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| **UČNI NAČRT PREDMETA / COURSE SYLLABUS** | | | | | | | | | | | | | | | | | |
| **Predmet:** | | | Avtomatizirani in virtualni merilni sistemi | | | | | | | | | | | | | | |
| **Course title:** | | | Automatized and virtual measurement systems | | | | | | | | | | | | | | |
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| **Študijski program in stopnja**  **Study programme and level** | | | | | **Študijska smer**  **Study field** | | | | | | | | **Letnik**  **Academic year** | | **Semester**  **Semester** | | |
| Podiplomski magistrski študijski program druge stopnje Elektrotehnika | | | | | Robotika, Avtomatika in informatika | | | | | | | | 1 | | 2 | | |
| 2nd cycle masters study programme in Electrical Engineering | | | | | Robotics, Control systems and computer engineering | | | | | | | | 1 | | 2 | | |
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| **Vrsta predmeta / Course type** | | | | | | | | | | | | Obvezni-strokovni / Compulsory professional | | | | | |
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| **Univerzitetna koda predmeta / University course code:** | | | | | | | | | | | | 64205 | | | | | |
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| **Predavanja**  **Lectures** | **Seminar**  **Seminar** | | | **Vaje**  **Tutorial** | | | **Klinične vaje**  **work** | | | | **Druge oblike študija** | | | **Samost. delo**  **Individ. work** | |  | **ECTS** |
| **45** | **0** | | | **30** | | |  | | | |  | | | **75** | |  | **6** |
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| **Nosilec predmeta / Lecturer:** | | | | | Janko Drnovšek, Jovan Bojkovski | | | | | | | | | | | | |
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| **Jeziki /**  **Languages:** | | **Predavanja / Lectures:** | | | | **Slovenščina/angleščina**  **Slovene/English** | | | | | | | | | | | |
| **Vaje / Tutorial:** | | | | **Slovenščina/angleščina**  **Slovene/English** | | | | | | | | | | | |
| **Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** | | | | | | | | |  | **Prerequisits:** | | | | | | | |
| Vpis v letnik. | | | | | | | | |  | Enrolment in the year of the course. | | | | | | | |
| **Vsebina:** | | | | | | | |  | | **Content (Syllabus outline):** | | | | | | | |
| a) zgradba avtomatiziranih in virtualnih merilnih sistemov (komponente sistemov, omejitve, koraki pri načrtovanju, končna integracija)  b) kvantizacija in analogno-digitalne pretvorbe (teoretična obravnava, praktična izvedba, prezentacija različnih načinov analogno-digitalne pretvorbe ter vpliv na merilni signal)  c) komunikacijski vmesniki (računalniški, industrijski, hitrost, doseg, odpornost na motnje, število merilnih instrumentov na vodilu)  d) programska in razvojna orodja za avtomatizacijo merjenj (klasična orodja, grafično programiranje, podatkovno in dogodkovno gnana programska orodja)  e) strojna oprema (zahteve za avtomatizacijo, integracija, motnje in odpravljanje motenj)  f) kakovost merilne programske opreme (preskušanje kakovosti programske opreme, metoda črne in prozorne škatle, omejitve pri preskušanju, praktični primeri) | | | | | | | |  | | a) structure of automatized and virtual measurement systems (system components, limitations, design steps, integration of the measurement system)  b) quantization and analogue to digital conversion (theory, practical implementation, presentation of different A/D conversions with their influences to the measurement signal)  c) communication interfaces (computer, industrial, speed, distance, fault tolerance, number of instruments on the bus)  d) software and development tools for automation of measurements (classical tools, graphical programming, data and event driven software)  e) hardware (requirements, integration, noise generation and troubleshooting)  f) software quality (software testing, black and white box, testing limitation, practical examples) | | | | | | | |

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| **Temeljni literatura in viri / Readings:** | | | | | |
| 1. Drnovšek, J.; Bojkovski, J, Batagelj, V.: Avtomatizirani in virtualni merilni sistemi, Ljubljana: Fakulteta za elektrotehniko 2016 2. Lang, T.T: Computerized Instrumentation. New York: John Wiley & Sons Inc. 1991 3. Carr, J.J.: Elements of Electronic Instrumentation and Measurement. 3. izdaja. Englewood Cliffs, New Jersey: Prentice-Hall. 1996 4. Morris, A.S.: The essence of measurement. London, New York: Prentice-Hall. 1996 5. Lang, T.T: Electronics of measuring systems. Chichester, New York: John Wiley & Sons Inc. 1994 6. Bentley, J.P.: Principles of Measurement Systems. 3. izdaja. New York: John Wiley & Sons Inc. 1995 7. Morris, A.S.: Measurement and Instrumentation Principles. Oxford: Butterworth-Heinemann. 2001 8. Regtien, P.P.L.: Measurement Science for Engineers. London, Sterling: Kogan Page Science. 2004 | | | | | |
| **Cilji in kompetence:** | |  | | **Objectives and competences:** | |
| a) razširiti in poglobiti znanje o programski opremi in elementih za avtomatizacijo merilnih sistemov  b) spoznati se z komunikacijskimi vmesniki (serijski, paralelni), ki so najbolj zastopljeni v industrijskih procesih  c) proučiti bistvene zahteve digitalne obdelave signalov z metrološkega stališča  d) spoznati razvojna okolja za avtomatizacijo merjenj v industrijskih in raziskovalnih okoljih  e) podrobno spoznati sodobne "vizualne jezike" in virtualne merilne instrumente ter njihovo uporabno vrednost  f) ugotoviti ključne parametre pri zagotavljanju kakovosti merilne programske opreme | |  | | a) increase awareness and knowledge regarding software and elements for automation of measurement systems  b) serial and parallel interfaces (laboratory and industrial measurement processes)  c) requirements regarding digital signal processing in metrology  d) development tools for automation of measurements in industrial and research  e) modern virtual programming languages and their implementation  f) identify key parameters of quality assurance of software measurement equipment | |
| **Predvideni študijski rezultati:** | | |  | **Intended learning outcomes:** | |
| Znanje in razumevanje:  napredni pojmi iz področja avtomatizacije merilnih sistemov, razumevanje ustroja virtualnih merilnih sistemov zgrajenih s pomočjo "vizualnih" jezikov in drugih sodobnih programskih orodij, osnovni pojmi iz kakovosti merilne programske opreme | | |  | Knowledge and understanding:  Advanced knowledge about automatized and virtual measurement system, understanding how virtual measuring systems are made using modern virtual programming languages, basic elements of software quality | |
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| **Metode poučevanja in učenja:** | | |  | **Learning and teaching methods:** | |
| predavanja, seminarji, laboratorijske vaje | | |  | Lectures, seminars, laboratory exercises | |
| **Načini ocenjevanja:** | Delež (v %) /  Weight (in %) | | | | **Assessment:** |
| Način: laboratorijske vaje, pisni izpit, ustni izpit  Ocene od 1 do vključno 5 so negativne, ocene od vključno 6 do 10 so pozitivne.  Pozitivna ocena laboratorijskih vaj je pogoj za pristop k izpitu.  Prispevki k oceni:   * laboratorijske vaje * pisni izpit * ustni izpit | 40%  30%  30% | | | | Type: laboratory exercises, written exam, oral exam.  Negative grades: from 1 to 5, positive grades: from 6 to 10.  Positive evaluation of laboratory exercises is a prerequisite for the exam.  Contributions to final grade:   * laboratory exercises * written exam * oral examination |
| **Reference nosilca / Lecturer's references:** | | | | | |
| 1. BEGUŠ, Samo, BOJKOVSKI, Jovan, DRNOVŠEK, Janko, GERŠAK, Gregor. Magnetic effects on thermocouples. Measurement science & technology, 2014, vol. 3, no. 25, str. 1-11. 2. MIKLAVEC, Andraž, PUŠNIK, Igor, BATAGELJ, Valentin, DRNOVŠEK, Janko. A large aperture blackbody bath for calibration of thermal imagers. Measurement science & technology, 2013, vol. 2, no. 24, str. 1-8. 3. BATAGELJ, Valentin, MIKLAVEC, Andraž, BOJKOVSKI, Jovan. Validation of calculations in a digital thermometer firmware, International journal of thermophysics, vol. 35, issue 3-4, April 2014, New York: Plenum Press, 2014, str. 681-692. 4. ŽUŽEK, Vincencij, BATAGELJ, Valentin, DRNOVŠEK, Janko, BOJKOVSKI, Jovan. Effect of bushings in thermometric fixed-point cells. Measurement, Jan. 2016, vol. 78, str. 289-295. 5. BATAGELJ, Valentin, ŽUŽEK, Vincencij, DRNOVŠEK, Janko, BOJKOVSKI, Jovan. A numerical and experimental investigation of the heat losses in thermometric fixed-point cells. International journal of heat and mass transfer, Jun. 2015, vol. 85, str. 321-335, ilustr | | | | | |