**Program Name** : **Diploma in Digital Electronics /Electronics Engineering Programme Group**

**Program Code** : **DE/EJ/ET/EN/EX/EQ**

**Semester** : **Fifth**

**Course Title** : **Microwave and RADAR**

**Course Code** : **22535**

## 1. RATIONALE

Microwave communication is the back bone of terrestrial communication and also the sole of mobile communication. To provide communication at difficult geographical locations and for specific task microwave links and RADAR are the established telecommunication solution. This course has been designed to develop skills in the diploma engineers to maintain microwave and RADAR based telecommunication systems.

## 2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain microwave and RADAR based communication systems.**

## 3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Use specified waveguides in microwave communication system.
b. Maintain passive microwave components and devices.
c. Maintain active microwave components and devices.
d. Interpret RADAR based systems for range detection.
e. Maintain various types of RADAR system for the specified application.

## 4. TEACHING AND EXAMINATION SCHEME

| Teaching Scheme | | | Credit (L+T+P) | Examination Scheme | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory | | | | | | | Practical | | | | | |
| L | T | P | | Paper Hrs. | ESE | | PA | | Total | | ESE | | PA | | Total | |
| | | | | | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min |
| 3 | - | 2 | 5 | 3 | 70 | 28 | 30* | 00 | 100 | 40 | 25@ | 10 | 25 | 10 | 50 | 20 |

*(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment 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,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment*

## 5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the

course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

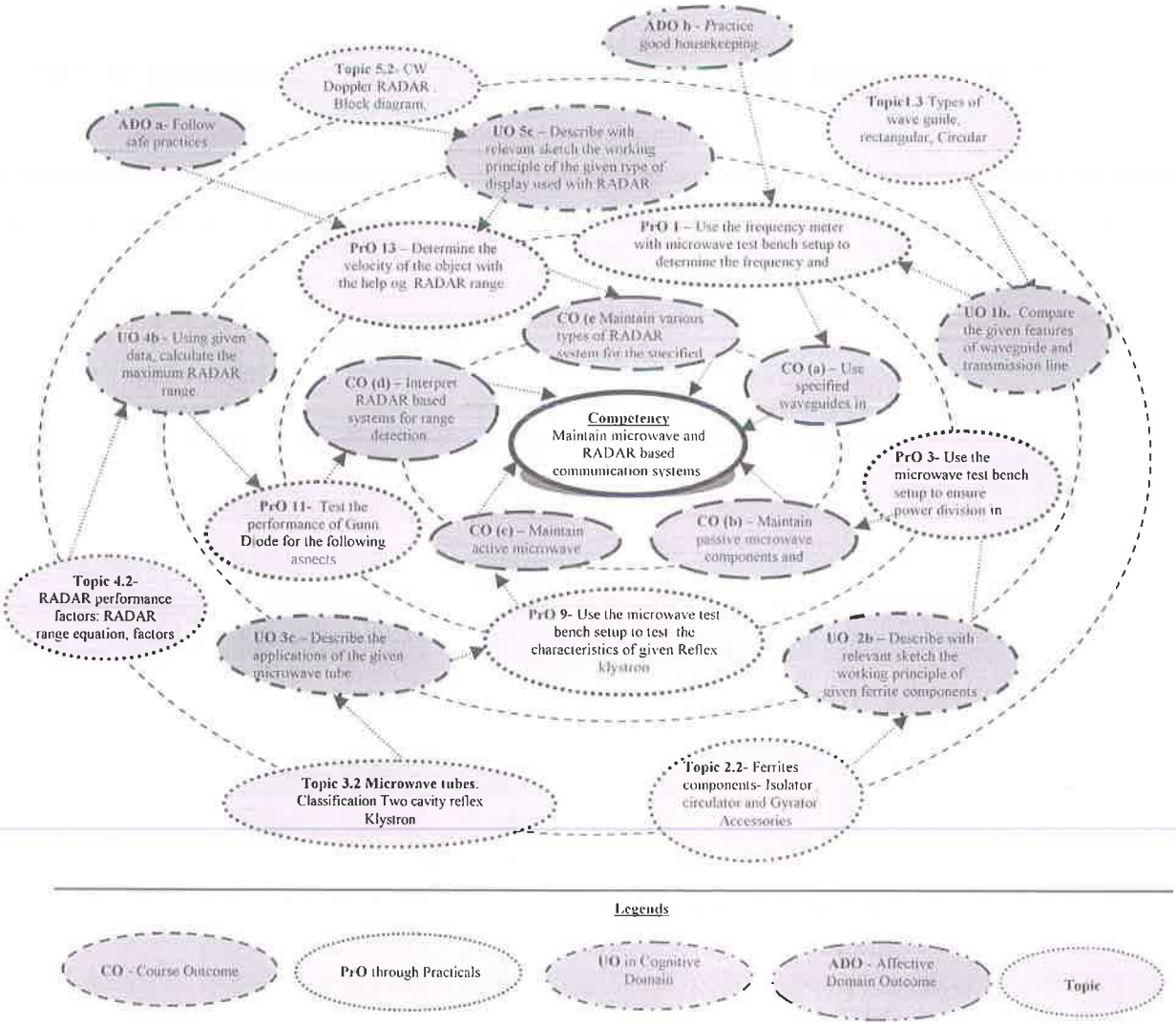


**Figure 1 - Course Map**

## 6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

| S. No. | Practical Outcomes (PrOs) | Unit No. | Approx. Hrs. Required |
|---|---|---|---|
| 1 | Use the frequency meter with microwave test bench setup to determine the frequency and wavelength of waveguide for TE10 mode. | I | 02* |
| 2 | Use freeware/open source simulation tools to perform Practicals related to microwave waveguide . | I | 02 |
| 3 | Use the microwave test bench setup to ensure power division in microwave tees E-plane, H-plane and E-H plane. | II | 02* |
| 4 | Determine coupling factor and insertion loss for the given circulator. | II | 02 |
| 5 | Measure VSWR for the given Microwave load. | II | 02* |
| 6 | Measure attenuation of the given attenuator. | I | 02 |

| S. No. | Practical Outcomes (PrOs) | Unit No. | Approx. Hrs. Required |
|---|---|---|---|
| 7 | Determine the directivity, insertion loss and coupling factor for the given Multi- Hole Directional Coupler. | II | 02 |
| 8 | Use given microwave test bench setup to measure the gain of the horn antenna. | II | 02 |
| 9 | Use the microwave test bench setup to test the performance of the given Reflex Klystron tube. | III | 02* |
| 10 | Test the performance parameter of the given type of microwave active components on freeware/open source simulation tools. | IV | 02 |
| 11 | Test the performance of Gunn Diode for the following aspects<br>i. V-I characteristics<br>ii. Output power and frequency as a function of voltage | IV | 02* |
| 12 | Use Doppler RADAR to detect the maximum range . | V | 02* |
| 13 | Determine the velocity of the moving object with the help of RADAR range. | V | 02 |
| 14 | Use RADAR system to measure the distance traveled by any object. | V | 02 |
| 15 | Use freeware/open source simulation tools to performance Practical related to RADAR communication. | V | 02 |
| | **Total** | | **30** |

***Note***

*i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

*ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

| S.No. | Performance Indicators | Weightage in % |
|---|---|---|
| a. | Preparation of experimental set up | 20 |
| b. | Setting and operation | 20 |
| c. | Safety measures | 10 |
| d. | Observations and Recording | 10 |
| e. | Interpretation of result and Conclusion | 20 |
| f. | Answer to sample questions | 10 |
| g. | Submission of report in time | 10 |
| **Total** | | **100** |

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Work as a leader/a team member.
e. Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

## 7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

| S. No. | Equipment Name with Broad Specifications | PrO. No. |
|---|---|---|
| 1 | **Microwave Test Bench –X Band (Klystron based) /** or any other equivalent, Klystron Power Supply, Klystron tube with Klystron mounts, Frequency meter, Variable attenuator, Detector mount, Wave guide stand, SWR meter and oscilloscope, E Plane Tee, H Plane Tee and Magic Tee Isolator and Circulator, Directional Coupler, Horn Antenna proto type | 1 To 10 |
| 2 | Microwave test bench –X Band (GUNN Diode based)/ or any other equivalent, Gunn oscillator, Gun power supply, PIN modulator, Isolator, Frequency meter, Variable attenuator, Detector mount, Wave guide stands, SWR Meter, Cables and accessories | 11 |
| 3 | RADAR Trainer ( X Band)/or any other equivalent Technical Specifications: Transmitting Frequency : 10 GHz, Output Power : 10 to 15mW, Operating Voltage : 8.6V or adjustable, Antenna : Horn and parabolic dish with LNA and mounting IF Output : Audio range, Power Supply : 230V ± 10%, 50Hz | 12,13, 14 |
| 4 | **List of Software/Learning Websites** List of software RF Tool box: MATLAB and SIMULINK or any other open source software. EZNEC, HFSS-CST, VSim, Microwave office | 15 |

## 8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

| Unit | Unit Outcomes (UOs) (in cognitive domain) | Topics and Sub-topics |
|---|---|---|
| **Unit– I Fundamentals of Microwave communication and Waveguides** | 1a. Summarize the range and applications of the given microwave frequency bands.<br>1b. Compare the given parameters of waveguide and transmission line.<br>1c. Explain the properties of the given parameters for the circular waveguide with example.<br>1d. Calculate the cut off wavelength, cut off frequency, group and phase velocity of the given rectangular waveguide.<br>1e. Describe with relevant sketch the field pattern of the given mode of rectangular waveguide.<br>1f. Compare the features of circular and rectangular waveguide for the given parameters. | 1.1 Microwave frequency spectrum , band designations and applications of microwave in various fields<br>1.2 Comparison of wave guide with Transmission line<br>1.3 Types of Waveguides: Rectangular ,Circular , Propagation of waves in rectangular waveguides Reflection of waves from a conducting plane, dominant mode, The parallel plane waveguide, cut off wavelength, cut off frequency, group and phase velocity (Simple numerical)<br>1.4 Rectangular waveguide modes: TE ,TM TEM, field patterns of TE1,0,TE2,0,TE1,1 modes<br>1.5 Circular waveguide: Advantages, disadvantages and applications of circular waveguide |
| **Unit– II Microwave Passive Components** | 2a. Describe with relevant sketch operation of the given microwave passive component.<br>2b. Describe with relevant sketch the working principle of given ferrite components.<br>2c. Describe the procedure to built/prepare the microwave test bench setup with the help of given microwave accessories and components<br>2d. Explain functions of the given parameters for a directional coupler. | 2.1 Multiple Junctions : Working principle and applications of - E plane, H- plane , Magic Tee and Rat race ring<br>2.2 Ferrites components- Isolator , circulator and Gyrator Accessories: Flanges, Rotating coupling, Bends and corners, Taper and Twist<br>2.3 Directional couplers : Two hole directional coupler- Working principle and applications , directivity, coupling factor and isolation<br>2.4 Basic microwave antenna (Horn and Dish) |
| **Unit-III Microwave Active Components** | 3a. Describe with relevant sketch the concept of velocity modulation and bunching effect for the given microwave tube.<br>3b. Prepare/Draw the apple gate diagram for the given parameters of the microwave tube.<br>3c. Describe the applications of the given microwave tube.<br>3d. Compare the performance of | 3.1 Microwave tubes Classification Two cavity ,Reflex klystron<br>i. Construction<br>ii. Modulation<br>iii. Bunching process<br>iv. Principle of operation<br>v. Magnetron: construction , operating principle and applications<br>3.2 Slow wave devices: Helix TWT construction and principle of operation and applications |

| Unit | Unit Outcomes (UOs) (in cognitive domain) | Topics and Sub-topics |
|---|---|---|
| | Klystron, Magnetron and TWT on the given parameters.<br>3e. Describe with relevant sketch the transfer electron effect for the given energy level diagram of Gunn Diode.<br>3f. Describe with relevant sketch the operation of the given active microwave component. | 3.3 Compare the performance of Klystron, Magnetron and TWT.<br>3.4 TED (Transferred Electron Devices): Gunn diode – construction, operation principle, modes and application of Gunn diode as an oscillator<br>Avalanche transient time device:<br>3.5 IMPATT diode - construction, operation and applications<br>3.6 PIN diode-. construction, operation and applications<br>Esaki diode: Tunnel diode –V-I Characteristics, equivalent circuit, application as an oscillator and as an amplifier |
| **Unit-IV RADAR Fundamentals** | 4a. Describe with relevant sketch functions of the given component of the RADAR system.<br>4b. Calculate the maximum RADAR range for the given data. | 4.1 Basic block diagram of RADAR system<br>4.2 RADAR performance factors: RADAR range equation, factors influencing range, effect of noise<br>4.3 Basic pulse RADAR system: Block diagram and description, applications |
| | 4c. State the affect on the RADAR range for the given the parameters.<br>4d. Explain with relevant sketch the given type of scanning and tracking methods used for RADAR communication.<br>4e. Describe with relevant sketch the construction and working of the given microwave antenna. | 4.4 Antenna Scanning (types and principle):<br>Horizontal, vertical, helical and spiral.<br>Antenna Tracking (types and principle):<br>Sequential, conical and mono pulse<br>4.5 Antenna feed Mechanism: horn and cassegrain feed antenna |
| **Unit –V RADAR Systems** | 5a. Explain with relevant sketch working principle of the given type of RADAR.<br>5b. Describe the applications of the given type of RADAR.<br>5c. Describe with relevant sketch the working principle of the given type of display used with RADAR system.<br>5d. Compare CW and Pulsed RADAR for the given parameters.<br>5e. Describe with relevant sketch | 5.1 Doppler effect<br>5.2 CW Doppler RADAR : Block diagram, operation and application<br>FM CW RADAR: Block diagram, operation and application<br>5.3 MTI: Block diagram, operation concept of blind speed, application, Automatic target detection RADAR<br>5.4 Display Methods: A-Scope: PPI, Beacons<br>5.5 SONAR system :working principle and applications |

| Unit | Unit Outcomes (UOs) (in cognitive domain) | Topics and Sub-topics |
|---|---|---|
| | the applications of the given SONAR system. | |

*Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

## 9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

| Unit No. | Unit Title | Teaching Hours | Distribution of Theory Marks | | | |
|---|---|---|---|---|---|---|
| | | | R Level | U Level | A Level | Total Marks |
| I | Fundamentals of Microwave communication and Waveguides | 08 | 04 | 04 | 06 | 14 |
| II | Microwave Passive Components | 08 | 04 | 04 | 04 | 12 |
| III | Microwave Active components | 16 | 06 | 08 | 06 | 20 |
| IV | RADAR Fundamentals | 08 | 04 | 04 | 04 | 12 |
| V | RADAR Systems | 08 | 04 | 04 | 04 | 12 |
| **Total** | | **48** | **22** | **24** | **24** | **70** |

***Legends:*** *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note****: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) 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 conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Prepare chart showing various microwave components.
b. Prepare /download an animation and share with the class to illustrate the working principle of the following
   i. Microwave Tubes
   ii. EM wave propagation.
c. Visit a place where waveguides are used for microwave communication (such as earth Station, Radio station, telephone exchange, airport, TV broadcast, navigation center) and prepare the report.
d. Conduct a Library / Internet based survey of microwave components.
e. Interpret the various BIS Code for microwave communication.
f. Compare specifications of at least two different types of RADAR system.

## 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. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Use proper equivalent analogy to explain different concepts.
g. Use Flash/Animations to explain various microwave components, tubes and RADAR systems.
h. Use open source /MATLAB models to explain different concepts of microwave devices.

## 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-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, 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 total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty:

a. Market survey of consumer microwave equipments with respect to working principle, manufacturer, technical specification and submit the detail report of it.
b. Prepare survey report on mobile van used for live telecast of any event.
c. Prepare a report on the applications of RADAR for Defense and Air navigation.
d. Prepare power point presentation to explain working of various microwave components and Microwave tubes.

## 13. SUGGESTED LEARNING RESOURCES

| S. No. | Title of Book | Author | Publication |
|---|---|---|---|
| 1 | RADAR systems and radio aids to navigation | Sen, A. K. and Bhattacharya, A. B. | Mercury Learning & Information. PVT.LTD. New Delhi, 2017,ISBN: 978-1683921189 |
| 2 | Microwave Engineering | Das, Annapurna and Das, S. K. | Mc Graw Hill, New Delhi(3rd edition 2017, ISBN: 978-9332902879 |
| 3 | Microwave Engineering | Gupta, Sanjeev | Khanna Publication, Nai sadak Delhi (3rd edition,2015, ISBN: 9788174090878 |
| 4 | Microwave and RADAR Engineering | Gautam, A. K. | S K Kataria Publications, New Delhi 2012, ISBN: 978-9350141519 |
| 5 | Fundamentals of | Sharma, K.K. | S.Chand and Company PVT. LTD. |

| S. No. | Title of Book | Author | Publication |
|---|---|---|---|
| | Microwave and RADAR Engineering | | New Delhi,2011, ISBN:9788121935371 |
| 6 | Electronics Communication System | Kennedy, George; Davis, Brendan ; Prasanna, Srm | Mc Graw Hill, New Delhi,5th edition,2011,ISBN: 978-0071077828 |
| 7 | Microwave devices and circuits | Liao Samuel Y | PHI Learning ,New Delhi,(Latest Edition), ISBN: 978-8131762288 |
| 8 | Microwave and RADAR Engineering | Kulkarni, M. | Umesh Publications, New Delhi,2009,ISBN978-8188114009 |

## 14. SOFTWARE/LEARNING WEBSITES

a. Microwave components:-www.youtube.com /microwave components and devices
b. RADAR:-www.youtube.com /RADARs
c. Microwave fundamentals:-www.nptelvideos.in/microwave engineering
d. Microwave:-www.learnerstv.com/free-engineering
e. Rectangular Waveguides:- www.ece.uprm.edu/ppt/rectangularwave
f. Waveguide:- www.academia.edu/waveguide
g. Microwave engineering Book:- monitor.westernfriend.org/microwave-engineering-by-sanjeev-gupta.pdf