# MODERN TRENDS IN MANAGEMENT OF ELECTROMECHANICAL SYSTEMS

# GENERAL DESCRIPTION OF THE DISCIPLINE *MODERN TRENDS IN MANAGEMENT OF ELECTROMECHANICAL SYSTEMS*

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

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| --- | --- | --- | --- |
| 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)*

## Abstract of the discipline content

The course *Modern Trends in Management of Electromechanical Systems* provides an insight into the key current problems of managing modern electric drives and electromechanical systems.

## Planned results of mastering the discipline

As a result of mastering the discipline, a student should:

* 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);
* 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).
* 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).

As a result of mastering the discipline, a student should:

**Know:**

* the modern natural-science and applied problems of electrical engineering as well as methods and means to solve them in research, design, production, technological and other types of professional activities,
* the potential areas of development of domestic and foreign technologies used in the electrical equipment.

**Be able:**

* to use innovative technologies at reconstructed and newly constructed electrical facilities.

**Demonstrate skills and experience:**

* in mastering methods for improving the electrical system management systems.

## Discipline scope

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| --- | --- | --- |
| **Types of the educational work, forms of control** | **Hours, total** | **Study terms,**  **number** |
| **5** |
| In-class learning, hours | **4** | **4** |
| Lectures, hours | 4 | 4 |
| Practical exercises, hours | - | - |
| Laboratory-based work, hours | - | - |
| Self-guided work of students, hours | **104** | **104** |
| Type of interim assessment (credit/test, exam) | **test** | **test** |
| Total work intensity according to the curriculum, hours | 108 | 108 |
| Total work intensity according to the curriculum, credits | 3 | 3 |

# DISCIPLINE CONTENT

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| --- | --- | --- |
| **Code of section, topic** | **Discipline section, topic\*** | **Content** |
| **Р1** | Section 1. Main provisions of the theory of robust control systems | Models of objects with variable parameters. Models of uncertainty. Interval models of objects. Basic principles of interval mathematics. Robust stability. Frequency methods for evaluating robust stability. Kharitonov’s theorem. Synthesis methods for the robustly stable control systems. The robust quality concept. The sensitivity of control systems. Synthesis methods for the robust control quality systems. |
| **Р2** | Section 2. Main provisions of the theory of adaptive control systems | Definition and classification of adaptive systems. Statement of the problem of synthesis of adaptive systems. The hypothesis of quasi-stationarity. Methods of synthesis of adaptive regulators. Search adaptive systems. Extreme regulation systems. Search algorithms for indirect adaptive control with a customisable model. Disappearing adaptive control systems. Synthesis by the Lyapunov function method. Speed gradient scheme. Algorithms with a variable structure. |
| **Р3** | Section 3. Use of fuzzy logic, artificial neural networks and genetic algorithms in the control systems of the electrical engineering systems | The main provisions of fuzzy logic: linguistic variable, fuzzification, defuzzification and operations on fuzzy sets. Problems that require the use of the fuzzy logic. The criteria for expediency of the use of ‘fuzzy’ regulators. The synthesis of regulators by using fuzzy logic. Typical tasks of fuzzy control.  The concept and principles of constructing artificial neural networks (ANN). The types of ANN. ANN training. The problems of recognition of static and dynamic images. The ANN structures focused on the recognition of static images. ANN with memory elements with a focus on recognition of dynamic images and analysis of time series. ANN-based control structures. Neural observers and regulators. Forecasting the dynamics of an object, ANN-based predictive control. The concept of unification of ANN and fuzzy logic. Typical structures of neuro-fuzzy networks. Problems solved with the use of neuro-fuzzy logic.  The problem of finding an extremum of many variables. Fundamentals of the theory of genetic algorithms. Formalisation of the problem for the genetic optimisation method. The use of the method in industrial automation tasks. |

*\** The discipline may contain division only into sections without specifying topics, or only topics

# STUDY TIME ALLOCATION

## Allocation of the classroom load and independent work by disciplines

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|  |  | | | | |  |  |  |  |  |  |  | | |  | | |  |  |  |  | |  |  | |  | |  | |  | |  | |  | |  | |  | Scope of discipline (credit):3 | | | | | | | | | |
| Discipline section | | | | | | | In-class  learning  (hour) | | | |  | | Self-guided work: types, number and volume of activities | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Code of section, topic | | Section, topic | | | Total of section, topic (hours) | | Classroom work, total (hour) | Lectures | Practical exercises | Laboratory-based work | Self-guided work of students, total (hour) | | |  | | Preparation for in-class learning (hours) | | | | | | | Performing independent extracurricular activities (quantity) | | | | | | | | | | | | | | | | | | | Preparation for the control qualification activities (quantity) | | | | | Preparation for  attestation  by discipline (hour) | | | Preparation for attestation by module in the discipline (hour) | | |
| Total | | | Lectures | Pract. seminar classes | Laboratory-based work |  | Research seminars, conference seminars and colloquiums | | Total | | Homework\* | | Graphical work\* | | Research paper, essay, creative work\* | | Individual or group project\* | | Translation of foreign literature\* | | Calculation work, software development\* | | Calculation and graphical work\* | | Term work\* | Term project\* | | Total | | Test\* | | Colloquium\* | Test if there is an exam | Test if there is no exam | Exam | Integrated assessment of the results of mastering the module disciplines | Integrated module exam | Preparation and defence of the module project |
| Р1 | | Main provisions of the theory of robust control systems | | | 30 | | 2 | 2 |  |  | 28 | | | 4 | | | 4 |  |  |  |  | |  | |  | |  | |  | |  | |  | |  | |  | |  |  | |  | |  | |  |
| Р2 | | Main provisions of the theory of adaptive control systems | | | 34 | | 2 | 2 |  |  | 32 | | | 4 | | | 4 |  |  |  |  | |  | |  | |  | |  | |  | |  | |  | |  | |  |  | |  | |  | |  |
| Р3 | | Use of the fuzzy logic, artificial neural networks and genetic algorithms in control systems of the electrical engineering systems | | | 40 | |  |  |  |  | 40 | | |  | | |  |  |  |  |  | |  | |  | |  | |  | |  | |  | |  | |  | |  |  | |  | |  | |  |
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|  | | Total (hour), without taking into account the preparation for the attestation activities**:** | | | 104 | | 4 | 4 | 0 | 0 | 100 | | | 8 | | | 8 |  | 0 |  | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 0 | | 0 | | 0 | | 0 |
|  | | Discipline, total (hour): | | | 108 | | 4 |  | | | 100 | | |  | |  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | **0** | 4 | 0 | **0** | **0** | **0** |
|  | | |  | \* The total amount in hours per activity  is specified in line ‘Total (hour) without taking into account the preparation for the attestation activities’ | | | | | | | | | | | | | | | | | |  |  |  | |  | |  | |  | |  | |  | |  | |  |  | |  | |  | |  | |  | |  |  |  | |

# ORGANISATION OF PRACTICAL CLASSES AND SELF-GUIDED WORK OF STUDENTS ON THE DISCIPLINE

## Laboratory work

Not applicable

## Practical exercises

Not applicable

* 1. **Sample topics of the self-guided work**

### **An indicative list of homework topics**

Not applicable

### **An indicative list of the graphical work topics**

Not applicable

### **An indicative list of the research paper topics (essays, creative works)**

Not applicable

### **An indicative list of the calculation work topics (software solutions)**

Not applicable

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

Not applicable

### **An indicative list of the term project topics (term works) [*list*]**

Not applicable

### **Sample topics of the colloquiums**

Not applicable

# RELATION BETWEEN THE DISCIPLINE SECTIONS AND APPLIED TEACHING TECHNOLOGIES\*

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Code of section, discipline topics** | **Active learning methods** | | | | | | **Distant learning technologies and e-learning** | | | | | |
| Project work | Case studying | Business games | Problem training | Teamwork | Other (please specify) | Network training courses | Online workshops and simulators | Webinars and videoconferences | Asynchronous web-conferences and seminars | Collaboration and content development | Other (please specify) |
| Р1 |  |  |  | \* |  |  |  |  |  |  |  |  |
| Р2 |  |  |  | \* |  |  |  |  |  |  |  |  |
| Р3 |  |  |  | \* |  |  |  |  |  |  |  |  |

\*mark with an asterisk or another symbol the applied teaching technologies by the discipline section and topic.

# PROCEDURES FOR MONITORING AND EVALUATION OF THE LEARNING OUTCOMES

Not applicable

1. **PROCEDURES FOR EVALUATING THE LEARNING OUTCOMES WITHIN THE INDEPENDENT TEST CONTROL**

Not applicable

# SET OF EVALUATION TOOLS FOR THE CURRENT AND INTERIM ATTESTATION BY THE DISCIPLINE (Annex 1)

# ACADEMIC AND INFORMATION SUPPORT TO THE DISCIPLINE

## 9.1. Recommended literature

## 9.1.2. Additional references

1. Astrom K.J., Wittenmark В. Adaptive control. Second edition. Dover Publications, Inc., Mineola, New York, 2008. 573 p.
2. Ackermann J. Robust control: system with uncertain physical parameters. New York: Springer-Verlag, 1993. 406 pp.
3. Dullerud G.E., Paganini F. A Course in Robust Control Theory: A Convex Approach. Ser. Texts in Ap­plied Mathematics, vol. 36. New York: Springer, 2000. 379 pp.
4. Feng Lin. Robust Control Design. An Optimal Control Approach. John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, England, 2007. 364 pp.
5. Green М., Limebeer D.J.N. Linear robust control. Englewood Cliffs, HJ: Prentice Hall, 1995. 265 pp.
6. Gu D.-W., Petkov P.Hr., Konstantinov M.M. Robust Control Design with MATLAB. London: Springer,
7. 2005. 389 pp.
8. Loannou P., Fidan B. Adaptive Control Tutorial. Philadelphia: SIAM, 2006. 387 pp.
9. Morari М., Zafmou M. Robust process control. Englewood Cliffs, HJ: Prentice-Hall, 1989. 512 pp.
10. Scherer C. Theory of Robust Control. The Netherlands: Delft University of Technology, 2001. 160 pp.
11. Tao G. Adaptive Control Design and Analysis. Hobocken, NJ: Wiley, 2003. 618 pp.
12. Zhong Q.-C. Robust Control of Time-delay Systems. London: Springer, 2006. 242 pp.
13. Zhou K., Doyle J.C., Glover K. Robust and Optimal Control. Engelwood Cliffs, NJ: Prentice Hall, 1996. 586 pp.

## 9.4. Databases, information, reference and search systems

## <http://lib.urfu.ru> UrFU library site

<http://study.urfu.ru> UrFU information and educational resources portal

**ANNEX 1**

**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**

The criteria approved at the Chair for assessing the students’ achievements per each monitoring and evaluation activity. The set of evaluation criteria as well as during the intermediate certification on a module is based on three levels of mastering the competence components, i.e. threshold, higher and high.

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| --- | --- | --- | --- |
| 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. 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 test topics**

Not applicable

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

1. Types of uncertainties in models of control objects. Methods for representing uncertainty models.

2. Sources of uncertainty. Causes of variation of parameters in an automated electric drive.

3. Fundamentals of interval mathematics. Arithmetic operations in interval mathematics.

4. The concept of interval model.

5. The concept of robust stability.

6. Kharitonov’s theorem and its use for the evaluation of robust stability.

7. The edge theorem and its use for the evaluation of robust stability.

8. Frequency methods for evaluating robust stability.

9. Methods of synthesis of robustly stable control systems.

10. Sensitivity of control systems.

11. Use of sensitivity functions to study the robust properties of the automatic control system.

12. Methods of the systems synthesis with the robust quality control.

13. Definition and classification of adaptive systems.

14. Statement of the problem of synthesis of adaptive systems.

15. Search adaptive systems.

16. Extreme regulation systems.

17. Search algorithms for indirect adaptive control with a customisable model.

18. Searchless adaptive control systems.

19. Fuzzy logic. Basic principles of information processing.

20. The linguistic variable concept. Operations over linguistic variables.

21. Types of artificial neural networks. Areas of use

22. Artificial neural network training principles

23. Recurrent neural networks. Main features, application

24. Recognition of images using artificial neural networks

25. Forecasting using artificial neural networks

26. Principles of constructing neural controllers

27. Typical applications of the genetic optimisation method

28. Genetic algorithms. Genotype and phenotype. Coding information

29. Genetic algorithms. Procedures for the genetic code modification

30. Optimisation comparison using the genetic algorithms with traditional methods

**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 applicable

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

Not applicable

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

Not applicable