National Technical University of Ukraine
"IGOR SIKORSKY KYIV POLYTECHNIC INSTITUTE"

Department of Theoretical Electrical Engineering

# Special issues of protection against electromagnetic effect of lightning

## Work program of the discipline (Syllabus)

### Details of the discipline

| Level of higher education | *Third (educational and scientific)* |
|---|---|
| **Branch of knowledge** | *14 Electrical Engineering* |
| **Specialty** | *141 Electric power, electrical engineering and electromechanics* |
| **Educational program** | *141 Electric power, electrical engineering and electromechanics* |
| **Discipline status** | *Selective* |
| **Form of study** | *Distance* |
| **Year of preparation, semester** | *2nd year, autumn semester* |
| **The scope of discipline** | *3 credits 90 hours* |
| **Semester control / control measures** | *test* |
| **Timetable** | *http://rozklad.kpi.ua* |
| **Language of instruction** | *English* |
| **Information about course leader / teachers** | Lecturer: Ph.D., Associate Professor, Trotsenko Yevgeniy Olexandrovich, trotsenko-fea@lll.kpi.ua<br>Practical / Seminar: Ph.D., Associate Professor, Trotsenko Yevgeniy Olexandrovich, trotsenko-fea@lll.kpi.ua |
| **Course placement** | *https://www.sikorsky-distance.org* |

### Curriculum of the discipline

#### 1. Description of the discipline, its purpose, subject of study and learning outcomes

*Important objects in various industries are exposed to serious dangers associated with electromagnetic influences during lightning discharges, direct and near. Therefore, it is important to be able to analyze such possible effects and choose adequate means of protection against them.*

*The purpose study of the credit module is to acquaint students with modern ideas about the physics of atmospheric electricity and geomagnetism (including electric discharges of various types and related electromagnetic fields), as well as the principles and methods of protection of buildings and equipment from hazardous factors with atmospheric electricity. It is planned to study the methods of modeling these phenomena, as well as to get acquainted with modern technical means and methodology of their research and collection of relevant statistics.*

*According to the results of studying the discipline, students must:*

*Know the basic concepts of electrophysical processes during lightning discharge; classification of types of atmospheric discharges and their main characteristics; conditions of occurrence, existence and characteristics of different stages of linear lightning; methods of modeling their main characteristics; varieties and principles of operation of modern automated systems for monitoring the phenomena of atmospheric electricity (in particular, systems for location and registration of lightning characteristics); examples of the use of data on lightning and geomagnetic phenomena in various fields; principles of methods of lightning protection of buildings and electronic equipment.*

*Be able to assess the characteristics of lightning current in the defeat of various objects; calculate the electric and magnetic fields associated with the development of different stages of lightning discharge, assess the conditions of discharge from the ground (including counter); to experiment experimentally on physical models of the lightning protection zone.*

*Have an idea of the mechanisms of development of electric discharges in the atmosphere and geomagnetic phenomena; characteristics of electric and magnetic fields that accompany them and affect various technical and biological systems; danger to people and technical systems associated with atmospheric electricity; on the relevant safety principles in different situations; principles of operation and construction of lightning protection systems of various objects.*

## 2. Prerequisites and post-requisites of the discipline (place in the structural and logical scheme of education according to the relevant educational program)

*The list of disciplines, knowledge and skills that the graduate student needs to successfully master the discipline: basic knowledge of general physics, theoretical foundations of electrical engineering, industrial electronics, electromagnetic compatibility of technical means; initial ideas about the main types and characteristics of electrical equipment in electrical and other systems and installations for which the electromagnetic effects of lightning discharges can be critical.*

## 3. The content of the discipline

*Section 1. Protection against lightning, overvoltages, strong currents.*

*Topic 1.1. Overvoltages and high currents (sources, levels, characteristics). Topic 1.2. Protection of lines and substations from lightning and overvoltages. Electromagnetic compatibility issues. Topic 1.3. External and internal lightning protection of structures and structures of different types. Topic 1.4. Grounding (types, characteristics. Practical aspects; equipotentialization).*

## 4. Training materials and resources

*Basic literature:*

*[1] Brzhezitsky VO, Isakova, AV, Rudakov VV and other. Engineering and electrophysics of high voltages. Tutorial. Edited by VO Brzezycki and VM Михайлова. - Kharkiv: NTU "KhPI" - Tornado, 2005. - 930 p. ISBN 966-635-561-2*

*[2] Kravchenko VI Lightning. Electromagnetic factors and their striking effects on technical means. - Kharkiv: NTMT Publishing House, 2010. - 292 p. ISBN 978-617-578-005-3*

*Additional literature:*

*[1] M.A. Uman. The Lightning Discharge. - Academic Press, Orlando, Florida, 1987. - 377 p.*

## Educational content

## 5. Methods of mastering the discipline (educational component)

*Lectures*

| № | *The title of the lecture topic and a list of key issues* |
|---|---|
| *1* | *Overvoltages and high currents (sources, levels, characteristics).* |
| *2* | *Protection of lines and substations from lightning and overvoltages. Electromagnetic compatibility issues.* |
| *3* | *External and internal lightning protection of structures and structures of different types.* |
| *4* | *Grounding (types, characteristics, practical aspects; equipotentialization).* |

*Practical training*

| № | *The name of the topic of the lesson and a list of main questions* |
|---|---|
| *1* | *Single- and double-rod lightning protection systems.* |
| *2* | *Three- and multi-rod lightning protection systems.* |

| | |
|---|---|
| 3 | *Cable lightning protection systems. Safe distances in lightning protection systems.* |

### 6. Independent work of a student / graduate student

| № | Names of topics and issues submitted for independent study | Number of hours of independent work of the graduate student |
|---|---|---|
| 1 | *Characteristics of protective devices and features of their use. Varieties of protective devices: arresters and surge arresters (lines, substations, distribution networks)* | 20 |
| 2 | *Data line protection and computer systems* | 13 |
| 3 | *Protective and separate gaps / arresters. Typical schemes with protective devices, errors and recommendations for their correction* | 20 |
| 4 | *Execution of calculation and graphic work* | 12 |
| 5 | *Preparation for modular control work* | 4 |
| 6 | *Preparation for the test* | 8 |

## Policy and control

### 7. Course policy (educational component)

*The system of requirements that the teacher puts before the student / graduate student:*

- *rules for attending classes: in accordance with Order 1-273 of 14.09.2020, it is prohibited to assess the presence or absence of the applicant in the classroom, including the accrual of incentive or penalty points. According to the RSO of this discipline, points are awarded for the relevant types of educational activity in lectures and practical classes.*
- *rules of conduct in the classroom: the student / graduate student has the opportunity to receive points for the relevant types of educational activities in lectures and practical classes provided by the RSO discipline. The use of means of communication to search for information on the teacher's Google drive, on the Internet, in a distance course on the Sikorsky platform is carried out under the guidance of the teacher;*
- *rules of protection of individual tasks: protection of individual tasks in the discipline is carried out individually in the form of a presentation to the audience at the last practical lesson;*
- *Deadline and rescheduling policy: works that are submitted in violation of deadlines without good reason are estimated at 60% of the possible maximum number of points for the type of activity points. Relocation of works occurs in the presence of valid reasons (for example, illness);*
- *Academic Integrity Policy: Code of Honor of the National Technical University of Ukraine "Kyiv Polytechnic Institute" https://kpi.ua/files/honorcode.pdf establishes general moral principles, rules of ethical conduct of persons and provides a policy of academic integrity for people who work and study at the university, which they should be guided in their activities, including the study and preparation of control measures in the discipline;*
- *when using digital means of communication with the teacher (mobile communication, e-mail, correspondence on forums and social networks, etc.) it is necessary to adhere to generally accepted ethical norms, in particular to be polite and limit communication during the teacher's working hours.*

### 8. Types of control and rating system for evaluation of learning outcomes (RSO)

*The postgraduate rating of the credit module is calculated from 100 points, of which 60 points is the starting scale. The starting rating (during the semester) consists of points that the graduate student receives for: work in practical classes; performance of settlement work; writing a modular test.*

*Scoring criteria. The maximum number of points for the performance of three practical works is 30 points. The maximum number of points for one practical work is 10 points. The maximum number of*

*points for the calculation work is 15 points. The maximum number of points for the modular test is 15 points.*
*The condition for admission to the test is the enrollment of all practical work, calculation work and a starting rating of at least 30 points.*

*On the test, graduate students perform a written task. The written task is evaluated at 40 points according to the following criteria:*
*- "excellent", complete answer, not less than 95% of the required information (complete, error-free problem solving) - 38-40 points;*
*- "very good", a fairly complete answer, at least 85% of the required information or minor inaccuracies (complete solution of the problem with minor inaccuracies) - 34-37 points;*
*- "good", a fairly complete answer, at least 75% of the required information or minor inaccuracies (complete solution of the problem with minor inaccuracies) - 30-33 points;*
*- "satisfactory", incomplete answer, not less than 65% of the required information and some errors (the task is performed with certain shortcomings) - 26-29 points;*
*- "enough", incomplete answer, less than 60% of the required information and some errors (the task is performed with certain shortcomings) - 24-25 points;*
*- "unsatisfactory", the answer does not meet the conditions for "satisfactory" - 0 points.*
*The sum of the received points is transferred to the final estimation according to the following table.*

*Table of correspondence of rating points to grades on the university scale:*

| *Scores* | *Rating* |
|---|---|
| *100-95* | *Perfectly* |
| *94-85* | *Very good* |
| *84-75* | *Fine* |
| *74-65* | *Satisfactorily* |
| *64-60* | *Enough* |
| *Less than 60* | *Unsatisfactorily* |
| *Admission conditions are not met* | *Not allowed* |

## 9. Additional information on the discipline (educational component)

*List of questions to be submitted for semester control.*

- *Dangerous effects of lightning. Direct lightning strike. Secondary influences, high potential.*
- *Lightning protection. Documents regulating the issues of lightning protection of buildings, structures, etc. Classification of buildings and structures according to the degree of lightning protection (categories, zones). Degrees of fire resistance of buildings. Zones of explosion and fire hazard classes.*
- *Means and methods of lightning protection. General requirements for lightning protection devices in different conditions and for different objects.*
- *Structure and main provisions of international standards for lightning protection.*
- *Lightning rods. Classification, design requirements.*
- *Lightning protection zones. Differences in lightning protection standards in different countries.*
- *Optimal forms of lightning rods. Active lightning rods.*
- *Lightning protection requirements for buildings and structures of the I category / 1 level of protection.*
- *Lightning protection requirements for buildings and structures of the II category / II level of protection.*
- *Lightning protection requirements for buildings and structures of III category / III and IV level of protection.*
- *Protection of buildings and structures from direct lightning strikes.*
- *Protection of buildings and structures from secondary lightning effects and from high potential.*

- *Grounding conductors. Requirements for the characteristics of materials and structures. Corrosion protection issues.*
- *Features of choosing safe (smallest) distances in the air, along solid dielectrics and in the ground from the building / structure to the current collector / support / grounding of the rod or cable lightning conductor.*
- *Lightning protection, grounding and surge limitation in lines up to 1 kV.*
- *Lightning protection, grounding and surge limitation in lines over 1 kV.*
- *Features of lightning protection for inputs in the building of power lines up to 1 kV and over 1 kV.*
- *Features of using reinforced concrete foundations as grounding conductors.*
- *Features of lightning protection of buildings for keeping animals (cattle, horses, etc.).*
- *Peculiarities of lightning protection of external installations / tanks with flammable liquids.*
- *Features of lightning protection of small buildings with non-metallic roofs in rural areas.*
- *Features of using a metal roof as a lightning rod.*
- *Features of lightning protection of high pipes (chimneys), towers, towers.*
- *Lightning protection of a modern office building.*
- *Lightning protection of a modern cottage.*
- *Lightning protection of oil and gas pipelines.*
- *Lightning protection of railway electric transport.*
- *Lightning protection of aircraft.*
- *Lightning protection of cars.*
- *Lightning protection of water transport.*
- *Lightning protection classes according to the standards of the International Electrotechnical Commission.*
- *Current trends in the calculation of the protection zone of buildings. Determination of the protection zone according to the concept of a rolling ball (sphere).*
- *Zone protection concept.*
- *Risk assessment in the development of lightning protection systems.*
- *Current trends in the calculation of protection zones of buildings. Determining the distance from which the lightning is oriented, taking into account the magnitude of the return current and the height of the object. Application of electrogeometric model to calculations of power line lesions.*
- *Description and comparison of methods of rolling sphere, grid and protective angles according to international norms.*
- *Calculation of lightning protection efficiency, determination of protection class according to international norms, assessment of risks of losses from lightning strikes.*

**Work program of the discipline (syllabus):**

***Folded*** *Ph.D., Associate Professor, Trotsenko Yevgeniy Olexandrovich*

***Approved*** *Department of Theoretical Electrical Engineering (protocol № ___ from _____)*

***Agreed*** *Methodical commission of the faculty (№ ___ from _____)*