# Power Engineering and Electrical Engineering

# GENERAL DESCRIPTION OF THE DISCIPLINE

The work programme of the discipline is compiled according to the Federal State Higher Professional Education Standards

|  |  |  |
| --- | --- | --- |
| Code of the field of study and attainment level | Field of study | Details of the order of the Ministry of Education and Science of the Russian Federation on approval and commissioning of the Federal State Higher Educational Standard |
| Date | **Number of order** |
|  | Power Engineering and Electrical Engineering | 30 July 2014 | 878 |

*The order of the Russian Ministry of Education and Science dated 30 July 2014 N 878 On Approval of the Federal State Higher Educational Standard in the Area of Focus 13.06.01 Electrical- and Thermal Engineering (level of training of highly qualified personnel)*

*(Registered in the Russian Ministry of Justice on 20 August 2014 N 33707)*

As a result of mastering the discipline, a post-graduate student should

## Discipline’s role in the structure of the Principal Educational Programme

### As a result of mastering the discipline, a graduate should obtain:

* the universal competencies that do not depend on the specific area of study;
* the general professional competence determined by the area of study;
* the professional competences determined by the focus area (profile)
* the postgraduate programmes in the area of study (hereinafter the programme focus).

As a result of mastering the discipline, a graduate should possess the universal competencies as follows:

* the ability to critically analyse and evaluate current scientific achievements, generate new ideas for solving research and practical problems, including in interdisciplinary areas (UC-1);
* the ability to design and implement complex research including inter-disciplinary one based on a holistic and scientific view of the world using knowledge in the field of history and philosophy of science (UC-2).
* the readiness to engage in the work of Russian and international research teams to tackle academic problems (UC-3);
* the readiness to use contemporary methods and technologies of scientific communication in the state and foreign languages (UC-4).
* the ability to follow ethical standards in professional activities (UC-5);
* the ability to plan and accomplish the professional and personal development tasks (UC-6).

As a result of mastering the postgraduate programme, a graduate should possess the general professional competencies as follows:

* the knowledge of the theoretical and experimental research methodology in the field of professional activities (GPC-1);
* the knowledge of the research culture including using the latest information and communication technologies (GPC-2).
* the ability to develop new research methods and their application in independent research in the field of professional activities (GPC-3);
* the readiness to arrange for the work of a research team in professional activities (GPC-4).
* the readiness for teaching activities in the key higher educational programmes (GPC -5).

As a result of mastering the postgraduate programme, a graduate should possess the professional competencies as follows:

* the ability to plan, prepare and perform experimental studies in the specialty (PC-1);
* the ability to process the experiment results (PC-2);
* the ability to develop mathematical models of individual and aggregate elements of the power system (PC-3).
* the ability to develop algorithms and a mathematical apparatus for solving problems in the electric power industry (PC-4).
* the ability to operate modern software systems designed to solve problems in the electric power industry (PC-5).
* the ability to collect, process, analyse and systematise information on the research topic, carry out a choice of methods and means for solving research problems (PC-6);
* the readiness to use the latest achievements of science and advanced technologies in the electric power research (PC-7).
* the ability to interpret the results in order to draw up practical recommendations on the future use of the research data (PC-8).

The discipline Power Plants and Electric Power Systems refers to the Variable Part section, item 1.8 of the curriculum.

## Planned results of mastering the discipline

**Know:**

* Special aspects about presenting the research outcomes in both oral and written forms when working in Russian and international research teams (UC-3).
* Scientific communication methods and technologies in the state and foreign languages (UC-4).
* Modern methods and techniques used in research on the relevant area of focus (GPC-1).
* Basic tendencies in computer science and natural-science and mathematical knowledge in the relevant field of science (GPC-3).
* Mathematical fundamentals of the methods for modelling electric power systems (PC-3).

Mathematical fundamentals of the methods for analysing the electric power system parameters (PC-4).

**Be able:**

* to analyse alternative solutions for solving research and practical problems and evaluate the potential gains/losses in the implementation of the solutions (UC-1)
* to use the provisions and categories of the philosophy of science for the analysis and evaluation of various facts and phenomena (UC-2).
* to use modern computer technology and specialised software in research work (GPC-2).
* to supervise the performance of qualification works of bachelors, specialists and masters (GPC-5).
* Arrange for research work (PC-1).
* to use software and tools for research work (PC-2).
* to use information technologies for obtaining and presenting information (PC-5).

**Master:**

* the culture of speech, manifested in the ability to competently, intelligibly and accurately convey thoughts (UC-5).
* ways to identify and evaluate individual, personal and professionally significant qualities and ways to achieve a higher level of their development (UC-6).
* the skills for compiling and submitting competitive bids for the research and design work (GPC-4).
* methods for solving inventive problems (PC-6).
* methods for improving power system management systems (PC-7).
* the mathematical methods for improving control systems for power system modes (PC-8);
* the technology of designing the educational process at the level of higher education (GPC-5).

## Work input in mastering the discipline

|  |  |  |
| --- | --- | --- |
| Types of the educational work, forms of control | Total, hours | Course |
| **2** |
| In-class learning, hours | **4** | **4** |
| Lectures | **4** | **4** |
| Practical exercises |  |  |
| Laboratory-based work |  |  |
| Self-guided work of students including all types of the current attestation | **104** | **104** |
| Interim assessment |  | Admission to the exam in a special discipline |
| Total scope according to the curriculum, hours | **108** | **108** |
| Total scope according to the curriculum, credits | 3 | 3 |

# DISCIPLINE CONTENT

|  |  |  |
| --- | --- | --- |
| **Section and topic code** | **Discipline section, topic** | **Contents** |
| **Р1** | Introduction. Structure and functions of the Automated Dispatch Management System (ADMS) |
| **Р1.Т1** | Hierarchy in management and main information flows. | The ADMS information flow structure. The features of information in the automated dispatch control system of EPS. The hierarchical structure of ADMS. The functions and structure of the automated systems of dispatching control of EPS. Telemetry-based control. The levels of information support. |
| **Р1.Т2** | Managing large systems. | Globalisation of the electric power industry and large electrical systems. The problems of power system integration and management of large systems. The current state and trends. The automatic and automated control features. Tasks solved at the real-time pace (on-line) and outside the continuous operational control contour (off-line). |
| **Р2** | Information support of power system ADMS. |
| **Р2.Т1** | Data transfer issues. | Measuring systems and sensors. Discrete information. Quantisation by time and level.Ways of information passing in the power management system. The communication channels and lines. Multichannel telemetry systems. High-frequency telemetering |
| **Р2.Т2** | Information and dispatcher control | Means of displaying information in ADMS. Local area networks. The potential of technical facilities in ADMS. The automated systems of electric power flow monitoring and control. |
| **Р3** | Increase in the teleinformation reliability | The sources of error in telemetry and information verification. Receiving and processing of primary information. Errors and ways to increase the reliability of information. Information filtering and special software. |
| **Р4.** | Receiving information in the real-time and sort-term control tasks |
| **Р4.Т1** | Ensuring the EPS observability and controllability | Creation of pseudo-measurements and archival information. |
| **Р4.Т2** | EPS model creation | Reduction for operational control. Methods for the real-time mode calculations. Simplified models. Linearisation of the steady-state electric system equations. |
| **Р5** | EPS mode planning and optimisation |
| **Р5 .Т1** | Non-linear programming fundamentals. | Creation of the objective function and its geometric interpretation. Mathematical programming and its sections. Limitations in the form of equality and inequality. Conditional and unconditional optimisation. Lagrange’s method of accounting for constraints in the form of equality. |
| **Р5.Т2**  | Recursive expressions for non-linear programming procedures. | Determination of the step direction and length. Localisation of the extremum methods. Zero-order methods: random search and coordinate descent. First-order methods: Gradient methods and organisation of early descent. Second-order methods, approximating programming: Newton’s generalised method. Penalty method for accounting for restrictions in the form of inequality |
| **Р5.Т3** | Addressing the electric power industry issues by using non-linear programming methods. | Target function and operating constraints. The stages of complicating the optimisation problem in connection with the improvement of computer technology, computer and information technology. Basic algorithms and assumptions when optimising the EPS mode. |
| **Р5.Т4** | Electricity and capacity market in EPS. | Market models in the electric power industry. Price bids and pricing taking into account the network factor and operating restrictions. |
| **Р6.** | Observability and assessment of the EPS state. |
| **Р6.Т1**. | Criteria for the state observability and evaluation. | The mathematical and electrical power interpretation of the criteria. The mathematical formulation of the problem: linear and non-linear evaluation of the state. Accounting for the measurement error and data telecasting. The bad data detection and exclusion. |
| **Р6.Т2** | Evaluation of the state in EPS. | The mathematical model of the electrical mode in evaluating the state. The use of vector synchronised measurements. Prospects for improving data support in ADMS. |
| **Р7.** | Preparation of advice to the dispatcher. | Dispatch control modes. Identification of modes (normal heavy, post-emergency). Real-time pre-optimisation and mode entry into the allowable area. Harmonisation of the operational correction of the EPS mode and the operation of the automatic control of the frequency and active power. Simulators in the electric power industry (the dispatchers of power systems, duty personnel of power plants and network enterprises |

# STUDY TIME ALLOCATION

|  |  |
| --- | --- |
| **Discipline sections** | **Work input in mastering discipline sections, hour** |
| **Number of section, topic** | **Section** | **State Educational Standard, total, h** | **In-class learning for section, h** | Lectures | Practical exercises | Laboratory research | **Self-guided work of postgraduate students, h** | Term project | Term work | Calculation and graphical work | Calculation work | Test work | Diploma work | Research paper | Colloquium | Other self-guided work of students | **Preparation for classroom studies, h** |
| Р1 | Introduction. The concept of information support. | **6** | 0 |   |   |   | 6 |   |   |   |   |   |   |   |   | 6 | 0 |
| Р2 | Information support for power system ADMS. | **12** | 0 |   |   |   | 12 |   |   |   |   |   |   |   |   | 12 | 0 |
| Р3 | Increase in teleinformation reliability. | **12** | 0 |   |   |   | 12 |   |   |   |   |   |   |   |   | 12 | 0 |
| Р4 | Obtaining information in the real-time and short-term management tasks. | **21** | 2 |   |   |   | 18 |   |   |   |   |   |   |   |   | 18 | 0,6 |
| Р5 | Planning and optimisation of EPS modes. | **21** | 2 |   |   |   | 19 |   |   |   |   |   |   |   |   | 18 | 0,6 |
| Р6 | Observability and assessment of the EPS state. | **28** | 0 |   |   |   | 28 |   |   |   |   |   |   |   |   | 28 | 0 |
| Р7 | Preparation of advice to the dispatcher. | **9** | 0 |   |   |   | 9 |   |   |   |   |   |   |   |   | 9 | 0 |
|   | Test | 0 | 0 |   |   |   | 0 |   |   |   |   |   |   |   |   |   | 0 |
|   | Exam | 0 | 0 |   |   |   | 0 |   |   |   |   |   |   |   |   |   | 0 |
|   | **Discipline, total**  | **108** | **4** | **0** | **0** | **0** | **104** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **103** | **1** |

# ORGANISATION OF PRACTICAL LESSONS, SELF-WORKING AND ATTESTATION BY DISCIPLINE

## Laboratory practicum

Not applicable.

## Practical exercises

Not applicable.

## Self-guided work of post-graduate students and ongoing monitoring activities

This involves an individual study of the theoretical sections of the discipline

### An indicative list of research paper topics

Not applicable.

### An indicative list of homework topics

Not applicable.

### An indicative list of test topics

Not applicable.

### An indicative list of calculation work topics

Not applicable.

### An indicative list of calculation and graphical work topics

Not applicable.

### Sample topics of the colloquiums

Not applicable

### Sample topics of the term project (work):

Not applicable

# RATIO BETWEEN THE DISCIPLINE SECTIONS AND THE APPLIED EDUCATION METHODS AND TECHNOLOGIES

| Discipline section | Education technology | Forms of educational sessions and types of educational activities |
| --- | --- | --- |
| Lecture | Practical exercise | Laboratory research | Colloquium | Term project | Term work (paper)  |  Calculation and graphical work |  Calculation work |  Homework |  Research paper |  Preparation for in-class learning |
| Р4 | Interactive learning Technologies |  |  |  |  |  |  |  |  |  |  |  |
| Project work |  |  |  |  |  |  |  |  |  |  |  |
| Case studying  |  |  |  |  |  |  |  |  |  |  |  |
| Simulation exercises (games etc.) |  |  |  |  |  |  |  |  |  |  |  |
| Problem learning methods (discussions, exploratory work, research method etc.) | 2 |  |  |  |  |  |  |  |  |  |  |
| Teamwork |  |  |  |  |  |  |  |  |  |  |  |
| OtherRunning an online task on the individual training path |  |  |  |  |  |  |  |  |  |  |  |
| Distance learning technologies and e-learning |  |  |  |  |  |  |  |  |  |  |  |
| Network training courses |  |  |  |  |  |  |  |  |  |  |  |
| Virtual workshops and simulators |  |  |  |  |  |  |  |  |  |  |  |
| Distance learning technologies and e-learning |  |  |  |  |  |  |  |  |  |  |  |
| Asynchronous web-conferences and seminars |  |  |  |  |  |  |  |  |  |  |  |
| Collaboration and content development |  |  |  |  |  |  |  |  |  |  |  |
| Other (please specify) |  |  |  |  |  |  |  |  |  |  |  |
| Р5 | Interactive learning Technologies |  |  |  |  |  |  |  |  |  |  |  |
| Project work |  |  |  |  |  |  |  |  |  |  |  |
| Case studying  |  |  |  |  |  |  |  |  |  |  |  |
| Simulation exercises (games etc.) |  |  |  |  |  |  |  |  |  |  |  |
| Problem learning methods (discussions, exploratory work, research method etc.) | 2 |  |  |  |  |  |  |  |  |  |  |
| Teamwork |  |  |  |  |  |  |  |  |  |  |  |
| OtherRunning an online task on the individual training path |  |  |  |  |  |  |  |  |  |  |  |
| Distance learning technologies and e-learning |  |  |  |  |  |  |  |  |  |  |  |
| Network training courses |  |  |  |  |  |  |  |  |  |  |  |
| Virtual workshops and simulators |  |  |  |  |  |  |  |  |  |  |  |
| Webinars and videoconferences |  |  |  |  |  |  |  |  |  |  |  |
| Asynchronous web-conferences and seminars |  |  |  |  |  |  |  |  |  |  |  |
| Collaboration and content development |  |  |  |  |  |  |  |  |  |  |  |
| Other (please specify) |  |  |  |  |  |  |  |  |  |  |  |

# PROCEDURES FOR THE TRAINING RESULTS MONITORING AND EVALUATION

Not applicable

# PROCEDURES FOR EVALUATING THE TRAINING RESULTS WITHIN THE INDEPENDENT TEST CONTROL

Not applicable

# SET OF APPRAISAL TOOLS FOR THE CURRENT AND INTERIM ATTESTATION BY DISCIPLINE

Annex 3

## Electronic educational resources

* Zonal research library http://lib.urfu.ru/
* Library catalogues http://lib.urfu.ru/about/department/catalog/rescatalog/
* Electronic catalogue http://lib.urfu.ru/resources/ec/
* Resources http://lib.urfu.ru/resources
* Search http://lib.urfu.ru/search.

## Software

* Operating system Windows XP.
* Package Microsoft Office 2010 Professional (Word word processor, Excel spreadsheet processor, Access database).
* Mathematical processor Mathcad.
* Platform .Net Framework 3.0 and programming environment Visual Studio 2008.

## Databases, information and reference systems and search systems

Not applicable

## Set of assessment tools (means for monitoring the learning achievements of postgraduate students as well as attestation and pedagogical measuring materials)

Not applicable

## Information services that support the learning process

Not applicable

**ANNEX 3**

**to the work programme of the discipline**

**8**. **SET OF EVALUATION TOOLS FOR THE CURRENT AND INTERIM ATTESTATION BY DISCIPLINE**

**8.1. CRITERIA FOR THE EVALUATION OF RESULTS OF THE TEST AND EVALUATION ACTIVITIES OF THE CURRENT AND INTERMEDIATE ATTESTATION BY DISCIPLINE**

|  |  |
| --- | --- |
| Competence components | Features of the level of mastering competence components |
| threshold level | higher level | high level |
| Knowledge | A post-graduate student demonstrates the acquaintance knowledge, copy knowledge, i.e. recognises objects, phenomena and concepts, finds some differences in them, shows the knowledge of the sources of information, can independently carry out reproductive actions on knowledge by self-reproduction and application of the information. | A post-graduate student demonstrates the analytical knowledge, i.e. confidently reproduces and understands the acquired knowledge, assigns them to one or another classification group, independently arranges them, establishes interrelations between them and effectively applies them in familiar situations. | A post-graduate student can independently obtain new knowledge from the surrounding world and creatively use it to make decisions in new and unusual situations. |
| Skills | A post-graduate student is capable of correctly performing the prescribed actions following the instructions and/or an algorithm in a known situation, independently performing actions to address typical issues that require a choice from among the known methods, in predictably changing situations | A post-graduate student is capable of independently performing the actions (techniques, operations) to solve non-standard problems that require selection based on a combination of known methods, in an unpredictably changing situation | A post-graduate student is capable of independently performing the actions associated with solving research problems, demonstrates the creative use of skills (technologies) |
| Personal qualities | A post-graduate student has a low learning motivation, shows an indifferent, irresponsible attitude to studying and/or the assigned task. | A post-graduate student has a pronounced learning motivation and demonstrates a positive attitude towards learning and future activities, and is active. | A post-graduate student has a developed motivation for training and work, shows perseverance and enthusiasm, hard work, independence and creativity. |

**8.2. CRITERIA FOR EVALUATING THE RESULTS OF INTERMEDIATE ATTESTATION DURING THE USE OF INDEPENDENT TESTING CONTROL**

Not applicable

## APPRAISAL TOOLS FOR CONDUCTING THE CURRENT AND INTERMEDIATE ATTESTATION

**8.3.1.** **Sample tasks for conducting mini-control in the training sessions**

Not applicable

**8.3.2**. **Sample test problems as part of the classroom sessions**

Not applicable

**8.3.3.** **Sample test cases**

Not applicable

**8.3.4.** **A list of sample questions for a test**

Not applicable

**8.3.5. A list of sample questions for preparation for the discipline attestation.**

* ADMS structure and functions. (PC-5)
* Information for operational and emergency control tasks. (UC-2, PC-2)
* Sources and causes of telemetry errors. (GPC-4, UC-5)
* Methods for increasing the reliability of telemetry. (PC-8)
* Relevance and problems of EPS reduction for the real-time and emergency control. (PC-4, PC-9)
* Mathematical programming. (UC-3, PC-7)
* Non-linear Programming. (PC-2, PC-1)
* Allowance for restrictions in the form of equations. The Lagrange method. (UC-4, PC-6)
* Statement of the problem of optimization of the EPS mode as a non-linear programming problem. Mode constraints. (GPC-3, PC-8)
* Description of the of zero- and first-order optimization methods. (UC-6, PC-7)
* Selecting the direction of motion in non-linear programming problems. (GPC-2)
* Determination of the step length in non-linear programming problems. (GPC-1, PC-5)
* Algorithm of the Newton generalized method for optimisation of the EPS mode. (UC-5, PC-6)
* EPS observability criteria, necessary and sufficient conditions. (GPC-3, PC-10)
* Electrical system as an observation and control item. (UC-1)
* Linear and non-linear evaluation of the EPS condition. (PC-3)
* Criteria for management and mode optimisation in a competitive market. (PC-4)
* Types of electricity markets. (GPC-5, PC-8)

**8.3.6. A** **list of sample questions for the exam**

Not applicable

**8.3.7.** **UrFU** **attestation and pedagogical measuring materials, UrFU** **means of control of the educational achievements for conducting the test control within the current and intermediate attestation**

Not used

**8.3.8**. **Federal exam in vocational education resources** **for independent testing**

Not used

**8.3.9.** **Internet simulators**

Not used