Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Radioengineering Department
Department of Applied Radio Electronics

[RE-232] DESIGN AND MANUFACTURE OF MICROWAVE EQUIPMENT (PN-15)

Curriculum of the academic discipline (Syllabus)

Course details

Level of higher education	***First (bachelor's)***
Field of knowledge	*17 Electronics, Automation, and Electronic Communications*
Special	*172 Electronic Communications and Radio Engineering*
Educational program	*172B ICR - Information and Communication Radio Engineering (EDEBO id:49228)* *172B ICRI+ - Information and Communication Radio Engineering (EDEBO id: 57910)* *G5B ICRI - Information and Communication Radio Engineering (EDEBO id: 83618)*
Discipline status	Regulatory
Form of study	*Full-time (day)*
Year of study, semester	*4th year, spring semester*
Scope of the discipline	Scope of the discipline 4 credits Lectures 20 hours, Practical work 20 hours, Laboratory work 40 hours, Self-study 40 hours)
Semester control/control measures	Test
Class schedule	https://schedule.kpi.ua
Language of instruction	*Ukrainian*
Information about the course leader/teachers	*Lecturer:* Antypenko R. V. *Lab:* Antypenko R. V. *SS:* Antypenko R. V.
Course location	The course is hosted on the Sikorsky distance learning platform.

Curriculum

1. Description of the academic discipline, its purpose, subject matter, and learning outcomes

The discipline "Design and manufacture of microwave equipment" is devoted to the study of:

- the process of designing planar microwave devices based on strip lines,
- the process of designing printed circuit boards (PCBs) based on the Altium Designer software product.
- technologies for manufacturing printed microwave components.

It includes an introduction to the features of planar microwave devices, types and technologies for manufacturing microwave PCBs, and the sequence of their design using the example of single-, double- or multi-layer PCBs. It begins with an analysis of the obtained electrical schematic diagram and ends with the creation of design documentation.

Subject of the course: the process of creating printed circuit boards for microwave devices from the electrical schematic diagram to the development of design documentation.

The aim of the course is to teach:

- analyze the technical tasks received for the development of printed circuit boards (PCBs) and electronic modules (EMs) from a design and technological point of view;
- design EM and the device housing for it according to ready-made diagrams with justification of the decisions made;
- use modern design environments (Altium Designer (AD)) when designing EM and devices;
- perform basic calculations for designing microwave range PCBs.

2. Prerequisites and post-requisites of the discipline (place in the structural-logical scheme of training under the relevant educational program)

The course is aimed at students with basic knowledge of circuitry and the element base of electronic equipment, microwave devices, and antenna systems.

The course is based on knowledge from the credit modules Circuit Design, Microwave Devices, Antennas, and Microwave Receiver Design.

3. Course content

Section 1. Basic concepts and definitions.
1.1 History of the emergence of DP and microwave range DP.
1.2 DPs, basic definitions.
1.3 Types of DPs.
1.4 Features of microwave range DPs.
1.5 Printed circuit elements.
1.6 Basic types of microstrip lines used to create microwave range DPs.
1.7 Microstrip line inhomogeneities and transitions in microwave range DP.
1.8 Sequence of designing a microwave range PCB.
Section 2. Materials for the manufacture of printed circuit boards (PCBs).
2.1 Foil.
2.2 Prepregs.
2.3 Laminates.
2.4 Features of materials for microwave range PCBs.
2.5 Other materials.

Section 3. Technologies for manufacturing antennas.
3.1 Overview of DP manufacturing technologies.
3.2 Manufacturing of single-sided antennas.
3.3 Manufacturing of double-sided antennas.
3.4 Manufacturing of multilayer DP.
3.5 Features of manufacturing microwave range DP.
3.6 Manufacturing flexible DP.
3.7 Manufacturing of flexible-rigid printed circuit boards.
Section 4. Technologies for manufacturing electronic modules (EM) in the microwave range
4.1. Types of mounting low-frequency EM and EM in the microwave range
4.2. Lead mounting.
4.3. Soldering. Solder. Traditional and lead-free solder. Wave soldering. Double wave soldering. Selective soldering.
4.4. Surface mount technology (SMT). Installation of SMT components. Soldering
Section 5. Defects and quality control in the manufacture of printed circuit boards
5.1. Typical screen printing defects
5.2. Defects in reflow soldering. Solder balls.
5.3. Lack of wetting. Lack of soldered connection.
5.4. Bridges, voids. Damage to components and soldered joints.
Section 6. Features of designing microwave range PCBs
6.1. Accuracy classes of DPs
6.2. Design characteristics of PCBs.
6.3. Calculation of low-frequency elements of the printed circuit
6.4. Scribing. Reference marks.
6.5. Features of topology in planar microwave devices.
6.6. Microwave connectors for installation on PCBs.
6.7. Microwave component housings for installation on PCBs.
6.8. Combating stray microwave radiation.
6.9. Features of designing housings for planar microwave devices.
Section 7. Preparation of design documentation.
7.1. General provisions.
7.2. Schematics.
7.3. List of elements.
7.4. DP drawing (part drawing).
7.5. Printed circuit board/EM drawing.
7.6. Device drawing.
7.7. Specifications for assembly units.

4. Training materials and resources

1. DSTU 2646-94. Printed circuit boards. Terms and definitions

2. Prepreg. Development of a stack of complex multilayer printed circuit boards. Features of stack formation taking into account conductor impedance control. Part 3 – Access mode: http://ictech.com.ua/publication.html#prepreg

3. Printed circuit board materials – Access mode: http://surl.li/hubig

4. IPC-6011. Generic Performance Specification for Printed Boards

5. IPC-6012. Qualification and Performance Specification for Rigid Printed Boards

6. IPC-2221. Generic Standard on Printed Board Design

7. IPC-2152. Standard for Determining Current-Carrying Capacity In Printed Board Design

8. PCB Trace Width Calculator [Electronic resource] // PCBway – Access mode:

https://www.pcbway.com/pcb_prototype/trace-width-calculator.html

9. PCBway [Electronic resource] – Access mode: https://www.pcbway.com/

10. JLCPCB [Electronic resource] – Access mode: https://jlcpcb.com/

11. Tutorial - A Complete Design Walkthrough with Altium Designer [Electronic resource] – Access mode: Tutorial - A Complete Design Walkthrough with Altium Designer |

Altium Designer 22 User Manual | Documentation

12. Altium Academy [Electronic resource] – Access mode:

https://www.youtube.com/@AltiumAcademy

13. Rogers Corporation - Access to the resource: https://rogerscorp.com/

Educational content

5. Methodology for mastering the academic discipline (educational component)

Lecture material in the form of lecture notes and presentations is available on Google Drive and is always accessible to students enrolled in the credit module.

The main goal of the lab work is to teach students how to design microwave frequency devices, make independent informed decisions, work with technical documentation, navigate the component base and manufacturing technology of devices and microwave frequency devices, and work in the Altium Designer environment.

Approximate list of topics for laboratory work:

1. Task selection. Analysis of the task received.

2. Setting up the software environment.

3. Creating a library of conventional graphic symbols.

4. Creating a library of EC mounting locations. Building/loading 3D models of enclosures.

5. Calculation and creation of a library of contact pads.

6. Creating an electrical schematic diagram and a list of components.

7. Checking the diagram, correcting errors.

8. Calculation and creation of PCB dimensions. Loading and placement of components.

9. Calculation of printed circuit board components. Setting up routing rules.

10. PCB routing. Checking the PCB, correcting errors.

11. Creating a PCB drawing.

12. Creating an EM drawing.

13. Creating technological files for PCB manufacturing.

14. Creating specifications for EM and devices.

6. Self-study by students

At the beginning of the semester, each student is given an individual assignment that is consistent throughout the course and may later become the basis for a thesis project.

Individual assignments are developed specifically for each course/group.

During laboratory work, students perform tasks according to the assignment received. Tasks for laboratory work are based on the completion of previous ones.

The curriculum provides for a final coursework assignment. It contains the calculations necessary for the successful completion of laboratory work. The final coursework assignment is defended.

Policy and control

7. Academic discipline policy (educational component)

The main focus is on the independent completion of individual tasks and their timely submission. As well as understanding the technological and design aspects of DP design. Laboratory work is structured as follows: at the beginning of the class, the instructor demonstrates the sequence of tasks for the given laboratory work, and the rest of the time students work on the relevant part of their individual assignment. During laboratory work, students are allowed to use their phones to search for the necessary information.

All reference materials are stored on Google Drive, which students always have access to.

8. 8. Types of control and rating system for assessing learning outcomes (RSA)

1. Completion of laboratory work

The completion of tasks in laboratory work is assessed

The timeliness of task completion is assessed

The completeness of the work is assessed

Each completed laboratory task is worth 2 points:

The maximum possible score is 2 points x 14 = 28 points.

2. Writing a modular test (MT)

The MT is conducted online in the form of test tasks. The MT has a time limit.

The maximum possible score is 12 points.

3. Completion and defense of the HCW

The HCW is submitted in electronic form as an archive file (*.zip).

A HCW that is not completed according to the individual assignment will not be accepted for defense.

If the HCW is only partially completed, it won't be accepted for defense.

The maximum possible score is 20 points.

4. Exam

The maximum possible score is 40 points.

5. Conditions for admission to the exam:

- successful completion of the MT;

- completion of laboratory assignments;
- completion of the HCW;
- obtaining at least 30 points per semester.

Table of correspondence between rating points and grades on the university scale

Number of points	Grade
100-95	Excellent
94	Very good
84	Good
74-65	Satisfactory
64-60	Sufficient
Less than 60	Unsatisfactory
Admission requirements not met	Not admitted

9. Additional information on the discipline (educational component)

Description of material, technical, and informational support for the discipline

Laboratory classes are conducted using Altium Designer software, which students download themselves under an academic license from the developer's website.

Work program of the academic discipline (syllabus):

Compiled by Antypenko R. V.;

Approved by the PRE Department (Minutes No. 06/2024 dated 06/27/2024).

Approved by the REF Methodological Commission (protocol No. 06/2024 dated 28.06.2024).