GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester -V

Course Title: Microwave and Radar Communication
(Course Code: 4351103)

Diploma programme in which this course is offered	Semester in which offered
Electronics and Communication Engineering	5th Semester

1. RATIONALE

The knowledge of microwave devices is essential for electronics and communication engineering diploma holders and they need to assimilate it in order to maintain Microwave devices used in Telecommunication Industry. Hence, the basic knowledge of microwave signal generation, propagation, amplification and measurement is vital. This course has been designed so that the diploma engineer can achieve skills to maintain microwave devices, components and accessories used in telecommunication industry.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competency:

- ✓ **Install and Maintain microwave devices, components and accessories used in telecommunication field.**

3. COURSE OUTCOMES (COs)

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

1. Distinguish Electromagnetic wave propagation through reflections from voltage and Current transmission.
2. Analyze performance of microwave components from field point of view.
3. Maintain microwave components and Set up of microwave bench for optimum Operation.
4. Maintain microwave semiconductor devices used to realized amplifiers and Oscillators.
5. Maintain SONAR and RADAR systems as microwave application.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	2	4	30*	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** -End Semester Examination.*

Note: It is the responsibility of the institute heads that marks for PA of theory & ESE and PA of practical for each student are entered online into the GTU Portal at the end of each semester within the dates specified by GTU.

5. SUGGESTED PRACTICAL EXERCISES

Following practical outcomes (PROs) are the sub-components of the Course Outcomes (Cos). Some of the **PROs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.

Sr. No.	Practical Outcomes (PROs)	Unit No.	Approx. Hrs. Required
1	Measure open circuit & short circuit parameters for the given length of Transmission line.	1	02
2	Measure VSWR & reflection coefficient for given length of transmission line.	1	02
3	Set the microwave bench for optimum frequency operation.	2	02*
4	Measure the voltage maxima and minima on slotted waveguide and calculate free space, cut off and guided wavelength.	2	02*
5	Identify various microwave components in the microwave circuit.(PART-1)	2	02*
6	Identify various microwave components in the microwave circuit.(PART-2)	2	02*
7	Determine the directivity, insertion loss , and coupling factor for a given directional coupler.	2	02*
8	Determine the isolation factor for a given isolator.	2	02*
9	Determine the coupling factor and, insertion loss, for a given circulator.	2	02*
10	Calibrate the given variable attenuator.	2	02*
11	Measure microwave frequency using the given (direct and /or indirect) frequency meter.	3	02*
12	Measure VSWR for given microwave loads.	3	02*
13	Measure attenuation of given attenuator.	3	02*
14	Test different controls and functions of GUNN / KLYSTRON power supply.	4	02*
	Minimum 14 Practical Exercises		**28**

Note

*i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the CO s. The above table is only a suggestive list.*

The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.

SR. No.	Sample Performance Indicators for the PROs	Weightage in %
1	Prepare The experimental setup.	20
2	Operate the equipment setup or circuit.	30
3	Follow safe practices measures.	10
4	Record observations correctly.	30
5	Interpret the result and conclude.	10
Total		**100**

6.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to user in uniformity of practical's in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PRO. No.
1.	VSWR meter Resonated at 01 KHZ	ALL
2.	Microwave bench.	ALL
3.	GUNN / KLYSTRON power supply 'X' band.	ALL
4.	Various Microwave 'X' band components.	ALL
5.	Microwave accessories BNC to BNC cables, Main Chords	ALL

8. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PRO s. More could be added to fulfill the development of this course competency.

a) Work as a leader/a team member.
b) Follow safety practices while using electrical, electronics, pneumatic instruments and tools.

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year

ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Major Learning Outcomes	Topics and Sub-topics
Unit – I. Transmission lines and Microwaves	1a. Describe EM wave frequency bands and spectrum. 1b. State the strengths and limitations of microwave communication.	1.1 Microwaves: frequency band, EM waves, General applications of microwaves.
	1c. Explain the equivalent circuit of a two wire transmission line. 1d. Obtain the general equation for a two wire transmission line. 1e. State characteristics of lossless transmission line. 1f. Explain impedance matching using stub. 1g. Using design equations solve examples of single stub matching.	1.2 Transmission lines: Parameters, general line equation, lossless line, λ/4 line, standing waves , VSWR, reflection coefficient ,stub matching (single and double) , skin effect.
Unit– II Microwave Propagation and Components	2a. Describe propagation of microwaves through waveguide and explain cutoff wavelength. 2b. Differentiate between transmission line and waveguide. 2c. Calculate cut off wavelength, group and phase velocities, characteristics wave impedance of any waveguide parameters.	2.1 Waveguides: Wave propagation through guided medium, reflections of waves.

	2d. Distinguish the following: cut off wavelength, group and phase velocities, characteristics wave impedance, TE, TM modes, S Parameters.	2.2 Rectangular waveguide : structure , cut off wavelength , group and phase velocities, characteristic wave impedance , TE ,TM modes , field patterns , examples, S Parameters basics.
	2e. Compare the working of rectangular waveguide and circular waveguide.	2.3 Circular waveguide: structure, cut off wavelength, modes, examples, comparison with rectangular waveguide.
	2f.State applications of following microwave components: Tees, hybrid ring , directional coupler , Duplexer , isolator ,circulator , cavity resonators. 2g. Differentiate E-Plane Tee, H-Plane Tee and magic Tee. 2h. Explain the working of directional coupler, isolator and circulator with sketches. 2i. Explain working of cavity resonators with sketches.	2.4 Microwave Components: Tees, hybrid ring , directional coupler , Duplexer , isolator , circulator , cavity resonators.
	2j. Describe working of bends, corner, twist and taper with sketches.	2.5 Microwave Accessories: corners and bends , twist and taper.
Unit– III Microwave tubes and measurements	3a.Describe the frequency limitations of vacuum tubes at microwave frequency.	3.1 Limitations of vacuum tubes at microwave frequency.
	3b.Explain function of reflex klystron with the help of applegate diagram. 3c.Explain structure and effects of various fields' acts on electron moving in the magnetron tube. 3d.Describe working of Travelling Wave Tube as an amplifier. 3e.Explain π mode oscillation and define frequency pushing and pulling. 3f. Explain two cavity klystron with applegate diagram. 3g.Describe working of	3.2 .Microwave tube amplifiers: Klystron - Two cavity and multi cavity, Travelling Wave Tube. 3.3 Microwave tube oscillators: Reflex klystron, Magnetron, Backward Wave Oscillator.

	Backward Wave Oscillator.	
	3h. Explain microwave power measurement methods. 3i. Explain significance of VSWR measurement. 3j. Explain attenuation measurement methods. 3k. Describe 'Q' measurement technique.	3.4. Microwave measurement: power, frequency, wavelength (free space, guided and cutoff), VSWR, attenuation, 'Q'.
	3l. Explain hazards due to microwave radiation.	3.5. Microwave radiation hazards: types (HERP, HERO, HERF), and protection from hazards.
Unit–IV Microwave semiconductor devices	4a. Explain Varactor diode's working with diagrams. 4b. Describe transfer electron effect using the energy level diagram for GUNN diode. 4c. Explain the working of GUNN diode as an oscillator. 4d. Explain principle, construction, working and application of TUNNEL diode. 4e. Explain the working of a PIN diode as a switch. 4f. Explain the negative resistance principle for IMPATT/TRAPATT diode with sketches.	4.1 Microwave diodes: VARACTOR diode , GUNN diode, TUNNEL diode, PIN diode, IMPATT diode, TRAPATT diode.
	4g. Explain the parametric amplifier with diagrams. 4h. Explain the frequency up and down conversion concepts for parametric amplifier.	4.2.Parametric amplifier
	4i. Explain the concept of high electron mobility transistor / strip line and micro strip circuits in brief.	4.3. High electron mobility transistors. 4.4 Strip line and micro strip circuits.
	4j. Describe working of RUBY MASER.	4.5 MASER: working principle, solid state RUBY MASER.
Unit-V RADAR systems	5a. Explain basic principle of RADAR and SONAR.	5.1 Introduction: Basic principle of RADAR and SONAR.

	5b. Using given data for RADAR calculate the RADAR range /minimum received power / operating frequency range. 5c. Obtain the equation for maximum RADAR range. 5d. Using RADAR range equation, describe, how various parameters affect the maximum range.	5.2 RADAR range equation and examples, factors affecting maximum range.
	5e. Explain scanning and tracking methods used in RADAR communication. 5f. Explain the working of pulsed RADAR with the help of block diagram. 5g. Describe display methods used for RADAR.	5.3 Pulse RADAR: block diagram, RADAR antenna , scanning and tracking methods, Display methods.
	5h. Explain the principle of CW Doppler RADAR and define blind speed. 5i. Describe the working of MTI RADAR with the help of suitable sketch. 5j. Explain how the CW RADAR used for range measurement. 5k. Compare the pulsed RADAR and CW RADAR.	5.4 CW Doppler RADAR: Moving target indicator RADAR, blind speed, Frequency modulated CW RADAR. RADAR applications.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Transmission lines and Microwaves	06	03	03	04	10
II	Microwave propagation and components	10	08	06	04	18
III	Microwave tubes and measurement	10	08	06	04	18
IV	Microwave semiconductor devices	10	02	06	04	12
V	RADAR systems	06	04	02	06	12

Total	42	25	23	22	70

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*

Note: This specification table shall be treated as only general guideline for students and teachers. The actual distribution of marks in the question paper may vary from above table

10. SUGGESTED STUDENT ACTIVITIES

- ✓ Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should perform following activities in group and prepare reports of about 5 pages for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:

  - Teacher guided tutorial exercises to solve problems based on all units.
  - Implement all circuits on breadboard and verify the design.

- ✓ Following is the list of proposed student activities such as:

i. Prepare chart showing various microwave components.

ii. Prepare/Download a dynamic animation to illustrate the following:

  a. Microwave tubes.

  b. EM waves propagation.

iii. Visit a place where waveguides are used for microwave communication. ((Such as airport, earth station, Telephone exchange, Microwave link repeater, TV broadcast).

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.

b) Guide student(s) in undertaking micro-projects.

c) ***'L' in section No. 4***means different types of teaching methods that are to be employed by teachers to develop the outcomes.

d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature can be given to the students for ***self-learning***, but to be assessed using different assessment methods.

e) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-projects are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs

which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The duration of the micro project should be about **14-16** ***(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented CO s.

A list of micro-projects has to match the competency and the COs. Micro-projects could be added by the concerned course teacher:

13. SUGGESTED LEARNING RESOURCES

Sr.No.	Title of Book	Author	Publication
1.	Microwave Engineering	Gupta Sanjeev	Khanna Publication, New Delhi (Latest edition)
2.	Electronics communication system	Kennedy George	Tata McGraw hill, New Delhi (Latest edition)
3.	Microwave engineering	Das Annapurna & Das S. K.	Mc. Graw Hill, New Delhi, (Latest edition)
4.	Microwave Devices & Circuits	Liao Samuel Y	PHI Learning, New Delhi, (Latest edition)
5.	Microwave & RADAR Engineering	Gautam A. K.	S K Kataria Publications, New Delhi, (Latest edition)

14. SOFTWARE/LEARNING WEBSITES

a. RF Tool box: MATLAB & SIMULINK:
b. http://www.rf

mw.org/transmission_lines_and_distributed_systems_transmission_lines_transmission_lines.html

c. http://www.rf

mw.org/transmission_lines_and_distributed_systems_transmission_lines_transmission_lines_video_lectures.html

d. www.nptel.ac.in

15. PO-COMPETENCY-CO MAPPING

Semester V	MICROWAVE & RADAR ENGINEERING (Course Code: 4351103)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ develop-ment of solutions	PO 4 Engineering Tools, Experimen-tation & Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Manage-ment	PO 7 Life-long learning
Competency	**Install and Maintain microwave devices, components and accessories used in telecommunication field.**						
Course Outcomes CO1 Distinguish Electromagnetic wave	3	2	2	2	2	-	2

propagation through reflections from voltage and current transmission.							
CO2 Analyze performance of microwave components from field point of view.	2	2	2	2	2	-	2
CO3 Maintain microwave components and Set up of microwave bench for optimum operation.	2	2	2	3	2	2	2
CO 4 Maintain microwave semiconductor devices used to realized amplifiers and oscillators.	3	1	3	2	-	2	2
CO 5 Maintain SONAR and RADAR systems as microwave application.	1	1	2	1	-	-	1

Legend: '3' for **high**, '2' for **medium**, '1' for **low** and '-' for **no correlation** of each CO with PO.

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Sr. No.	Name and Designation	Institute	Contact No.	Email
1.	Prof. M. N. Charel, HOD (EC)	Government Polytechnic, Ahmedabad		
2.	Ms. Kshama Rajesh Shah Lecturer EC	Government Polytechnic, Gandhinagar		

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