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	*G - Engineering, manufacturing, and construction*
Special	*G5 Electronics, electronic communications, instrument engineering, 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, accelerated full-time (daytime)*
Year of training, semester	*4th year, spring semester (full-time daytime)* *3rd year, spring semester (full-time accelerated day)*
Scope of the discipline	Scope of the discipline 4 credits (Lectures 20 hours, Practical work 20 hours, Laboratory work 32 hours, Self-study 48 hours)
Semester control/control measures	Final 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 (PCB) 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 SHF PCBs.

In accordance with the professional educational programs (PEP) of the first "bachelor's" level of higher education, after mastering the academic discipline, students should acquire **the** following program **competencies**:

General competencies (GC)

GC-2 – Ability to apply knowledge in practical situations.

GC-4 – Knowledge and understanding of the subject area and understanding of professional activity.

Professional competencies (PC)

PC-8 – Readiness to promote the implementation of promising technologies and standards.

PC-14 – Willingness to study scientific and technical information, domestic and foreign experience on the subject of investment (or other) projects in telecommunications and radio engineering.

PC-21 – Ability to design radio frequency printed circuit boards and microwave module structures.

Program learning results (PLR)

According to the first bachelor's degree level higher education program, upon completion of the course, students should demonstrate **the** following **program learning results**:

PLR-14 – Apply the basic properties of the component base to ensure the quality and reliability of telecommunications and radio engineering systems and devices.

PRL-15 – Apply means of automation of design and technical operation of telecommunications and radio engineering systems in professional activities.

PLR-24 – Perform calculations, numerical optimization, and design of antennas and microwave devices, active microwave receiving systems using modern CAD systems.

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 Design of Microwave Receiving Devices.

3. Course content

Section 1. Basic concepts and definitions.

1.1 History of the emergence of PCB and microwave range PCB.

1.2 PCB, basic definitions.

1.3 Types of PCB.

1.4 Features of microwave range PCB.

1.5 Printed circuit elements.

1.6 Basic types of microstrip lines used to create microwave range PCBs.

1.7 Microstrip line inhomogeneities and transitions in microwave range PCB.

1.8 Sequence of designing microwave range PCB.

Section 2. Materials for the manufacture of printed circuit boards (PCB).

2.1 Foil.

2.2 Prepregs.

2.3 Laminates.

2.4 Features of materials for microwave range PCB.

2.5 Other materials.

Section 3. Technologies for manufacturing antennas.

3.1 Overview of PCB manufacturing technologies.

3.2 Manufacturing of single-sided antennas.

3.3 Manufacturing of double-sided antennas.

3.4 Manufacturing of multilayer PCB.

3.5 Features of manufacturing microwave range PCB.

3.6 Manufacturing flexible PCB.

3.7 Manufacturing of flexible-rigid PCB.

Section 4. Technologies for manufacturing microwave range electronic modules (EM)

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 PCBs

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 microwave side emissions.

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. PCB 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 they have received. Tasks for laboratory work are based on the completion of previous ones.

The curriculum provides for an CGW. It contains the calculations of the PCB necessary for the successful completion of laboratory work. The CGW 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 PCB design. Laboratory work is structured as follows: at the beginning of the class, the teacher 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. 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 3 points:
The maximum possible score is 3 points x 14 = 42 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 20 points.

3. Completion and defense of the CGW

The CGW is submitted in electronic form as an archive file (*.zip).
CGWs that are not completed according to the individual assignment will not be accepted for defense.
CGWs that are only partially completed will not be accepted for defense.
The maximum possible score is 20 points.

4. Completion of self-study and answers in practical classes.

The maximum possible score is 18 points.

5. Conditions for admission to the exam:

- successful completion of the MT;
- completion of laboratory tasks;
- completion of the CGW;
- obtaining at least 60 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. 06/2025 dated 06/25/2025)

Approved by the methodological commission of the faculty/research institute (protocol No. 06/2025 dated 06/26/2025)