Ministry of Education and Science of Ukraine
National Aerospace University
"Kharkiv Aviation Institute"

Department of Aircraft Control Systems (dep. 301)

APPROVED:

Head of Educational Program

_____ A. S. Kulik

"29" 08 2020

WORK PROGRAM OF THE OPTIONAL DISCIPLINE

Digital Control Systems

(code and name of the discipline)

Field of Study: 17 – Electronics and Telecommunication

Program Subject Area: 173 – Avionics

Educational Program: Systems of Autonomous Navigation and Adaptive Control of Aircrafts
(code number and the name of specialization)

Tutorial form: full-time
Level of Qualification: 1st (bachelor degree)

Kharkiv 2020

The working program of optional discipline «Digital Control Systems» is for students in Program subject area 173 – Avionics (English medium education)

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Developer: Zymovin A. Ya., professor of dep. 301, Candidate of Science (Engineering) _____ (sign)

Adopted at the meeting of dep. 301 "Aircraft Control Systems".

Minutes of meeting: #1 on " 29 " August 2020

Head of the department
Associate professor, PhD (Engineering) _____ (sign) K. Yu. Dergachov

1. Course description

<table>
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<tr><td>Full-time study</td></tr>
<tr><td colspan="2">ECTS credits – 5</td><td rowspan="3">Field of Study:
17 – Electronics and Tele-communication</td><td>Optional</td></tr>
<tr><td colspan="2">Modules – 1</td><td rowspan="2">Calendar year</td></tr>
<tr><td colspan="2">Substantial modules – 2</td></tr>
<tr><td colspan="2" rowspan="3">Total hours for full-time study:
academic hours of contact learning / total academic hours – 64/150</td><td rowspan="3">Program Subject Area:
173 – Avionics</td><td>2020-2021</td></tr>
<tr><td>Semester</td></tr>
<tr><td>7</td></tr>
<tr><td colspan="2" rowspan="2">Academic hours per day for full-time study</td><td rowspan="8">Educational Program:
Systems of Autonomous Navigation and Adaptive Control of Aircrafts</td><td>Lectures</td></tr>
<tr><td>24[1)]</td></tr>
<tr><td colspan="2">Semester 7</td><td>Tutorial classes</td></tr>
<tr><td>contact training (classes)
4 hrs.</td><td>self-study
4 hrs.</td><td>16</td></tr>
<tr><td colspan="2"></td><td>Lab classes</td></tr>
<tr><td></td><td></td><td>24[1)]</td></tr>
<tr><td colspan="2" rowspan="3"></td><td>Self-study work</td></tr>
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<tr><td rowspan="3">Education level:
1st (bachelor degree)</td><td></td></tr>
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<tr><td>Exam</td></tr>
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[1)] depending on timetable, classroom studies can decrease or enlarge by one hour per week
Note: Ratio of contact and independent study makes: 60/120 (under full-time education).

2. Purpose and objectives of academic discipline

Learning Aims – forming of knowing and proficiency related to a theory and practice of contemporary automatic control systems analysis design.
Learning Objectives – relatively aircrafts and other vehicles' digital control systems, the acquiring of basic methods of mathematical describing the dynamic processes that run in discrete-time systems, providing for an analysis and synthesis of these systems in accordance with requirements given.

In accordance with the educational and professional program requirements, students should obtain the following **competencies**:

GC1. Ability of abstract and subject thinking while analyzing and designing the digital systems.

GC 2,5. Applying the acquired knowledge into practice. Ability to master and develop subject knowledge, and understand methods for mathematical introducing discrete system features.

GC 3. Handling a technical foreign language.

PCS2. Aptitude to choose a method to solve a particular task in assessment of a discrete system stability and a tool to obtain the given performance characteristics.

PCS 3. Executing verbal, graphic and mathematical description of discrete signals, elements and systems in time and frequency domains.

PCS 7. Ability to evaluate the stability, controllability, and observability of the linear digital ACS using algebraic and frequency approaches.

Program learning outcomes:

PLO1. Grounded choice of elements and dedicated element characteristics to perceive the specified digital control specifications.

PLO3. Execution of verbal, graphic and mathematical models for discrete signals, elements and systems description in time and frequency domains.

PLO4. Applying up-to-date sensors database while engineering transducers associated with control systems and instruments of aircrafts.

PLO8. Solving actual problems of digitally controlled objects positioning and stabilization with the use of computer simulation and semi–native modeling.

Interdisciplinary links:

Prerequisites for studying this discipline: Higher math, Fundamentals of algorithmization, Fundamentals of system simulation, Theory of automatic control;

Discipline outcomes for using by adjacent courses: Control system designing, Bachelor's thesis.

3. Content of the course

Substantial Module 1. Discrete time signals and systems

Topic 1. Intro. Continuous time and discrete time CS; advantage of digital controllers. Analysis of sampled data, sampling and hold. Impulse Sampling; data-hold; Zero-Order Hold.

Topic 2. Features of sampled data reconstruction. Sampling theorem. Folding and aliases.

Topic 3. The z-Transform. Z-Transforms of elementary functions (unit step function, unit ramp function, exponential function); Theorems and properties of Z-transform.

Topic 4. Inverse Z –transform and solving of difference equations.

Topic 5. Starred transfer function; Impulse response of a ZOH; Z-plane analysis; Pulse transfer function. Pulse transfer function of cascaded elements.

Topic 6. Pulse transfer function of open-loop and closed-loop systems. Modeling of discrete time systems. Causality and system realizability.

Topic 7. Mapping between *s*- plane and *z*-plane. Criteria of automatic digital control system stability.

Substantial Module 2. DCS Analysis and Synthesis

Topic 8. Stability analysis of a closed loop system in z-plane; Routh-Hurwitz stability criterion.

Topic 9. Time response of discrete time systems. Time response of second order discrete time systems.

Topic 10. Design of sampled data control systems. Estimation of digital systems performance quality.

Topic 11. Design of digital controller. The concept of dominant pole pair implementation.

Topic 12. Assignment outcomes discussion. Subject summary.

4. Course structure

Substantial modules and topics	Hours					
	full-time					part-time
	total	among them				
		lec	tut	lab	indep	
1	**2**	**3**	**4**	**5**	**6**	**7**
Module 1						
Substantial Module 1 – Discrete time signals and systems						
Topic 1. Introduction to digital CS; Discrete time CS; Advantage of digital controllers. Analysis of sampled data	6	2	–	–	4	–
Topic 2 Features of sampled data reconstruction. Sampling theorem	8	2	2	–	7	–
Topic 3. Solution of difference equation. The $\mathcal{Z}$-transform	6	2	2	–	7	–
Topic 4. Inverse $\mathcal{Z}$-transform and solving of difference equations	6	2	–	4	10	–
Topic 5. Z-plane analysis; Pulse Transfer Function	6	2	2	–	6	–
Topic 6. Pulse TF of open-loop and closed-loop systems. Modeling of discrete time systems	8	2	–	4	6	–
Topic 7. Mapping between *s*- plane and *z*-plane. Criteria of DCS stability	10	2	2	4	8	–
Total for Substantial module 1	64	14	8	12	48	–

1	2	3	4	5	6	7
Substantial Module 2 – DCS analysis and synthesis						
Topic 8. Stability analysis of a closed loop system in z-plane; Routh-Hurwitz stability criterion	7	2	2	–	8	–
Topic 9. Time response of discrete time systems. Time response of 2nd order discrete time systems	9	4	–	4	8	–
Topic 10. Design of sampled data control systems	10	2	–	4	6	–
Topic 11. Design of digital controller. Dominant pole pair concept implementation	10	2	2	4	8	–
Topic 12. Subject summary. Assignment outcomes discussion	8		2	–	8	–
Total for Substantial module 2	56	10	8	12	38	–
Course total	**120**	**24**	**16**	**24**	**86**	–

5. Topics of seminar classes

№ a/o	Topic name	Hours
	not appointed	–

6. Topics of Tutorial classes

№ a/o	Topic name	Hours
1	Sampled data reconstruction.	4
2	Solution of difference equation	2
3	Z-plane analysis; Pulse Transfer Function	2
4	TF of open-loop and closed-loop systems	4
5	Mapping between *s*- plane and *z*-plane	4
6	Stability analysis of a closed loop system in z-plane	4
7	Dominant pole pair concept for digital controller design	4
8	Quiz	4
Total hours		**30**

7. Topics of Lab classes

№ a/o	Topic name	Hours
1	**2**	**3**
1	Introduction to lab course and laboratory orientation	2
2	Discrete-time simulation with Simulink. Study of DAC and ADC	4

1	2	3
3	Digital effects examination. Sampling, aliasing, zero-order hold	4
4	Time-domain controller and control plant emulation	4
5	Frequency-domain controller emulation	4
6	Frequency-response controller design	4
7	Quiz	2
Total hours		**24**

8. Independent work

№ a/o	Topic name	Hours
1	Types of description of discrete signals and elements	6
2	Mathematical tools associated with digital ACS	9
3	Discrete-time simulation with Simulink	8
4	Time-domain controller emulation	8
5	Frequency-domain controller emulation	8
6	Sampling, aliasing, zero-order hold	8
7	Discrete-time plant modeling	7
8	Frequency-response controller design	8
9	Synthesis of the cascade digital PID controller	10
10	Techniques of ACS analysis and synthesis on the base of PC simulation	7
11	Analysis and synthesis of ACS with using semi-native simulation	6
Total hours		**86**

9. Individual assignments

Direct controller design method: individual task on calculation of a digital controller that would meet specified indicators

10. Teaching methods

Lectures delivering, conducting lab classes, individual consultations (if necessary), independent work of students with tutorials issued by the department (learning manuals)

11. Modes of Assessment

Current control tests, lab reports submission, submission of assignments related to substantial modules and topics, defense of the final course assignment, final examination

12. Assessment criteria and points distribution

12.1. Distribution of points goaled to a student

Components of learning	Assessment marks per lesson (task)	Number of classes (tasks)	Total marks
1	**2**	**3**	**4**
Substantial Module 1			

1	2	3	4
Lectures work	0…1	6	0…6
Execution and submission of practical (lab) works	0...3	6	0...18
Tutorial class work	0…2	3	0…7
Module 1 submission	0…5	1	0…5
Substantial Module 2			
Lectures work	0…1	10	0…9
Execution and submission of practical (lab) works	0...3	10	0...30
Tutorial class work	0…2	5	0…10
Execution and submission of individual assignments	0…16	1	0…10
Module 2 submission	0…5	1	0…5
Total for the semester			**0…100**

The semester control (exam /credit) is carried out in case of the student refusal from current testing points and in the presence of the admission to exam / credit.

During the semester exam / test the student has the opportunity to receive a maximum of 100 points. The exam /test card consists of one theoretical question (30 points), one practical question (30 points) and one laboratory task to be performed on a computer (40 points).

Grading scale: national assessments

Total marks	National validation grade	
	Exam	Pass-fail exam
90 – 100	excellent	pass
83 – 89	good	
75 – 82		
68 – 74	satisfactory	
60 – 67		
0 – 59	unsatisfactory	failure

13. Methodical aids

1. Summary of lectures on discipline "Electrical Engineering".
2. Slides with presentations of lecture materials
3. Instructions and assignment for laboratory course
4. Learning aids for tutorial classes
5. Learning aid for the calculation-and-graphics assignment performance

14. Recommended reading

Basic sources

1. Кулік А. С., Дибська І. Ю. Введення в теорію ЦАС. - Х.: Харк. авіац. ін-т, 2007. – 165 с. / Introduction to Digital Automatic Control systems Theory / A.

Kulik, I. Dybska. The textbook. – Kharkiv: National Aerospace University, 2007. – 165 p.

2. M. Sami Fadali, Antonio Vidio Visioli. Digital Control Engineering Analysis and Design. – Elsevier Inc., 2013. – 582 p.

3 Nagle T., Chakrabortty A., Phillips C.L. Digital Control System Analysis & Design. London: Pearson, 2014.

Complementary reading

1. Симонов В.Ф. Цифрові системи автоматичного управління/ В. Ф.Симонов, І. Ю. Дибська, В. Г.Джулгаков та ін. – Навч. посіб. до лаб. практикуму. – Х.: Харк. авіац. ін-т, 2007. – 93с.

2. Landan I.D. Digital Control System. London, Springer, 2006. – 484p.

3. Kuo Benjamin C. Automatic Control Systems – Englewood Chffs, NJ: Prentice Hill, 1995 – 417p.

14. Інформаційні ресурси/ Information Resources

Department site k301.info