (17EC73)	BREAK	DIP (17EC72)	MWA (17EC71)	LUNCH BREAK	PEDAGOGY CRYPT (17EC744)	PEDAGOGY MWA (17EC71)

Sub-Code	Subject Name	Faculty Name
17EC71	Microwave and Antennas	Dr. B Surekha
17EC72	Digital Image Processing	Mr. Saleem S Tevaramani
17EC73	Power Electronics	Mrs. Vishalini Divakar
17EC744	Cryptography (Professional Elective-3)	Dr. P.N Sudha
17EC752	IOT and Wireless Sensor Networks (Professional Elective	Mr. Praveen.A
17EC755	Satellite Communication (Professional Elective-4)	Mr. Saleem S Tevaramani
17ECL76	Advanced Communication Lab	Mr. Sampath Kumar S , Mr. Saleem S Tevaramani
17ECL77	VLSI Lab	Mr. Praveen.A, Mrs. Aruna Rao B , Mrs. Pooja S
17ECP78	Project Work Phase–I + Project work Seminar	Dr. Sudarshan B , Mrs. Sahana Salagare

Time Table Co-ordinator

HOD

HEAD OF THE DEPARTMENT
Dept. of Electronics & Communication Engg

Principal 1/9/2020

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

INDIVIDUAL TIME TABLE FOR THE YEAR - 2020 (ODD SEMESTER)

W.E.F. : 1/9/2020

NAME OF THE FACULTY : Dr. SUREKHA B

DESIGNATION: PROFESSOR

PERIOD	1	2		3	4		5	6
TIME / DAY	9.00 AM 10.00 AM	10.00 AM 11.00 AM	11.00 AM 11.15 AM	11.15 AM 12.15 PM	12.15 PM 1.15 PM	1.15 PM 1.45 PM	1.45 PM 2.45 PM	2.45 PM 3.45 PM
MON			TEA BREAK			LUNCH BREAK		PEDAGOGY MWA - A & B (17EC71)
TUE	MWA - B (17EC71)				MWA - A (17EC71)		← HDL LAB - B (18ECL58) →	
WED	MWA - A (17EC71)			MWA - B (17EC71)				
THU		MWA - A (17EC71)			MWA - B (17EC71)		MWA - A (17EC71)	
FRI								
SAT	← PROJECT WORK PHASE - I (17ECP78) →							

	Subject Code	Subject Name	Sem	Section	Work Load
Subject 1	17EC71	Microwave and Antennas	VII	A&B	10
Lab -1	18ECL58	HDL Laboratory	V		9
Project	17ECP78	Project Work Phase–I + Project work Seminar	VII		2
ADDITIONAL WORK: MENTORING AND OTHERS					
TOTAL LOAD =21 Hrs/Week					

Time Table Co-ordinator

HOD 26/8

Principal

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B.E E&C SEVENTH SEMESTER SYLLABUS

MICROWAVES AND ANTENNAS B.E., VII Semester, Electronics &Communication Engineering [As per Choice Based Credit System (CBCS) Scheme]			
Course Code	**17EC71**	**CIE Marks**	**20**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**80**
Total Number of LectureHours	**50 (10 Hours / Module)**	**Exam Hours**	**03**
CREDITS – 04			

Course objectives: This course will enable students to:

- Describe the microwave properties and its transmission media
- Describe microwave devices for several applications
- Understand the basics of antenna theory
- Select antennas for specific applications

Module-1

Microwave Tubes: Introduction, Reflex Klystron Oscillator, Mechanism of Oscillations, Modes of Oscillations, Mode Curve (Qualitative Analysis only). (Text 1: 9.1, 9.2.2)

Microwave Transmission Lines: Microwave Frequencies, Microwave devices, Microwave Systems, Transmission Line equations and solutions, Reflection Coefficient and Transmission Coefficient, Standing Wave and Standing Wave Ratio, Smith Chart, Single Stub matching. (Text 2: 0.1, 0.2, 0.3, 3.1, 3.2, 3.3, 3.5, 3.6 Except Double stub matching) **L1,L2**

Module-2

Microwave Network theory: Symmetrical Z and Y-Parameters for Reciprocal Networks, S matrix representation of Multi-Port Networks. (Text 1: 6.1, 6.2, 6.3)

Microwave Passive Devices: Coaxial Connectors and Adapters, Attenuators, Phase Shifters, Waveguide Tees, Magic tees. (Text 1: 6.4.2, 6.4.14, 6.4.15, 6.4.16) **L1, L2**

Module-3

Strip Lines: Introduction, Micro Strip lines, Parallel Strip lines, Coplanar Strip lines, Shielded Strip Lines. (Text 2: Chapter 11)

Antenna Basics: Introduction, Basic Antenna Parameters, Patterns, Beam Area, Radiation Intensity, Beam Efficiency, Directivity and Gain, Antenna Apertures, Effective Height, Bandwidth, Radio Communication Link, Antenna Field Zones & Polarization. (Text 3: 2.1- 2.11, 2.13,2.15) **L1, L2, L3**

Module-4

Point Sources and Arrays: Introduction, Point Sources, Power Patterns, Power Theorem, Radiation Intensity, Field Patterns, Phase Patterns, Arrays of Two Isotropic Point Sources, Pattern Multiplication, Linear Arrays of n Isotropic Point Sources of equal Amplitude and Spacing.(Text 3: 5.1 – 5.11,5.13)

Electric Dipoles: Introduction, Short Electric Dipole, Fields of a Short Dipole (General and Far Field Analyses), Radiation Resistance of a Short Dipole, Thin Linear Antenna (Field Analyses), Radiation Resistances of Lambda/2 Antenna. (Text 3: 6.1 -6.6) **L1, L2, L3,L4**

Module-5

Loop and Horn Antenna: Introduction, Small loop, Comparison of Far fields of Small Loop and Short Dipole, The Loop Antenna General Case, Far field Patterns of Circular Loop Antenna with Uniform Current, Radiation Resistance of Loops, Directivity of Circular Loop Antennas with Uniform Current, Horn antennas Rectangular Horn Antennas.(Text 3: 7.1-7.8, 7.19, 7.20)

Antenna Types: Helical Antenna, Helical Geometry, Practical Design Considerations of Helical Antenna, Yagi-Uda array, Parabola General Properties, Log Periodic Antenna. (Text 3: 8.3, 8.5, 8.8, 9.5, 11.7) **L1, L2, L3**

Course Outcomes: At the end of the course, students will be able to:

- Describe the use and advantages of microwave transmission
- Analyze various parameters related to microwave transmissionlines and waveguides
- Identify microwave devices for several applications
- Analyze various antenna parameters necessary for building an RF system Recommend various antenna configurations according to the applications

TextBooks:

1. **Microwave Engineering** – Annapurna Das, Sisir K Das TMH Publication, 2nd, 2010.
2. **Microwave Devices and circuits**- Liao, PearsonEducation.
3. **Antennas and Wave Propagation,** John D. Krauss, Ronald J Marhefka and Ahmad S Khan,4thSpecial Indian Edition , McGraw- Hill Education Pvt. Ltd., 2010.

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K.S. INSTITUTE OF TECHNOLOGY BANGALORE
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

NAME OF THE FACULTY : Dr. B.SUREKHA
SUBJECT CODE/NAME : 17EC71/ MICROWAVES AND ANTENNAS
SEMESTER/YEAR/ SECTION : VII/ IV/B
ACADEMIC YEAR : 2019-2020

Sl. No.	Module	Topic to be covered	Mode of Delivery	Teaching Aid	Number of Periods	Cumulative No. of Periods	Proposed Date
1	1	Introduction:Microwave Transmission Lines: Microwave Frequencies, Microwave devices, Microwave Systems	L+AV	Zoom	1	1	1/9/20
2	1	Limitations of Conventional Vacuum Tubes	L+AV	Zoom	1	2	2/9/20
3	1	Velocity Modulation, Reflex Klystron	L+AV	Zoom	1	3	3/9/20
4	1	Mechanism of Oscillations, Mode Curves	L+AV	Zoom	1	4	5/9/20
5	1	Problems: Reflex Klystron	L+AV	Zoom	1	5	8/9/20
6	1	Problems: Reflex Klystron	L+AV	Zoom	1	6	9/9/20
7	2	S-parameters	L+AV	Zoom	1	7	10/9/20
8	2	Losses in Microwave Devices and Networks	L+AV	Zoom	1	8	12/9/20
9	2	Short range Wireless Communications	L+AV	Zoom	1	9	15/9/20
10	2	Properties of S-Matrix	L+AV	Zoom	1	10	16/9/20
11	2	Symmetry of Z and Y parameters	L+AV	Zoom	1	11	19/9/20
12	2	E-Plane Tee & H-Plane	L+AV	Zoom	1	12	22/9/20
13	2	Magic Tee	L+AV	Zoom	1	13	22/9/20
14	2	Problems on Microwave Tees	L+AV	Zoom	1	14	23/9/20
15	2	Problems on Microwave Tees	L+AV	Zoom	1	15	24/9/20
16	2	Microwave Connectors	L+AV	Zoom	1	16	26/9/20
17	3	Modes of Propagation, Microstrip lines Characteristic Impedance	L+AV	Zoom	1	17	29/9/20
18	3	Losses in Microstrip lines	L+AV	Zoom	1	18	30/9/20
19	3	Ohmic Losses, Radiation Losses	L+AV	Zoom	1	19	1/10/20
20	3	Friss Formula-Problems	L+AV	Zoom	1	20	3/10/20
21		IA-1	L+AV	Zoom	1	21	6/10/20
22	2	Microwave attenuator	L+AV	Zoom	1	22	7/10/20
23	2	Microwave Phase shifter	L+AV	Zoom	1	23	8/10/20
24	3	Parallel Strip Lines	L+AV	Zoom	1	24	10/10/20

25	3	Coplanar strip lines and shielded strip lines	L+AV	Zoom	1	25	13/10/20
26	1	Transmission Line equations and solutions	L+AV	Zoom	1	26	14/10/20
27	1	Reflection Coefficient and Transmission Coefficient Standing Wave and Standing Wave Ratio	L+AV	Zoom	1	27	15/10/20
28	1	Smith Chart	L+AV	Zoom	1	28	17/10/20
29	1	Single Stub matching	L+AV	Zoom	1	29	19/10/20
30	3	Antenna Basics: Introduction, Basic Antenna Parameters	L+AV	Zoom	1	30	20/10/20
31	3	Patterns, Beam Area	L+AV	Zoom	1	31	21/10/20
32	3	Radiation Intensity, Beam Efficiency, Directivity and Gain, Antenna Apertures	L+AV	Zoom	1	32	22/10/20
33	3	Effective Height, Bandwidth, Radio Communication Link	L+AV	Zoom	1	33	27/10/20
34	3	Antenna Field Zones & Polarization.	L+AV	Zoom	1	34	28/10/20
35	4	Point Sources and Arrays: Introduction, Point Sources, Power Patterns, Power Theorem	L+AV	Zoom	1	35	29/10/20
36	4	Radiation Intensity, Field Patterns, Phase Patterns	L+AV	Zoom	1	36	2/11/20
37	4	Arrays of Two Isotropic Point Sources	L+AV	Zoom	1	37	3/11/20
38	4	Pattern Multiplication	L+AV	Zoom	1	38	4/11/20
39	4	Linear Arrays of n Isotropic Point Sources of equal Amplitude and Spacing	L+AV	Zoom	1	39	5/11/20
40		IA-2				40	9/11/20
41	4	Electric Dipoles: Introduction, Short Electric Dipole	L+AV	Zoom	1	41	12/11/20
42	4	Fields of a Short Dipole (General and Far Field Analyses)	L+AV	Zoom		42	17/11/20
43	4	Radiation Resistance of a Short Dipole	L+AV	Zoom	1	43	18/11/20
44	4	Thin Linear Antenna (Field Analyses)	L+AV	Zoom	1	44	19/11/20
45	4	Radiation Resistances of Lambda/2 Antenna	L+AV	Zoom	1	45	23/11/20
46	5	Loop and Horn Antenna: Introduction, Small loop, Comparison of Far fields of Small Loop and Short Dipole,	L+AV	Zoom	1	46	24/11/20
47	5	The Loop Antenna General Case, Far field Patterns of Circular Loop Antenna with Uniform Current	L+AV	Zoom	1	47	25/11/20
48	5	Radiation Resistance of Loops, Directivity of Circular Loop Antennas with Uniform Current	L+AV	Zoom	1	48	26/11/20
49	5	Horn antennas Rectangular Horn Antennas.	L+AV	Zoom	1	49	30/11/20
50	5	Antenna Types: Helical Antenna, Helical Geometry	L+AV	Zoom	1	50	1/11/20
51	5	Practical Design Considerations of Helical Antenna	L+AV	Zoom	1	51	2/12/20
52	5	Yagi-Uda array	L+AV	Zoom	1	52	7/12/20
52	5	Parabola General Properties , Log Periodic Antenna	L+AV	Zoom	1	52	8/12/20
53	5	IA-3				53	14/12/20
54	5	Revision	L+AV	Zoom	1	54	17/12/20

Text Books:

1. **Microwave Engineering** – Annapurna Das, Sisir K Das TMH Publication, 2nd, 2010.
2. **Microwave Devices and circuits**- Liao, Pearson Education.
3. **Antennas and Wave Propagation,** John D. Krauss, Ronald J Marhefka and Ahmad S Khan,4th Special Indian Edition , McGraw- Hill Education Pvt. Ltd., 2010.

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WEB MATERIALS:

W1: Basic Building Blocks of Microwave Engineering
https://nptel.ac.in/syllabus/117105130/
W2&3. Microwave Engineering
https://www.youtube.com/watch?v=_SNwJknISXA&list=PLgwJf8NK-2e6A4Mtxud6xPHE1UecxWsHW
W4&5: Microwave Theory and Techniques
https://nptel.ac.in/courses/108101112/
W6&7: Wave Theory and Antenna
https://www.youtube.com/watch?v=S1rJGgT910k&list=PLNhFkFk6qEgLpDVji2rZtRHJig2jeJ5Gi
W8&9: Analysis and Design Principles of Microwave Antennas
https://nptel.ac.in/courses/108105114/
W10 &11: Antennas
https://nptel.ac.in/syllabus/108101092/
W12,13,14,15:. Advanced Antenna Theory
https://nptel.ac.in/syllabus/117107035/

Details for the teaching Aids

1. Zoom
2.Teamlink

Signature of Course In charge **Signature ofModule Coordinator** **Signature of HOD**

K.S. INSTITUTE OF TECHNOLOGY BANGALORE
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

NAME OF THE FACULTY : **Dr. B.SUREKHA**
SUBJECT CODE/NAME : **17EC71/ MICROWAVES AND ANTENNAS**
SEMESTER/YEAR : **VII/ IV/A**
ACADEMIC YEAR : **2019-2020**

Sl. No.	Module	Topic to be covered	Mode of Delivery	Teaching Aid	Number of Periods	Cumulative No. of Periods	Proposed Date
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2	1	Limitations of Conventional Vacuum Tubes	L+AV	Zoom	1	2	2/9/20
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4	1	Mechanism of Oscillations, Mode Curves	L+AV	Zoom	1	4	5/9/20
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11	2	Symmetry of Z and Y parameters	L+AV	Zoom	1	11	19/9/20
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19	3	Ohmic Losses, Radiation Losses	L+AV	Zoom	1	19	1/10/20
20	3	Friss Formula-Problems	L+AV	Zoom	1	20	3/10/20
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22	2	Microwave attenuator	L+AV	Zoom	1	22	7/10/20
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25	3	Coplanar strip lines and shielded strip lines	L+AV	Zoom	1	25	13/10/20
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53	5	IA-3				53	14/12/20
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W2&3. Microwave Engineering
https://www.youtube.com/watch?v=_SNwJknISXA&list=PLgwJf8NK-2e6A4Mtxud6xPHE1UecxWsHW
W4&5: Microwave Theory and Techniques
https://nptel.ac.in/courses/108101112/
W6&7: Wave Theory and Antenna
https://www.youtube.com/watch?v=S1rJGgT910k&list=PLNhFkFk6qEgLpDVji2rZtRHJig2jeJ5Gi
W8&9: Analysis and Design Principles of Microwave Antennas
https://nptel.ac.in/courses/108105114/
W10 &11: Antennas
https://nptel.ac.in/syllabus/108101092/
W12,13,14,15:. Advanced Antenna Theory
https://nptel.ac.in/syllabus/117107035/

Details for the teaching Aids

1. Zoom
2.Teamlink

Signature of Course In charge | **Signature ofModule Coordinator** | **Signature of HOD**

KSIT Bangalore

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

ASSIGNMENT-1

Academic Year	2020-2021
Batch	2017-2021
Year/Semester/section	IV/VII/A&B
Subject Code-Title	17EC71-Microwaves and Antenna
Name of the Instructor	Dr.B.Surekha / Dept: ECE

Assignment No: 1 | **Total marks:20**
Date of Issue: 4/09/2020 | **Date of Submission:1/10/2020**

Sl.No	Assignment Questions	K Level	CO	Marks
1.	**Interpret** the high frequency limitations of conventional vacuum tubes.	Evaluating (K5)	CO3	2
2.	a) **Explain** the construction and working of a microwave tube that can be used as a low power microwave oscillator. b) **Evaluate** the mechanics of oscillation in Reflex Klystron with schematic. Describe the different mode curves in the case of reflex klystron	Evaluating (K5)	CO3	4
3.	**Interpret** the high frequency limitations of conventional vacuum tube / transistors? A Reflex Klystron is to be operated at 10GHz with dc beam voltage 300V, repeller space 0.1 cm for $1\frac{3}{4}$ mode. Estimate P_{RFmax} and corresponding repeller voltage for a beam current of 20mA.	Evaluating (K5)	CO3	2
4.	a) **Compare** six types of co- axial connectors with their frequency ranges. **b) Distinguish** the following losses in microwave circuits/devices in terms of S-parameters: i) Insertion loss ii) Transmission loss iii) Reflection loss iv) Return loss.	Evaluating (K5)	CO3	4
5.	a) **State** and derive the properties of S-parameters. b) Show that impedance and admittance matrices are symmetrical for a reciprocal junction.	Evaluating (K5)	CO2	4
6.	Pedagogy Activity (Pick and Speak)	Evaluating (K5)	CO4	4

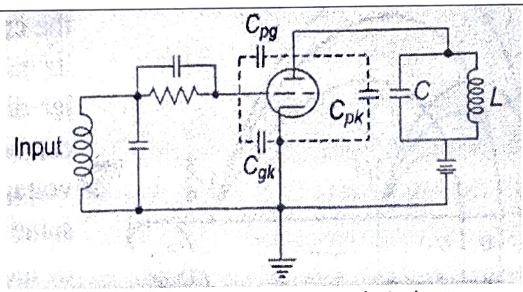
Signature of Course Incharge | **Signature of HOD/ECE**

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109
ASSIGNMENT 1SCHEME
2020 – 21 ODD SEMESTER

Degree	:	B.E	Semester	:	VII
Branch	:	ECE	Course Code	:	17EC71
Course Title	:	MICROWAVES AND ANTENNAS	Max Marks	:	10

Q.NO.	POINTS	MARKS
1	(see below)	2
2	(see below)	4

1



Interelectrode capacitances, Lead inductances, Transit time delay, Gain-BW product, Radiation losses

Marks: 2

2

a)

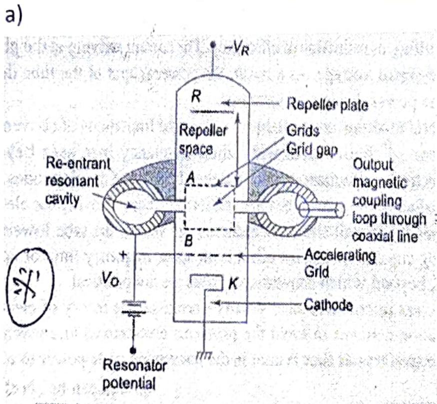
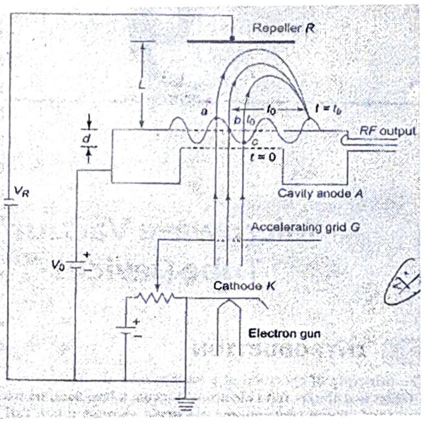


Fig. 9.3 Functional diagram of a reflex klystron



Explanation

b)

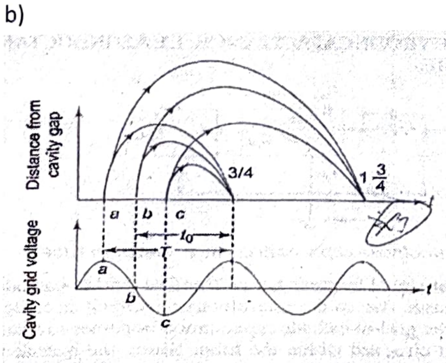


Fig. 9.5 Reflex klystron modes

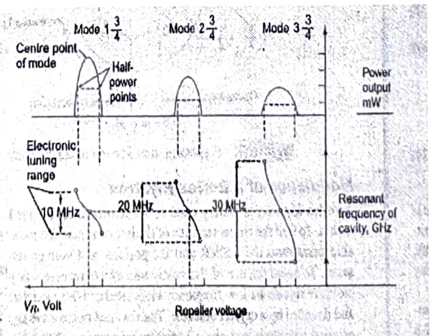


Fig. 9.6 Electronic tuning and output mode power of a reflex klystron

Explanation

Marks: 4

3	P_{RFMax} =0.398 $V_o I_o/N$=1.365 watts V_R= V_R=367.08 volts	2
4	**a) Typs: N,BNC,TNC,SMA,APC-7, APC 3.5** **Comparisons in terms of Sex, dielectric in mating space, Impedance, frequency range** b) 1. Insertion loss (dB) = $10 \log \frac{P_i}{P_o} = 10 \log \frac{\lvert a_1\rvert^2}{\lvert b_2\rvert^2} = 20 \log \left\lvert \frac{a_1}{b_2} \right\rvert = 20 \log \frac{1}{\lvert S_{21}\rvert} = 20 \log \frac{1}{\lvert S_{12}\rvert}$ 2. Transmission loss (dB) = $10 \log \frac{P_i - P_r}{P_o} = 10 \log \frac{1-\lvert S_{11}\rvert^2}{\lvert S_{12}\rvert^2}$ 3. Reflection loss (dB) = $10 \log \frac{P_i}{P_i - P_r} = 10 \log \frac{1}{1-\lvert S_{11}\rvert^2}$ 4. Return loss (dB) = $10 \log \frac{P_i}{P_r} = 10 \log \frac{\lvert a_1\rvert^2}{\lvert b_1\rvert^2} = 20 \log \frac{1}{\lvert S_{11}\rvert}$	4
5	a) ▪ $[S]$ is a symmetric matrix i.e., $S_{ij} = S_{ji}$ ▪ $[S]$ is a unitary matrix i.e., $[S][S]^* = I$ ▪ The sum of the products of each term of any row or column multiplied by the complex conjugate of the corresponding terms of any other row or column is zero. i.e., $\sum_{i=j}^{n} S_{ik} S_{ik}^* = 0 \; for \; k \neq j$ $(k = 1,2,3,\ldots n) \; and \; (j = 1,2,3,\ldots n)$ ▪ If the electrical distance between some k^{th} port and the junction is $\beta_k I_k$, then the coefficients of S_{ij} involving k, will be multiplied by the factor $e^{-j\beta k I k}$ b)	4

$$\int_S (E_r \times H_j - E_j \times H_r) \cdot ds = 0$$

where 'S' is the closed surface area of the conducting walls enclosing the junction and N ports. In the absence of any source, since the integral over the perfectly conducting walls vanishes, the only non-zero integrals are those taken over the reference planes of corresponding ports, so that

$$\sum_{n=1}^{N} \int_{t_n} (E_r \times H_j - E_j \times H_r) \cdot ds = 0$$

Since V_n except V_r and V_j are zero, $E_{tr} = n \times E_r$ and $E_{tj} = n \times E_j$ are zero on all reference planes at the corresponding ports except t_r and t_j. Therefore

$$\int_{t_r} (E_r \times H_j)\, ds = \int_{t_j} (E_j \times H_r)\, ds$$

$$P_{rj} = P_{jr} \quad \text{— (A)}$$

where P_{rj} represents the power at reference plane r due to an input voltage at plane j

From the admittance matrix representation $I = YV$

(A) $P_{rj} = P_{jr} \Rightarrow V_r V_j Y_{rj} = V_j V_r Y_{jr}$

$P = VI$ $\qquad Y_{rj} = Y_{jr}$

$Z_{rj} = Z_{jr}$

... symmetrical for a

6	Pedagogy Activity Pick a topic which is already covered in the class and Speak about it Make PPT. Use any video conferencing tool, share PPT, explain the topic with audio and video ON.	4

Signature of Course In charge **Signature of HOD ECE**

KSIT Bangalore

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

ASSIGNMENT-2

Academic Year	2020-2021
Batch	2017-2021
Year/Semester/section	IV/VII/A&B
Subject Code-Title	17EC71-Microwaves and Antenna
Name of the Instructor	Dr.B.Surekha — Dept: ECE

Assignment No: 2 | **Total marks:20**
Date of Issue: 16/10/2020 | **Date of Submission:5/11/2020**

Sl.No	Assignment Questions	K Level	CO	Marks
1.	a) **Analyze** with the aid of diagram, E-plane and its S-Matrix. b) **Analyze** with the aid of diagram, H-plane and its S-Matrix.	Applying (K3)	CO1	2
2.	a) **Examine** the features and functions of magic tee. Simplify its s-matrix. b) **Examine** S-parameters in terms of impedance when each line is matched terminated, given a two-transmission lines of characteristic impedance Z_1 and Z_2 are joined at plane PP'.	Applying (K3)	CO1	3
3.	a) **Find** the power delivered to the loads 40 ohms and 60 ohms connected to arms 1 and 2 when 10mW power is delivered to matched port 3 of a H-plane T- junction. Assume characteristic impedance of line = 50 0hm. b) **Examine** the power delivered through each port when other ports are terminated in Matched load if a 20mW signal is fed into one of the collinear ports 1 of a lossless H-plane T junction.	Applying (K3)	CO1	2
4.	a) **Inspect** the working of precision type attenuator with the help of neat diagrams. b) **Inspect** the working of phase shifter with the help of neat diagrams.	Applying (K3)	CO1	2
5.	a) **Derive** the transmission line equations by the method of distributed circuit theory. b) **Find** i) characteristic impedance ii) propagation constant for a transmission line having the parameters, R=2 Ω/m, G=0.5 mmho /m, f=1GHz, L=8nH/m. C=0.23pF/m. c) **Find** i) Reflection coefficient ii) Transmission coefficient, when a certain transmission line has a characteristic impedance of 75 + j0.01Ω and is terminated in a load impedance of 70+ j50Ω.	Applying (K3)	CO1	3
6.	a) **Apply** smith chart to identify the location and length of a single stub nearest to the load to produce an impedance match when a line of 400Ω is connected to a load of 200 + j300Ω, which is excited by a matched generator at 800MHz b) **Apply** Smith chart to determine the VSWR, first V_{max}, first V_{min} from the load, given the normalized load impedance Z_L=1+j1, operating wavelength λ=5 cms	Analyzing (K4)	CO2	4
7.	Pedagogy Activity-2 (Prepare the Module wise list/chart of the Formulas for Microwaves chapters)	Analyzing (K4)	CO2	4

Signature of Course Incharge | **Signature of HOD/ECE**

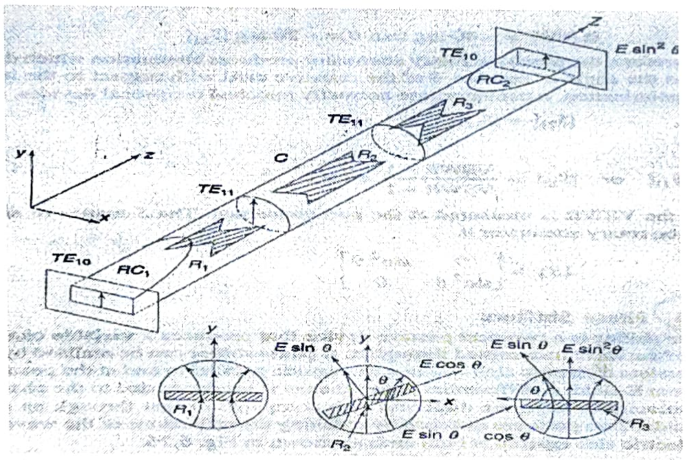
K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

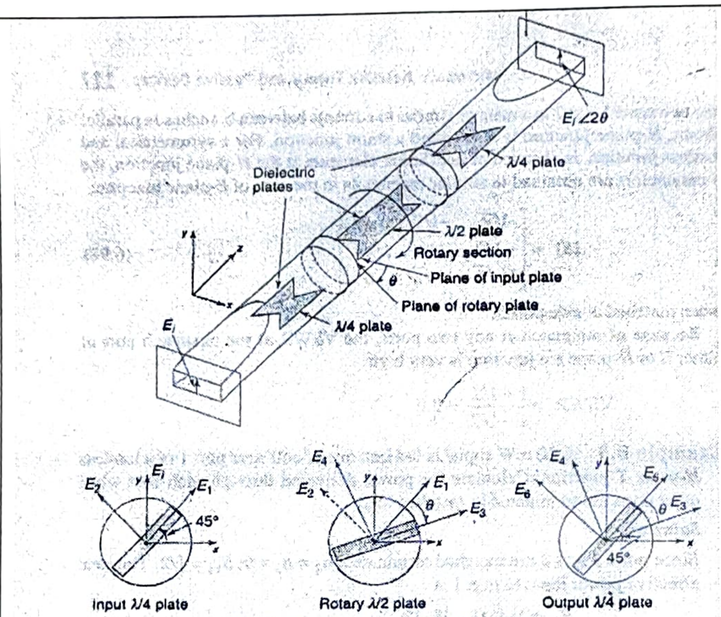
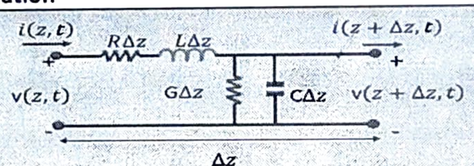
ASSIGNMENT 2

SCHEME

Degree	:	**B.E**	**Semester**	:	**VII A &B**
Branch	:	**ECE**	**Course Code**	:	**17EC71**
Course Title	:	**MICROWAVES AND ANTENNAS**	**Max Marks**	:	**30**

Q.NO.	POINTS	MARKS
1(a)	$[S] = \begin{bmatrix} S_{11} & S_{12} & S_{13} \\ S_{12} & S_{22} & -S_{13} \\ S_{13} & -S_{13} & 0 \end{bmatrix}$ .... Equation 5 We can say that we have four unknowns, considering the symmetry property. From the Unitary property $[S][S]* = [I]$ $\begin{bmatrix} S_{11} & S_{12} & S_{13} \\ S_{12} & S_{22} & -S_{13} \\ S_{13} & -S_{13} & 0 \end{bmatrix} \begin{bmatrix} S_{11}^* & S_{12}^* & S_{13}^* \\ S_{12}^* & S_{22}^* & -S_{13}^* \\ S_{13}^* & -S_{13}^* & 0 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ $[S] = \begin{bmatrix} \frac{1}{2} & \frac{1}{2} & \frac{1}{\sqrt{2}} \\ \frac{1}{2} & \frac{1}{2} & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 \end{bmatrix}$ **Fig** **Exp**	**2**
1(b)	$[S] = \begin{bmatrix} S_{11} & S_{12} & S_{13} \\ S_{12} & S_{22} & S_{13} \\ S_{13} & S_{13} & 0 \end{bmatrix}$ **Usage of identity property** $[S] = \begin{bmatrix} \frac{1}{2} & -\frac{1}{2} & \frac{1}{\sqrt{2}} \\ -\frac{1}{2} & \frac{1}{2} & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \end{bmatrix}$ **Fig** **Exp**	
2 (a)	$[S] = \begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{12} & S_{22} & S_{13} & -S_{14} \\ S_{13} & S_{13} & 0 & 0 \\ S_{14} & -S_{14} & 0 & 0 \end{bmatrix}$ **Use of Identity Property**	**3**

	$[S] = \begin{bmatrix} 0 & 0 & \frac{1}{2} & \frac{1}{\sqrt{2}} \\ 0 & 0 & \frac{1}{2} & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 & 0 \\ \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 & 0 \end{bmatrix}$ **Fig** **Exp**	
2(b)	**Fig** **$S_{11}=z_2-z_1/z_1+z_2$** **$S_{12}=2z_1\ /z_1+z_2$** **$S_{22}=z_1-z_2/z_1+z_2$** **$S_{21}=2z_2/z_1+z_2$**	
3 (a)	**Fig** **R1=40-50/40+50=1/9** **R2=60-50/60+50=1/11** **$P1=P(1-(R_1)^2)$=4.93mw** **$P2=P(1-(R_2)^2)$=4.95mw**	**2**
3 (b)	**Fig** **$P1=p[1-(s_{11})^2]$ =15mw** **$P2=P(s_{21})^2$=5mw** **$P3=P(s_{31})^2$=10mw**	
4 (a)	 **Fig** **Equations** **Explanation**	**2**

4 (b)	 Fig. 6.27 *Precision rotary phase shifter* **Fig** **Equations** **Explanation**	
5(a)	 Fig. 1. Lumped element circuit model of transmission line L and KCL on the circuit given in Fig. 1, we get: $v(z,t) - R\Delta z i(z,t) - L\Delta z \frac{\partial i(z,t)}{\partial t} - v(z+\Delta z,t) = 0$ $i(z,t) - G\Delta z v(z+\Delta z,t) - C\Delta z \frac{\partial v(z+\Delta z,t)}{\partial t} - i(z+\Delta z,t) = 0.$ $\Rightarrow \frac{\partial v(z,t)}{\partial z} = -Ri(z,t) - L\frac{\partial i(z,t)}{\partial t}$ $\frac{\partial i(z,t)}{\partial z} = -Gv(z,t) - C\frac{\partial v(z,t)}{\partial t}$ $v(z,t) = Re\{V(z)e^{j\omega t}\}$ $i(z,t) = Re\{I(z)e^{j\omega t}\}$ $\frac{d^2V(z)}{dz^2} - \gamma^2 V(z) = 0$ $\frac{d^2I(z)}{dz^2} - \gamma^2 I(z) = 0$	3

	$V(z) = V_0^+ e^{-\gamma z} + V_0^- e^{\gamma z}$ $I(z) = I_0^+ e^{-\gamma z} + I_0^- e^{\gamma z}$	
5(b)	Given R=2 Ω/m ,G=0.5 mmho /m, f=1GHz, L=8nH/m. C=0.23pF/m. $Z_0 = \sqrt{\frac{R+jwL}{G+jwC}} = 181.39\angle 8.40$=179.44+j26.5 $\gamma = \sqrt{(R+jwL)(G+jwC)} = 0.277\angle 79.31 = 0.051 + j0.273$	**4**
5(c)	Z_o=75 + j0.01Ω , Z_L= 70 + j50Ω Γ=(Z_L-Z_0)/(Z_L+Z_0)=0.33L76.68=0.08+j0.32 T=2Z_L/(Z_L+Z_0)=1.12L16.51=1.08+j0.32	
6(a)	Z_L=0.5+j0.75, Y_L=0.62+-j0.88, Y_d=1+j1.3, Y_s=-j1.3 d=.5λ-0.36λ+0.16 λ=0.31 λ, l=0.355 λ-0.25 λ=0.105 λ	**4**
6(b)	Fig. Z_L=1+j1 VSWR=2.6 d1 (Vmax)=0.25 λ-0.162 λ=0.44 cm d2 (Vmin)=0. 5 λ-0.162 λ=1.69 cm	

Signature of course in charge **Signature of Module Coordinator** **Signature of HOD**

KSIT Bangalore

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

ASSIGNMENT-3

Academic Year	2020-2021
Batch	2017-2021
Year/Semester/section	IV/VII/A&B
Subject Code-Title	17EC71-Microwaves and Antenna
Name of the Instructor	Dr.B.Surekha — Dept: ECE

Assignment No: 3 | **Total marks:20**

Date of Issue: 1/12/2020 | **Date of Submission:30/12/2020**

Sl.No	Assignment Questions	K Level	CO	Marks
1.	**a) Explain** i) Directivity ii) Gain iii) Beam Area iv) Beam efficiency v) Effective aperture b)**Deduct** expression **for** radiation resistance of short electric dipole	Evaluating(K5)	CO4	4
2.	a) **Prove** that the radiation resistance of a linear antenna with sinusoidal current distribution is equal to 73Ω. b) **Deduct** the expression for field of dipole in general for the case of thin linear antenna c) **Prove** that the maximum effective aperture of λ/2 dipole antenna is 0.13 λ^2	Evaluating(K5)	CO4	4
3.	a) **Deduct** power theorem and its application to an isotropic source. b) **Deduct** the field expression of two isotropic point sources of same amplitude and phase.	Evaluating(K5)	CO5	2
4.	a) **Deduct** an array factor expression in case of linear array of n isotropic point sources of equal amplitude and spacing. b) **Explain** the principle of pattern multiplication with an example.	Evaluating(K5)	CO5	2
5.	a) **Deduct** the expression for strength $E\phi$ and $H\theta$ in case of small loop. b) **Prove** that the radiation resistance of small loop is 31171 $(A/\lambda^2)^2$.	Evaluating(K5)	CO5	2
6.	**Explain** a) Yagi-Uda Antenna b) Helical Antenna c) Paraboloid Antenna d) Log-periodic antenna	Evaluating(K5)	CO5	6

Signature of Course Incharge

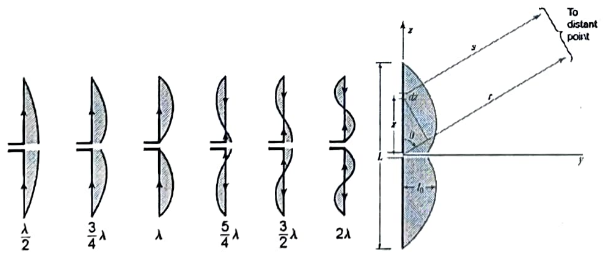
Signature of HOD/ECE

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

ASSIGNMENT 3

SCHEME

Degree	: **B.E**		**Semester :**	**VII A &B**
Branch	: **ECE**		**Course Code :**	**17EC71**
Course Title	: MICROWAVES AND ANTENNAS		**Max Marks :**	**30**

Q.NO.	POINTS	MARKS
1(a)	i) Directivity ii) Gain iii) Beam Area iv) Beam efficiency v) Effective aperture	**4**
2 (a)	$P = \frac{15 I_0^2}{\pi} \int_0^{2\pi} \int_0^{\pi} \frac{\{\cos[(\beta L/2)\cos\theta] - \cos(\beta L/2)\}^2}{\sin\theta} d\theta\, d\phi$ $= 30 I_0^2 \int_0^{\pi} \frac{\{\cos[(\beta L/2)\cos\theta] - \cos(\beta L/2)\}^2}{\sin\theta} d\theta$ Equating the radiated power as given by (2) to $I_0^2 R_0/2$ we have $P = \frac{I_0^2 R_0}{2}$ and $R_0 = 60 \int_0^{\pi} \frac{\{\cos[(\beta L/2)\cos\theta] - \cos(\beta L/2)\}^2}{\sin\theta} d\theta$ $R_r = 30\,\mathrm{Cin}(2\pi) = 30 \times 2.44 = 73\,\Omega$ $Z = 73 + j42.5\,\Omega$	**4**
2(b)	$[I] = I_0 \sin\left[\frac{2\pi}{\lambda}\left(\frac{L}{2} \pm z\right)\right] e^{j\omega[t-(r/c)]}$ $\sin\left[\frac{2\pi}{\lambda}\left(\frac{L}{2} \pm z\right)\right]$ 	

Far fields of center-fed dipole

$$H_\phi = \frac{j[I_0]}{2\pi r}\left[\frac{\cos[(\beta L\cos\theta)/2] - \cos(\beta L/2)}{\sin\theta}\right]$$

$$E_\theta = \frac{j60[I_0]}{r}\left[\frac{\cos[(\beta L\cos\theta)/2] - \cos(\beta L/2)}{\sin\theta}\right]$$

where $[I_0] = I_0 e^{j\omega[t-(r/c)]}$ and

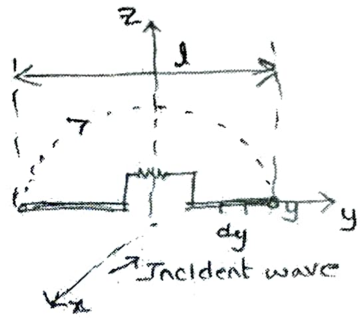
$$E_\theta = 120\pi H_\phi$$

Explanation and derivation

2 (c)

prove that the maximum effective aperture of $\frac{\lambda}{2}$ dipole antenna is $0.13\lambda^2$, find its directivity

Sol:



In a $\frac{\lambda}{2}$ antenna, current is not uniform and hence entire length is to be considered.

The current at any point 'y' is given by

$$I = I_0 \cos\left(\frac{2\pi}{\lambda} y\right)$$

Voltage induced $dv = E \cdot dy \cdot \cos\left(\frac{2\pi}{\lambda} y\right)$

Total voltage $V = 2\int_0^{\lambda/4} E\cos\left(\frac{2\pi y}{\lambda}\right) dy$

$$= 2E\left[\frac{\sin\frac{2\pi y}{\lambda}}{\frac{2\pi}{\lambda}}\right]_0^{\lambda/4}$$

$$= 2E \cdot \frac{1}{2\pi/\lambda} = \frac{E\lambda}{\pi}$$

$$V = \frac{E\lambda}{\pi}$$

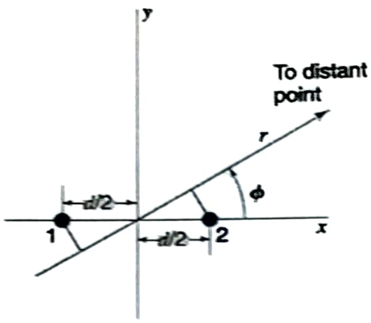
Maximum effective aperture $A_{em} = \frac{V^2}{4SR_r}$, $S = \frac{E^2}{120\pi}$, $R_r = 73\Omega$

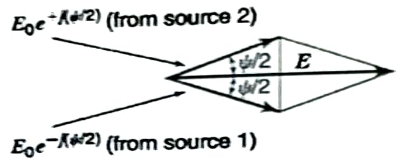
$$\therefore A_{em} = \frac{\left(\frac{E\lambda}{\pi}\right)^2}{\frac{4E^2}{120\pi} \times 73} = \frac{30}{73}\lambda^2 = 0.13\lambda^2$$

Directivity $D = \frac{4\pi A_e}{\lambda^2} = \frac{4\pi \times 0.13\lambda^2}{\lambda^2} = 1.63$

3 (a)	$$P = \oiint \mathbf{S} \cdot d\mathbf{s} = \oiint S_r\, ds$$ where P = power radiated, W S_r = radial component of average Poynting vector, W m^{-2} ds = infinitesimal element of area of sphere (see Fig. 3–2*b*) $= r^2 \sin\theta\, d\theta\, d\phi$, m^2 For an *isotropic source*, S_r is independent of θ and ϕ so $$P = S_r \oiint ds = S_r \times 4\pi r^2 \quad \text{(W)}$$ and $$S_r = \frac{P}{4\pi r^2} \quad (\text{W m}^{-2})$$ Radiation Intensity The radiation intensity U is expressed in watts per unit solid angle (W sr^{-1}). The radiation intensity is independent of radius. $r^2 S_r = P/4\pi = U$ (W/sr) $P = 4\pi U$ For an isotropic source : $P = 4\pi U_0$ (W) where U_0 = radiation intensity of isotropic source, W sr^{-1}. the power theorem may be restated as follows: The total power radiated is given by the integral of the radiation intensity over a solid angle of 4π steradians.	2

3 (b)





$$E = E_0e^{-j\psi/2} + E_0e^{+j\psi/2}$$

$$E = 2E_0\frac{e^{+j\psi/2} + e^{-j\psi/2}}{2}$$

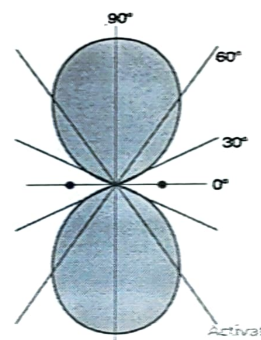
which by a trigonometric identity is

$$E = 2E_0 \cos\frac{\psi}{2} = 2E_0 \cos\left(\frac{d_r}{2}\cos\phi\right)$$

Let $2E_0=1$ and $d=\lambda/2$

$d_r = \beta d = (2\pi/\lambda)(\lambda/2) = \pi$

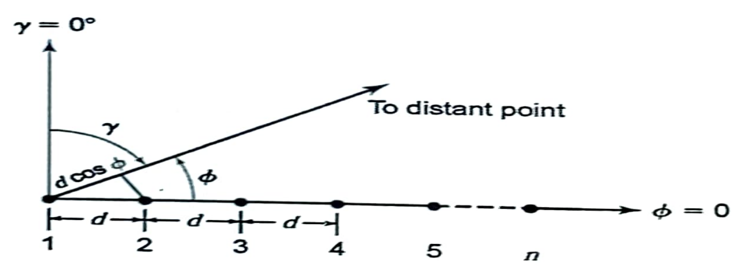
$$E = \cos\left(\frac{\pi}{2}\cos\phi\right)$$



(c)

Explanation and Derivation

4 (a)

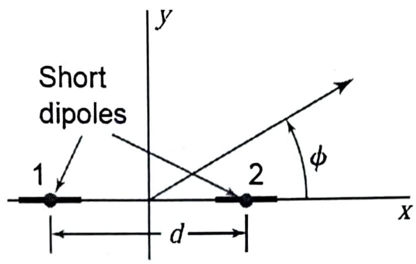


$$E = 1 + e^{j\psi} + e^{j2\psi} + e^{j3\psi} + \cdots + e^{j(n-1)\psi}$$

$$E = \frac{1}{n}\frac{\sin(n\psi/2)}{\sin(\psi/2)}$$

Array factor Derivation

4 (b)



short dipoles oriented parallel to the x axis

Both sources 1 and 2 have field patterns given by E_0 = E sinϕ.

Substituting in the equation for , General Case of Two Isotropic Point Sources of Equal Amplitude and Any Phase Difference,

$$E = E_0(e^{j\psi/2} + e^{-j\psi/2}) = 2E_0 \cos\frac{\psi}{2}$$

Where

$$\psi = d_r \cos\phi + \delta$$

Ex: E_0 = E sinϕ, d = $\lambda/2$ and the phase angle $\delta = 0$

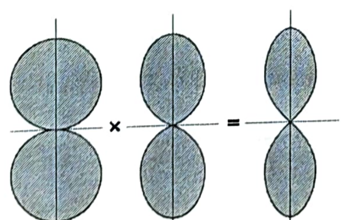
dr=βd=(2π/λ)(λ/2)= π

$$\psi = d_r \cos\phi + \delta$$

Ψ= πCosΦ

$$E = \sin\phi \cos\left(\frac{\pi}{2}\cos\phi\right)$$

This result is the same as obtained by multiplying the pattern of the individual source (sin ϕ) by the pattern of two isotropic point sources (cos ψ/2).



(a) (b) (c)

5 (a)

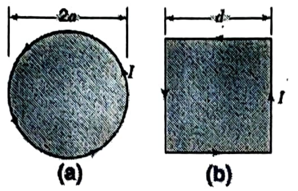


Figure 7-1 Circular loop (*a*) and square loop (*b*) of equal area.

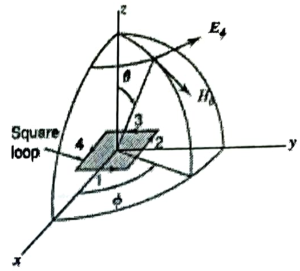


Fig-

$$E_{\phi 0} = \frac{j60\pi[I]L}{r\lambda} \quad (6)$$

where $[I]$ is the retarded current on the dipole and r is the distance from the dipole. Substituting (6) in (5) then gives

$$E_\phi = \frac{60\pi[I]L d_r \sin\theta}{r\lambda} \quad (7)$$

However, the length L of the short dipole is the same as d, that is, $L = d$. Noting also that $d_r = 2\pi d/\lambda$ and that the area A of the loop is d^2, (7) becomes

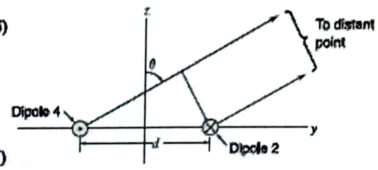


Figure 7-3 Construction for finding far field of dipoles 2 and 4 of square loop.

$$\text{Small loop} \quad E_\phi = \frac{120\pi^2[I]\sin\theta}{r}\frac{A}{\lambda^2} \quad \text{Far } E_\phi \text{ field} \quad (8)$$

$$H_\theta = \frac{E_\phi}{120\pi} = \frac{\pi[I]\sin\theta}{r}\frac{A}{\lambda^2}$$

Derivation and explanation

2

5(b)

$$P = \frac{I_0^2}{2}R_r$$

$$S_r = \tfrac{1}{2}|H|^2 \operatorname{Re} Z$$

$$S_r = \frac{15\pi(\beta a I_0)^2}{r^2}J_1^2(\beta a \sin\theta)$$

$$P = \iint S_r\, ds = 15\pi(\beta a I_0)^2 \int_0^{2\pi}\int_0^{\pi} J_1^2(\beta a \sin\theta)\sin\theta\, d\theta\, d\phi$$

$$P = 30\pi^2(\beta a I_0)^2 \int_0^{\pi} J_1^2(\beta a \sin\theta)\sin\theta\, d\theta$$

In the case of a loop that is small in terms of wavelengths, the approximation of (7·
Thus (5) reduces to

$$P = \frac{15}{2}\pi^2(\beta a)^4 I_0^2 \int_0^{\pi} \sin^3\theta\, d\theta = 10\pi^2\beta^4 a^4 I_0^2$$

Since the area $A = \pi a^2$, (6) becomes

$$P = 10\beta^4 A^2 I_0^2$$

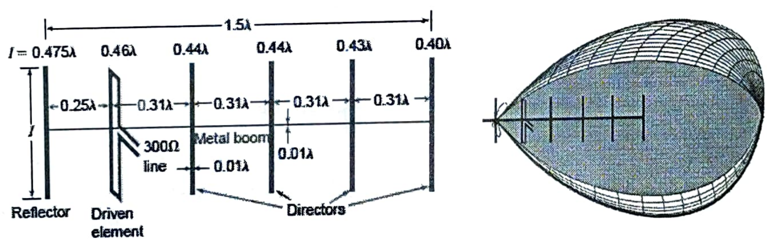
Assuming no antenna losses, this power equals the power delivered to the loop term
Therefore,

$$R_r \frac{I_0^2}{2} = 10\beta^4 A^2 I_0^2$$

and

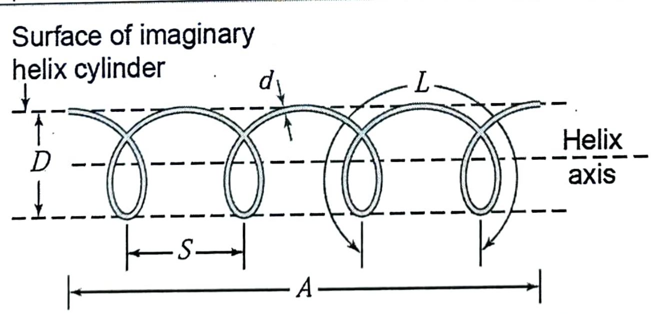
Small loop	$R_r = 31{,}171\left(\frac{A}{\lambda^2}\right)^2 = 197C_\lambda^4 \quad (\Omega)$ or $R_r \simeq 31{,}200\left(\frac{A}{\lambda^2}\right)^2 \quad (\Omega)$	*Radiation resistance*

6(a) 6

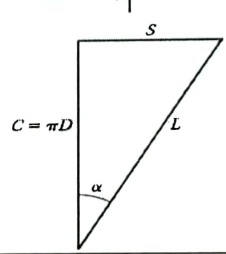


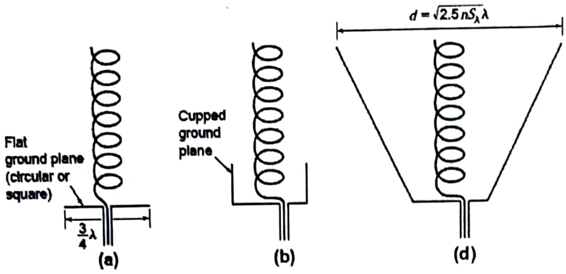
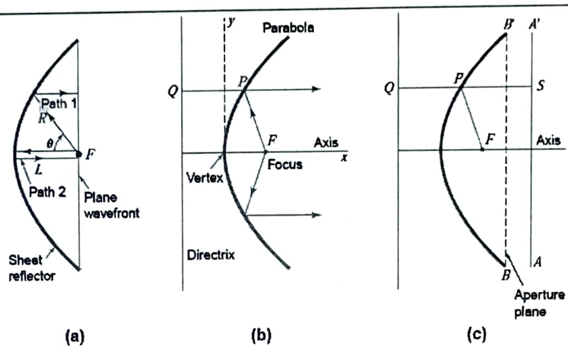
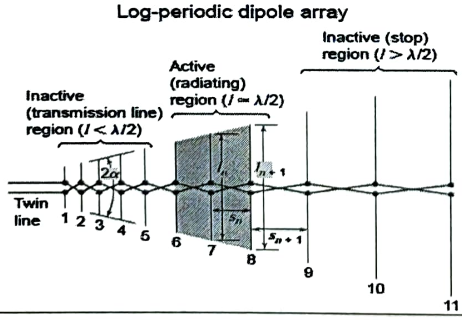
Explanation

6(b)



D = diameter of helix (center to center)
C = circumference of helix = πD
S = spacing between turns (center to center)
α = pitch angle = arctan $S/\pi D$
L = length of 1 turn
n = number of turns
A = axial length = nS
d = diameter of helix conductor

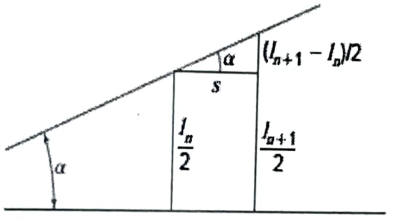


	 Explanation	
6 (c)	 **Figure 9–18** Parabolic reflectors. PF = PQ PS = QS – PQ PF + PS = PF + QS – PQ = QS Explanation	
6 (d)	$\tan\alpha = \frac{(l_{n+1} - l_n)/2}{s}$ $k_1 = \frac{R_n + 1}{R_n}$ and the tooth-width parameter $k_2 = \frac{r_n}{R_n}$ Log-periodic dipole array  $\frac{l_{n+1}}{l_1} = k^n = F$	

$$\text{HPBW } (H \text{ plane}) \leq \frac{41{,}000}{D \times 60^{\circ}} \quad \text{(deg)}$$

For the antenna of the example $D = 5$, since $\log_{10} 5 = 7$ dBi, so

$$\text{HPBW } (H \text{ plane}) \leq \frac{41{,}000}{5 \times 60^{\circ}} = 137^{\circ}$$



$$\tan\alpha = \frac{[1 - (1/k)](l_{n+1}/2)}{s}$$

Taking $l_{n+1} = \lambda/2$ (when active) we have

$$\tan\alpha = \frac{1 - (1/k)}{4s_\lambda}$$

where

α = apex angle
k = scale factor
s_λ = spacing in wavelengths shortward of $\lambda/2$ element

$$\frac{l_{n+1}}{l_n} = \frac{s_{n+1}}{s_n} = k$$

3M

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K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

I SESSIONAL TEST QUESTION PAPER 2020 – 21 ODD SEMESTER

SET – A

USN										

Degree : B.E
Branch : ECE
Course Title : MICROWAVES AND ANTENNAS
Duration : 90 Minutes

Semester : VII A& B
Course Code : 17EC71
Date : 5-10-2020
Max Marks : 30

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1(a)	**Estimate** P_{RFmax} and corresponding repeller voltage for a beam current of 20mA, and if a Reflex Klystron is to be operated at 10GHz with dc beam voltage 300V, repeller space 0.1 cm for 1 3/4 mode.	6	CO3	K5 [Evaluating]
(b)	**Evaluate** different types of losses in micro strip lines.	12	CO3	K5 [Evaluating]
	OR			
2(a)	**Interpret** with neat diagram, the structure and field pattern of microstrip line and derive expression for characteristic impedance' Zo'	6	CO3	K5 [Evaluating]
(b)	**Evaluate** the construction and working of a microwave tube, along with modes of oscillations.	12	CO3	K5 [Evaluating]
	PART-B			
3(a)	**Compare** six types of co- axial connectors with their frequency ranges.	6	CO2	K4 [Analyzing]
(b)	**Deduct** Friss Formula for transmission problem.	6	CO4	K5 [Evaluating]
	OR			
4(a)	**Interpret** the high frequency limitations of conventional vacuum tube / transistors?	6	CO2	K4 [Analyzing]
(b)	**Determine** the power received by the receiving antenna, if the effective apertures of transmitting and receiving antennas in a communication system are $8\lambda^2$ and $12\lambda^2$ respectively. With a separation of 1.5km between them. The EM wave travelling with frequency of 6 MHz and the total input power is 25KW.	6	CO4	K5 [Evaluating]

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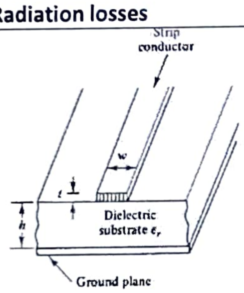
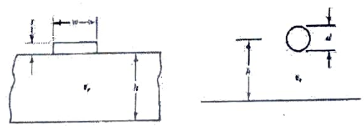
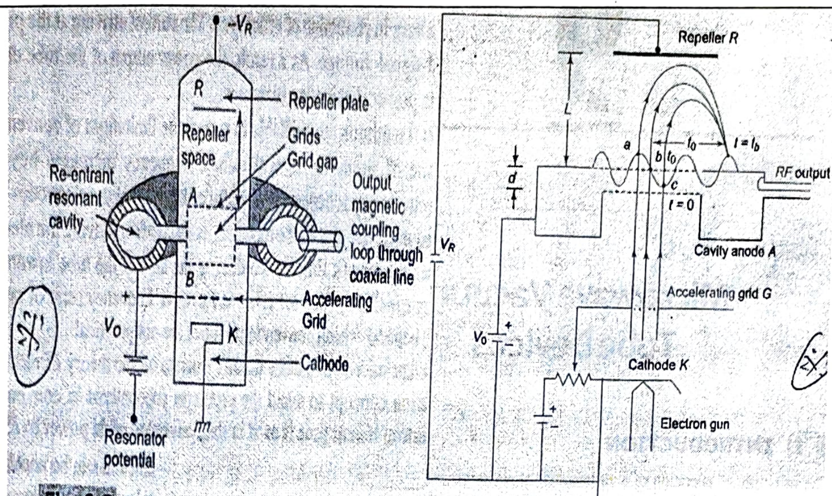
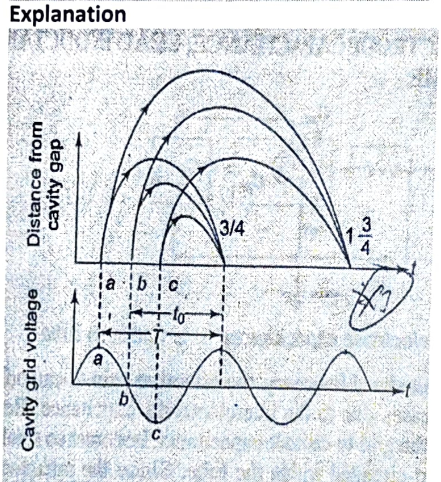
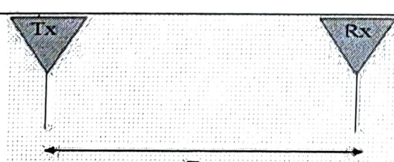
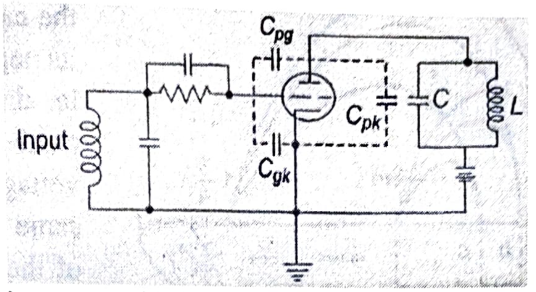
I SESSIONAL TEST QUESTION PAPER 2020 – 21ODD SEMESTER

SCHEME AND SOLUTION SET A

Degree	: B.E		**Semester :**	VII A &B
Branch	: ECE		**Course Code :**	17EC71
Course Title	: MICROWAVES AND ANTENNAS		**Max Marks :**	30

Q.NO.	POINTS	MARKS
1(a)	b. PRFMax =0.398 Volo/N=1.365 watts VR=$6.74 \times 10^{-6} \times f \times l \times \frac{\sqrt{v_0}}{N}$ = 367.08 volts (3+3)M	6
1(b)	Power losses Dielectric Losses Ohmic losses Radiation losses (4+2+3+3)M	12
2(a)	 Comparison method Comparing with a wire over ground, For a wire over ground,  $Z_o = \frac{60}{\sqrt{\epsilon_r}} \ln \frac{4h}{d}$ for $h \gg d$ Changes for microstrip lines, The effective permittivity will be $\epsilon_{re} = 0.475\epsilon_r + 0.67$ Other relation will be $d = 0.67w\left(0.8 + \frac{t}{w}\right)$ t/w<0.8 $Z_o = \frac{87}{\sqrt{\epsilon_r + 1.41}} \ln\left[\frac{5.98h}{0.8w + t}\right]$ for $(h < 0.8w)$ $Z_o = \frac{h}{w}\sqrt{\frac{\mu}{\epsilon}} = \frac{377}{\sqrt{\epsilon_r}}\frac{h}{w}$ for $(w \gg h)$ [derived by Assadourian] (1+1+4)M	6

2 (b)	 Fig. 9.3 Functional diagram of a reflex klystron **Explanation** **(1.5+1.5+3)M**  Fig. 9.5 Reflex klystron modes Explanation (2+4)M	12
3(a)	**Types: N,BNC,TNC,SMA,APC-7, APC 3.5 -1M** **Comparisons in terms of Sex, dielectric in mating space, Impedance, frequency range, features-(1+1+1+1+1)M**	6
3(b)	 1M $p=\frac{P_T}{4\pi R^2}$ $p=\frac{P_T}{4\pi R^2}G_T$ $P_R=\frac{P_T}{4\pi R^2}G_T A_{ER}$ 3M $A_e=\frac{\lambda^2}{4\pi}G$ $P_R=\frac{P_T G_T G_R c^2}{(4\pi Rf)^2}$ **or equivalent formula** **2M**	6

4(a)	 **Interelectrode capacitances, Lead inductances, Transit time delay, Gain-BW product, Radiation losses (2+4) M**	6
4(b)	Λ=c/f=50m 3M Pr=PtAetAer/r2λ2=2.67Kw 3 M	6

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I SESSIONAL TEST QUESTION PAPER 2020 – 21 ODD SEMESTER

SET – B

USN										

Degree	:	B.E	Semester	:	VII A& B
Branch	:	ECE	Course Code	:	17EC71
Course Title	:	MICROWAVES AND ANTENNAS	Date	:	5-10-2020
Duration	:	90 Minutes	Max Marks	:	30

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1(a)	**Estimate** the repeller voltage, electronic efficiency, and output power if a reflex kystron is operated at 9GHz with a DC beam voltage of 6000 v for 1 ¾ mode, repeller space length of 1mm, and dc beam current of 10 mA. The beam coupling coefficient is assumed to be 1.	6	CO3	K5 [Evaluating]
(b)	**Evaluate** the working principle and mechanics of oscillation in Reflex Klystron with schematic. Describe the different mode curves in the case of reflex klystron	6	CO3	K5 [Evaluating]
	OR			
2(a)	**Compare** the following losses in microwave circuits/devices i) Insertion loss ii) Transmission loss iii) Reflection loss iv) Return loss	6	CO3	K5 [Evaluating]
(b)	**Evaluate** different types of losses in micro strip lines.	6	CO3	K5 [Evaluating]
	PART-B			
3(a)	**Compare** six types of co- axial connectors with their frequency ranges.	6	CO2	K4 [Analyzing]
(b)	**Deduct** Friss Formula for transmission problem.	6	CO4	K5 [Evaluating]
	OR			
4(a)	**Inspect** that impedance and admittance matrices are symmetrical for a reciprocal junction.	6	CO2	K4 [Analyzing]
(b)	**Estimate** the power received by receiving antenna kept at a distance of 100 km by a transmitter radiating at 3 MHz. Assume G_T=40 and G_R=15 and P_T=1000 Kw	6	CO4	K5 [Evaluating]

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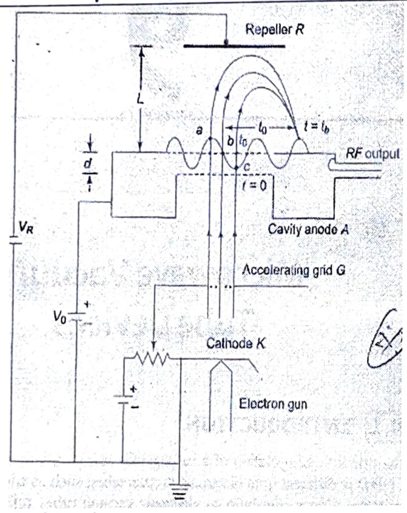
I SESSIONAL TEST QUESTION PAPER 2020 – 21ODD SEMESTER

SCHEME AND SOLUTION SET B

Degree	:	**B.E**	**Semester**	:	**VII A &B**
Branch	:	**ECE**	**Course Code**	:	**17EC71**
Course Title	:	**MICROWAVES AND ANTENNAS**	**Max Marks**	:	**30**

<table>
<tr><th>Q.NO.</th><th>POINTS</th><th>MARKS</th></tr>
<tr><td>1(a)</td><td>b. PRFMax =0.398 Volo/N=1.364 watts

VR= — 249 volts
Efficiency=0.398/N=22.74%(2+2+2)M</td><td>6</td></tr>
<tr><td>1 (b)</td><td>


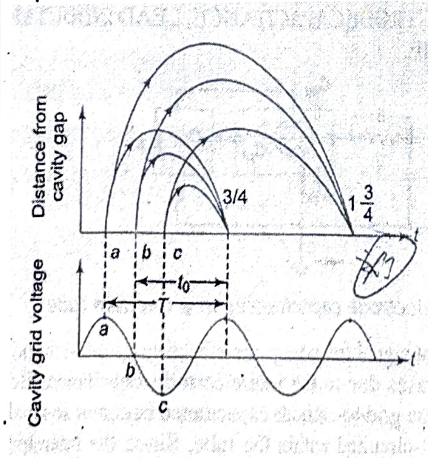
Explanation (2+4)


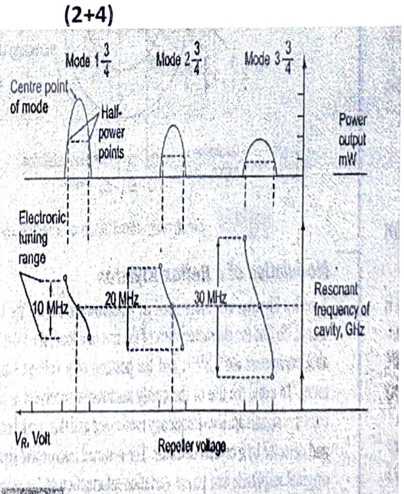
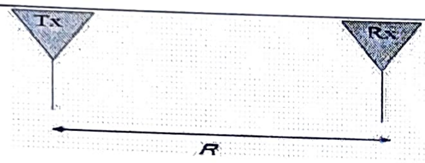
Fig. 9.5 Reflex klystron modes


Fig. 9.6 Electronic tuning and output mode power of a reflex klystron

Explanation (1.5+1.5+3)M</td><td>12</td></tr>
</table>

2(a)	1. Insertion loss (dB) $= 10\log \frac{P_i}{P_0} = 10\log \frac{\lvert a_1\rvert^2}{\lvert b_2\rvert^2} = 20\log \left\lvert\frac{a_1}{b_2}\right\rvert = 20\log \frac{1}{\lvert S_{21}\rvert} = 20\log \frac{1}{\lvert S_{12}\rvert}$ 2. Transmission loss (dB) $= 10\log \frac{P_i - P_r}{P_0} = 10\log \frac{1-\lvert S_{11}\rvert^2}{\lvert S_{12}\rvert^2}$ 3. Reflection loss (dB) $= 10\log \frac{P_i}{P_i - P_r} = 10\log \frac{1}{1-\lvert S_{11}\rvert^2}$ 4. Return loss (dB) $= 10\log \frac{P_i}{P_r} = 10\log \frac{\lvert a_1\rvert^2}{\lvert b_1\rvert^2} = 20\log \frac{1}{\lvert S_{11}\rvert}$ (4*1.5)	6 M
2(b)	Power losses Dielectric Losses Ohmic losses Radiation losses (4+2+3+3) M	12 M
3(a)	Types: N,BNC,TNC,SMA,APC-7, APC 3.5 -1M Comparisons in terms of Sex, dielectric in mating space, Impedance, frequency range, features-(1+1+1+1+1)M	6
3(b)	 1M $p = \frac{P_T}{4\pi R^2}$ $p = \frac{P_T}{4\pi R^2} G_T$ $P_R = \frac{P_T}{4\pi R^2} G_T A_{ER}$ 3M $A_e = \frac{\lambda^2}{4\pi} G$ $P_R = \frac{P_T G_T G_R c^2}{(4\pi R f)^2}$ or equivalent formula 2M	6
4(a)	$\int_S (E_r \times H_j - E_j \times H_r) \cdot ds = 0$ where S is the closed surface area of the conducting walls enclosing the junction and N ports in the absence of any Source. Since the integral over the perfectly conducting walls vanishes, the only non-zero integrals are those taken over the reference planes of corresponding ports, so that $\sum_{n=1}^{N} \int_{t_n} (E_r \times H_j - E_j \times H_r) \cdot ds = 0$ Since V_n except V_r and V_j are zero, $E_{tr} = n \times E_r$ and $E_{tj} = n \times E_j$ are zero on all reference planes at the corresponding ports except t_r and t_j. Therefore $\int_{t_r} (E_r \times H_j)\, ds = \int_{t_j} (E_j \times H_r)\, ds$ $P_{rj} = P_{jr}$ — (A) Where P_{rj} represents the power at reference plane r due to an input voltage at plane j. From the admittance matrix representation $I = YV$ (A) $P_{rj} = P_{jr} \Rightarrow V_r V_j Y_{rj} = V_j V_r Y_{jr}$ $P = VI$ $Y_{rj} = Y_{jr}$ $Z_{rj} = Z_{jr}$ ... are Symmetrical for a (2+4) M	6

4(b)	$\Lambda = c/f = 100m$ $P_r = P_t A_{et} A_{er} / r^2 \lambda^2 = 3.79Kw$	3M 3 M	6

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K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

II SESSIONAL TEST QUESTION PAPER 2020 – 21 ODD SEMESTER

SET – A

USN

Degree	: B.E		Semester	:	VII A& B
Branch	: ECE		Course Code	:	17EC71
Course Title	: MICROWAVES AND ANTENNAS		Date	:	17-11-2020
Duration	: 90 Minutes		Max Marks	:	30

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1(a)	**Derive** the transmission line equations by the method of distributed circuit theory.	6	CO1	K3 [Applying]
(b).	**Find** i) characteristic impedance ii) propagation constant for a transmission line having the parameters, R=2 Ω/m, G=0.5 mmho /m, f=1GHz, L=8nH/m. C=0.23pF/m.	6	CO1	K3 [Applying]
(c)	**Apply** smith chart to identify the location and length of a single stub nearest to the load to produce an impedance match when a line of 400Ω is connected to a load of 200 + j300Ω, which is excited by a matched generator at 800MHz.	6	CO1	K3 [Applying]
	OR			
2(a)	**Find** i) Reflection coefficient ii) SWR, when a certain transmission line has a characteristic impedance of 50 + j0.01Ω and is terminated in a load impedance of 73- j42.5Ω.	6	CO1	K3 [Applying]
(b)	**Apply** Smith chart to determine the VSWR, first V_{max}, first V_{min} from the load, given the normalized load impedance Z_L=1+j1, operating wavelength λ=5 cms.	6	CO1	K3 [Applying]
(c)	**Find** the power delivered to the loads 40 ohms and 60 ohms connected to arms 1 and 2 when 10mW power is delivered to matched port 3 of a H-plane T- junction. Assume characteristic impedance of line = 50 0hm.	6	CO1	K3 [Applying]
	PART-B			
3(a)	**Analyze** with the aid of diagram, E-plane and its S-Matrix.	6	CO2	K4 [Analyzing]
(b)	**Inspect** the working of phase shifter with the help of neat diagrams.	6	CO2	K4 [Analyzing]
	OR			
4(a)	**Examine** the features and functions of magic tee. Simplify its s-matrix.	6	CO2	K4 [Analyzing]
(b)	**Examine** S-parameters in terms of impedance when each line is matched terminated, given a two-transmission lines of characteristic impedance Z_1 and Z_2 are joined at plane PP'.	6	CO2	K4 [Analyzing]

Note:

1. Strictly rename your pdf as "Section_USN_MWA_IA2"

Ex: A_1KS16EC038_MWA_IA2

2. Mail the renamed pdf to Email: surekhaborra@ksit.edu.in

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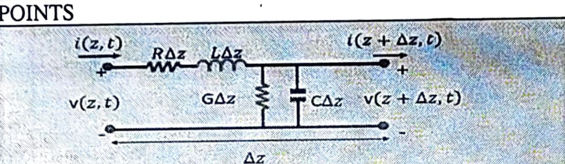
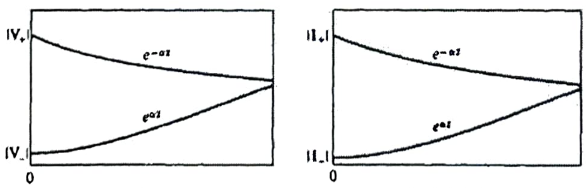
II SESSIONAL TEST QUESTION PAPER 2020 – 21 ODD SEMESTER

SCHEME AND SOLUTION SET A

Degree	:	**B.E**	**Semester**	:	**VII A &B**
Branch	:	**ECE**	**Course Code**	:	**17EC71**
Course Title	:	**MICROWAVES AND ANTENNAS**	**Max Marks**	:	**30**

Q.NO.	POINTS	MARKS
1(a)	 Fig. 1. Lumped element circuit model of transmission line L and KCL on the circuit given in Fig. 1, we get: $$v(z,t) - R\Delta z i(z,t) - L\Delta z\frac{\partial i(z,t)}{\partial t} - v(z+\Delta z,t) = 0$$ $$i(z,t) - G\Delta z v(z+\Delta z,t) - C\Delta z\frac{\partial v(z+\Delta z,t)}{\partial t} - i(z+\Delta z,t) = 0.$$ **2M** $$\Rightarrow \frac{\partial v(z,t)}{\partial z} = -Ri(z,t) - L\frac{\partial i(z,t)}{\partial t}$$ $$\frac{\partial i(z,t)}{\partial z} = -Gv(z,t) - C\frac{\partial v(z,t)}{\partial t}$$ $$v(z,t) = Re\{V(z)e^{j\omega t}\}$$ $$i(z,t) = Re\{I(z)e^{j\omega t}\}$$ **1M** $$\frac{d^2V(z)}{dz^2} - \gamma^2 V(z) = 0$$ $$\frac{d^2I(z)}{dz^2} - \gamma^2 I(z) = 0$$ $$V(z) = V_0^+ e^{-\gamma z} + V_0^- e^{\gamma z}$$ $$I(z) = I_0^+ e^{-\gamma z} + I_0^- e^{\gamma z}$$ **1M** **Explanation after every step , 1M**  (a) Voltage wave (b) Current wave **Fig of standing waves 1M**	**6**
1(b)	Given R=2 Ω/m ,G=0.5 mmho /m, f=1GHz, L=8nH/m. C=0.23pF/m. $Z_0 = \sqrt{\frac{R+jwL}{G+jwC}}$ = 181.39∠8.40=179.44+j26.5 $\gamma = \sqrt{(R+jwL)(G+jwC)}$ = 0.277∠79.31 = 0.051 + j0.273 **(3 +3)M**	**6**
1(c)	Smith chart indicating total lengths, proper marking and drawings Z_L=0.5+j0.75, Y_L=0.62+-j0.88, Y_d=1+j1.3, Y_s=-j1.3 d=.5λ-0.36λ+0.16 λ=0.31 λ,	**6**

	$l=0.355\lambda-0.25\lambda=0.105\lambda$ (1+1+1+1+1)M Fig of stub-1M	
2(a)	$Z_o=50 + j0.01\Omega$, $Z_L= 73- j42.5\Omega$ $\Gamma=(Z_L-Z_o)/(Z_L+Z_o)=0.377\angle-42.7^{\circ}$ SWR=1+ Γ /1- Γ = 2.21 **(2.5 +2.5)M**	
2(b)	Fig. Smith chart indicating total lengths, proper marking and drawings $Z_L=1+j1$ VSWR=2.6 d1 (Vmax)=0.25 λ-0.162 λ=0.44 cm d2 (Vmin)=0. 5 λ-0.162 λ=1.69 cm (2+1+1+1+1)M	6
2 (c)	Fig -2M R1=40-50/40+50=1/9 -1M R2=60-50/60+50=1/11 -1M $P1=P(1-(R_1)^2)=4.93mw$ -1M $P2=P(1-(R_2)^2)=4.95mw$ -1M	6
3(a)	$[S]=\begin{bmatrix} S_{11} & S_{12} & S_{13} \\ S_{12} & S_{22} & -S_{13} \\ S_{13} & -S_{13} & 0 \end{bmatrix}$ .... Equation 5 We can say that we have four unknowns, considering the symmetry property. From the Unitary property $[S][S]*=[I]$ 2M $\begin{bmatrix} S_{11} & S_{12} & S_{13} \\ S_{12} & S_{22} & -S_{13} \\ S_{13} & -S_{13} & 0 \end{bmatrix}\begin{bmatrix} S^*_{11} & S^*_{12} & S^*_{13} \\ S^*_{12} & S^*_{22} & -S^*_{13} \\ S^*_{13} & -S^*_{13} & 0 \end{bmatrix}=\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ 1M $[S]=\begin{bmatrix} \frac{1}{2} & \frac{1}{2} & \frac{1}{\sqrt{2}} \\ \frac{1}{2} & \frac{1}{2} & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 \end{bmatrix}$ 1M Fig 1M Exp 1M	6

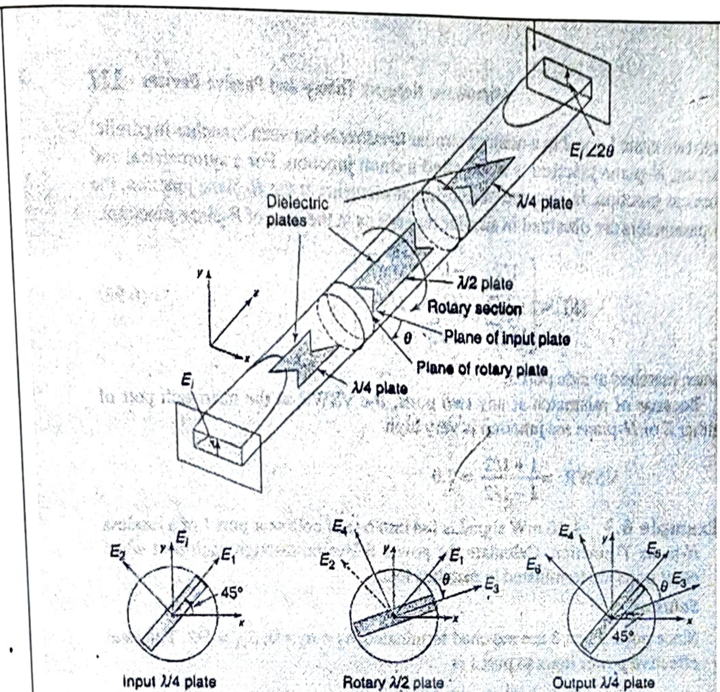
<table>
<tr><td>3 (b)</td><td>


Fig. 6.27 Precision rotary phase shifter

Fig 2M
Equations with derivations 3M
Explanation 2M
</td><td>6</td></tr>
<tr><td>4 (a)</td><td>

$$[S] = \begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{12} & S_{22} & S_{13} & -S_{14} \\ S_{13} & S_{13} & 0 & 0 \\ S_{14} & -S_{14} & 0 & 0 \end{bmatrix}$$

1M
Use of Identity Property 1M

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

2M
Fig 1M
Exp 1M
</td><td>6</td></tr>
<tr><td>4(b)</td><td>
Fig -2M
$S_{11}=z_2-z_1/z_1+z_2$ -1M
$S_{12}=2z_1/z_1+z_2$ -1M
$S_{22}=z_1-z_2/z_1+z_2$ -1M
$S_{21}=2z_2/z_1+z_2$ -1M
</td><td>6</td></tr>
</table>

Signature of course in charge **Signature of Module Coordinator** **Signature of HOD**

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

II SESSIONAL TEST QUESTION PAPER 2020 – 21 ODD SEMESTER

SET – B

USN | | | | | | | | | | |

Degree : B.E		**Semester** :	VII A& B
Branch : ECE		**Course Code** :	17EC71
Course Title : MICROWAVES AND ANTENNAS		**Date** :	17-11-2020
Duration : 90 Minutes		**Max Marks** :	30

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1(a)	**Apply** Smith chart to determine the VSWR, first V_{max}, first V_{min} from the load, given the normalized load impedance Z_L=1+j1, operating wavelength λ=5 cms.	6	CO1	K3 [Applying]
(b)	**Apply** smith chart to find the location and length of a single stub nearest to the load to produce an impedance match when a line of 400Ω is connected to a load of 200 + j300Ω, which is excited by a matched generator at 800MHz.	6	CO1	K3 [Applying]
(c)	**Interpret** the structures and characteristic impedances of coplanar strip line sand shielded strip lines	6	CO1	K3 [Applying]
	OR			
2(a)	**Find** i) Reflection coefficient ii) Transmission coefficient, when a certain transmission line has a characteristic impedance of 75 + j0.01Ω and is terminated in a load impedance of 70+ j50Ω.	6	CO1	K3 [Applying]
(b)	**Find** i) characteristic impedance ii) propagation constant for a transmission line having the parameters, R=2 Ω/m, G=0.5 mmho /m, f=1GHz, L=8nH/m. C=0.23pF/m.	6	CO1	K3 [Applying]
(c)	**Derive** the transmission line equations by the method of distributed circuit theory.	6	CO1	K3 [Applying]
	PART-B			
3(a)	**Analyze** with the aid of diagram, H-plane and its S-Matrix.	6	CO2	K4 [Analyzing]
(b)	**Inspect** the working of precision type variable attenuator with the help of neat diagrams.	6	CO2	K4 [Analyzing]
	OR			
4(a)	**Examine** the features and functions of magic tee. Simplify its s-matrix.	6	CO2	K4 [Analyzing]
(b)	**Examine** the power delivered through each port when other ports are terminated in Matched load if a 20mW signal is fed into one of the collinear ports 1 of a lossless H-plane T junction.	6	CO2	K4 [Analyzing]

Note:

1. Strictly rename your pdf as "Section_USN_MWA_IA2"

Ex: A_1KS16EC038_MWA_IA2

2. Mail renamed pdf to Email: surekhaborra@ksit.edu.in

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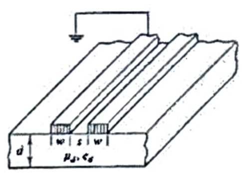
K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

II SESSIONAL TEST QUESTION PAPER 2020 – 21 ODD SEMESTER

SCHEME AND SOLUTION SET B

Degree	: B.E	**Semester :**	VII A &B
Branch	: ECE	**Course Code :**	15EC71
Course Title	: MICROWAVES AND ANTENNAS	**Max Marks :**	30

Q.NO.	POINTS	MARKS
1 (a)	Fig. Z_L=1+j1 VSWR=2.6 d1 (Vmax)=0.25 λ-0.162 λ=0.44 cm d2 (Vmin)=0. 5 λ-0.162 λ=1.69 cm **(2+1+1+1+1)M**	**6**
1 (b)	Z_L=0.5+j0.75, Y_L=0.62+-j0.88, Y_d=1+j1.3, Y_s=-j1.3 d=.5λ-0.36λ)+0.16 λ=0.31 λ, l=0.355 λ-0.25 λ=0.105 λ **(1+1+1+1+1+1)M**	**6**
1 (c)	• Coplanar striplines  $Z_0 = \frac{2\,P_{avg}}{I_0^2}$ • Shielded striplines  $Z_0 = \frac{94.15}{\sqrt{\epsilon_r}}\left(\frac{w}{d}K + \frac{C_f}{8.854\epsilon_r}\right)^{-1}$ where $K = \frac{1}{1 - t/d}$ t = the strip thickness d = the distance between the two ground planes $C_f = \frac{8.854\epsilon_r}{\pi}[2K \ln (K+1) - (K-1)\ln(K^2-1)]$ and is the fringe capacitance in pF/m **3 +3**	**6**
2(a)	Z_0=75 + j0.01Ω , Z_L= 70 + j50Ω Γ=(Z_L-Z_0)/(Z_L+Z_0)=0.33L76.68=0.08+j0.32 T=2Z_L/(Z_L+Z_0)=1.12L16.51=1.08+j0.32 **(3+3)M**	**6**
2(b)	Given R=2 Ω/m ,G=0.5 mmho /m, f=1GHz, L=8nH/m. C=0.23pF/m. $Z_0 = \sqrt{\frac{R+jwL}{G+jwC}}$ = 181.39L8.40=179.44+j26.5 $\gamma = \sqrt{(R+jwL)(G+jwC)}$ = 0.277L79.31 = 0.051 + j0.273 **(2.5 +2.5)M**	**6**

2 (c))

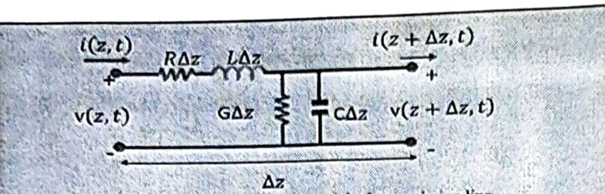


Fig. 1. Lumped element circuit model of transmission line

L and KCL on the circuit given in Fig. 1, we get:

$$v(z,t) - R\Delta z i(z,t) - L\Delta z\frac{\partial i(z,t)}{\partial t} - v(z+\Delta z,t) = 0$$

$$i(z,t) - G\Delta z v(z+\Delta z,t) - C\Delta z\frac{\partial v(z+\Delta z,t)}{\partial t} - i(z+\Delta z,t) = 0.$$

2M

$$\Rightarrow \frac{\partial v(z,t)}{\partial z} = -Ri(z,t) - L\frac{\partial i(z,t)}{\partial t}$$

$$\frac{\partial i(z,t)}{\partial z} = -Gv(z,t) - C\frac{\partial v(z,t)}{\partial t}$$

1M

$$v(z,t) = Re\{V(z)e^{j\omega t}\}$$

$$i(z,t) = Re\{I(z)e^{j\omega t}\}$$

1M

$$\frac{d^2V(z)}{dz^2} - \gamma^2 V(z) = 0$$

$$\frac{d^2I(z)}{dz^2} - \gamma^2 I(z) = 0$$

1M

$$V(z) = V_0^+e^{-\gamma z} + V_0^-e^{\gamma z}$$

$$I(z) = I_0^+e^{-\gamma z} + I_0^-e^{\gamma z}$$

1M

Marks: 6

3(a)

$$[S] = \begin{bmatrix} S_{11} & S_{12} & S_{13} \\ S_{12} & S_{22} & S_{13} \\ S_{13} & S_{13} & 0 \end{bmatrix}$$

1M

Usage of identity property 1M

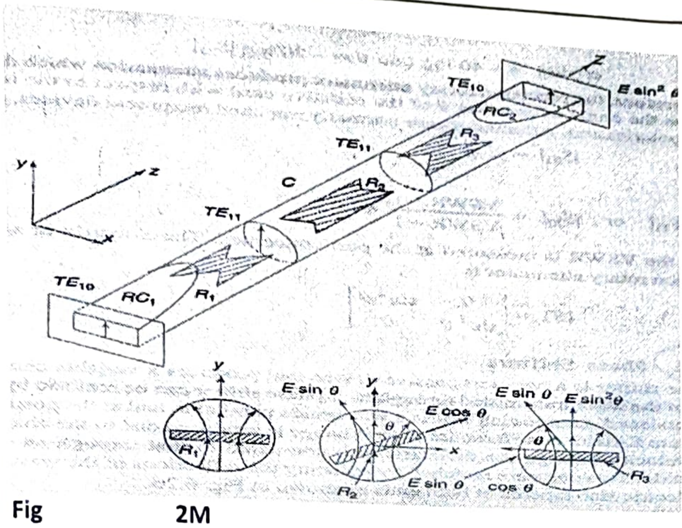
$$[S] = \begin{bmatrix} \frac{1}{2} & -\frac{1}{2} & \frac{1}{\sqrt{2}} \\ -\frac{1}{2} & \frac{1}{2} & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \end{bmatrix}$$

1M

Fig 1M

Exp 1M

Marks: 6

3(b)	 Fig 2M Equations 1M Explanation 2M	6
4 (a)	$[S] = \begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{12} & S_{22} & S_{13} & -S_{14} \\ S_{13} & S_{13} & 0 & 0 \\ S_{14} & -S_{14} & 0 & 0 \end{bmatrix}$ 1M Use of Identity Property 1M $[S] = \begin{bmatrix} 0 & 0 & \frac{1}{2} & \frac{1}{\sqrt{2}} \\ 0 & 0 & \frac{1}{2} & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 & 0 \\ \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 & 0 \end{bmatrix}$ 1M Fig 1M Exp 1M	6
4(b)	Fig 1M $P1=p[1-(s_{11})^2] =15mw$ 2M $P2=P(s_{21})^2=5mw$ 1M $P3=P(s_{31})^2=10mw$ 1M	6

Signature of course in charge   Signature of Module Coordinator   Signature of HOD

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

III SESSIONAL TEST QUESTION PAPER 2020 – 21 ODD SEMESTER

SET – A

USN | | | | | | | | | |

Degree	:	**B.E**	**Semester**	:	**VII**
Branch	:	**ECE**	**Course Code**	:	**17EC71**
Course Title	:	**Microwave and Antennas**	**Date**	:	**11/1/21**
Duration	:	**90 Minutes**	**Max Marks**	:	**30**

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1(a)	**Deduct** power theorem and its application to an isotropic source.	6	CO5	K5 [Evaluating]
(b)	**Deduct** an array factor expression in case of linear array of n isotropic point sources of equal amplitude and spacing.	6	CO5	K5 [Evaluating]
(c)	**Explain** Yagi-Uda antenna structure with a neat diagram.	6	CO5	K5 [Evaluating]
	OR			
2(a)	**Prove** that the radiation resistance of a linear antenna with sinusoidal current distribution is equal to 73Ω.	6	CO5	K5 [Evaluating]
(b)	**Deduct** the expression for strength Eϕ and Hθ in case of small loop.	6	CO5	K5 [Evaluating]
(c)	**Explain** the operation of log-periodic antenna.	6	CO5	K5 [Evaluating]
	PART-B			
3(a)	**Explain** i) Directivity ii) Gain iii) Beam Area iv) Beam efficiency v) Effective aperture	6	CO4	K5 [Evaluating]
(b)	**Determine** i) HPBW ii) Axial ratio iii) Directivity and draw the pattern for a 18-turn helical beam antenna has a circumference of λ and turn spacing of λ/4.	6	CO4	K5 [Evaluating]
	OR			
4(a)	**Explain** the operation of Horn antenna.	6	CO4	K5 [Evaluating]
(b)	**Determine** the total power and directivity if a source has a radiation intensity power pattern, $U=U_m \sin^2 \Theta \sin^3 \phi$, $0 \leq \Theta \leq \pi$, $0 \leq \phi \leq 2\pi$.	6	CO4	K5 [Evaluating]

Note:

1. Strictly rename your pdf as "Section_USN_MWA_IA3"
Ex: A_1KS16EC038_MWA_IA1
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K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109
III SESSIONAL TEST 2019 – 20 ODD SEMESTER
SCHEME AND SOLUTION SET A

Degree : **B.E**
Branch : **ECE**
Course Title : **MICROWAVES AND ANTENNAS**

Semester : **VII A &B**
Course Code : **17EC71**
Max Marks : **30**

<table>
<tr><th>Q.NO.</th><th>POINTS</th><th>MARKS</th></tr>
<tr><td>1(a)</td><td>

$$P = \oint\!\!\oint S \cdot ds = \oint\!\!\oint S_r\, ds$$

where

P = power radiated, W
S_r = radial component of average Poynting vector, W m^{-2}
ds = infinitesimal element of area of sphere (see Fig. 3–2*b*)
= $r^2 \sin\theta\, d\theta\, d\phi$, m^2

For an *isotropic source,* S_r is independent of θ and ϕ so

$$P = S_r \oint\!\!\oint ds = S_r \times 4\pi r^2 \quad \text{(W)}$$

and

$$S_r = \frac{P}{4\pi r^2} \quad (\text{W m}^{-2})$$

3M

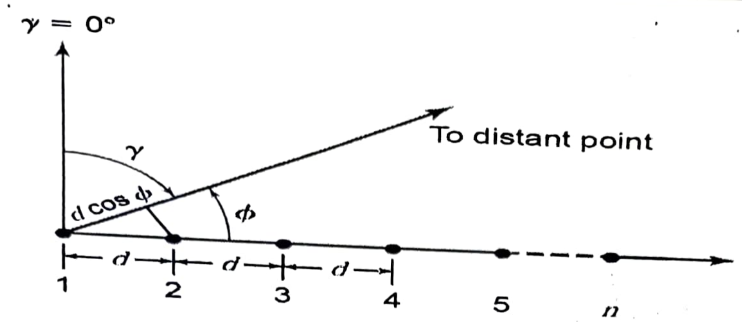
Radiation Intensity
The radiation intensity U is expressed in watts per unit solid angle (W sr^{-1}).
The radiation intensity is independent of radius.

$$r^2 S_r = P/4\pi = U \text{ (W/sr)}$$
$$P = 4\pi U$$

1M

For an isotropic source :
$P = 4\pi U_0$ (W)
1M
where U_0 = radiation intensity of isotropic source, W sr^{-1}.
the power theorem may be restated as follows:
The total power radiated is given by the integral of the radiation intensity over a solid angle of 4π steradians.
1M
</td><td>6</td></tr>
</table>

1(b) — 6



- 1M

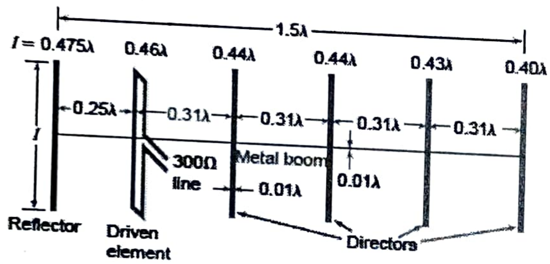
$$E = 1 + e^{j\psi} + e^{j2\psi} + e^{j3\psi} + \cdots + e^{j(n-1)\psi}$$

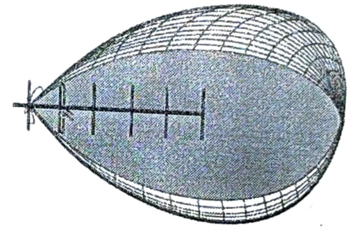
-1M

$$E = \frac{1}{n}\frac{\sin(n\psi/2)}{\sin(\psi/2)}$$

Array factor Derivation-4M

1 (c) — 6





Explanation 2M+3M

2(a) — 6

$$P = \frac{15 I_0^2}{\pi}\int_0^{2\pi}\int_0^{\pi}\frac{\{\cos[(\beta L/2)\cos\theta] - \cos(\beta L/2)\}^2}{\sin\theta}\,d\theta\,d\phi$$

$$= 30 I_0^2 \int_0^{\pi}\frac{\{\cos[(\beta L/2)\cos\theta] - \cos(\beta L/2)\}^2}{\sin\theta}\,d\theta$$

Equating the radiated power as given by (2) to $I_0^2 R_0/2$ we have

$$P = \frac{I_0^2 R_0}{2}$$

and

$$R_0 = 60\int_0^{\pi}\frac{\{\cos[(\beta L/2)\cos\theta] - \cos(\beta L/2)\}^2}{\sin\theta}\,d\theta$$

3M

$$\boxed{R_r = 30\,\mathrm{Cin}(2\pi) = 30 \times 2.44 = 73\,\Omega}$$

$$\boxed{Z = 73 + j42.5\,\Omega}$$

3M

2(b) — **6**

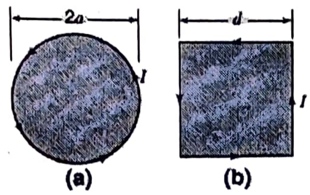


Figure 7–1 Circular loop (*a*) and square loop (*b*) of equal area.

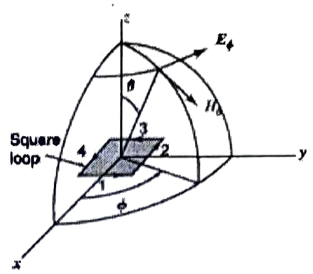


Fig- 2M

$$E_{\phi 0} = \frac{j60\pi [I] L}{r\lambda} \qquad (6)$$

where $[I]$ is the retarded current on the dipole and r is the distance from the dipole. Substituting (6) in (5) then gives

$$E_{\phi} = \frac{60\pi [I] L d_r \sin\theta}{r\lambda} \qquad (7)$$

However, the length L of the short dipole is the same as d, that is, $L = d$. Noting also that $d_r = 2\pi d/\lambda$ and that the area A of the loop is d^2, (7) becomes

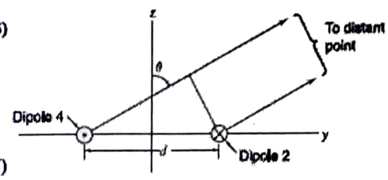


Figure 7–3 Construction for finding far field of dipoles 2 and 4 of square loop.

Small loop	$E_{\phi} = \dfrac{120\pi^2 [I] \sin\theta}{r} \dfrac{A}{\lambda^2}$	Far E_{ϕ} field

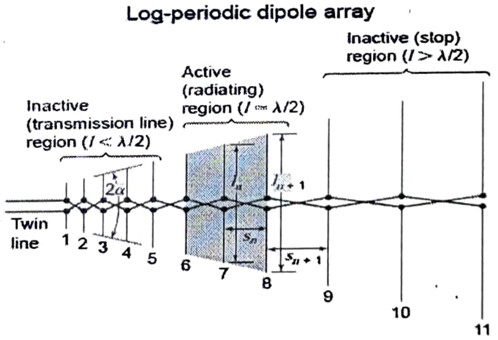
(8)

$$H_{\theta} = \frac{E_{\phi}}{120\pi} = \frac{\pi [I] \sin\theta}{r} \frac{A}{\lambda^2}$$

Derivation and explanation -4M

2(c) — **6**

Log-periodic dipole array



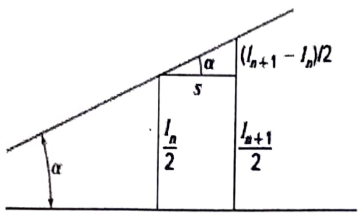
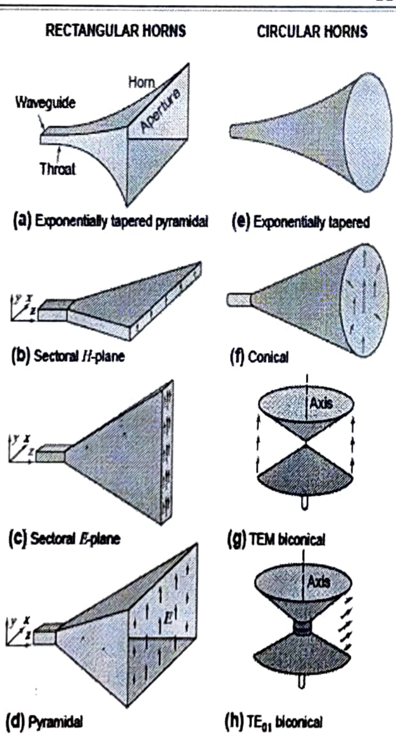
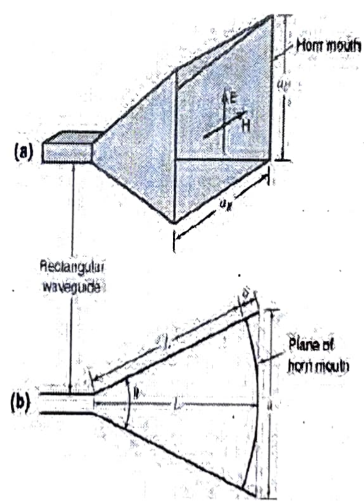
$$\tan\alpha = \frac{(l_{n+1} - l_n)/2}{s}$$

2M

$$\frac{l_{n+1}}{l_1} = k^n = F$$

1M

$$\text{HPBW } (H \text{ plane}) \le \frac{41{,}000}{D \times 60^{\circ}} \quad \text{(deg)}$$

	 $$\tan\alpha = \frac{[1-(1/k)](l_{n+1}/2)}{s}$$ Taking $l_{n+1} = \lambda/2$ (when active) we have $$\tan\alpha = \frac{1-(1/k)}{4s_\lambda}$$ where α = apex angle k = scale factor s_λ = spacing in wavelengths shortward of $\lambda/2$ element $$\frac{l_{n+1}}{l_n} = \frac{s_{n+1}}{s_n} = k$$ Explanation 3M	
3 (a)	i) Directivity -1M ii) Gain -1M iii) Beam Area -2M iv) Beam efficiency -1M v) Effective aperture -1M	**6**
3 (b)	HPBW= $\frac{52}{c\sqrt{n\lambda}}$ = ~~26~~° 24.51 1M n = 18 Axial ratio= $\frac{2n+1}{2n}$ =1.03 1M Cλ= 1, Sλ= 1/4 1M Directivity=$12nC_\lambda^2S_\lambda$=~~48~~ 54 1M $(\text{Directivity})_{dB}$=~~16.81dB~~ 17.32dB 1M Pattern 1M	**6**
4 (a)	 3M +Explanation 3M	**6**

4(b)	$P_{rad} = \int \int U \sin\theta \, d\theta \, d\phi$ $= \int_{\phi=0}^{\pi} \int_{\theta=0}^{\pi} U_m \sin^2\theta \sin^3\phi \cdot \sin\theta \, d\theta \, d\phi$ $= U_m \int_{\phi=0}^{\pi} \sin^3\phi \, d\phi \cdot \int_{\theta=0}^{\pi} \sin^3\theta \, d\theta = U_m \cdot \frac{4}{3} \cdot \frac{4}{3} = \frac{16}{9} U_m$ $4\pi U_0 = \frac{16}{9} U_m$ $D = \frac{U_m}{U_0} = \frac{4\pi \times 9}{16} = 7.06$ 1M+3M+1M+1M	6

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III SESSIONAL TEST QUESTION PAPER 2020 – 21 ODD SEMESTER

SET – B

USN

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Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1(a)	**Deduct** the field expression of two isotropic point sources of same amplitude and phase.	6	CO5	K5 [Evaluating]
(b)	**Deduct** the expression for field of dipole in general for the case of thin linear antenna.	6	CO5	K5 [Evaluating]
(c)	**Explain** Paraboloid antenna with a neat diagram.	6	CO5	K5 [Evaluating]
	OR			
2(a)	**Deduct** the expression for far field components of short dipole.	6	CO5	K5 [Evaluating]
(b)	**Prove** that the radiation resistance of small loop is 31171. $(A/\lambda^2)^2$.	6	CO5	K5 [Evaluating]
(c)	**Explain** the structure of Helical antenna with its characteristics.	6	CO5	K5 [Evaluating]
	PART-B			
3(a)	**Explain** i) Directivity ii) Gain iii) Beam Area iv) Beam efficiency v) Effective aperture	6	CO4	K5 [Evaluating]
(b)	**Determine** i) HPBW ii) Axial Ratio iii) Directivity and draw the pattern for a 20-turn helical beam antenna has a circumference of 2λ and turn spacing of $\lambda/4$.	6	CO4	K5 [Evaluating]
	OR			
4(a)	**Determine** the exact directivity for three-dimensional source having pattern $U=U_m \sin^2 \Theta$, $0 \leq \Theta \leq \pi$, $0 \leq \acute{\emptyset} \leq \pi$	6	CO4	K5 [Evaluating]
(b)	**Determine** the radiation resistance of short electric dipole.	6	CO4	K5 [Evaluating]

Note:

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K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

III SESSIONAL TEST 2020 – 21 ODD SEMESTER

SCHEME AND SOLUTION SET B

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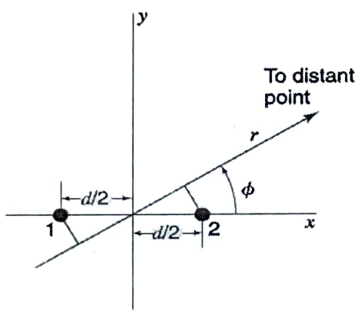
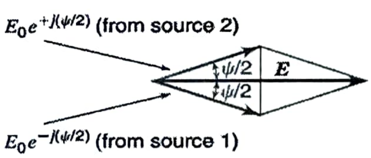
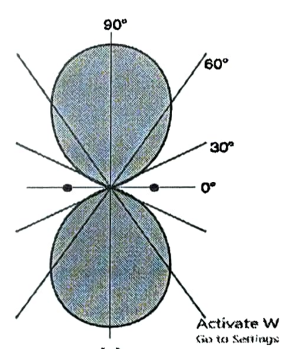
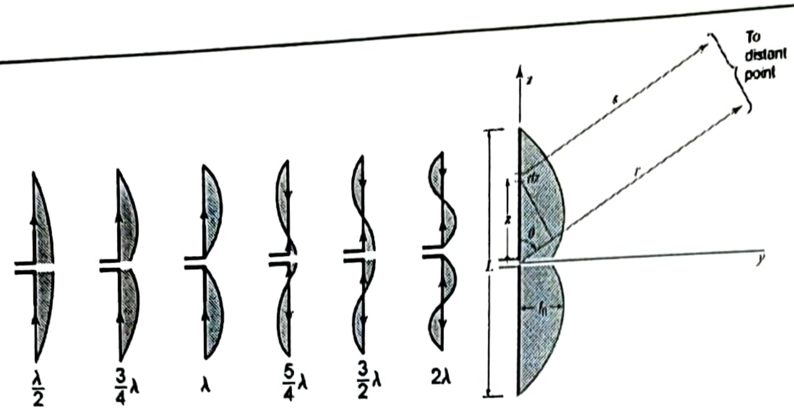
Branch	:	**ECE**	**Course Code**	:	**17EC71**
Course Title	:	**MICROWAVES AND ANTENNAS**	**Max Marks**	:	**30**

Q.NO.	POINTS	MARKS
1(a)	  1M $$E = E_0e^{-j\psi/2} + E_0e^{+j\psi/2}$$ $$E = 2E_0\frac{e^{+j\psi/2} + e^{-j\psi/2}}{2}$$ which by a trigonometric identity is $$E = 2E_0 \cos\frac{\psi}{2} = 2E_0 \cos\left(\frac{d_r}{2}\cos\phi\right)$$ Let $2E_0$=1 and d=λ/2 dr= βd=(2π/λ)(λ/2)=π $$E = \cos\left(\frac{\pi}{2}\cos\phi\right)$$ 1M  (c) Explanation and Derivation-4M	6
1(b)	$$[I] = I_0 \sin\left[\frac{2\pi}{\lambda}\left(\frac{L}{2} \pm z\right)\right] e^{j\omega[t-(r/c)]}$$ $$\sin\left[\frac{2\pi}{\lambda}\left(\frac{L}{2} \pm z\right)\right]$$	6



2M

Far fields of center-fed dipole

$$H_\phi = \frac{j[I_0]}{2\pi r}\left[\frac{\cos[(\beta L\cos\theta)/2] - \cos(\beta L/2)}{\sin\theta}\right]$$

$$E_\theta = \frac{j60[I_0]}{r}\left[\frac{\cos[(\beta L\cos\theta)/2] - \cos(\beta L/2)}{\sin\theta}\right]$$

where $[I_0] = I_0 e^{j\omega[t-(r/c)]}$ and

$$E_\theta = 120\pi H_\phi$$

Explanation and derivation-4M

1 (c)

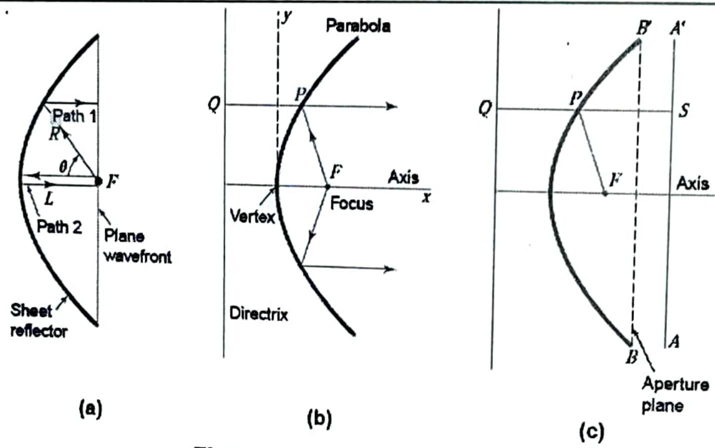


Figure 9–18 Parabolic reflectors.

2M

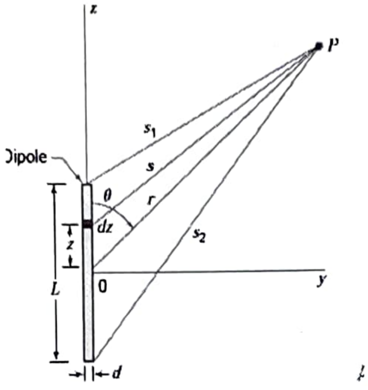
$$PF = PQ$$

$$PS = QS - PQ$$

$$PF + PS = PF + QS - PQ = QS$$ 2M

Explanation-2M

2(a) — 6



$$[I] = I_0 e^{j\omega[t-(r/c)]}$$

1M

$$A_z = \frac{\mu_0}{4\pi}\int_{-L/2}^{L/2} \frac{[I]}{s}\, dz$$

where $[I]$ is the retarded current given by

$$[I] = I_0 e^{j\omega[t-(s/c)]}$$

In (3) and (3a),

z = distance to a point on the conductor
I_0 = peak value in time of current (uniform along dipole)
μ_0 = permeability of free space = $4\pi \times 10^{-7}$ H m^{-1}

$$A_z = \frac{\mu_0 L I_0 e^{j\omega[t-(r/c)]}}{4\pi r}$$

The retarded scalar potential V of a charge distribution is

$$V = \frac{1}{4\pi\varepsilon_0}\int_V \frac{[\rho]}{s}\, d\tau$$

where $[\rho]$ is the retarded charge density given by

$$[\rho] = \rho_0 e^{j\omega[t-(s/c)]}$$

3M

Electric and magnetic fields of short dipole — *Far-field case*

$$E_\theta = \frac{j\omega I_0 L \sin\theta\, e^{j\omega[t-(r/c)]}}{4\pi\varepsilon_0 c^2 r} = j\frac{I_0 \beta L}{4\pi\varepsilon_0 c r}\sin\theta\, e^{j\omega[t-(r/c)]}$$

$$H_\phi = \frac{j\omega I_0 L \sin\theta\, e^{j\omega[t-(r/c)]}}{4\pi c r} = j\frac{I_0 \beta L}{4\pi r}\sin\theta\, e^{j\omega[t-(r/c)]}$$

2M

2(b) — 6

$$P = \frac{I_0^2}{2} R_r$$

$$S_r = \tfrac{1}{2}|H|^2 \operatorname{Re} Z$$

$$S_r = \frac{15\pi(\beta a I_0)^2}{r^2} J_1^2(\beta a \sin\theta)$$

$$P = \iint S_r\, ds = 15\pi(\beta a I_0)^2 \int_0^{2\pi}\int_0^{\pi} J_1^2(\beta a \sin\theta)\sin\theta\, d\theta\, d\phi$$

2M

$$P = 30\pi^2(\beta a I_0)^2 \int_0^\pi J_1^2(\beta a \sin\theta)\sin\theta\, d\theta$$

In the case of a loop that is small in terms of wavelengths, the approximation of (7· Thus (5) reduces to

$$P = \frac{15}{2}\pi^2(\beta a)^4 I_0^2 \int_0^\pi \sin^3\theta\, d\theta = 10\pi^2\beta^4 a^4 I_0^2$$

Since the area $A = \pi a^2$, (6) becomes

$$P = 10\beta^4 A^2 I_0^2$$

Assuming no antenna losses, this power equals the power delivered to the loop term Therefore,

$$R_r \frac{I_0^2}{2} = 10\beta^4 A^2 I_0^2$$

and

Small loop

$$R_r = 31{,}171\left(\frac{A}{\lambda^2}\right)^2 = 197C_\lambda^4 \quad (\Omega)$$

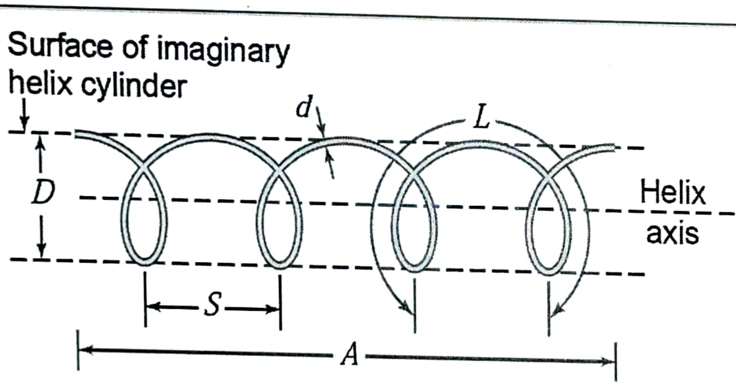
or

$$R_r \simeq 31{,}200\left(\frac{A}{\lambda^2}\right)^2 \quad (\Omega)$$

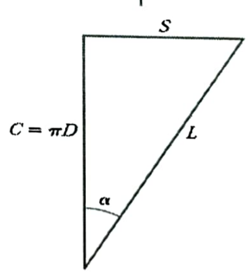
Radiation resistance

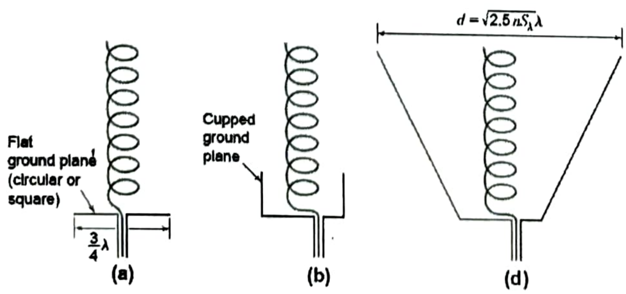
1+1+1+1 = 4M

2 (c) | 6



D = diameter of helix (center to center)
C = circumference of helix = πD
S = spacing between turns (center to center)
α = pitch angle = arctan $S/\pi D$
L = length of 1 turn
n = number of turns
A = axial length = nS
d = diameter of helix conductor





3M

Explanation

	Directivity $D \simeq 15C_\lambda^2 n S_\lambda$ **Directivity** $D \simeq 12C_\lambda^2 n S_\lambda$ Restrictions are that (4) to (7) apply only for $0.8 < C_\lambda < 1.15$, $12° < \alpha < 14°$ and $n > 3$. **Axial ratio** $= (2n+1)/2n$ where n = number of turns -3M	
3 (a)	i) Directivity -1M ii) Gain -1M iii) Beam Area -2M iv) Beam efficiency -1M v) Effective aperture -1M	6
3 (b)	HPBW= $\frac{52}{c\sqrt{n\lambda}}$=26o 1M Axial ratio= $\frac{2n+1}{2n}$=1.03 1M Cλ= 1, Sλ= 1/4 1M Directivity=12nCλ2Sλ=48 1M (Directivity)dB=16.81dB 1M Pattern 1M	6
4 (a)	Formula for Power radiated -1M $P= 8\pi U_m/3$ -2M Power radiated by isotropic source=$4\pi U_o$ -1M Directivity = 5 -1M Pattern -1M	6
4 (b)	The *average* Poynting vector is given by $S = \frac{1}{2}\text{Re}(E \times H^*)$ The far-field components are E_θ and H_ϕ so that the radial component of the Poynting vector is $S_r = \frac{1}{2}\text{Re}\, E_\theta H_\phi^*$ where E_θ and H_ϕ^* are complex. $E_\theta = H_\phi Z = H_\phi \sqrt{\frac{\mu}{\varepsilon}}$ Thus, (2) becomes $S_r = \frac{1}{2}\text{Re}\, Z H_\phi H_\phi^* = \frac{1}{2}\lvert H_\phi\rvert^2 \text{Re}\, Z = \frac{1}{2}\lvert H_\phi\rvert^2 \sqrt{\frac{\mu}{\varepsilon}}$ The total power P radiated is then $P = \iint S_r\, ds = \frac{1}{2}\sqrt{\frac{\mu}{\varepsilon}} \int_0^{2\pi}\int_0^{\pi} \lvert H_\phi\rvert^2 r^2 \sin\theta\, d\theta\, d\phi$ 3M the absolute value of the magnetic field is	6

	$$\lvert H_\phi \rvert = \frac{\omega I_0 L \sin\theta}{4\pi c r}$$ $$\sqrt{\frac{\mu}{\varepsilon}}\frac{\beta^2 I_0^2 L^2}{12\pi} = \left(\frac{I_0}{\sqrt{2}}\right)^2 R_r$$ Solving for R_r, $$R_r = \sqrt{\frac{\mu}{\varepsilon}}\frac{\beta^2 L^2}{6\pi}$$ For air or vacuum $\sqrt{\mu/\varepsilon} = \sqrt{\mu_0/\varepsilon_0} = 377 = 120\pi\,\Omega$ so that (10) becomes[1] ***Dipole with uniform current*** $R_r = 80\pi^2\left(\frac{L}{\lambda}\right)^2 = 80\pi^2 L_\lambda^2 = 790 L_\lambda^2 \quad (\Omega)$ ***Radiation resistance***	3M

Signature of course in charge   Signature of Module Coordinator   Signature of HOD

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGG

Course:MWA/17EC71 sem:7 sec:A&B

Sl No.	USN No.	Name	IA1	IA2	IA3	A1	A2	A3	Average Assignment	Average of three IA's	Final IA(Assignment+IA)
1	1KS16EC038	KSHITIZ GURUNG	21	24	8	10	7	0	6	18.0	24.0
2	1KS16EC068	PURUSHOTHAMA.	16	28	2	8	2	0	4	16.0	20.0
3	1KS16EC086	SHIVDATT .B	22	18	0	8	10	9	9	14.0	23.0
4	1KS16EC113	VINAYAK.Y.BAJAN	21	28	2	3	3	2	3	17.0	20.0
5	1KS17EC001	ABHISHEK.K.V	22	26	7	10	8	0	6	19.0	25.0
6	1KS17EC002	ABIJITH SUDHIR	29	22	8	10	8	7	9	20.0	29.0
7	1KS17EC003	AKKSHAY.U.L	29	26	17	10	8	9	9	24.0	33.0
8	1KS17EC004	AKSHITHA.V.RAME	28	26	21	10	10	9	10	25.0	35.0
9	1KS17EC005	AMOGHAVARSHA.	20	26	10	8	7	9	8	19.0	27.0
10	1KS17EC006	AMULYA.S.IYENGA	29	28	13	10	10	9	10	24.0	34.0
11	1KS17EC007	ANA EPSIBA.F	27	29	13	10	10	9	10	23.0	33.0
12	1KS17EC008	ANAGHA.A.KASHY	27	28	3	10	10	9	10	20.0	30.0
13	1KS17EC009	ANITHA.R	28	30	23	10	10	9	10	27.0	37.0
14	1KS17EC010	ANOOP DEEKSHITH	27	27	5	0	7	8	5	20.0	25.0
15	1KS17EC011	ANUPAM.M.L	24	25	6	2	0	1	1	19.0	20.0
16	1KS17EC012	ANUSHA.L	20	28	0	10	10	8	10	16.0	26.0
17	1KS17EC013	ANUSHREE.M	24	30	8	10	10	0	7	21.0	28.0
18	1KS17EC014	ANUSHRI.V.K	21	29	22	8	10	8	9	24.0	33.0
19	1KS17EC015	APEKSHA RAVI KU	30	29	23	10	10	9	10	28.0	38.0
20	1KS17EC016	ARPITHA	26	29	8	6	6	0	4	21.0	25.0
21	1KS17EC017	ASIYA FATHIMA.N	17	27	18	0	0	8	3	21.0	24.0
22	1KS17EC018	AYESHA ROSHEEN	27	27	4	10	8	5	8	20.0	28.0
23	1KS17EC019	B.D.SHREENIDHI	29	29	15	2	6	0	3	25.0	28.0
24	1KS17EC020	BHAVANA.B.S	28	30	18	10	10	8	10	26.0	36.0
25	1KS17EC021	BHAVANA.J	29	28	24	8	6	9	8	27.0	35.0
26	1KS17EC022	BHOOMIKA.P.K	28	29	19	9	6	0	5	26.0	31.0
27	1KS17EC023	BINDU.J	28	26	11	10	10	9	10	22.0	32.0

28	1KS17EC024	CHAITHRA.V.M	28	30	25	10	10	8	10	28.0	38.0
29	1KS17EC025	CHARAN SAI.Y	28	25	17	8	8	0	6	24.0	30.0
30	1KS17EC026	CHETHAN.D.R	27	28	0	8	5	7	7	19.0	26.0
31	1KS17EC027	CHETHAN.G	27	26	6	10	8	5	8	20.0	28.0
32	1KS17EC028	CHETHANA.K.S	26	28	27	10	10	7	9	27.0	36.0
33	1KS17EC029	CHETHANA PRASA	21	23	3	10	10	7	9	16.0	25.0
34	1KS17EC030	DARSHAN.T.G	28	26	9	0	10	8	6	21.0	27.0
35	1KS17EC031	DEVALE SUDARSH	21	28	6	10	5	8	8	19.0	27.0
36	1KS17EC032	DEVIYANI.G	28	24	4	0	4	9	5	19.0	24.0
37	1KS17EC033	DHAKSHITH.N.K	29	27	2	8	10	9	9	20.0	29.0
38	1KS17EC035	DISHA.S	29	29	16	10	10	8	10	25.0	35.0
39	1KS17EC036	DIVYA.T.M	26	24	14	10	10	8	10	22.0	32.0
40	1KS17EC038	GOPINATH.H.C	23	29	14	8	6	8	8	22.0	30.0
41	1KS17EC039	GOWTHAM.B	21	25	7	8	10	9	9	18.0	27.0
42	1KS17EC040	G.S.SURABHI	27	27	11	10	10	9	10	22.0	32.0
43	1KS17EC041	H.G.SRINIDHI	25	25	9	10	2	0	4	20.0	24.0
44	1KS17EC042	JEEVAN.R.S	24	29	1	8	2	8	6	18.0	24.0
45	1KS17EC043	K.SHREYA	22	28	5	8	2	0	4	19.0	23.0
46	1KS17EC044	KAMNOOR SUSHM	27	27	6	10	7	7	8	20.0	28.0
47	1KS17EC045	KRITHIKA.P	29	29	25	10	10	9	10	28.0	38.0
48	1KS17EC046	LAKSHAN.N.S	28	25	10	0	0	0	0	21.0	21.0
49	1KS17EC047	LEKHA YADAV.B	30	27	8	10	10	9	10	22.0	32.0
50	1KS17EC048	M.R.SRINIVAS	29	25	3	10	9	8	9	19.0	28.0
51	1KS17EC049	RANJITH.M	29	27	10	10	5	8	8	22.0	30.0
52	1KS17EC050	M.SIRISHA	29	28	27	10	10	9	10	28.0	38.0
53	1KS17EC051	MADHU.S	29	30	29	10	10	9	10	30.0	40.0
54	1KS17EC052	MAHADEVA.G	21	28	3	10	8	0	6	18.0	24.0
55	1KS17EC053	MAMATHA.K.S	27	29	0	10	10	5	9	19.0	28.0
56	1KS16EC093	SOMASHEKAR S	20	28	0	0	0	0	0		12.0
57	1KS16EC431	RAKESH . M D	22	27	0	0	7	5	4		15.0
58	1KS16EC33	K.UNNIMAYA	18	29	0	8	7	9	8		16.0
59	1KS17EC414	YATHISH S DHANA	19	27	0	8	0	0	3		13.0
60	1KS17EC403	BHAVANA G	16	28	0	8	7	8	8		15.0
61	1KS16EC069	SHARATH KUMAR	19	25	0	8	0	0	3		13.0
62	1KS16EC007	AMAN KUMAR SIN	27	24	0	10	7	9	9		18.0

63	1KS16EC001	A.YESWANTH	23	0	5	10	10	10	10	10.0	20.0
64	1KS17EC054	MANOJ.E	23	0	5	10	10	10	10	10.0	20.0
65	1KS17EC055	MANOJ KUMAR.R	22	27	7	8	10	0	6	19.0	25.0
66	1KS17EC056	MOHAMMAD FAIZ	20	28	5	8	4	8	7	18.0	25.0
67	1KS17EC057	MOHAMMED SAD	28	29	7	10	10	9	10	22.0	32.0
68	1KS17EC058	MONISHA.A	21	29	4	10	10	8	10	18.0	28.0
69	1KS17EC059	NAGANETRA.M	27	29	14	10	8	8	9	24.0	33.0
70	1KS17EC060	NAGELI JAYASAI N	20	22	9	0	8	8	6	17.0	23.0
71	1KS17EC061	NAVEEN KUMAR B	24	27	8	0	10	9	7	20.0	27.0
72	1KS17EC062	NAVIN KUMAR.H.C	25	28	8	8	8	8	8	21.0	29.0
73	1KS17EC063	NAVYA.S	22	27	9	8	8	7	8	20.0	28.0
74	1KS17EC064	NIKHIL.V	18	25	5	8	6	0	5	16.0	21.0
75	1KS17EC065	NIKHIL.V	18	26	15	8	10	9	9	20.0	29.0
76	1KS17EC066	PALLAVI.S	25	29	8	10	4	9	8	21.0	29.0
77	1KS17EC067	PAVAN PRASAD.R	28	26	18	10	10	9	10	24.0	34.0
78	1KS17EC068	PENUJURI NAGA S	27	28	12	10	10	8	10	23.0	33.0
79	1KS17EC069	PRAJWAL.C	22	26	10	8	8	7	8	20.0	28.0
80	1KS17EC070	PRAJWAL SIMHA.S	19	26	12	8	2	5	5	19.0	24.0
81	1KS17EC071	PRATIMA.P.AGNIH	24	28	26	8	10	9	9	26.0	35.0
82	1KS17EC072	PRATIMA V KASHY	22	26	18	8	8	8	8	22.0	30.0
83	1KS17EC073	PRUTHVIRAJ.N	24	27	5	8	8	8	8	19.0	27.0
84	1KS17EC074	R.YASHAS	21	26	1	4	4	4	4	16.0	20.0
85	1KS17EC075	RACHANA.S	29	30	13	10	10	9	10	24.0	34.0
86	1KS17EC076	RAHUL.R.NADIG	27	28	16	10	10	7	9	24.0	34.0
87	1KS17EC077	RAJESH.C.S	20	23	2	5	5	5	5	15.0	20.0
88	1KS17EC078	RAMYA.R	21	29	17	10	10	8	10	23.0	33.0
89	1KS17EC079	RITU PATIL	22	25	8	2	2	0	1	19.0	20.0
90	1KS17EC080	ROHINI.D	27	30	11	10	8	8	9	23.0	32.0
91	1KS17EC082	RUTHVIK RAVISH	26	27	4	8	8	3	7	19.0	26.0
92	1KS17EC084	SAHANA.M.K	24	29	10	10	8	8	9	21.0	30.0
93	1KS17EC085	SAHANA.V	28	29	21	10	10	8	10	26.0	36.0
94	1KS17EC086	SANDEEP KUMAR.	28	28	11	8	2	8	6	23.0	29.0
95	1KS17EC087	SHAMANTH RAJ.D	17	22	3	0	10	0	6	14.0	20.0
96	1KS17EC088	SHIVANI.K	27	28	13	10	10	7	9	23.0	32.0
97	1KS17EC089	SHRAVYA.S.ACHAR	20	29	10	8	2	8	6	20.0	26.0

98	1KS17EC090	SHREYAS.H.R	19	23	12	10	10	8	10	18.0	28.0
99	1KS17EC092	SRIVIDYA.V.R	26	28	12	10	10	8	10	22.0	32.0
100	1KS17EC093	SUPRIYA.V	25	28	5	10	8	8	9	20.0	29.0
101	1KS17EC094	SURYA.N	25	24	15	8	8	8	8	22.0	30.0
102	1KS17EC095	SUSHMITHA.B.L	27	28	5	10	8	8	9	20.0	29.0
103	1KS17EC096	SUSHMITHA.K.N	26	27	7	10	10	8	10	20.0	30.0
104	1KS17EC097	SYED WAQAR KASI	27	28	11	5	5	5	5	22.0	27.0
105	1KS17EC098	TEJAS.K	20	29	0	0	7	0	3	17.0	20.0
106	1KS17EC099	VAIBHAVI SREENIV	25	26	20	10	10	8	10	24.0	34.0
107	1KS17EC100	VAISHNAVI.K.KATT	26	28	7	10	10	0	7	21.0	28.0
108	1KS17EC101	VAISHNAVI.S	26	29	11	8	0	8	6	22.0	28.0
109	1KS17EC102	VAISHNAVI SRIHAF	26	26	14	10	9	8	9	22.0	31.0
110	1KS17EC103	VIDYA.V	28	28	7	2	10	8	7	21.0	28.0
111	1KS17EC104	VISHAL GOUTHAM	27	29	11	10	10	8	10	23.0	33.0
112	1KS17EC105	YASHASWINI.R	22	29	14	10	8	8	9	22.0	31.0
113	1KS18EC403	HARSHITHA B	20	29	0	8	8	8	8	17.0	25.0
114	1KS18EC406	MAHADEVA G R	20	25	1	0	6	0	4	16.0	20.0
115	1KS18EC408	VANITHA C	20	26	1	8	8	8	8	16.0	24.0
116	1KS16EC075	RENUKAPRASAD M	19	28	11	8	6	0	7		16.0
117	1KS14EC101	SOWJANYA K N	19	0	8	0	9	9	9		12.0
118	1KS16EC030	NIKHIL JAMDAGNI	16	24	0	0	4	2	3		12.0

K S INSTITUTE OF TECHNOLOGY

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

2020-21ODD

List of students who are identified as slow learners and their marks after the remedial classes:

Subject with Code:**Microwave and Antennas/17EC71**
Semester and Section:**V1I A & B**

Sl. No.	USN	Name of the student	First Test Marks	Remedial class attendance Date:12/10/20	Second Test Marks	Remedial class attendance Date:23/11/20	Th Test Marks
1	1KS16EC001	A. YESWANTH	Ab	P	23	P	5
2	1KS17EC054	MANOJ.E	AB	P	23	P	0
3	1KS14EC101	SOWJANYA K N	AB	P	19	P	8

Name and Signature of the Faculty

Signature of the HOD

K. S. INSTITUTE OF TECHNOLOGY, BANGALORE-109
DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGG.

MICROWAVES AND ANTENNAS (15EC71)

CHALLENGING QUESTIONS

Module -1

Microwave Tubes and Transmission Lines

1. Compare common transmission lines and waveguides?
   Sol:
   http://www.ittc.ku.edu/~jstiles/723/handouts/chapter_3_Transmission_Lines_and_Waveguides_package.pdf
2. What are the design issues in transmission lines?
   Sol:
   https://www.ee.iitb.ac.in/course/~dghosh/uWave.pdf
3. Why do different modes of operation exist for a reflex klystron?
   Sol:
   https://blog.oureducation.in/what-and-how-of-microwave-communication-reflex-klystron/
4. What is mechanical tuning and electronic tuning in a reflex klystron?

   Sol:
   https://blog.oureducation.in/what-and-how-of-microwave-communication-reflex-klystron/

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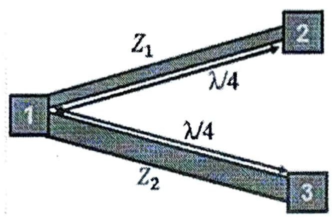
MICROWAVES AND ANTENNAS (15EC71)

CHALLENGING QUESTIONS

Module -2

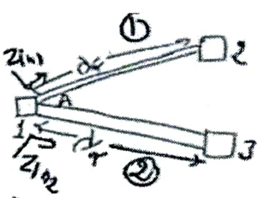
Microwave Network theory and Passive Devices

1. For a two-way unequal power divider as shown in Fig. 2, all the three ports are matched with a characteristic impedance of 50 Ω and the desired output power ratio is 1:2. The characteristic impedances of the lines (Z1 and Z2) for S11=0 should be:



Sol:

Given data:



all ports are terminated with 50Ω

desired power ratio $P_2 : P_3 = 1:2$

let $P_1 = P_{in}$ then $P_2 = \frac{1}{3} P_{in}$ — (1)

$P_3 = \frac{2}{3} P_{in}$ — (2)

let voltage at junction A is V_0 then

$P_{in} = P_1 = \frac{1}{2}\frac{V_0^2}{Z_0}$ $P_2 = \frac{V_0^2}{2Z_{in1}}$ $P_3 = \frac{V_0^2}{2Z_{in2}}$

Equate P_2 & P_3 using equations 1 & 2

$P_2 = \frac{1}{3} P_{in} = \frac{V_0^2}{2Z_{in1}} \Rightarrow \frac{1}{3}\frac{V_0^2}{2Z_0} = \frac{V_0^2}{2Z_{in1}} \Rightarrow Z_{in1} = \frac{3}{1} Z_0$ — (3)

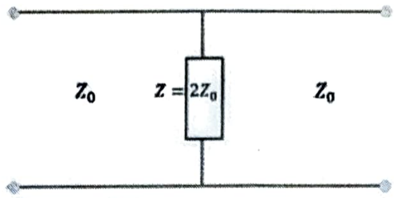
$P_3 = \frac{2}{3} P_{in} \Rightarrow \frac{2}{3}\frac{V_0^2}{2Z_0} = \frac{V_0^2}{2Z_{in2}} \Rightarrow Z_{in2} = \frac{3}{2} Z_0$ — (4)

2. A coupled line directional coupler with characteristic impedance of 50 Ω is to be designed for 15 dB coupling. Calculate even mode impedance and odd mode impedance.

$$Zoe = Zo\sqrt{\frac{1+C}{1-C}}$$

$$Zo0 = Zo\sqrt{\frac{1-C}{1+C}}$$

3. The scattering matrix for the following network is



$$S_{11} = \left.\frac{V_1^-}{V_1^+}\right|_{V_2^+=0} = \text{Reflection coefficient} = \frac{(Z_o \| 2Z_o) - Z_o}{(Z_o \| 2Z_o) + Z_o} = \frac{\frac{2}{3}Z_o - Z_o}{\frac{2}{3}Z_o + Z_o}$$

$$S_{11} = -0.2$$

$$S_{22} = S_{11} = -0.2$$

$$S_{21} = \left.\frac{V_2^-}{V_1^+}\right|_{V_2^+=0}$$

when $V_2^+ = 0$, $V_1^+ + V_1^- = V_2^-$

$$\Rightarrow 1 + \frac{V_1^-}{V_1^+} = \frac{V_2^-}{V_1^+}$$

$$\Rightarrow 1 + S_{11} = S_{21}$$

$$\Rightarrow S_{21} = 0.8$$

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MICROWAVES AND ANTENNAS (15EC71)

CHALLENGING QUESTIONS

Module -3

Strip Lines& Antenna Basics

1. For FR4 substrate (ε_r= **4.4** of height (h) = 1.6 mm) the value of microstrip line width (W) forcharacteristic impedance (Z_0) of 50 Ω is approximately

Given data: $\varepsilon_r = 4.4$, $h = 1.6mm$, $Z_0 = 50\Omega$

Case 1 $\frac{W}{h} < 2$

$$A = \frac{Z_0}{60}\sqrt{\frac{\varepsilon_r+1}{2}} + \frac{\varepsilon_r-1}{\varepsilon_r+1}\left(0.23+\frac{0.11}{\varepsilon_r}\right)$$

$A = 1.37 + 0.16$

$A = 1.53$

$$\frac{W}{h} = \frac{8e^A}{e^{2A}-2} = \frac{8e^{1.53}}{e^{2\times1.53}-2} \Rightarrow 1.9 < 2 \text{ - condition satisfied}$$

$W = 1.9\times1.6 \Rightarrow 3mm$

Case 2 $\frac{W}{h} > 2$ $B = \frac{377\pi}{2Z_0\sqrt{\varepsilon_r}} = \frac{377\pi}{2\times50\sqrt{4.4}} = 5.65$

$$\frac{W}{h} = \frac{2}{\pi}\left[B-1-\ln(2B-1) + \frac{\varepsilon_r-1}{2\varepsilon_r}\left(\ln(B-1)+0.39-\frac{0.61}{\varepsilon_r}\right)\right]$$

$\Rightarrow 1.9 \not> 2 \Rightarrow$ condition not satisfied

therefore Case 1 will be the correct one and width of the microstrip line will be approximately 3mm i.e.

2. A 10 W 2G transmitter unit has output impedance of 150 W. For effective communication in 2G frequency band, a microstrip antenna matched with 50 W is connected at the output of transmitter. The received signal strength is very low in comparison with the expected one. Which one of the following units should be added between the transmitter and the antenna to improve the received signal strength?

Since the output impedance of a 2G transmitter is 150Ω and the microstrip antenna is matched with 50Ω, their impedances don't match. It results in reflection when you connect the antenna with transmitter. To effectively transmit power from the transmitter to the antenna, impedance matching network should be placed between them.

3. An antenna of 20 dBi gain is transmitting 10 W of power in 3G frequency band (2210-2170 MHz). The power density at a distance of 30 m in its line of sight will be:

Given data: Antenna gain in dB = $20 = 10 \log G_t$

$G_t = 10^2 \Rightarrow G_t = 100$

transmitter power $P_t = 10W$, distance $r = 30m$

Power density $P_d = \frac{P_t G_t}{4\pi r^2} \Rightarrow P_d = \frac{10 \times 100}{4\pi \times (30)^2} = 0.0884\ W/m^2$

4. A small antenna provides half power beamwidths of 90 and 140 in E- and H-planes, respectively. For antenna efficiency of 90%, approximate antenna gain in dBi will be:

Given data: $\theta_E = 90°$ $\theta_H = 140°$, $\eta = 90\% = 0.9$

for small antenna (Slide 5)

$D = \frac{41253}{\theta_E \theta_H} \Rightarrow D = \frac{41253}{90 \times 140} \Rightarrow D = 3.274$

Gain $= \eta D \Rightarrow G = 0.9 \times 3.274 \Rightarrow G = 2.95$

Gain in dB $= 10 \log G_t \Rightarrow$ Gain (dB) $= 4.7dB$

Gain of the antenna will be 4.7dB (b)

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MICROWAVES AND ANTENNAS (15EC71)

CHALLENGING QUESTIONS

Module -4

Point Sources and Arrays, Electric Dipoles

1. A broadside linear array of isotropic elements is designed for 13 dBi gain with equal amplitude and inter-element spacing of 0.65λo. For 90% array efficiency, the number of elements in the array should be:

Given data: Gain = 13 = $10 \log G \Rightarrow G = 10^{1.3} \Rightarrow G = 19.95$

$d = 0.65\lambda_0 \Rightarrow d_\lambda = 0.65$, $\eta = 90\% = 0.9$

for linear array (slide 19) $D = 2L_\lambda$ where $D = \frac{G}{\eta} = 22.17$

$$22.17 = 2(n-1)d_\lambda$$

$$n-1 = 17$$

$$n = 18$$

2. A circular loop antenna is designed with circumference C = 0.2l. The number of turns required to match the antenna impedance with 50 W will be:

Given data: $C = 0.2\lambda \Rightarrow C_\lambda = 0.2$, $R_r = 50\,\Omega$

for a N turn loop antenna (slide 18)

$$R_r = 20\pi^2 N^2 \left(\frac{C}{\lambda}\right)^4$$

$$50 = 20\pi^2 (0.2)^4 N^2$$

$$N^2 = 158.3 \Rightarrow N = 12.6 = 13$$

3. A dipole antenna is designed using a wire of diameter 0.3 cm. Approximate length of the dipole antenna will be ______ cm for resonance at 2.5 GHz.

Given data: $d = 0.3$ cm, $f = 2.5$ GHz, $\lambda = \frac{c}{f} = \frac{3\times10^{10}}{2.5\times10^9} = 12$

for a dipole (resonant) antenna

$$l + d = 0.48\lambda$$

$$l + 0.3 = 5.76$$

$$l = 5.46\text{ cm}$$

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MICROWAVES AND ANTENNAS (15EC71)

CHALLENGING QUESTIONS

Module -5

Types of Antennas

1. A circularly polarized axial mode helical antenna is designed for directivity of 18 dBi at 1.8 GHz. The number of turns in the helical antenna should be approximately: (Assume C = πD = λ and α = 14°)

Given data: $D(dB) = 18\,dB \Rightarrow D = 10^{18/10} = 63.1$, $f = 1.8\,GHz$

$C = \pi D = \lambda \Rightarrow C_\lambda = 1$, $\alpha = 14°$

$\alpha = \tan^{-1}\left(\frac{S}{C}\right) \Rightarrow \tan\alpha = \frac{S}{C} \Rightarrow S = C\tan\alpha$

$S_\lambda = C_\lambda \tan\alpha \Rightarrow S_\lambda = \tan 14 = 0.249$

$D = 12\,C_\lambda^2\, n\, S_\lambda$ (slide 7)

$63.1 = 12 \times 1 \times n \times 0.249$

$n = 21$

Number of turns in helical antenna will be 21 (d)

2. A coaxial feed pyramidal horn antenna is to be operated at 2.45 GHz with following dimensions: Waveguide (WR340) = 8.64 cm x 4.32 cm, Aperture = 20 cm x 16 cm, Horn length from neck to mouth = 10 cm. Assuming efficiency of horn is 70%, then approximate gain of the antenna in dBi will be equal to:

Given data: $f = 2.45\,GHz$ $A = 20\,cm$ $B = 16\,cm$, $a = 8.64\,cm$, $b = 4.32\,cm$

$\eta = 70\% = 0.7$

Gain of Horn antenna is given by $G = \eta\, 4\pi \frac{AB}{\lambda^2}$ (slide 18)

$\lambda = \frac{c}{f} = \frac{3\times10^{10}}{2.45\times10^9} = 12.245$

$G = \frac{0.7 \times 4\pi \times 20 \times 16}{12.245 \times 12.245} \Rightarrow G = 18.77$

Gain in dB $= 10\log G = 12.7\,dB$ Gain of antenna will be 12.7dB (b)

3. A log-periodic dipole array is designed to cover the frequency band 450 – 700 MHz with gain of 6 dBi. What will be the minimum number of dipole elements used to design this array? (Assume antenna efficiency is 80%)

Given data: frequency band - 450 - 700 MHz

$f_L = 450\,MHz$ $f_H = 700\,MHz$

Gain = 6 dB

$10 \log G = 6$

$G = 10^{0.6}$

$G = 3.981$

$\eta = 80\%$

$= 0.8$

$D = \frac{G}{\eta} = 4.98$

Directivity $= 10 \log D$

$= 7\,dBi$

$L_1 = \frac{\lambda_L}{2} = \frac{c}{2f_L} = \frac{3\times10^{8}}{2\times450\times10^{6}}$

$L_1 = 33.3\,cm$

$L_N = \frac{\lambda_H}{2} = \frac{c}{2f_H} = \frac{3\times10^{8}}{2\times700\times10^{6}}$

$L_N = 21.4\,cm$

4. A parabolic reflector antenna of diameter 2.35 m is designed at 5.8 GHz. Due to manufacturing error, the antenna efficiency is reduced to 50%. What will be the gain of the reflector antenna in dBi?

efficiency $\eta = 50\% = 0.5$

$\lambda = \frac{c}{f} = \frac{3\times10^{8}}{5.8\times10^{9}} = 0.052\,m$

$G = \eta \cdot \frac{4\pi A_e}{\lambda^2}$

$G = \eta \cdot 4\pi \cdot \frac{\pi d^2}{4} \cdot \frac{1}{\lambda^2}$

$G = \eta \times \left(\frac{\pi d}{\lambda}\right)^2$

$G = 10078.6$

Gain in dBi = $10 \log G = 40\,dBi$

Gain of the reflector antenna will be 40 dBi (C)

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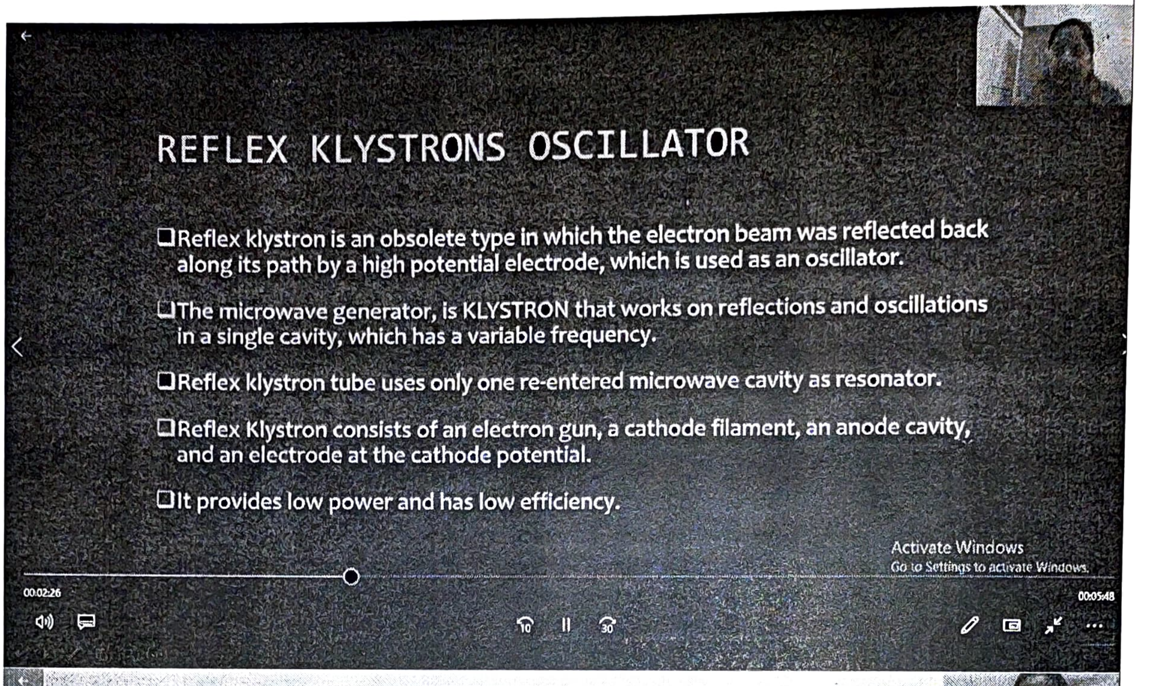
DEARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

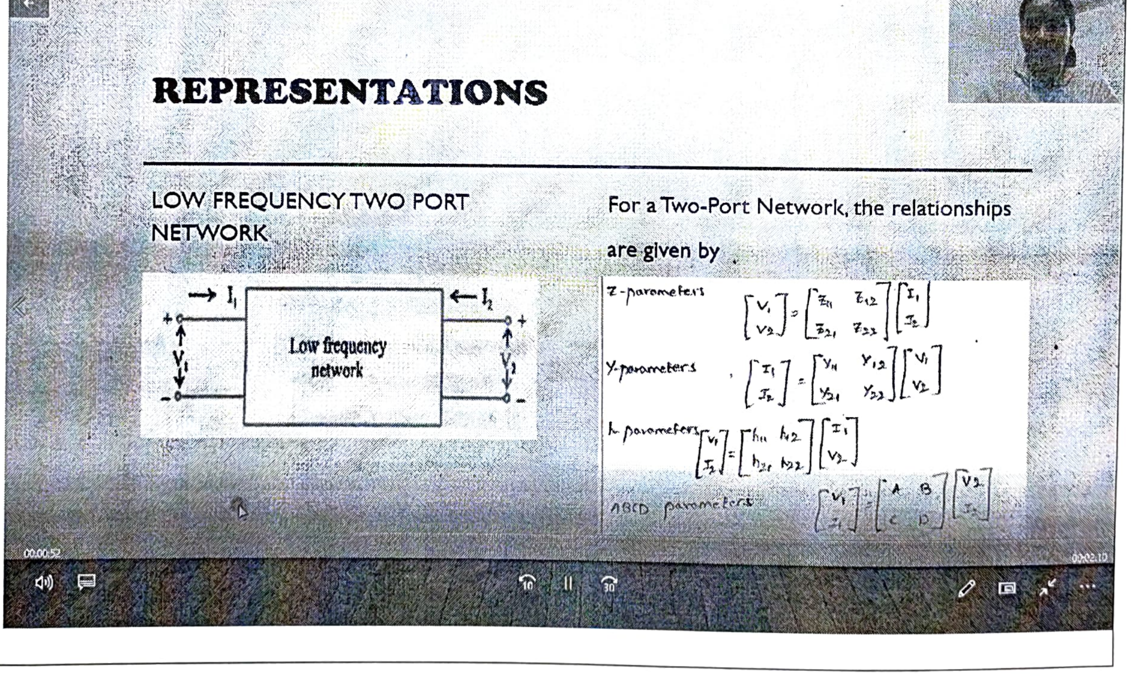
TEACHING AND LEARNING

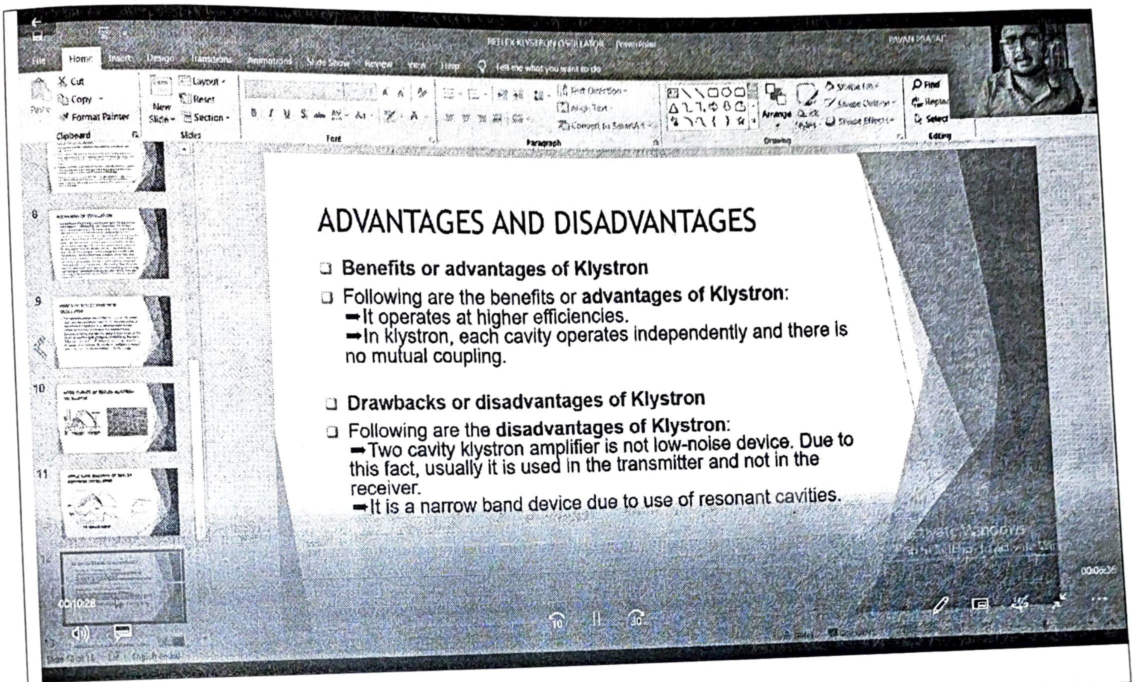
PEDAGOGY REPORT

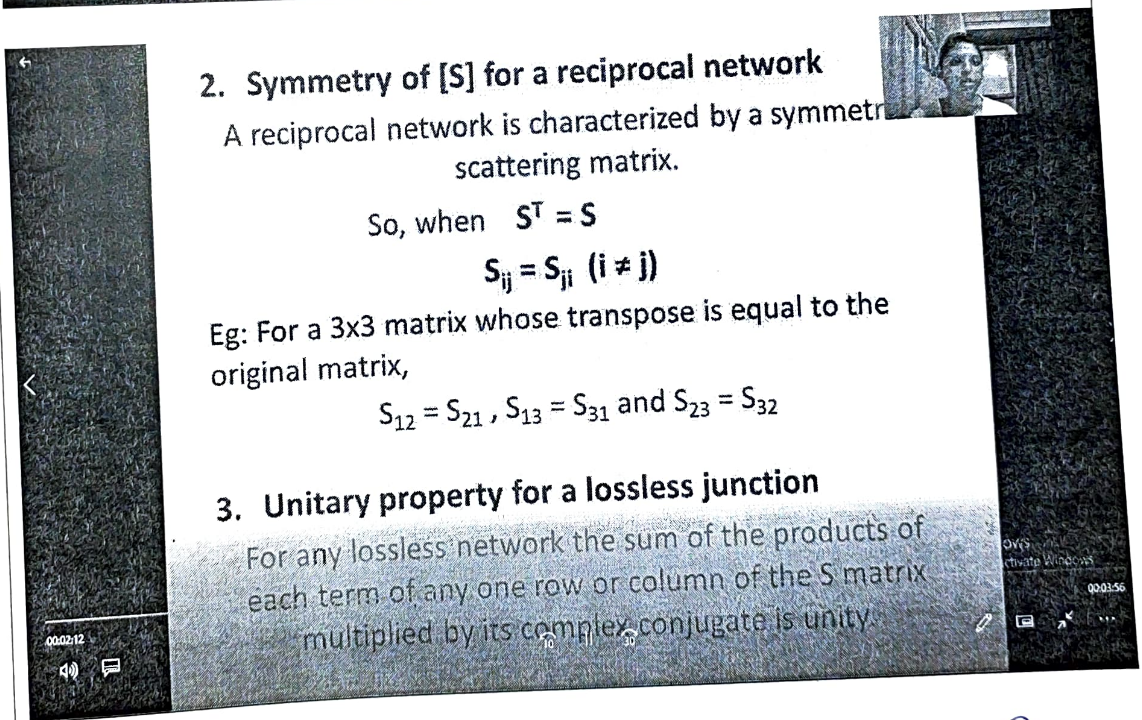
Academic Year	2020-21 (Odd)
Name of the Faculty	Dr.Surekha Borra
Course Name /Code	Microwaves and Antennas/17EC71
Semester/Section	VI/A & B
Activity Name	Pick and Speak
Topic Covered	Microwaves
Date	1/8/2020 to 20/10/20
No. of Participants	60
Objectives/Goals	• To improve the self-learning skills ofstudents • To improve the communication skills ofstudents. • To improve the ICT usage skillsof students
ICT Used	PPTs/Zoom
Appropriate Method/Instructional materials/Exam Questions • Initially delivered lecture on Microwaves devices topics. • Later students were asked to pick any topic of their interest, prepare their own PPT and speak about it, record with audio and video ON. • Students are given with additional information/sources from which they can prepareinnovatively and deliver a seminar on thesame.	
Relevant PO's	1,2,5,9,10,12
Significance of Results/Outcomes	• Students tried to open up and improve their PPT making skills and communication skills. • 60Students prepared PPTs and delivered theirpresentation.
Reflective Critique	• The activity improved the learning, and communication skills ofstudents • The activity provided a platform for students to interact with peers, improve their communication skills and work as individuals.

Proofs (Photographs/Videos/Reports/Charts/Models)









Signature of CourseIncharge

Signature of HODECE

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MICROWAVES AND ANTENNAS (15EC71)

QUESTION BANK

Module -1

1. What are the high frequency limitations of conventional vacuum tube / transistors?
2. Discuss mechanics of oscillation in Reflex Klystron with schematic.
3. Describe the construction and working of a microwave tube that can be used as a low power microwave oscillator.
4. Describe the different mode curves in the case of reflex klystron.
5. A Reflex Klystron is to be operated at 10GHz with dc beam voltage 300V, repeller space 0.1 cm for $1\frac{3}{4}$ m0de. Calculate $P_{RFmax}$and corresponding repeller voltage for a beam current of 20mA.
6. Derive the general transmission line equation to find voltage and current on the line in terms of position 'z' and time 't'.
7. Derive the transmission line equations by the method of distributed circuit theory.
8. Define reflection coefficientand transmission coefficient of a transmission line. Derive the equation for reflection coefficient at the load end.
9. Write a short note on standing wave and standing wave ratio.
10. A transmission line has the following parameter R = 2 Ω/m, G = 0.5m mho/m, f = 1 GHz, L = 8 nH/m, C = 0.23 pF. Calculate the characteristic impedance and propagation constant.
11. A transmission line has a characteristic impedance of 50+ j0.01Ω and a load impedanceof 73 - j42.5Ω calculate. i) Reflection coefficient ii) SWR.
12. A certain transmission line has a characteristic impedance of 75 + j0.01Ω and is terminated in a load impedance of 75 + j50Ω. Compute: i) Reflection coefficient ii) The transmission coefficient.
13. What is a stub? A single stub is used in shunt to match a lossless line of 400Ω to a load of 800 -j300Ω. The frequency of operation is 3GHz. Determine the 'location' of the stub from the load and the 'length' of the stub using Smith Chart.
14. A line of 400Ω is connected to a load of 200 + j300Ω which is excited by a matched generator at 800MHz. Find the location and length of a single stub nearest to the load to produce an impedance match.
15. A load impedance of Z_R = 60 – j80Ω is required to be matched to a 50 Ω co-axial line, by using a short circuited stub of length 'l' located at a distance 'd' from the load. The wavelength of operation is 'l' meter. Using Smith chart find'd' and 'l'.

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MICROWAVES AND ANTENNAS (15EC71)

QUESTION BANK

Module -2

- Show that impedance and admittance matrices are symmetrical for a reciprocal junction.
- State and derive the properties of S-parameters.
- Explain the following losses in microwave circuits/devices in terms of S-parameters:i) Insertion loss ii) Transmission loss iii) Reflection loss iv) Return loss.
- What are Waveguide Tees? Explain with the aid of diagram E-plane and H-plane Tee.
- Explain the S-parameters in terms of impedances.
- Stating the features of magic tee. With a neat diagram, explain the function of magic tee and deduce its s-matrix.
- Why are co-axial adaptors used? List six types of co- axial connectors with their frequency ranges.
- With a neat diagram, explain the working of precision type variable attenuator.
- With a neat diagram explain the working of precision type variable phase shifter.
- Two-transmission lines of characteristic impedance Z_1 and Z_2 are joined at plane PP'. Express S-parameters in terms of impedance when each line is matched terminated.
- In an H-plane T- junction, compute power delivered to the loads 40 ohms and 60 ohms connected to arms 1 and 2 when 10mW power is delivered to matched port 3. Assume characteristic impedance of line = 50 0hm.
- A magic T is terminated at collinear ports 1 and 2 and difference port 4 by impedances of reflection coefficients $\gamma 1 = 0.5$, $\gamma 2 = 0.6$ and $\gamma 4 = 0.8$ respectively. If 1 W power is fed at sum port 3, calculate the power reflected at port 3 and power transmitted to other three ports.
- A 20mW signal is fed into one of the collinear port 1 of a lossless H-plane T junction. Calculate the power delivered through each port when other ports are terminated in Matched load

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MICROWAVES AND ANTENNAS (15EC71)

QUESTION BANK

Module -3

1. Explain the construction and field pattern for microstrip line.
2. Explain co-planar strip line and shielded strip line.
3. With the aid of schematic diagram explain coplanar strip line.
4. Discuss different types of losses in micro strip lines.
5. Explain with neat diagram, the structure and field pattern of microstrip line and derive expression for characteristic impedance' Z_0'
6. With neat diagram, explain the operation of parallel strip line. Also write the expression for characteristic impedance and attenuation of the same.
7. A lossless parallel strip line has a conducting strip width of 'W', the substrate dielectric separating the two conducting strips has a relative dielectric constant t_{rd} of '6' and thickness 'd' of 4mm. Calculate: (i)The required width 'W' of the conducting strip in order to have a characteristic impedance of 50Ω. (ii)The strip Iine capacitance. (iii)The strip line inductance. (iv)The phase velocity of the wave.
8. Write a note on antenna field zones.
9. Explain the following terms related to antenna system: (i)directivity ii) beam efficiency iii) effective aperture.
10. Explain the basic principle of radiation using basic radiation equation.
11. Define the following terms with respect to antenna – Beam solid angle, beam area, Radiation intensity, directivity.
12. Explain different types of aperture and their relationships.
13. Show that maximum effective aperture of a λ/2 dipole antenna is $0.13\lambda_2$.
14. An antenna has a field pattern given by E(□) =Cos□ Cos2□ for 0≤ □ ≤ 90^0. Find : i)HPBW (ii) Beam Width between first nulls.
15. State and prove Friis transmission formula.
16. The effective apertures of transmitting and receiving antennas in a communication systemare $8\lambda^2$ and $12\lambda^2$ respectively.With a separation of 1.5km between them. The EM wavetravelling with frequency of 6 MHz and the total input power is 25KW. Find the power received by the receiving antenna.
17. An antenna has a field pattern given by E(□)=cos^2□ for 0≤□≤$\frac{\pi}{2}$. Find the beam area and directivity.
18. Calculate the exact directivity for 3 dimensional source having the pattern $U = U_m \sin^2\theta \sin^3\Phi$ where $0\leq \theta \leq \pi, 0 \leq \Phi \leq \pi$.
19. Compute the power received by receiving antenna kept at a distance of 100km by a transmitter radiating at 3MHz. Assume G_T = 40 and G_R = 15 and P_T =1000kW. Derive the relation used.

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MICROWAVES AND ANTENNAS (15EC71)

QUESTION BANK

Module -4

1. State and prove power theorem and explain its application to an isotropic source.
2. Explain the principle of pattern multiplication with an example.
3. Derive an expression for radiation resistance of λ/2 antenna (lambda by 2).
4. Derive an expression for far field intensity for two isotropic sources with equal amplitude and phase.
5. Show that the radiation resistance of a linear $\lambda/2$ antenna with sinusoidal current distribution is equal to 73Ω.
6. Obtain the field pattern for two point source situated symmetrically with respect to the origin. Two sources are feed with equal amplitude and equal phase signals. Assume distance between two sources = λ/2.
7. Derive an array factor expression in case of linear array of 'n' isotropic point source of equal amplitude and spacing.
8. Obtain the expression for field of dipole in general for the case of thin linear antenna.
9. Derive an expression and draw the field pattern for an array of 2 isotropic point sources withsame amplitude and phase spaced λ/2 apart.
10. Derive the expressions for the far field components of short dipole.
11. A source has a cosine radiation intensity pattern given by U=$U_m cos$□ for 0 ≤ □ ≤$\pi/2$ and
0≤ ϕ ≤ 2π. Find the total power and directivity.
12. The radiation intensity of an antenna is given by U=: $U_m sin$□ for 0 ≤□≤π;0≤ϕ≤ 2π. and find directivity 'D'.
13. A source has a radiation-intensity power pattern given by U= $U_m sin^2$□ for 0 ≤ □ ≤π;
0 ≤ ϕ ≤ 2π. Find the total power and directivity. Draw pattern.

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MICROWAVES AND ANTENNAS (15EC71)

QUESTION BANK

Module -5

1. Derive the far field expression for small loop antenna.
2. Obtain the expression for radiation resistance of small loop antenna.
3. Derive the expression for strength E_ϕ and H□ in case of small loop.
4. Show that the radiation resistance of small loop is $31171\left(\frac{A}{\lambda^2}\right)^2$.
5. The radius of a circular loop antenna is 0.02λ. How many turns of the antenna radiation resistance of 35 Ω?
6. With neat diagram explain the operation of log-periodic antenna.
7. Explain yagi-uda antenna structure with a neat diagram.
8. Explain various types of horn antenna with a neat diagram.
9. Discuss the following antenna types (i) Helical Antenna (ii) Yagi-uda-array iii) parabolic reflector.
10. Determine the length L_l H-plane aperture and flare angle $\theta_E$and $\theta_H$of a pyramidal horn for which the E-plane aperture a_E= 10λ.The horn is fed by a rectangular waveguide with TE_{10}mode. Let δ = 0.2λ in the E plane and 0.375λ in the H plane. Also find what beam widths are and what is the directivity?
11. The diameter of a circular loop antenna is 0.04. How many turns of antenna will give a Radiation resistance of 36Ω.
12. Explain the features and practical design consideration of a Mono filar Helical Antenna.
13. A 16-turn helical beam antenna has a circumference of λ and turn spacing of $\lambda/4$. Find i) HPBW ii) axial ratio iii) directivity.
14. Determine the length-L, H-plane aperture and flare angles $□_E$ and $□_H$ of a pyramidal horn for which the E-plane aperture a_E=10λ. Let δ =0.2λ in the E-plane and 0.375λ in the H-plane. Also determine beam widths and directivity.

CBCS SCHEME

USN | | | | | | | | | |

17EC71

Seventh Semester B.E. Degree Examination, July/August 2021
Microwaves and Antennas

Time: 3 hrs. Max. Marks: 100

Note: *Answer any FIVE full questions.*

Important Note: 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. 2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

1 a. Describe the mechanism of oscillations in case of Reflex klystron. (07 Marks)
b. Give the solutions of Transmission line equations and find the expression for phase velocity. (08 Marks)
c. A transmission line has following parameters $R = 2\Omega/m$, $G = 0.5mmho/m$, $f = 1GHz$, $L = 8nH/m$, $C = 0.23PF$.
Calculate:
i) Characteristic impedance
ii) Propagation Constant. (05 Marks)

2 a. Define reflection coefficient. Derive the equation for reflection coefficient at the load end at a dist "d" from the load. (07 Marks)
b. Describe the different mode curve in the case of reflex klystron. (07 Marks)
c. A transmission line has a characteristic impedance of $50 + j0.01\Omega$ and is terminated in a load impedance of $73 - j42.5\Omega$. Calculate:
i) Reflection coefficient
ii) Standing wave ratio. (06 Marks)

3 a. State and explain the properties of s-parameters. (07 Marks)
b. Explain the working of precision type variable attenuator with a neat diagram. (06 Marks)
c. Two transmission lines of characteristic impedance Z_1 and Z_2 are joined at plane PP′. Express s-parameters in terms of impedances. (07 Marks)

4 a. Draw the diagrams of coaxial connectors and explain. (07 Marks)
b. Discuss E plane Tee. Derive its scattering matrix. (06 Marks)
c. A 20mW signal is fed into one of collinear port 1 of a lossless H-plane T-junction. Calculate the power delivered through each port when other ports are terminated in matched load. (07 Marks)

5 a. Find the Quality factor Q_d of microstrip lines. (07 Marks)
b. Draw the diagram of parallel strip lines. Find the characteristic impedance of a lossless parallel strip lines. (07 Marks)
c. Define the following :
i) Antenna ii) Beam efficiency iii) Effective Aperture iv) Directivity. (06 Marks)

6 a. Explain the concept of shielded strip line and co-planar strip lines with diagrams. (07 Marks)
b. Define the following :
i) Radiation pattern
ii) Radiation Intensity
iii) Gain
iv) Effective Height. (07 Marks)

c. A radio link has a 15w transmitter connected to an antenna of $2.5m^2$ effective aperture at 5GHz. The receiving antenna has effective aperture of $0.5m^2$ and is located at a 15km line of sight distance from the transmitting antenna. Assuming lossless matched antennas, find the power delivered to the receiver. (06 Marks)

7 a. Explain power theorem and its application to an Isotropic source. (07 Marks)
b. Explain the principle of pattern multiplication. (07 Marks)
c. A source has a radiation intensity power pattern given by $U = U_m \sin^2\theta$ for $0 \le \theta \le \pi$; $0 \le \phi \le 2\pi$. Find the total power and directivity. Draw pattern. (06 Marks)

8 a. Derive the equation for radiation Intensity. Explain the concept of field patterns. (07 Marks)
b. Find the radiation resistance of a $\frac{\lambda}{2}$ Antenna. (07 Marks)
c. With diagram, explain the concept of Thin linear Antenna. (06 Marks)

9 a. Draw the diagram of a loop Antenna and explain. (07 Marks)
b. Find the radiation resistance of loops, as related of Antenna. (07 Marks)
c. Explain the working and design consideration of log periodic antenna. (06 Marks)

10 a. Explain the concept of Rectangular Horn Antenna. (07 Marks)
b. Write short notes on :
i) Yagi-uda Array ii) Parabolic reflector. (07 Marks)
c. A 16 turn helical beam Antenna has a circumference of λ and turn spacing of $\frac{\lambda}{4}$. Find
i) HPBW ii) Axial Ratio iii) Directivity. (06 Marks)

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CBCS SCHEME

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15EC71

Seventh Semester B.E. Degree Examination, Aug./Sept. 2020
Microwaves and Antennas

Time: 3 hrs. Max. Marks: 80

Note: ***Answer any FIVE full questions, choosing ONE full question from each module.***

Module-1

1 a. Explain the operation of Reflex Klystron with the help of neat sketch. **(06 Marks)**

b. A two-cavity Klystron operates at 5 GHz with a DC beam voltage of 10KV and 2mm cavity gap. For a given input RF voltage, the magnitude of the gap voltage is 100V. Calculate the transit time at the cavity gap, the transit angle, and velocity of the electrons leaving the gap. **(06 Marks)**

c. Define standing wave and standing wave ratio. **(04 Marks)**

OR

2 a. Derive transmission line equations. **(06 Marks)**

b. A certain transmission line has a characteristic impedance of 75 + j0.01Ω and is terminated in load impedance of 70 + j50Ω. Compute : i) reflection coefficient ii) transmission coefficient. **(06 Marks)**

c. Mention characteristics of Smith chart with the help of necessary equations. **(04 Marks)**

Module-2

3 a. Write short notes on :
i) Attenuator
ii) Phase shifters. **(08 Marks)**

b. Explain the properties of S-parameters for junction of ports having common characteristic impedance. **(08 Marks)**

OR

4 a. A 20 MW signal is fed into one of the collinear part 1 of a lossless H plane T junction. Calculate the power delivered through each port when other ports are terminated in matched load. **(04 Marks)**

b. Write the characteristics of Magic Tee. Also obtain scattering matrix for Magic Tee. **(08 Marks)**

c. Write short notes on : Coaxial connectors and adapters. **(04 Marks)**

Module-3

5 a. A microstrip line is composed of zero thickness copper conductors on a substrate having $\epsilon_r = 8.4$ tan $\delta = 0.0005$ and thickness 2.4mm. If the line width is 1mm and operated at 10 GHz, calculate :
i) The characteristic impedance ii) the attenuation due to conductor loss and dielectric loss. **(08 Marks)**

b. Define the following :
i) Beam area
ii) Radiation resistance
iii) Beam efficiency
iv) Radiation intensity. **(08 Marks)**

OR

6 a. Obtain effective aperture and directivity of a half wave dipole. (05 Marks)
b. Derive Friis transmission formula. (05 Marks)
c. Obtain relationship between directivity and effective aperture. (06 Marks)

Module-4

7 a. Define power theorem. (04 Marks)
b. Find the directivity 'D' for the following sources with radiation intensity.
i) $U = U_m \sin^2\theta,\ 0 \le \theta \le \pi,\ 0 \le \phi \le 2\pi$ ii) $U = U_m \cos^2\theta,\ 0 \le \theta \le \pi/2,\ 0 \le \phi \le \pi/2$. (05 Marks)
c. Plot the field pattern for an array of two isotropic point sources with equal amplitude and same phase. Take $d = \lambda/2$. (07 Marks)

OR

8 a. Obtain the field pattern for a linear uniform array of isotropic antennas, satisfy the following $n = 5,\ d = \lambda/2,\ \delta = -d_r$. (06 Marks)
b. Derive an expression for radiation resistance of a short electric dipole. (06 Marks)
c. Explain principle of pattern multiplication with the help of suitable example. (04 Marks)

Module-5

9 a. Compare far fields of small loop and short electric dipole. (04 Marks)
b. Obtain an expression for radiation resistance of a loop antenna. (06 Marks)
c. Develop an expression for the field intensity ratio in the aperture plane for a parabolic reflector. (06 Marks)

OR

10 a. Determine the length L, H-plane aperture and flare angles θ_E and θ_H of a pyramidal horn for which the Eplane aperture $a_E = 10\lambda$. The horn is fed by a rectangular waveguide with TE_{10} mode. Let $\delta = 0.2\lambda$ in the Eplane and 0.375λ in the H plane. Also find the directivity. (06 Marks)
b. Define helix geometry. Explain practical design considerations for the monofilar axial mode helical antenna. (06 Marks)
c. Explain Yagi – Uda array with the help of diagram. (04 Marks)

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CBCS SCHEME

USN | | | | | | | | | | |

15EC71

Seventh Semester B.E. Degree Examination, Jan./Feb. 2021
Microwaves and Antennas

Time: 3 hrs. Max. Marks: 80

Note: *1. Answer any FIVE full questions, choosing ONE full question from each module.*
2. Smith chart are permitted.

Module-1

1 a. Describe basic principle and working mechanism of oscillation in Reflex Klystron through Apple gate diagram. **(06 Marks)**

b. What is reflection co-efficient? Obtain an expression for the same. How it is related to standing wave ratio. **(06 Marks)**

c. A microwave transmission line has a characteristic impedance of $Z_0 = 100 \angle 53.13^\circ\ \Omega$ when it is terminated in a unknown load impedance Z_L, the transmission coefficient was observed to be $1.09 \angle 35.34^\circ$. Find :
i) Reflection coefficient
ii) Terminating load impedance Z_L. **(04 Marks)**

OR

2 a. What are standing waves? How are they formed? Obtain expression for voltage standing wave and phase pattern of travelling wave. **(06 Marks)**

b. A load impedance of $Z_L = 60 - j80\Omega$ is required to be matched to a 50Ω co-axial line by using a short circuited stub length 'ℓ' located at a distance 'd' from the load. The wave length of operation is 1 mtr. Using Smith chart find 'd' and 'ℓ'. **(06 Marks)**

c. Obtain expression for line impedance interms of reflection coefficient. **(04 Marks)**

Module-2

3 a. Explain with neat sketches the construction and operation of a precision type variable attenuator. **(06 Marks)**

b. Consider a losses H-plane TeeJunction with 50mw of power being fed into port(1) and other two ports(2) and (3) are terminated in matched termination. Calculate the power fed into each of the ports by the junction. **(04 Marks)**

c. Discuss applications of Magic Tee. **(06 Marks)**

OR

4 a. Explain with neat sketches the construction and operation of a H-plane TeeJunction. List the characteristics and hence derive its S Matrix. **(10 Marks)**

b. Give relations of Z, Y and ABCD parameter with S-parameter. **(06 Marks)**

Module-3

5 a. What are the losses encountered in microstriplines? Discuss briefly. **(06 Marks)**

b. Find the directivity for the following pattern :
i) Bidirectional sine squared pattern
ii) Unidirectional cosine squared pattern. **(06 Marks)**

c. Find the solid angle Ω in square degrees on a spherical surface for θ ranging between 20° and 40° and ϕ ranging between 30° and 70°. **(04 Marks)**

OR

6 a. Derive an expression for Aem for short dipole. (06 Marks)
b. Obtain an expression for FRIS transmission formula used in radio communication link. (06 Marks)
c. The normalized field pattern of an antenna is given by $E_n = \sin\theta \sin\phi$ where θ and ϕ ranges between 0 and e_{total}. Find the directivity by accurate method and approximate method. (04 Marks)

Module-4

7 a. Drive an expression for e total, peaks array factor, side lobes and nulls for linear uniform array for N-isotropic point sources of equal amplitude and spacing. (06 Marks)
b. Obtain an expression for radiation resistance of dipole. (06 Marks)
c. Find length of half wave dipole at 30 MHz. (04 Marks)

OR

8 a. Explain various forms of antenna arrays with neat diagram. (06 Marks)
b. A linear array consists of 4 isotropic point sources. The distance between adjacent element λ/2. The power applied with equal magnitude and phase difference – d_r obtain field pattern and find BWFN and HPBW. (10 Marks)

Module-5

9 a. Derive expression for field component for general loop antenna. (06 Marks)
b. Write general characteristics of Yagi-Uda Antenna. (04 Marks)
c. Calculate directivity of 20 turn helix with $\alpha = 12°$ and circumstances equal to one wave length. (06 Marks)

OR

10 a. With neat sketch, explain design equation of Horn Antenna. (06 Marks)
b. Write short note on :
i) Helical antenna
ii) Log periodic antenna. (06 Marks)
c. Calculate the horn parameters :
i) Length L
ii) Width a
iii) Flare angle θ
iv) Flare angle ϕ
If the month height b is 10λ.
The horn is fed by a rectangular wave guide with TE_{10} mode. (04 Marks)

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CBCS SCHEME

USN | | | | | | | | | | | **15EC71**

Seventh Semester B.E. Degree Examination, June/July 2019
Microwave and Antennas

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg. 42+8 = 50, will be treated as malpractice.

Module-1

1 a. Discuss mechanism of oscillation in Reflex Klystron with schematic. **(06 Marks)**

b. A Reflex Klystron is to be operated at 10GHz with dc beam voltage 300V, repeller space 0.1cm for $1\frac{3}{4}$ mode. Calculate $P_{RF_{max}}$ and corresponding repeller voltage for a beam current of 20mA. **(05 Marks)**

c. A transmission line has the following parameters:
R = 2Ω/m, G = 0.5mho/m, f = 1GHz, L = 8nH/m and C = [illegible] PF.
Calculate its characteristics impedance and propagation constant. **(05 Marks)**

OR

2 a. A line of 400Ω is connected to a load of 200 [illegible] j300Ω which is excited by a matched generator at 800MHz. Find the location and length of a single stub nearest to the load to produce an impedance match. **(08 Marks)**

b. A certain transmission line has a characteristic impedance of 75 + j0.01Ω and is terminated in a load impedance of 75 [illegible] j50Ω. Compute: i) Reflection coefficient ii) The transmission coefficient. **(04 Marks)**

c. What are the high frequency limitations of conventional vacuum tube / transistors? **(04 Marks)**

Module-2

3 a. Show that impedance and admittance matrices are symmetrical for a reciprocal junction. **(06 Marks)**

b. In a H-plane T-junction, compute power delivered to the loads 40ohm and 60ohm connected to arms 1 and 2 when 10mw power is delivered to matched port 3. Assume characteristics impedance of line = 50ohm. **(04 Marks)**

c. Two transmission lines of characteristic impedance z_1 and z_2 are joined at plane pp'. Express S-parameters in terms of impedances. **(06 Marks)**

OR

4 a. Discuss the following properties of S-parameters:
i) Symmetry of [S] for a reciprocal network
ii) Unitary property for a lossless junction. **(08 Marks)**

b. A magic T is terminated at collinear ports 1 and 2 and difference port 4 by impedances of reflection coefficients $\gamma_1 = 0.5$, $\gamma_2 = 0.6$ and $\gamma_4 = 0.8$ respectively. If 1W power is fed at sum port 3, calculate the power reflected at port 3 and power transmitted to other three ports. **(08 Marks)**

Module-3

5 a. A lossless parallel strip line has a conducting strip width W. The substrate dielectric separating the two conducting strips has a relative dielectric constant ε_{rd} of 6 and a thickness d of 4mm. Calculate: i) The required width W of the conducting strip in order to have a characteristic impedance of 50Ω ; ii) The strip-line capacitance. (04 Marks)

b. Discuss different types of losses in microstrip lines. (06 Marks)

c. Calculate the exact directivity for 3 dimensional source having the pattern $U = U_m \sin^2\theta \sin^3\phi$ where $0 \le \theta \le \pi$, $0 \le \phi \le \pi$. (06 Marks)

OR

6 a. Show that maximum effective aperture of a λ/2 depole antenna is $0.13\lambda^2$. (06 Marks)

b. With the aid of schematic diagram explain coplanar strip line. (05 Marks)

c. Compute the power received by receiving antenna kept at a distance of 100km by a transmitter radiating at 3MHz. Assume $G_T = 40$ and $G_R = 15$ and $P_t = 1000$ kW. Derive the relation used. (05 Marks)

Module-4

7 a. Obtain the fields pattern for two point source situated symmetrically with respect to the origin. Two sources are feed with equal amplitude and equal phase signals. Assume distance between two sources = λ/2. (08 Marks)

b. Derive the expression for radiation resistance of short electric dipole. (08 Marks)

OR

8 a. Derive an array factor expression in case of linear array of 'n' isotropic point source of equal amplitude and spacing. (08 Marks)

b. Obtain the expression for field of dipole in general for the case of thin linear antenna. (08 Marks)

Module-5

9 a. Obtain the expression for radiation resistance of small loop antenna. (08 Marks)

b. With neat diagram explain the operation of log-periodic antenna. (08 Marks)

OR

10 a. Determine the length L_1 H-plane aperture and flare angle θ_E and θ_H of a pyramidal horn for which the E-plane aperture $a_E = 10\lambda$. The horn is fed by a rectangular waveguide with TE_{10} mode. Let δ = 0.2λ in the E plane and 0.375λ in the H plane. Also find what are beam widths and what is the directivity. (08 Marks)

b. Discuss the following antenna types (i) Helical Antenna (ii) Yagi-uda-array. (08 Marks)

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K.S.Institute of Technology,Bangalore -109
Department of Electronics and Communication Engg
7th sem Course End Survey 2020-21

Subject : Microwave and Antennas **Subject Code:17EC71**

Q1. How well are you able to apply Smith charts to find solutions to transmission line problems?

Q2. How well are you able to analyze passive microwave devices using S-parameters ?

Q3. How well are you able to evaluate various parameters and characteristics of the microwave strip lines and devices.

Q4. How well are you able to estimate radiation patterns and performance parameters of n-isotropic antennas?

Q5. How well are you able to recommend various antenna configurations based on application?

Sl No	Date	USN	Student Name	Sec	Faculty Name	Q1	Q2	Q3	Q4	Q5
3	1/24/2021	1ks14ec101	1	B	Dr B.Surekha	2	2	2	2	2
4	1/22/2021	1KS16EC007	AMAN KUMAR SINGH	A	Dr B.Surekha	2	2	2	2	2
5	1/25/2021	1ks16ec030	Nikhil hm	B	Dr B.Surekha	3	3	3	3	3
6	1/24/2021	1KS16EC033	K Unnimaya	A	Dr B.Surekha	3	3	3	3	2
7	1/22/2021	1ks16ec038	kshitiz gurung	A	Dr B.Surekha	1	2	2	3	3
8	1/22/2021	1KS16EC069	R sharath Kumar	A	Dr B.Surekha	3	3	3	3	3
9	1/22/2021	1KS16EC075	RENUKAPRASAD M R	B	Dr B.Surekha	3	3	3	3	3
10	1/22/2021	1ks16ec086	Shivdatt B	A	Dr B.Surekha	2	2	2	2	2
11	1/22/2021	1ks16ec431	Rakesh	A	Dr B.Surekha	3	2	3	3	2
12	1/22/2021	1KS17EC001	Abhishek K V	A	Dr B.Surekha	3	3	2	2	3
13	1/22/2021	1KS17EC002	Abijith Sudhir	A	Dr B.Surekha	3	2	3	3	3
14	1/22/2021	1KS17EC003	Akkshay U.L	A	Dr B.Surekha	3	3	3	2	3
15	1/22/2021	1KS17EC004	Akshitha V Ramesh	A	Dr B.Surekha	3	3	3	3	3
16	1/22/2021	1KS17EC005	Amoghavarsha N D	A	Dr B.Surekha	3	2	3	3	3
17	1/22/2021	1KS17EC006	Amulya S Iyengar	A	Dr B.Surekha	3	3	3	3	3
18	1/22/2021	1KS17EC007	ANA EPSIBA F	A	Dr B.Surekha	3	2	3	2	3
19	1/22/2021	1KS17EC007	Ana Epsiba F	A	Dr B.Surekha	3	3	2	2	2
20	1/22/2021	1ks17ec008	Anagha A Kashyap	A	Dr B.Surekha	3	3	3	3	3
21	1/22/2021	1KS17EC009	ANITHA R	A	Dr B.Surekha	3	3	3	3	3

Sl No	Date	USN	Student Name	Sec	Faculty Name	Q1	Q2	Q3	Q4	Q5
22	1/22/2021	1KS17EC010	Anoop Deekshith R	A	Dr B.Surekha	3	3	3	3	3
23	1/22/2021	1KS17EC011	Anupam ML	A	Dr B.Surekha	3	3	3	3	3
24	1/22/2021	1KS17EC012	ANUSHA.L	A	Dr B.Surekha	1	1	1	1	1
25	1/22/2021	1KS17EC014	Anushri VK	A	Dr B.Surekha	3	3	3	3	3
26	1/22/2021	1KS17EC015	Apeksha Ravi Kumar	A	Dr B.Surekha	3	3	3	3	3
27	1/22/2021	1KS17EC016	Arpitha	A	Dr B.Surekha	3	3	3	3	3
28	1/22/2021	1KS17EC017	Asiya Fathima	A	Dr B.Surekha	3	3	3	3	3
29	1/22/2021	1ks17ec018	Ayesha rosheen	A	Dr B.Surekha	3	3	3	3	3
30	1/22/2021	1KS17EC019	BD Shreenidhi	A	Dr B.Surekha	3	3	3	3	3
31	1/22/2021	1KS17EC020	Bhavana B S	A	Dr B.Surekha	2	2	2	2	2
32	1/22/2021	1KS17EC021	Bhavana. J	A	Dr B.Surekha	3	3	3	3	2
33	1/22/2021	1KS17EC022	Bhoomika PK	A	Dr B.Surekha	3	3	2	3	3
34	1/22/2021	1KS17EC024	Chaithra VM	A	Dr B.Surekha	3	3	3	3	3
35	1/22/2021	1ks17ec025	Charan Sai Y	A	Dr B.Surekha	3	3	3	3	3
36	1/22/2021	1KS17EC027	Chethan G	A	Dr B.Surekha	3	3	3	3	3
37	1/22/2021	1ks17ec028	Chethana k s	A	Dr B.Surekha	3	2	2	2	2
38	1/22/2021	1KS17EC029	Chethana Prasad K	A	Dr B.Surekha	2	2	2	2	2
39	1/22/2021	1KS17EC031	Devale Sudarshan	A	Dr B.Surekha	2	2	2	2	2
40	1/22/2021	1KS17EC032	Deviyani G	A	Dr B.Surekha	3	3	2	2	3
41	1/22/2021	1ks17ec035	Disha S	A	Dr B.Surekha	2	2	2	2	2
42	1/22/2021	1KS17EC036	Divya TM	A	Dr B.Surekha	3	3	3	3	3
43	1/22/2021	1KS17EC038	GOPINATH H C	A	Dr B.Surekha	2	3	3	2	2
44	1/22/2021	1KS17EC039	Gowtham B	A	Dr B.Surekha	2	3	3	3	3
45	1/22/2021	1KS17EC040	G S Surabhi	A	Dr B.Surekha	3	3	3	3	2
46	1/22/2021	1KS17EC041	H G SRINIDHI	A	Dr B.Surekha	2	2	2	2	2
47	1/22/2021	1KS17EC042	Jeevan r s	A	Dr B.Surekha	3	3	3	3	3
48	1/22/2021	1KS17EC044	Kamnoor sushma	A	Dr B.Surekha	3	3	3	3	3
49	1/22/2021	1KS17EC045	Krithika P	A	Dr B.Surekha	3	3	3	3	3

Sl No	Date	USN	Student Name	Sec	Faculty Name	Q1	Q2	Q3	Q4	Q5
50	1/22/2021	1KS17EC046	Lakshan	A	Dr B.Surekha	1	1	1	1	1
51	1/22/2021	1KS17EC047	LEKHA YADAV B	A	Dr B.Surekha	3	3	3	3	3
52	1/22/2021	1KS17EC048	M.R.Srinivas	A	Dr B.Surekha	3	2	3	2	2
53	1/22/2021	1KS17EC049	M RANJITH	A	Dr B.Surekha	3	3	3	3	3
54	1/22/2021	1KS17EC050	M Sirisha	A	Dr B.Surekha	3	2	3	3	2
55	1/22/2021	1KS17EC051	Madhu S	A	Dr B.Surekha	3	3	3	3	3
56	1/22/2021	1KS17EC052	Mahadeva g	A	Dr B.Surekha	3	3	3	3	3
57	1/22/2021	1ks17ec053	Mamatha	A	Dr B.Surekha	3	3	3	3	3
58	1/22/2021	1ks17ec055	Manoj kumar R	B	Dr B.Surekha	1	1	2	2	2
59	1/24/2021	1KS17EC056	Mohammad Faizal	B	Dr B.Surekha	2	3	3	3	3
60	1/22/2021	1KS17EC057	Mohammed Sadath	B	Dr B.Surekha	3	3	3	3	3
61	1/22/2021	1KS17EC058	Monisha.A	B	Dr B.Surekha	1	2	2	3	3
62	1/22/2021	1KS17EC059	Naganetra. M	B	Dr B.Surekha	2	2	2	2	2
63	1/24/2021	1KS17EC060	Nageli jayasai Naidu	B	Dr B.Surekha	2	2	2	3	2
64	1/22/2021	1KS17EC061	Naveen Kumar Burugupally	B	Dr B.Surekha	3	3	2	2	2
65	1/22/2021	1ks17ec062	Navin Kumar H G	B	Dr B.Surekha	3	3	3	3	3
66	1/22/2021	1KS17EC063	Navya S	B	Dr B.Surekha	3	3	3	3	3
67	1/22/2021	1KS17EC067	Pavanprasad.R	B	Dr B.Surekha	3	3	3	3	3
68	1/22/2021	1KS17EC068	Penujuri Naga Sai Snehitha	B	Dr B.Surekha	3	3	3	3	3
69	1/22/2021	1ks17ec070	Prajwalsimha	B	Dr B.Surekha	1	3	3	2	2
70	1/22/2021	1ks17ec071	Pratima Agnihotri	B	Dr B.Surekha	2	2	3	3	3
71	1/22/2021	1ks17ec072	Pratima V Kashyap	B	Dr B.Surekha	1	1	1	1	1
72	1/22/2021	1ks17ec073	Pruthviraj	B	Dr B.Surekha	2	2	2	2	2
73	1/22/2021	1KS17EC075	Rachana S	B	Dr B.Surekha	3	3	3	3	3
74	1/22/2021	1KS17EC076	Rahul R Nadig	B	Dr B.Surekha	2	2	2	2	2
75	1/24/2021	1KS17EC077	Rajesh C S	B	Dr B.Surekha	3	3	3	2	3
76	1/22/2021	1KS17EC078	Ramya R	B	Dr B.Surekha	2	3	3	3	3
77	1/22/2021	1KS17EC079	Ritu Patil	B	Dr B.Surekha	3	3	3	3	3

Sl No	Date	USN	Student Name	Sec	Faculty Name	Q1	Q2	Q3	Q4	Q5
78	1/22/2021	1KS17EC080	ROHINI D	B	Dr B.Surekha	2	1	1	1	2
79	1/22/2021	1KS17EC084	Sahana M K	B	Dr B.Surekha	2	2	2	2	2
80	1/22/2021	1KS17EC085	Sahana V	B	Dr B.Surekha	3	3	3	3	3
81	1/22/2021	1KS17EC087	Shamanth raj D N	B	Dr B.Surekha	3	3	3	3	3
82	1/22/2021	1KS17EC088	Shivani K	B	Dr B.Surekha	2	2	2	2	2
83	1/22/2021	1KS17EC089	Shravya Acharya	B	Dr B.Surekha	2	2	2	2	2
84	1/22/2021	1KS17EC090	Shreyas	B	Dr B.Surekha	2	2	2	2	2
85	1/22/2021	1KS17EC092	SRIVIDYA VR	B	Dr B.Surekha	2	3	3	3	3
86	1/22/2021	1KS17EC094	Surya N	B	Dr B.Surekha	3	2	3	2	3
87	1/22/2021	1KS17EC095	Sushmitha BL	B	Dr B.Surekha	3	3	3	3	1
88	1/22/2021	1KS17EC096	Sushmitha KN	B	Dr B.Surekha	3	2	3	3	3
89	1/22/2021	1KS17EC097	Syed Waqar Kashif	B	Dr B.Surekha	2	2	3	3	3
90	1/24/2021	1KS17EC098	Tejas K	B	Dr B.Surekha	3	3	3	3	3
91	1/22/2021	1KS17EC099	Vaibhavi sreenivasa	B	Dr B.Surekha	3	3	3	3	3
92	1/22/2021	1KS17EC100	Vaishnavi Katti	B	Dr B.Surekha	3	3	3	3	3
93	1/22/2021	1KS17EC101	Vaishnavi S	B	Dr B.Surekha	2	2	2	2	2
94	1/22/2021	1KS17EC102	Vaishnavi Sriharshan	B	Dr B.Surekha	3	3	3	3	3
95	1/22/2021	1KS17EC103	Vidya.V	B	Dr B.Surekha	2	3	3	3	3
96	1/22/2021	1KS17EC104	VISHAL GOUTHAM N	B	Dr B.Surekha	3	3	3	2	2
97	1/22/2021	1KS17EC403	Bhavana G	A	Dr B.Surekha	2	2	2	2	2
98	1/22/2021	1ks18ec403	Harshitha B	B	Dr B.Surekha	3	3	3	3	3
99	1/22/2021	1ks18ec406	Mahadeva gr	B	Dr B.Surekha	3	3	3	3	3
100	1/22/2021	1ks18ec408	Vanitha. C	B	Dr B.Surekha	3	3	3	3	3
101	1/22/2021	a	a	A	Dr B.Surekha	3	3	3	3	3
					NO. OF 1S	7	5	4	4	4
					Total count	99	99	99	99	99
					Percentage	92.93	94.95	95.96	95.96	95.96
					Average	95.15				

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGG

YEAR / SEMESTER	IV/VII
COURSE TITLE	MICROWAVES AND ANTENNAS
COURSE CODE	17EC71
ACADEMIC YEAR	2020-21
BATCH	2017-18

CO Attainment	Significance
Level 3	60% and above students should have scored >= 60% of Total marks
Level 2	55% to 59% of students should have scored >= 60% of Total marks
Level 1	50% to 54% of students should have scored >= 60% of Total marks

For Direct attainment , 50% of CIE and 50% of SEE marks are considered.
For indirect attainment, Course end survey is considered.
CO attainment is 90%of direct attainment + 10% of Indirect atttainment.
PO attainment = CO-PO mapping strength/3 * CO attainment .

Sl. NO.	USN	NAME	IA1							Assignment 1							IA2									
			IA1	CO 1	Scores	Target 60	CO 2	Scores	Target 60	A1	CO 1	Scores	Target 60	CO 2	Scores	Target 60	IA2	CO 2	Scores	Target 60	CO 3	Scores	Target 60	CO 4	Scores	Target 60
	Maximum Marks		30	18			12			10	6			4			30	6			18			6		
1	1KS17EC001	ABHISHEK.K.V	22	16	3	Y	6	1	N	10	6	3	Y	4	3	Y	26	6	3	Y	14	3	Y	6	3	Y
2	1KS17EC002	ABIJITH SUDHIR	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	22	4	3	Y	12	3	Y	6	3	Y
3	1KS17EC003	AKKSHAY.U.L	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	14	3	Y	6	3	Y
4	1KS17EC004	AKSHITHA.V.RAMESH	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	14	3	Y	6	3	Y
5	1KS17EC005	AMOGHAVARSHA.N.D	20	10	2	N	10	3	Y	8	4.8	3	Y	3.2	3	Y	26	6	3	Y	16	3	Y	4	3	Y
6	1KS17EC006	AMULYA.S.IYENGAR	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	16	3	Y	6	3	Y
7	1KS17EC007	ANA EPSIBA.F	27	16	3	Y	11	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y
8	1KS17EC008	ANAGHA.A.KASHYAP	27	16	3	Y	11	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	16	3	Y	6	3	Y
9	1KS17EC009	ANITHA.R	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	30	6	3	Y	18	3	Y	6	3	Y
10	1KS17EC010	ANOOP DEEKSHITH.R	27	16	3	Y	11	3	Y	0	0	0	N	0	0	N	27	4	3	Y	17	3	Y	6	3	Y
11	1KS17EC011	ANUPAM.M.L	24	12	3	Y	12	3	Y	2	1.2	0	N	0.8	0	N	25	5	3	Y	16	3	Y	4	3	Y
12	1KS17EC012	ANUSHA.L	20	14	3	Y	6	1	N	10	6	3	Y	4	3	Y	28	6	3	Y	17	3	Y	5	3	Y
13	1KS17EC013	ANUSHREE.M	24	14	3	Y	10	3	Y	10	6	3	Y	4	3	Y	30	6	3	Y	18	3	Y	6	3	Y
14	1KS17EC014	ANUSHRI.V.K	21	15	3	Y	6	1	N	8	4.8	3	Y	3.2	3	Y	29	5	3	Y	18	3	Y	6	3	Y
15	1KS17EC015	APEKSHA RAVI KUMAR	30	18	3	Y	12	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y
16	1KS17EC016	ARPITHA	26	15	3	Y	11	3	Y	6	3.6	3	Y	2.4	3	Y	29	5	3	Y	18	3	Y	6	3	Y
17	1KS17EC017	ASIYA FATHIMA.N	17	12	3	Y	5	0	N	0	0	0	N	0	0	N	27	5	3	Y	18	3	Y	4	3	Y
18	1KS17EC018	AYESHA ROSHEEN	27	17	3	Y	10	3	Y	10	6	3	Y	4	3	Y	27	5	3	Y	17	3	Y	5	3	Y
19	1KS17EC019	B.D.SHREENIDHI	29	18	3	Y	11	3	Y	2	1.2	0	N	0.8	0	N	29	6	3	Y	17	3	Y	6	3	Y
20	1KS17EC020	BHAVANA.B.S	28	17	3	Y	11	3	Y	10	6	3	Y	4	3	Y	30	6	3	Y	18	3	Y	6	3	Y
21	1KS17EC021	BHAVANA.J	29	17	3	Y	12	3	Y	8	4.8	3	Y	3.2	3	Y	28	5	3	Y	18	3	Y	5	3	Y

Sl. NO.	Assignment 2										IA3							Assignment 3							EXTERNA		
	A2	CO 2	Scores	Target 60	CO 3	Scores	Target 60	CO 4	Scores	Target 60	IA3	CO 4	Scores	Target 60	CO 5	Scores	Target 60	A3	CO 4	Scores	Target 60	CO 5	Scores	Target 60	SEE	Scores	Target
Maximum Marks	10	2			6			2			30	12			18			10	6			4			60		
1	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	7	7	2	N	0	0	N	0	0	0	N	0	0	N	30	1	N
2	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	8	4	0	N	4	0	N	7	4	3	Y	2.8	3	Y	29	0	N
3	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	17	5	0	N	12	3	Y	9	5	3	Y	3.6	3	Y	24	0	N
4	10	2	3	Y	6	3	Y	2	3	Y	21	11	3	Y	10	2	N	9	5	3	Y	3.6	3	Y	27	0	N
5	7	1.4	3	Y	4.2	3	Y	1.4	3	Y	10	7	2	N	3	0	N	9	5	3	Y	3.6	3	Y	26	0	N
6	10	2	3	Y	6	3	Y	2	3	Y	13	9	3	Y	4	0	N	9	5	3	Y	3.6	3	Y	36	3	Y
7	10	2	3	Y	6	3	Y	2	3	Y	13	4	0	N	9	0	N	9	5	3	Y	3.6	3	Y	29	0	N
8	10	2	3	Y	6	3	Y	2	3	Y	3	3	0	N	0	0	N	9	5	3	Y	3.6	3	Y	21	0	N
9	10	2	3	Y	6	3	Y	2	3	Y	23	11	3	Y	12	3	Y	9	5	3	Y	3.6	3	Y	55	3	Y
10	7	1.4	3	Y	4.2	3	Y	1.4	3	Y	5	5	0	N	0	0	N	8	5	3	Y	3.2	3	Y	30	1	N
11	0	0	0	N	0	0	N	0	0	N	6	5	0	N	1	0	N	1	1	0	N	0.4	0	N	29	0	N
12	10	2	3	Y	6	3	Y	2	3	Y	0	0	0	N	0	0	N	8	5	3	Y	3.2	3	Y	23	0	N
13	10	2	3	Y	6	3	Y	2	3	Y	8	5	0	N	3	0	N	0	0	0	N	0	0	N	21	0	N
14	10	2	3	Y	6	3	Y	2	3	Y	22	10	3	Y	12	3	Y	8	5	3	Y	3.2	3	Y	42	3	Y
15	10	2	3	Y	6	3	Y	2	3	Y	23	11	3	Y	12	3	Y	9	5	3	Y	3.6	3	Y	30	1	N
16	6	1.2	3	Y	3.6	3	Y	1.2	3	Y	8	3	0	N	5	0	N	0	0	0	N	0	0	N	23	0	N
17	0	0	0	N	0	0	N	0	0	N	18	4	0	N	14	3	Y	8	5	3	Y	3.2	3	Y	21	0	N
18	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	4	2	0	N	2	0	N	5	3	1	N	2	0	N	41	3	Y
19	6	1.2	3	Y	3.6	3	Y	1.2	3	Y	15	5	0	N	10	2	N	0	0	0	N	0	0	N	23	0	N
20	10	2	3	Y	6	3	Y	2	3	Y	18	8	3	Y	10	2	N	8	5	3	Y	3.2	3	Y	38	3	Y
21	6	1.2	3	Y	3.6	3	Y	1.2	3	Y	24	9	3	Y	15	3	Y	9	5	3	Y	3.6	3	Y	23	0	N

22	1KS17EC022	BHOOMIKA.P.K	28	17	3	Y	11	3	Y	9	5.4	3	Y	3.6	3	Y	29	5	3	Y	18	3	Y	6	3	Y	6	1.2	3	Y	3.6	3	Y	1.2	3	Y	19	10	3	Y	9	0	N	0	0	0	N	0	0	N	**36**	3	Y
23	1KS17EC023	BINDU.J	28	17	3	Y	11	3	Y	10	6	3	Y	4	3	Y	26	4	3	Y	18	3	Y	4	3	Y	10	2	3	Y	6	3	Y	2	3	Y	11	6	1	N	5	0	N	9	5	3	Y	3.6	3	Y	**21**	0	N
24	1KS17EC024	CHAITHRA.V.M	28	17	3	Y	11	3	Y	10	6	3	Y	4	3	Y	30	6	3	Y	18	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	25	8	3	Y	17	3	Y	8	5	3	Y	3.2	3	Y	**28**	0	N
25	1KS17EC025	CHARAN SAI.Y	28	16	3	Y	12	3	Y	8	4.8	3	Y	3.2	3	Y	25	5	3	Y	14	3	Y	6	3	Y	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	17	9	3	Y	8	0	N	0	0	0	N	0	0	N	**47**	3	Y
26	1KS17EC026	CHETHAN.D.R	27	15	3	Y	12	3	Y	8	4.8	3	Y	3.2	3	Y	28	5	3	Y	17	3	Y	6	3	Y	5	1	1	N	3	1	N	1	1	N	0	0	0	N	0	0	N	7	4	3	Y	2.8	3	Y	**31**	1	N
27	1KS17EC027	CHETHAN.G	27	16	3	Y	11	3	Y	10	6	3	Y	4	3	Y	26	5	3	Y	15	3	Y	6	3	Y	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	6	2	0	N	4	0	N	5	3	1	N	2	0	N	**25**	0	N
28	1KS17EC028	CHETHANA.K.S	26	15	3	Y	11	3	Y	10	6	3	Y	4	3	Y	28	5	3	Y	17	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	10	3	Y	17	3	Y	7	4	3	Y	2.8	3	Y	**42**	3	Y
29	1KS17EC029	CHETHANA PRASAD.K	21	11	3	Y	10	3	Y	10	6	3	Y	4	3	Y	23	5	3	Y	14	3	Y	4	3	Y	10	2	3	Y	6	3	Y	2	3	Y	3	0	0	N	3	0	N	7	4	3	Y	2.8	3	Y	**25**	0	N
30	1KS17EC030	DARSHAN.T.G	28	17	3	Y	11	3	Y	0	0	0	N	0	0	N	26	6	3	Y	14	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	9	9	3	Y	0	0	N	8	5	3	Y	3.2	3	Y	**33**	2	N
31	1KS17EC031	DEVALE SUDARSHAN	21	11	3	Y	10	3	Y	10	6	3	Y	4	3	Y	28	5	3	Y	17	3	Y	6	3	Y	5	1	1	N	3	1	N	1	1	N	6	3	0	N	3	0	N	8	5	3	Y	3.2	3	Y	**26**	0	N
32	1KS17EC032	DEVIYANI.G	28	16	3	Y	12	3	Y	0	0	0	N	0	0	N	24	5	3	Y	15	3	Y	4	3	Y	4	0.8	0	N	2.4	0	N	0.8	0	N	4	4	0	N	0	0	N	9	5	3	Y	3.6	3	Y	**36**	3	Y
33	1KS17EC033	DHAKSHITH.N.K	29	17	3	Y	12	3	Y	8	4.8	3	Y	3.2	3	Y	27	6	3	Y	15	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	2	2	0	N	0	0	N	9	5	3	Y	3.6	3	Y	**24**	0	N
34	1KS17EC035	DISHA.S	29	18	3	Y	11	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	16	4	0	N	12	3	Y	8	5	3	Y	3.2	3	Y	**39**	3	Y
35	1KS17EC036	DIVYA.T.M	26	16	3	Y	10	3	Y	10	6	3	Y	4	3	Y	24	5	3	Y	15	3	Y	4	3	Y	10	2	3	Y	6	3	Y	2	3	Y	14	5	0	N	9	0	N	8	5	3	Y	3.2	3	Y	**29**	0	N
36	1KS17EC038	GOPINATH.H.C	23	11	3	Y	12	3	Y	8	4.8	3	Y	3.2	3	Y	29	6	3	Y	17	3	Y	6	3	Y	6	1.2	3	Y	3.6	3	Y	1.2	3	Y	14	3	0	N	11	3	Y	8	5	3	Y	3.2	3	Y	**33**	2	N
37	1KS17EC039	GOWTHAM.B	21	11	3	Y	10	3	Y	8	4.8	3	Y	3.2	3	Y	25	5	3	Y	14	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	7	7	2	N	0	0	N	9	5	3	Y	3.6	3	Y	**40**	3	Y
38	1KS17EC040	G.S.SURABHI	27	17	3	Y	10	3	Y	10	6	3	Y	4	3	Y	27	5	3	Y	16	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	11	8	3	Y	3	0	N	9	5	3	Y	3.6	3	Y	**28**	0	N
39	1KS17EC041	H.G.SRINIDHI	25	17	3	Y	8	3	Y	10	6	3	Y	4	3	Y	25	5	3	Y	14	3	Y	6	3	Y	2	0.4	0	N	1.2	0	N	0.4	0	N	9	3	0	N	6	0	N	0	0	0	N	0	0	N	**33**	2	N
40	1KS17EC042	JEEVAN.R.S	24	14	3	Y	10	3	Y	8	4.8	3	Y	3.2	3	Y	29	6	3	Y	17	3	Y	6	3	Y	2	0.4	0	N	1.2	0	N	0.4	0	N	1	1	0	N	0	0	N	8	5	3	Y	3.2	3	Y	**26**	0	N
41	1KS17EC043	K.SHREYA	22	11	3	Y	11	3	Y	8	4.8	3	Y	3.2	3	Y	28	6	3	Y	17	3	Y	5	3	Y	2	0.4	0	N	1.2	0	N	0.4	0	N	5	5	0	N	0	0	N	0	0	0	N	0	0	N	**32**	1	N
42	1KS17EC044	KAMNOOR SUSHMA	27	15	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	15	3	Y	6	3	Y	7	1.4	3	Y	4.2	3	Y	1.4	3	Y	6	4	0	N	2	0	N	7	4	3	Y	2.8	3	Y	**21**	0	N
43	1KS17EC045	KRITHIKA.P	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	29	5	3	Y	18	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	25	8	3	Y	17	3	Y	9	5	3	Y	3.6	3	Y	**35**	2	N
44	1KS17EC046	LAKSHAN.N.S	28	16	3	Y	12	3	Y	0	0	0	N	0	0	N	25	5	3	Y	14	3	Y	6	3	Y	0	0	0	N	0	0	N	0	0	N	10	6	1	N	4	0	N	0	0	0	N	0	0	N	**29**	0	N
45	1KS17EC047	LEKHA YADAV.B	30	18	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	15	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	8	6	1	N	2	0	N	9	5	3	Y	3.6	3	Y	**31**	1	N
46	1KS17EC048	M.R.SRINIVAS	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	25	6	3	Y	13	3	Y	6	3	Y	9	1.8	3	Y	5.4	3	Y	1.8	3	Y	3	3	0	N	0	0	N	8	5	3	Y	3.2	3	Y	**23**	0	N
47	1KS17EC049	RANJITH.M	29	18	3	Y	11	3	Y	10	6	3	Y	4	3	Y	27	5	3	Y	16	3	Y	6	3	Y	5	1	1	N	3	1	N	1	1	N	10	10	3	Y	0	0	N	8	5	3	Y	3.2	3	Y	**24**	0	N
48	1KS17EC050	M.SIRISHA	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	16	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	9	3	Y	18	3	Y	9	5	3	Y	3.6	3	Y	**48**	3	Y
49	1KS17EC051	MADHU.S	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	30	6	3	Y	18	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	29	11	3	Y	18	3	Y	9	5	3	Y	3.6	3	Y	**39**	3	Y
50	1KS17EC052	MAHADEVA.G	21	11	3	Y	10	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	16	3	Y	6	3	Y	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	3	1	0	N	2	0	N	0	0	0	N	0	0	N	**34**	2	N
51	1KS17EC053	MAMATHA.K.S	27	16	3	Y	11	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	0	0	0	N	0	0	N	5	3	1	N	2	0	N	**21**	0	N
52	1KS17EC054	MANOJ.E	23	11	3	Y	12	3	Y	10	6	3	Y	4	3	Y	0	0	0	N	0	0	N	0	0	N	10	2	3	Y	6	3	Y	2	3	Y	5	5	0	N	0	0	N	10	6	3	Y	4	3	Y	**11**	0	N
53	1KS17EC055	MANOJ KUMAR.R	22	10	2	N	12	3	Y	8	4.8	3	Y	3.2	3	Y	27	6	3	Y	15	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	7	6	1	N	1	0	N	0	0	0	N	0	0	N	**26**	0	N
54	1KS17EC056	MOHAMMAD FAIZAL	20	10	2	N	10	3	Y	8	4.8	3	Y	3.2	3	Y	28	6	3	Y	16	3	Y	6	3	Y	4	0.8	0	N	2.4	0	N	0.8	0	N	5	3	0	N	2	0	N	8	5	3	Y	3.2	3	Y	**14**	0	N
55	1KS17EC057	MOHAMMED SADATH	28	17	3	Y	11	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	7	3	0	N	4	0	N	9	5	3	Y	3.6	3	Y	**27**	0	N
56	1KS17EC058	MONISHA.A	21	10	2	N	11	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	4	3	0	N	1	0	N	8	5	3	Y	3.2	3	Y	**23**	0	N
57	1KS17EC059	NAGANETRA.M	27	17	3	Y	10	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	14	4	0	N	10	2	N	8	5	3	Y	3.2	3	Y	**36**	3	Y
58	1KS17EC060	NAGELI JAYASAI NAIDU	20	10	2	N	10	3	Y	0	0	0	N	0	0	N	22	6	3	Y	10	2	N	6	3	Y	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	9	4	0	N	5	0	N	8	5	3	Y	3.2	3	Y	**31**	1	N
59	1KS17EC061	NAVEEN KUMAR BURUGUPALLY	24	14	3	Y	10	3	Y	0	0	0	N	0	0	N	27	6	3	Y	15	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	8	6	1	N	2	0	N	9	5	3	Y	3.6	3	Y	**29**	0	N
60	1KS17EC062	NAVIN KUMAR.H.G	25	15	3	Y	10	3	Y	8	4.8	3	Y	3.2	3	Y	28	6	3	Y	16	3	Y	6	3	Y	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	8	6	1	N	2	0	N	8	5	3	Y	3.2	3	Y	**38**	3	Y
61	1KS17EC063	NAVYA.S	22	16	3	Y	6	1	N	8	4.8	3	Y	3.2	3	Y	27	5	3	Y	16	3	Y	6	3	Y	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	9	5	0	N	4	0	N	7	4	3	Y	2.8	3	Y	**30**	1	N

62	1KS17EC064	NIKHIL.V	18	8	0	N	10	3	Y	8	4.8	3	Y	3.2	3	Y	25	6	3	Y	15	3	Y	4	3	Y	6	1.2	3	Y	3.6	3	Y	1.2	3	Y	5	2	0	N	3	0	N	0	0	0	N	0	0	N	**29**	0	N
63	1KS17EC065	NIKHIL.V	18	8	0	N	10	3	Y	8	4.8	3	Y	3.2	3	Y	26	6	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	15	5	0	N	10	2	N	9	5	3	Y	3.6	3	Y	**29**	0	N
64	1KS17EC066	PALLAVI.S	25	15	3	Y	10	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	4	0.8	0	N	2.4	0	N	0.8	0	N	8	5	0	N	3	0	N	9	5	3	Y	3.6	3	Y	**35**	2	N
65	1KS17EC067	PAVAN PRASAD R	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	4	3	Y	16	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	18	4	0	N	14	3	Y	9	5	3	Y	3.6	3	Y	**39**	3	Y
66	1KS17EC068	PENUJURI NAGA SAI SNEHITHA	27	16	3	Y	11	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	16	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	12	4	0	N	8	0	N	8	5	3	Y	3.2	3	Y	**37**	3	Y
67	1KS17EC069	PRAJWAL.C	22	13	3	Y	9	3	Y	8	4.8	3	Y	3.2	3	Y	26	6	3	Y	16	3	Y	4	3	Y	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	10	10	3	Y	0	0	N	7	4	3	Y	2.8	3	Y	**21**	0	N
68	1KS17EC070	PRAJWAL SIMHA S	19	10	2	N	9	3	Y	8	4.8	3	Y	3.2	3	Y	26	5	3	Y	17	3	Y	4	3	Y	2	0.4	0	N	1.2	0	N	0.4	0	N	12	9	3	Y	3	0	N	5	3	1	N	2	0	N	**21**	0	N
69	1KS17EC071	PRATIMA.P.AGN IHOTRI	24	14	3	Y	10	3	Y	8	4.8	3	Y	3.2	3	Y	28	6	3	Y	16	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	26	10	3	Y	16	3	Y	9	5	3	Y	3.6	3	Y	**39**	3	Y
70	1KS17EC072	PRATIMA V KASHYAP	22	16	3	Y	6	1	N	8	4.8	3	Y	3.2	3	Y	26	6	3	Y	14	3	Y	6	3	Y	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	18	9	3	Y	9	0	N	8	5	3	Y	3.2	3	Y	**37**	3	Y
71	1KS17EC073	PRUTHVIRAJ.N	24	15	3	Y	9	3	Y	8	4.8	3	Y	3.2	3	Y	27	5	3	Y	16	3	Y	6	3	Y	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	5	5	0	N	0	0	N	8	5	3	Y	3.2	3	Y	**21**	0	N
72	1KS17EC074	R.YASHAS	21	11	3	Y	10	3	Y	4	2.4	0	N	1.6	0	N	26	5	3	Y	16	3	Y	5	3	Y	4	0.8	0	N	2.4	0	N	0.8	0	N	1	1	0	N	0	0	N	4	2	0	N	1.6	0	N	**21**	0	N
73	1KS17EC075	RACHANA.S	29	18	3	Y	11	3	Y	10	6	3	Y	4	3	Y	30	6	3	Y	18	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	13	2	0	N	11	3	Y	9	5	3	Y	3.6	3	Y	**42**	3	Y
74	1KS17EC076	RAHUL.R.NADIG	27	17	3	Y	10	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	16	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	16	5	0	N	11	3	Y	7	4	3	Y	2.8	3	Y	**42**	3	Y
75	1KS17EC077	RAJESH.C.S	20	10	2	N	10	3	Y	5	3	1	N	2	1	N	23	5	3	Y	14	3	Y	4	3	Y	5	1	1	N	3	1	N	1	1	N	2	2	0	N	0	0	N	5	3	1	N	2	0	N	**15**	0	N
76	1KS17EC078	RAMYA.R	21	10	2	N	11	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	17	10	3	Y	7	0	N	8	5	3	Y	3.2	3	Y	**31**	1	N
77	1KS17EC079	RITU PATIL	22	16	3	Y	6	1	N	2	1.2	0	N	0.8	0	N	25	6	3	Y	13	3	Y	6	3	Y	2	0.4	0	N	1.2	0	N	0.4	0	N	8	5	0	N	3	0	N	0	0	0	N	0	0	N	**26**	0	N
78	1KS17EC080	ROHINI.D	27	16	3	Y	11	3	Y	10	6	3	Y	4	3	Y	30	6	3	Y	18	3	Y	6	3	Y	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	11	5	0	N	6	0	N	8	5	3	Y	3.2	3	Y	**31**	1	N
79	1KS17EC082	RUTHVIK RAVISH	26	17	3	Y	9	3	Y	8	4.8	3	Y	3.2	3	Y	27	5	3	Y	16	3	Y	6	3	Y	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	4	4	0	N	0	0	N	3	2	0	N	1.2	0	N	**26**	0	N
80	1KS17EC084	SAHANA.M.K	24	14	3	Y	10	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	10	10	3	Y	0	0	N	8	5	3	Y	3.2	3	Y	**27**	0	N
81	1KS17EC085	SAHANA.V	28	17	3	Y	11	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	21	10	3	Y	11	3	Y	8	5	3	Y	3.2	3	Y	**34**	2	N
82	1KS17EC086	SANDEEP KUMAR M	28	17	3	Y	11	3	Y	8	4.8	3	Y	3.2	3	Y	28	6	3	Y	16	3	Y	6	3	Y	2	0.4	0	N	1.2	0	N	0.4	0	N	11	5	0	N	6	0	N	8	5	3	Y	3.2	3	Y	**29**	0	N
83	1KS17EC087	SHAMANTH RAJ.D.N	17	6	0	N	11	3	Y	0	0	0	N	0	0	N	22	2	0	N	14	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	3	1	0	N	2	0	N	0	0	0	N	0	0	N	**21**	0	N
84	1KS17EC088	SHIVANI.K	27	17	3	Y	10	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	16	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	13	4	0	N	9	0	N	7	4	3	Y	2.8	3	Y	**21**	0	N
85	1KS17EC089	SHRAVYA.S.ACH ARYA	20	10	2	N	10	3	Y	8	4.8	3	Y	3.2	3	Y	29	6	3	Y	17	3	Y	6	3	Y	2	0.4	0	N	1.2	0	N	0.4	0	N	10	6	1	N	4	0	N	8	5	3	Y	3.2	3	Y	**26**	0	N
86	1KS17EC090	SHREYAS.H.R	19	12	3	Y	7	2	N	10	6	3	Y	4	3	Y	23	6	3	Y	13	3	Y	4	3	Y	10	2	3	Y	6	3	Y	2	3	Y	12	9	3	Y	3	0	N	8	5	3	Y	3.2	3	Y	**36**	3	Y
87	1KS17EC092	SRIVIDYA.V.R	26	16	3	Y	10	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	16	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	12	9	3	Y	3	0	N	8	5	3	Y	3.2	3	Y	**29**	0	N
88	1KS17EC093	SUPRIYA.V	25	15	3	Y	10	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	16	3	Y	6	3	Y	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	5	5	0	N	0	0	N	8	5	3	Y	3.2	3	Y	**35**	2	N
89	1KS17EC094	SURYA.N	25	15	3	Y	10	3	Y	8	4.8	3	Y	3.2	3	Y	24	5	3	Y	14	3	Y	5	3	Y	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	15	6	1	N	9	0	N	8	5	3	Y	3.2	3	Y	**26**	0	N
90	1KS17EC095	SUSHMITHA.B.L	27	16	3	Y	11	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	16	3	Y	6	3	Y	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	5	4	0	N	1	0	N	8	5	3	Y	3.2	3	Y	**25**	0	N
91	1KS17EC096	SUSHMITHA.K.N	26	16	3	Y	10	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	15	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	7	4	0	N	3	0	N	8	5	3	Y	3.2	3	Y	**22**	0	N
92	1KS17EC097	SYED WAQAR KASHIF	27	15	3	Y	12	3	Y	5	3	1	N	2	1	N	28	5	3	Y	17	3	Y	6	3	Y	5	1	1	N	3	1	N	1	1	N	11	11	3	Y	0	0	N	5	3	1	N	2	0	N	**31**	1	N
93	1KS17EC098	TEJAS.K	20	10	2	N	10	3	Y	0	0	0	N	0	0	N	29	6	3	Y	17	3	Y	6	3	Y	7	1.4	3	Y	4.2	3	Y	1.4	3	Y	0	0	0	N	0	0	N	0	0	0	N	0	0	N	**27**	0	N
94	1KS17EC099	VAIBHAVI SREENIVASA	25	15	3	Y	10	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	14	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	20	9	3	Y	11	3	Y	8	5	3	Y	3.2	3	Y	**35**	2	N
95	1KS17EC100	VAISHNAVI.K.K ATTI	26	16	3	Y	10	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	16	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	7	3	0	N	4	0	N	0	0	0	N	0	0	N	**34**	2	N
96	1KS17EC101	VAISHNAVI.S	26	16	3	Y	10	3	Y	8	4.8	3	Y	3.2	3	Y	29	6	3	Y	17	3	Y	6	3	Y	0	0	0	N	0	0	N	0	0	N	11	4	0	N	7	0	N	8	5	3	Y	3.2	3	Y	**26**	0	N
97	1KS17EC102	VAISHNAVI SRIHARSHAN	26	16	3	Y	10	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	14	3	Y	6	3	Y	9	1.8	3	Y	5.4	3	Y	1.8	3	Y	14	6	1	N	8	0	N	8	5	3	Y	3.2	3	Y	**43**	3	Y
98	1KS17EC103	VIDYA.V	28	18	3	Y	10	3	Y	2	1.2	0	N	0.8	0	N	28	6	3	Y	16	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	7	2	0	N	5	0	N	8	5	3	Y	3.2	3	Y	**32**	1	N
99	1KS17EC104	VISHAL GOUTHAM N	27	17	3	Y	10	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	11	2	0	N	9	0	N	8	5	3	Y	3.2	3	Y	**42**	3	Y
##	1KS17EC105	YASHASWINI.R	22	14	3	Y	8	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	14	4	0	N	10	2	N	8	5	3	Y	3.2	3	Y	**30**	1	N
##	1KS18EC403	HARSHITHA B	20	10	2	N	10	3	Y	8	4.8	3	Y	3.2	3	Y	29	6	3	Y	17	3	Y	6	3	Y	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	0	0	0	N	0	0	N	8	5	3	Y	3.2	3	Y	**26**	0	N

##	1KS18EC406	MAHADEVA G R	20	11	3	Y	9	3	Y	0	0	0	N	0	0	N	25	6	3	Y	13	3	Y	6	3	Y	6	1.2	3	Y	3.6	3	Y	1.2	3	Y	1	1	0	N	0	0	N	0	0	0	N	0	0	N	21	0	N
##	1KS18EC408	VANITHA C	20	10	2	N	10	3	Y	8	4.8	3	Y	3.2	3	Y	26	6	3	Y	14	3	Y	6	3	Y	8	1.6	3	Y	4.8	3	Y	1.6	3	Y	1	1	0	N	0	0	N	8	5	3	Y	3.2	3	Y	9	0	N
	CO				CO1			CO2				CO1			CO2				CO2			CO3			CO4				CO2			CO3			CO4				CO4			CO5				CO4			CO 5			SE E	
	Number of Not Attempted(NA)					0			0				0			0				0			0			0				0			0			0				0			0				0			0			0
	Score index & No of Y's				2.80	88		2.84	95			2.52	86		2.52	86			2.94	68		2.96	101			102			2.47	83		2.47	83		2.5	83			0.96	28		0.67	19			2.30	77		2.2	77		1.0	24
	No. of N's					15			8				17			17				1			2			1				20			20			20				75			84				26			26			79
	CO Attainment					85			92				83			83				99			98			99				81			81			81				27			18				75			75			23
	Level					3			3				3			3				3			3							3			3							0			0				3			3			0

CO	CIE	SEE	DIRECT ATTAIN MENT	Level	INDI REC T ATT	Final Att
CO1	84.47	23.3	53.88	1.00	3.00	1.20
CO2	88.72	23.3	56.01	2.00	3.00	2.10
CO3	89.32	23.3	56.31	2.00	3.00	2.10
CO4	70.39	23.3	46.84	0.00	3.00	0.30
CO5	46.60	23.3	34.95	0.00	3.00	0.3
AVERAGE						1.20

CO	Score index out of 3
CO1	1.91
CO2	2.27
CO3	1.99
CO4	0.99
CO5	0.84

					Co-Po Mapping Table								
CO'S	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	_	1	_	_	_	2	1	_	_	3	_
CO2	3	2	1	_	1	_	_	_	2	1	_	_	3	_
CO3	3	2	1	_	1	_	_	_	2	1	_	_	3	_
CO4	3	2	1	_	1	_	_	_	2	1	_	_	3	_
CO5	3	2	1	_	1	_	_	_	2	1	_	_	3	_
AVG	3.0	2.0	1.0	_	1.0	_	_	_	2.0	1.0	_	_	3.0	_

PO Attainment

CO'S	CO Attainment	CO RES ULT	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	1.20	N	1.2	0.8	0.4	_	0.4	_	_	_	0.8	0.4	_	_	1.2	_
CO2	2.10	Y	2.1	1.4	0.7	_	0.7	_	_	_	1.4	0.7	_	_	2.1	_
CO3	2.10	Y	2.1	1.4	0.7	_	0.7	_	_	_	1.4	0.7	_	_	2.1	_
CO4	0.30	N	0.3	0.2	0.1	_	0.1	_	_	_	0.2	0.1	_	_	0.3	_
CO5	0.30	N	0.3	0.2	0.1	_	0.1	_	_	_	0.2	0.1	_	_	0.3	_
Average			**1.2**	**0.8**	**0.4**	_	**0.4**	_	_	_	**0.8**	**0.4**	_	_	**1.2**	_

MICROWAVES AND ANTENNAS

(17EC71/15EC71)

MODULE-2

NOTES

Microwave Network theory: Symmetrical Z and Y-Parameters for Reciprocal Networks, S matrix representation of Multi-Port Networks.

Microwave Passive Devices: Coaxial Connectors and Adapters, Attenuators, Phase Shifters, Waveguide Tees, Magic tees.

Text Books:

1. **Microwave Engineering** – Annapurna Das, Sisir K Das TMH Publication, 2nd, 2010.
2. **Microwave Devices and circuits**- Liao, Pearson Education.

Reference Books:

1. **Microwave Engineering** – David M Pozar, John Wiley India Pvt. Ltd. 3rdEdn, 2008.
   Microwave Engineering – Sushrut Das, Oxford Higher Education, 2ndEdn, 2015.

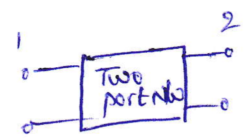
Microwave Network Theory

→ A microwave network is formed when several microwave devices and components such as sources, attenuators, resonators, filters, amplifiers etc., are coupled together by transmission lines or wave guides for the desired transmission of a microwave signal.

→ The point of interconnection of two or more devices is called a junction

→ At low frequencies

- The physical length of the network is much smaller than the wavelength of the signal transmitted.
- The measurable input and output variables are voltage and current which are related interms of of Z-parameters (impedance), Y-parameters (Admittance), h-parameters (Hybrid) and ABCD parameters.
- A port in a low-frequency network is a pair of terminals.
- for a Two-port network, the relationships are given by



Z-parameters
$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

Y-parameters
$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

h parameters
$$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$$

ABCD parameters
$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ I_2 \end{bmatrix}.$$

where Z_{ij}, Y_{ij}, h_{ij} and ABCD are the suitable constants that characterize the junction.

→ for a cascade connection of circuits, the resultant ABCD matrix, can be obtained by multiplying the individual ABCD matrices

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} \cdots \begin{bmatrix} A_n & B_n \\ C_n & D_n \end{bmatrix}$$

ABCD parameters are convinient to be represented at each junction, and can be measured under short or open circuit conditions.

→ At microwave frequencies, the physical length of the component or line is much larger than the wavelength.

- The voltage and current are not well-defined at a given point for a microwave circuit, such as waveguide system.
- Measurement of Z, Y, h and ABCD parameters is difficult at microwave frequencies due to following reasons:

1. Non-availability of terminal voltage and current-measuring equipment.
2. Short-circuit and especially open circuit are not easily achieved for a wide range of frequencies.
3. Presence of active devices makes the circuit unstable for short or open circuit.

→ Therefore, microwave circuits are analysed using scattering or S-parameters, which linearly relate the reflected waves amplitude with those of incident waves.

→ Many of the circuit analysis techniques and circuit properties that are valid at low frequencies are also valid for microwave circuits.

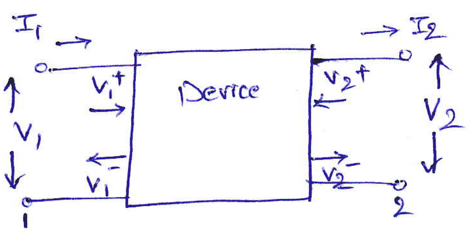
→ S parameters can be related to Z or Y or ABCD parameters.

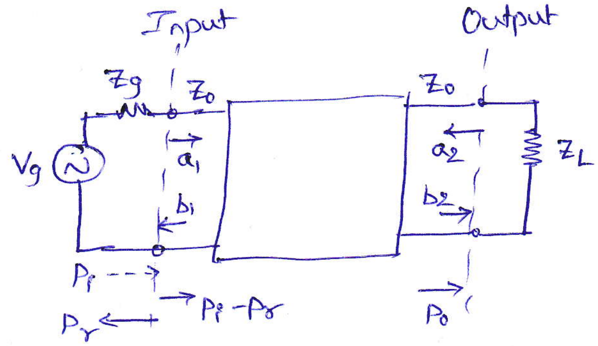
Scattering or S-Matrix Representation of Multiport Network

→ A microwave circuit is characterized by the incident and reflected amplitudes of microwaves at any port.

→ The amplitudes are normalized in such a way that the square of these variables gives the average power in that wave.

→ Consider a 2-port N/w, where the waves are normalized, to result normalized voltages as follows:





→ The voltages (V_1 and V_2) are the sum of incident(V^+) and reflected voltages(V^-) at each port

$$V_1 = V_1^+ + V_1^-$$

$$V_2 = V_2^+ + V_2^-$$

→ The normalized incident (a) and reflected (b) waves at the corresponding ports are

$$a_1 = \frac{V_1^+}{\sqrt{Z_0}} = \frac{V_1 - V_1^-}{\sqrt{Z_0}} \quad , \quad a_2 = \frac{V_2^+}{\sqrt{Z_0}} = \frac{V_2 - V_2^-}{\sqrt{Z_0}}$$

$$b_1 = \frac{V_1^-}{\sqrt{Z_0}} = \frac{V_1 - V_1^+}{\sqrt{Z_0}} \quad , \quad b_2 = \frac{V_2^-}{\sqrt{Z_0}} = \frac{V_2 - V_2^+}{\sqrt{Z_0}}$$

– These amplitudes are normalized in such a way that the square of any of these variables gives the average power in that wave.

Incident power at n^{th} port : $P_{in} = \frac{|a_n|^2}{2}$

Reflected power at n^{th} port : $P_{rn} = \frac{|b_n|^2}{2}$

→ The total or net power flow into any port : $P = P_i - P_r = \frac{|a_n|^2}{2} - \frac{|b_n|^2}{2} = \frac{|a|^2 - |b|^2}{2}$

the characteristic impedance being normalized to unity

→ The relation between incident and reflected waves is expressed in terms of Scatting parameters S_{ij}

$$b_1 = S_{11} a_1 + S_{12} a_2$$

$$b_2 = S_{21} a_1 + S_{22} a_2$$

where

$S_{11} = \frac{b_1}{a_1}\Big|_{a_2=0}$: reflection coefficient Γ_1 at port 1 when port 2 is terminated with a matched load $(a_2=0)$

$S_{22} = \frac{b_2}{a_2}\Big|_{a_1=0}$: reflection coefficient Γ_2 at port 2 when port 1 is terminated with a matched load $(a_1=0)$

$S_{12} = \frac{b_1}{a_2}\Big|_{a_1=0}$: attenuation of wave travelling from port 2 to port 1 when $a_1=0$ [Transmission Coef]

$S_{21} = \frac{b_2}{a_1}\Big|_{a_2=0}$: attenuation of wave travelling from port 1 to port 2 when $a_2=0$ [Transmission Coef]

Note: The incident and reflected waves have both amplitude and phase. Hence the S-parameters are complex numbers.

→ In microwave devices and/or circuits, several losses are expressed in terms of S-parameters, when the ports are matched terminated.

→ In a two-port N/w, let the power fed at port 1 be P_i
power reflected at port 1 be P_r
net power flow into port 1 be $P_i - P_r$
output power at port 2 is P_o.

the losses are defined as follows:

1. Insertion loss (dB) $= 10\log\frac{P_i}{P_o} = 10\log\frac{|a_1|^2}{|b_2|^2} = 20\log\left|\frac{a_1}{b_2}\right| = 20\log\frac{1}{|S_{21}|} = 20\log\frac{1}{|S_{12}|}$

2. Transmission loss (dB) $= 10\log\frac{P_i - P_r}{P_o} = 10\log\frac{1-|S_{11}|^2}{|S_{12}|^2}$

$\frac{(P_i-P_r)/P_i}{P_o/P_i} = \frac{1-\frac{P_r}{P_i}}{P_o/P_i} = \frac{1-|S_{11}|^2}{|S_{12}|^2}$

3. Reflection loss (dB) $= 10\log\frac{P_i}{P_i - P_r} = 10\log\frac{1}{1-|S_{11}|^2}$

$\frac{P_i/P_i}{(P_i-P_r)/P_i} = \frac{1}{1-\frac{P_r}{P_i}} = \frac{1}{1-|S_{11}|^2}$

4. Return loss (dB) $= 10\log\frac{P_i}{P_r} = 20\log\frac{|a_1|^2}{|b_1|^2} = 20\log\frac{1}{|S_{11}|}$

For a multiport(N) networks or Components, the S-parameters equations are expressed by

$$\begin{bmatrix} b_1 \\ b_2 \\ \vdots \\ b_N \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} & \cdots & S_{1N} \\ S_{21} & S_{22} & \cdots & S_{2N} \\ \vdots & \vdots & & \vdots \\ S_{N1} & S_{N2} & \cdots & S_{NN} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ \vdots \\ a_N \end{bmatrix}$$

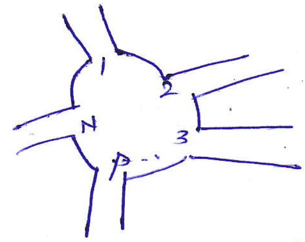


fig: N-port Network

properties of S-parameters for junction of ports having common characteristic impedance

a) Zero diagonal elements for perfect Matched Network with matched termination
- for an ideal N-port matched network with matched termination, $S_{ii}=0$ (diagonal elements), since there is no reflection at all the ports from any port. Therefore under perfect matched conditions, the diagonal elements of [S] are zero.

b) Symmetry of [S] for a reciprocal Network
- A reciprocal device has the same characteristics in either direction of a pair of ports and is characterized by a symmetric scattering matrix,

$S_{ij} = S_{ji}$ $(i \neq j)$, which results in $S^T = S$

c) Unitary property for a lossless junction
For any lossless Network, the sum of products of each term of any one row (or column) of the S-matrix multiplied by its complex conjugate is unity.

$$\sum_{n=1}^{N} S_{ni} S_{ni}^{*} = 1$$

In matrix notation

$S^* S^T = U \rightarrow$ Identity matrix

$S^* = S_T^{-1}$

If all $a_n = 0$, except a_i and a_k, then

$$\sum_{n=1}^{N} S_{nk} \cdot S_{ni}^{*} = 0 \quad , i \neq k$$

A matrix 'S' for a lossless network which satisfies the above three conditions is called unitary matrix.

d) Phase shift property :

For a two-port N/w with unprimed reference planes 1 and 2, shifted outward to 1' and 2' by electrical phase shift $\phi_1 = \beta_1 l_1$ and $\phi_2 = \beta_2 l_2$, then the new wave variables are $a_1 e^{j\phi_1}$, $b_1 e^{-j\phi_1}$, $a_2 e^{j\phi_2}$, $b_2 e^{-j\phi_2}$

The new 's- matrix S' is then given by

$$[S'] = \begin{bmatrix} e^{-j\phi_1} & 0 \\ 0 & e^{-j\phi_2} \end{bmatrix} [S] \begin{bmatrix} e^{-j\phi_1} & 0 \\ 0 & e^{-j\phi_2} \end{bmatrix}$$

This property is valid for any number of ports and is called the phase shift property applicable to a shift of reference planes.

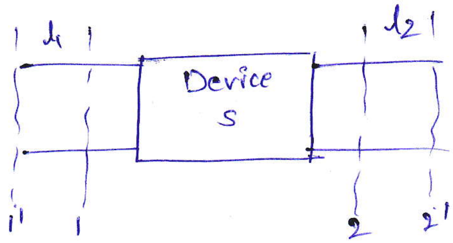


fig: phase shift property of 'S'

Symmetrical Z and Y matrices for reciprocal Network

→ In a reciprocal network, the impedance and admittance matrices are symmetrical and the junction media are characterized by scalar electrical parameters μ and ε.

→ for multiport network (N ports), let the incident wave amplitude V_n^+ be chosen such that the total voltage $V_n = V_n^+ + V_n^- = 0$ at all ports $n = 1, 2 \ldots N$ except the ith port, where the fields are E_i, H_i.

– Similarly let $V_n = 0$ at all ports except jth one where the the fields are E_j, H_j

– from the Lorentz reciprocity theorem

$$\int_S (E_i \times H_j - E_j \times H_i) \cdot ds = 0$$

where 's' is the closed surface area of the conducting walls enclosing the junction and N ports in the absence of any source.

– Since the integral over the perfectly conducting walls vanishes, the only non-zero integrals are those taken over the reference planes of corresponding ports, so that

$$\sum_{n=1}^{N} \int_{t_n} (E_i \times H_j - E_j \times H_i) \cdot ds = 0$$

– Since V_n except V_i and V_j are zero, $E_{ti} = n \times E_i$ and $E_{tj} = n \times E_j$ are zero on all reference planes at the corresponding ports except t_i and t_j. Therefore

$$\int_{t_i} (E_i \times H_j)\, ds = \int_{t_j} (E_j \times H_i)\, ds$$

$$P_{ij} = P_{ji} \quad \text{— (A)}$$

where P_{ij} represents the power at reference plane i due to an input voltage at plane j.

from the admittance matrix representation $I = YV$

(A) $P_{ij} = P_{ji} \implies V_i V_j Y_{ij} = V_j V_i Y_{ji}$

$P = VI$

$$Y_{ij} = Y_{ji}$$

$$Z_{ij} = Z_{ji}$$

This proves that impedance and admittance matrices are symmetrical for a reciprocal junction.

Coaxial Connectors and Adapters

→ Coaxial cables are terminated or connected to other cables and components by means of shielded standard connectors.

→ The outer shield makes a 360° extremely low impedance joint to maintain shielding integrity.

– The connectors are of various types depending on the freq range and cable diameter.

→ Commonly used Standard microwave connectors are:

	Type	Sex	Dielectric in mating Space	Impedance (ohms)	Characteristics
1.	N (Navy	M/F	Air	50/75	- designed for military applications - suitable for Flexible or rigid cables in freq range 1-18 GHz
2.	BNC [Bayonet Navy Connector	M/F	Solid	50/75	- Suitable for 0.25 inch 50/75Ω Flexible cables upto 1GHz
3.	TNC [Threaded Navy Connector]	M/F	Solid	50/75	- Outer conductor has a thread to make firm contact in the mating surface to minimize radiation leakage at high frequencies. - used upto 12GHz
4	SMA [Subminiature A]	M/F	Solid	50	- used for thin flexible or semi-rigid cables. - Higher freq. limited to 24GHz b'coz of generation of higher-order-modes beyond this limit
5.	APC-7 [Amphenol precision connector]	Sexless	Air	50	- very accurate 50Ω, low VSWR which can operate upto 18GHz
6.	APC 3.5	Sexed	~~Sexed~~ Air	50	- High precision 50Ω, low VSWR connector, either M/F, operate upto 34GHz

→ Adapters, having different connectors at the two ends, are also made for interconnection between two different ports in a microwave system.

Attenuators

→ Attenuators are passive devices used to control power levels in a microwave system by partially absorbing the transmitted signal wave.

→ Types: fixed and variable - designed using resistive films (aquadag)

→ Coaxial fixed attenuator: uses a film with losses on the center conductor to absorb some of the power.

→ Fixed waveguide attenuator: consists of thin dielectric strip coated with resistive film and placed at the center of the waveguide parallel to the maximum E field.

- Induced current on the resistive film due to the incident wave results in power dissipation leading to attenuation of microwave energy.
- The dielectric strip is tapered at both ends upto a length of more than half wavelength to reduce reflections.
- The resistive vane is supported by two dielectric rods seperated by an odd multiple of quarter wave length and ⊥ to the electric field.

→ Variable waveguide attenuator: It can be constructed by moving the resistive vane by means of micrometer screw from one side of the narrow wall to the centre where the E field is maximum.

- It can also be constructed by changing the depth of insertion of a resistive vane at an E field maximum through a longitudinal slot at the middle of the broad wall.
- A maximum of 90dB attenuation is possible with VSWR of 1.05.
- The resistive card can be shaped to give a linear variation of attenuation with the depth of insertion.

Precision type variable attenuator

→ It makes use of a circular section (C) containing a very thin tapered resistive card (R_2), to both sides of which are connected axisymmetric sections of circular to rectangular waveguide tapered transitions (RC_1 and RC_2)

→ The center circular section with the resistive card can be precisely rotated by 360° with respect to the fixed sections of circular to rectangular waveguide transitions.

→ The induced current on the resistive card R_2 due to the incident signal is dissipated as heat producing attenuation of the Tx signal.

→ The incident TE_{10} dominant wave in the rectangular waveguide is converted into a dominant TE_{11} mode in the circular waveguide

→ A very thin tapered resistive card is placed ⊥ to the E field at the circular end of each transition section so that it has a negligible effect on the field ⊥ to it but absorbs any component ∥ to it.

Therefore a pure TE_{11} mode is excited in the middle section

→ If the resistive card in the centre section is kept at an angle θ relative to the E field direction of the TE_{11} mode, the component E Cosθ parallel to the card gets absorbed while the component E Sinθ is transmitted without attenuation.

– This E Sinθ component finally appears as E $Sin^2θ$ in a rectangular output guide.

– Therefore the attenuation of the incident wave is

$$\alpha = \frac{E}{E\sin^2\theta} = \frac{1}{\sin^2\theta} = \frac{1}{|S_{21}|}$$

$$\alpha\,(dB) = -40\log(\sin\theta) = -20\log|S_{21}|$$

→ The precision rotary attenuator produces attenuation which depends only on the angle of rotation 'θ' of the resistive card with respect to the incident wave polarisation.

→ Attenuators are normally matched reciprocal devices

$$\therefore\ |S_{21}| = |S_{12}|$$

and $S_{11} = S_{22} = \dfrac{VSWR-1}{VSWR+1} << 0.1$

→ The S-matrix of ideal precision rotary attenuator is

$$[S] = \begin{bmatrix} 0 & \sin^2\theta \\ \sin^2\theta & 0 \end{bmatrix}$$

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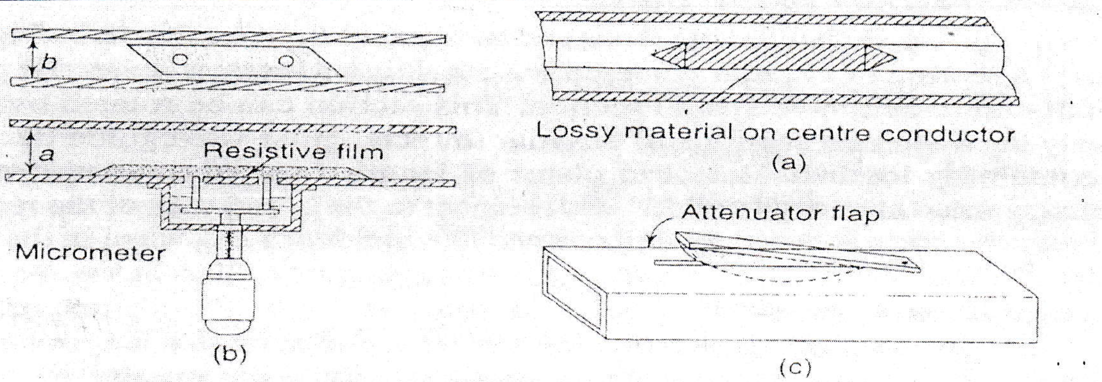

Fig. 6.24 *Microwave attenuator (a) Coaxial line fixed attenuator (b) & (c) Waveguide attenuators*

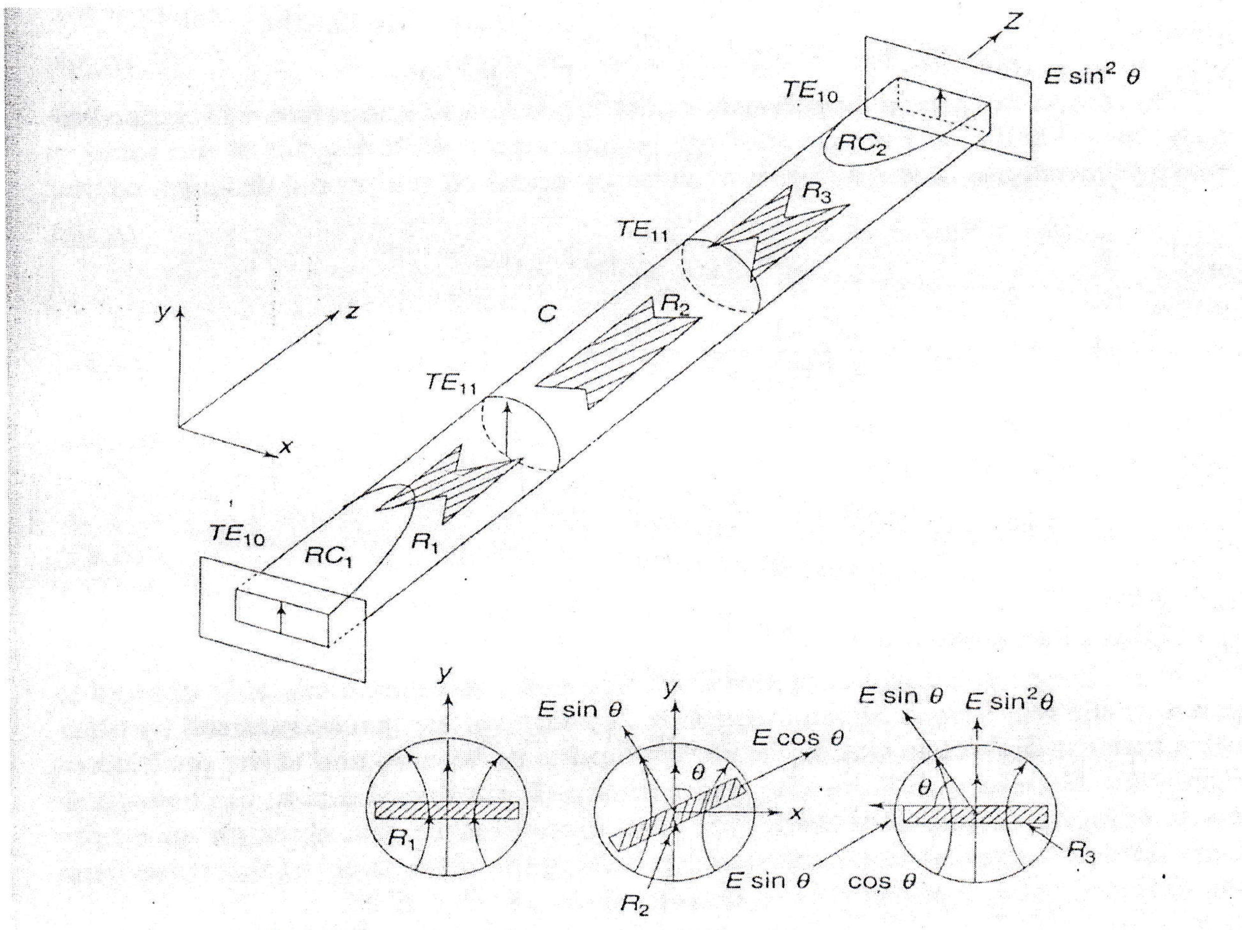

Fig. 6.25 *Precision type variable attenuator*

R_1, R_2, R_3 – Tapered resistive cards

RC_1 & RC_2 – Rectangular-to-circular waveguide transitions

C – Circular Waveguide Section

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Phase shifters

→ A phase shifter is a two port passive device that produces a variable change in phase of the wave transmitted through it.

→ A phase shifter can be realized by placing a lossless dielectric slab with in a waveguide parallel to and at the position of max E field.

→ A differential phase change is produced due to the change of wave velocity through the dielectric slab compared to that through an empty waveguide.

→ Two ports are matched by reducing the reflections of the wave ~~forms~~ from the dielectric slab tapered at both ends.

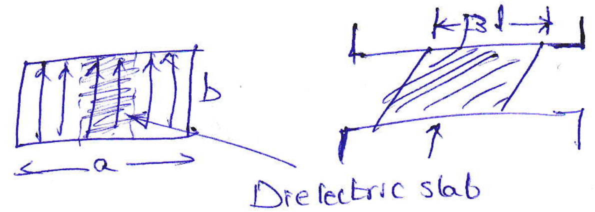


fig: phase shifters

→ The propagation constant through a length 'l' of a dielectric slab and of an empty guide are respectively.

$$\beta_1 = \frac{2\pi}{\lambda_{g_1}} = \frac{2\pi\sqrt{\left[1-\left[\lambda_0/2a\sqrt{\epsilon_r}\right]^2\right]}}{\lambda_0/\sqrt{\epsilon_r}}$$

$$\beta_2 = \frac{2\pi}{\lambda_{g_2}} = \frac{2\pi\sqrt{1-(\lambda_0/2a)^2}}{\lambda_0/\sqrt{\epsilon_r}}$$

→ The differential phase shift produced by the phase shifter is $\Delta\phi = (\beta_1-\beta_2)l$

→ By adjusting the length 'l', different phase shifts can be produced.

→ The S matrix of an ideal phase-shifter is

$$[S] = \begin{bmatrix} 0 & e^{-j\Delta\phi} \\ e^{-j\Delta\phi} & 0 \end{bmatrix}$$

Precision phase shifter

→ The precision phaseshifter of rotary type uses a section of circular waveguide containing a lossless dielectric plate of length 2l called halfwave section (180°).

→ This section can be rotated over 360° precisely between two circular to rectangular waveguide transitions, each containing sections of lossless dielectric plates of length 'l' called quarterwave (90°) sections oriented at an angle of 45° with respect to the broadwall of the rectangular waveguide ports at the input and output.

→ The incident TE_{10} wave in the rectangular guide becomes a TE_{11} wave in the circular guide.

→ The half-wave section produces a phase shift equal to twice its rotation angle θ with respect to the quarter wave section.

→ The dielectric plates are tapered through a length of quarter wavelength at both ends for reducing reflection due to discontinuity.

→ Operation:

- The TE_{11} mode incident field E_i in the input quarterwave section can be decomposed into two transverse components: E_1 polarized parallel and E_2 ⊥ to quarterwave plate
- After propagation through quarterwave plate these components are

$$E_1 = E_i \cos 45^\circ e^{-j\beta_1 l} = E_0 e^{-j\beta_1 l} \quad \text{where } E_0 = \frac{E_i}{\sqrt{2}}$$

$$E_2 = E_i \sin 45^\circ e^{-j\beta_2 l} = E_0 e^{-j\beta_2 l}$$

- The length 'l' is adjusted such that, these two components have equal magnitude but a differential phase change of $(\beta_1-\beta_2)l = 90^\circ$.

$$\beta_2 l = \beta_1 l - 90^\circ = \beta_1 l - \frac{\pi}{2}$$

∴ E_2 can be rewritten as $E_2 = E_0 e^{-j(\beta_1 l - \frac{\pi}{2})} = E_0 e^{-j\beta_1 l} \cdot e^{j\frac{\pi}{2}}$

$$= E_1 e^{j\frac{\pi}{2}}$$

- Thus, the quarterwave sections convert a linearly polarized TE_{11} wave to a circularly polarized wave and vice-versa.
- After emergence from the halfwave section, the field components parallel and ⊥ to the halfwave plate can be represented as

$$E_3 = (E_1 \cos\theta - E_2 \sin\theta) e^{-j\beta_2 2l} = E_0 e^{-j\theta} e^{-j3\beta_1 l}$$

$$E_4 = (E_2 \cos\theta + E_1 \sin\theta) e^{-j2\beta_2 l} = E_0 e^{-j\theta} \cdot e^{-j3\beta_1 l} \cdot e^{-j\pi/2}$$

Since $2(\beta_1-\beta_2)l = \pi$ or $-2\beta_2 l = \pi - 2\beta_1 l$

→ After emergence from the halfwave section, the field components E_3 and E_4 may again be decomposed into two TE_{11} modes, polarized parallel and ⊥ to the output quarterwave plate.

→ At the output end of this quarterwave plate, the field components parallel and ⊥ to the quarterwave plate can be written as

$$E_5 = (E_3 \cos\theta + E_4 \sin\theta) e^{-j\beta_1 l} = E_0 e^{-j2\theta} e^{-j4\beta_1 l}$$

$$E_6 = (E_4 \cos\theta - E_3 \sin\theta) e^{-j\beta_1 l} = E_0 e^{-j2\theta} \cdot e^{-j4\beta_1 l}$$

→ Therefore the parallel component E_5 and ⊥ component E_6 at the o/p of quarterwave plate are equal in magnitude and inphase to produce a resultant field which is a linearly polarized TE_{11} wave

$$E_{out} = \sqrt{2}\, E_0 e^{-j2\theta} \cdot e^{-j4\beta_1 l} = E_i e^{-j2\theta} \cdot e^{-j4\beta_1 l}$$

having the same direction of polarization as the incident field E_i with a phase change of $2\theta + 4\beta_1 l$. Since θ can be varied and $4\beta_1 l$ is fixed at a given frequency and structure, a phase shift of 2θ can be obtained by rotating the halfwave plate precisely through an angle of θ with respect to the quarterwave plates.

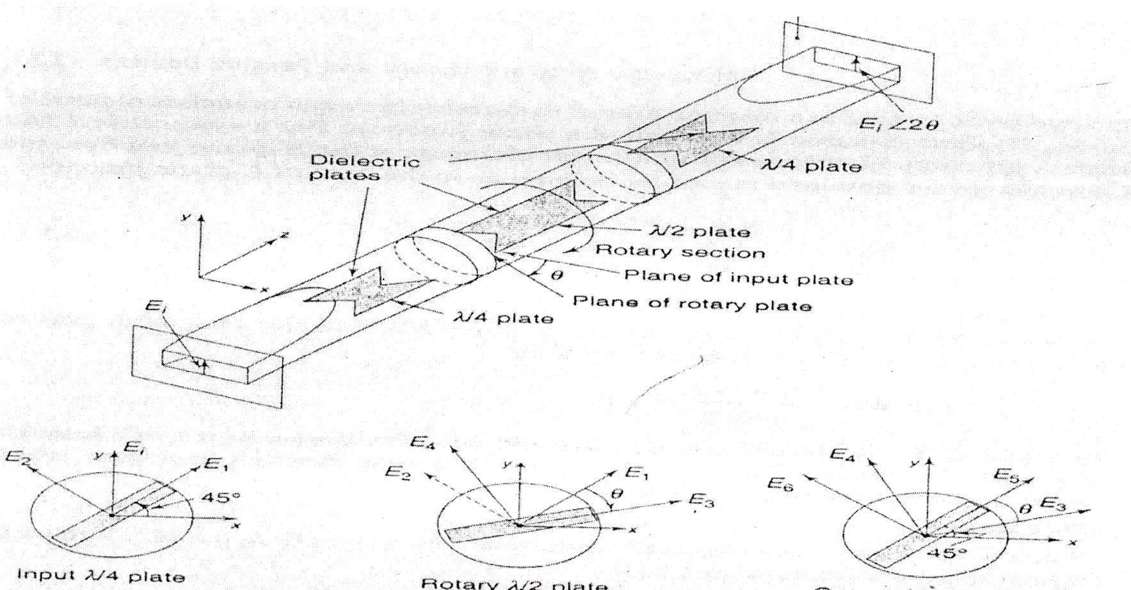


Fig. 6.27 *Precision rotary phase shifter*

Waveguide Tees

→ Waveguide tees are 3-port components.

→ They are used to connect a branch or section of the waveguide in series or parallel with the main waveguide transmission line for providing means of splitting, and also of combining power in a waveguide system.

→ Two types : E plane (series) T and H-plane (shunt) T, according to the axis of the side arm which is parallel to the E field or the H field in the collinear arms respectively.

→ Because of the junction, waveguide tees are poorly matched devices.

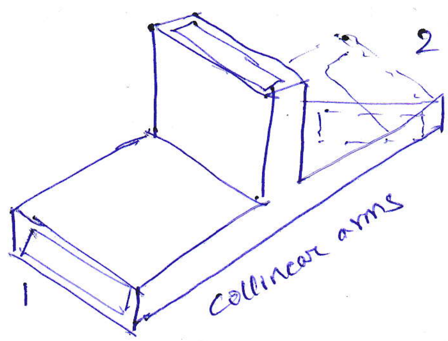
- Because of the symmetry and absence of nonlinear elements in the junction, the S-matrix is symmetric. $S_{ij} = S_{ji}$; $i = 1,2$; $j = 1,2$

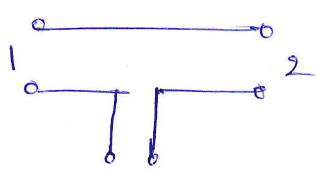
- The general S-matrix for a tee junction is

$$[S] = \begin{bmatrix} S_{11} & S_{12} & S_{13} \\ S_{12} & S_{11} & S_{23} \\ S_{13} & S_{23} & S_{33} \end{bmatrix}$$

E-plane Tee

~~H plane~~ Tee





E-Tee or Series-T

E-plane Tee

→ A wave incident at port 3 will result in waves at port 1 and port 2 which are equal in magnitude and opposite in phase i.e., $S_{31} = S_{13}$.

$$S_{31} = S_{13} = -S_{23} = -S_{32} \quad , S_{12} = S_{21}$$

→ If two in-phase input waves are fed into ports 1 and 2 of the collinear arm, the output waves at port 3 will be opposite in phase and subtractive.

→ The third port is called difference port. By analogy with the voltage relationship in the series circuit, E-plane junction is also called as series junction.

→ All the diagonal elements of the S-matrix of an E plane T junction can't be zero simultaneously since the tee junction can't be matched to all the three arms simultaneously.

→ Considering the port 3 as matched, the S-matrix of a E-plane-T can be derived as follows:

→ Denoting the incident and outgoing signal variables as the ith port by a_i and b_i,

for an input power at port 3, the net input power to port 3

$$= \frac{1}{2}\{|a_3|^2 - |b_3|^2\} = \frac{1}{2}|a_3|^2[1 - |S_{33}|^2]$$

The o/p power is $\frac{1}{2}\{|b_1|^2 + |b_2|^2\} = |a_3|^2 |S_{13}|^2$ by Symmetry $|S_{31}| = |S_{32}|$

→ For lossless junction input power must be equal to output power.

$$\frac{1}{2}|a_3|^2[1 - |S_{33}|^2] = |a_3|^2 |S_{13}|^2$$

$$1 - |S_{33}|^2 = 2|S_{13}|^2$$

By suitable matching elements $S_{33} = 0$, so that $|S_{13}| = \frac{1}{\sqrt{2}}$

from symmetry characteristics

$$S_{13} = S_{31} = \frac{1}{\sqrt{2}}, \quad S_{23} = S_{32} = \frac{-1}{\sqrt{2}}$$

$$S_{11} = S_{22} = \frac{1}{2}, \quad S_{12} = S_{21} = \frac{1}{2} \quad \text{for } S_{33} = 0$$

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

∴ with matching port at port 3, the S-matrix of an E-plane T can be expressed by real values with proper choice of reference plane.

H-plane Tee

→ In a H plane tee, if two in-phase input waves are fed into ports 1 and 2 of the collinear arm, the output waves at port 3 will be inphase and oddtitive. Because of this port 3 is called sum arm.

→ Reversely, an input wave at port 3 will be equally divided into ports 1 and 2 inphase

→ Because the magnetic field loops get divided into two arms '1' and '2' in a manner similar to currents between branches in the parallel circuit, an H-plane junction is also called as shunt junction

→ for a symmetrical and lossless junction, in absence of non linear elements at the H plane junction, the S parameters are obtained in a similar manner as in the case of E-plane junction

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

– when matched at the side port 3.

→ The device provides a 3dB power split from arm 3, with the waves inphase at the symmetrical ports 1 and 2.

If power P_1 is applied to the port 1

Reflected power at port 1 = $P_1/4$

Transmitted power to port 2 = $P_1/4$

Tranmitted power to port 3 = $P_1/2$

→ Because of the mismatch at any two ports, the VSWR at the mismatch port of either E or H plane tee junction is very high.

$$VSWR = \frac{1+\frac{1}{2}}{1-\frac{1}{2}} = 3.00$$

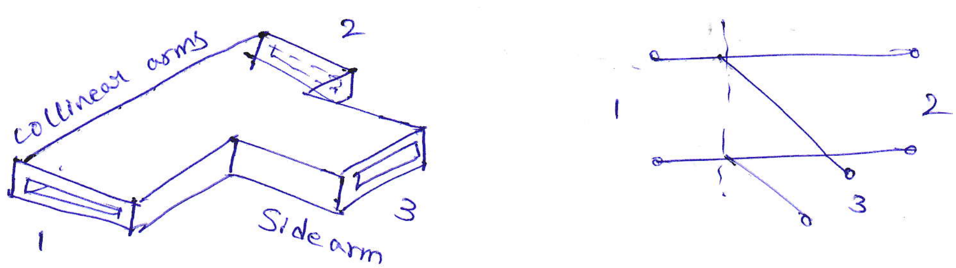
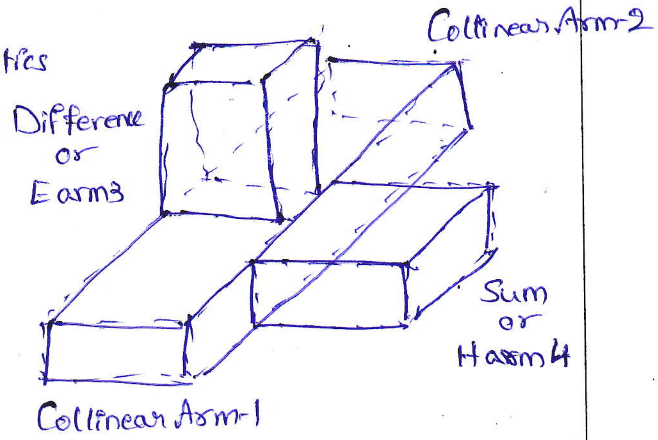


fig: H-Tee or Shunt-T

Magic-T or Hybrid-T

→ A combination of E plane and H plane tees forms a hybrid tee, called a magic T having 4 ports.



→ The magic tee has the following characteristics when all the ports are terminated with matched load.

1. If two in-phase waves of equal magnitude are fed into ports '1' and '2' the o/p at port 3 is subtractive and hence zero. Hence the total power appear additively at port 4. Hence port 3 is called difference or E arm. port 4 the sum arm.

2. A wave incident at port 3 (E-arm) divides equally between ports '1' and '2' but opposite in phase with no coupling to port 4. (H-arm).

$$\therefore \quad S_{13} = S_{31} = \frac{1}{\sqrt{2}} = -S_{23} = -S_{32}$$

$$S_{32} = S_{23} = \frac{1}{\sqrt{2}}$$

$$S_{34} = 0$$

3. A wave incident at port 4 (H arm) divides equally b/w ports 1 and 2 inphase with no coupling to port 3 (E-arm).

$$\therefore \quad S_{14} = S_{41} = \frac{1}{\sqrt{2}} = S_{24} = S_{42}$$

$$S_{43} = 0$$

4. A wave fed into one collinear port '1' or '2', will not appear in the other collinear ports 2 or '1'. Hence two collinear ports are isolated from each other.

$$S_{12} = S_{21} = 0$$

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

- A magic T can be matched by putting screws suitably in the E and H arms without destroying the symmetry of the junctions.
- Therefore for an ideal loss less magic-T matched at ports 3 and 4

$$S_{33} = S_{44} = 0.$$

- The S matrix for a magic T, matched at ports 3 and 4 is given by

$$[S] = \begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{12} & S_{22} & -S_{13} & S_{14} \\ S_{13} & -S_{13} & 0 & 0 \\ S_{14} & S_{14} & 0 & 0 \end{bmatrix}$$

From the unitary property applied to rows ① and ② we get

$$|S_{11}|^2 + |S_{12}|^2 + |S_{13}|^2 + |S_{14}|^2 = 1 \quad \text{— (A)}$$

$$|S_{12}|^2 + |S_{22}|^2 + |S_{13}|^2 + |S_{14}|^2 = 1$$

Subtracting the above two Eqn gives

$$|S_{11}|^2 - |S_{22}|^2 = 0$$

$$\text{or } |S_{11}| = |S_{22}| \quad \text{— (B)}$$

From unitary property applied to rows '3' and '4'

$$2|S_{13}|^2 = 1. \Rightarrow S_{13} = \frac{1}{\sqrt{2}}$$

$$2|S_{14}|^2 = 1 \Rightarrow S_{14} = \frac{1}{\sqrt{2}}$$

Substituting these values in (A)

$$|S_{11}|^2 + |S_{12}|^2 + |S_{13}|^2 + |S_{14}|^2 = 1 \Rightarrow |S_{11}|^2 + |S_{12}|^2 + \frac{1}{2} + \frac{1}{2} = 1$$

$$|S_{11}|^2 + |S_{12}|^2 = 0$$

which is valid only if $S_{11} = S_{12} = 0$

from B $S_{22} = S_{11} = 0$

$$\therefore S_{13} = \frac{1}{\sqrt{2}}$$

$$\therefore [S] = \begin{bmatrix} 0 & 0 & S_{13} & S_{13} \\ 0 & 0 & -S_{13} & S_{13} \\ S_{13} & -S_{13} & 0 & 0 \\ S_{13} & S_{13} & 0 & 0 \end{bmatrix} = \frac{1}{\sqrt{2}} \begin{bmatrix} 0 & 0 & 1 & 1 \\ 0 & 0 & -1 & 1 \\ 1 & -1 & 0 & 0 \\ 1 & 1 & 0 & 0 \end{bmatrix}$$