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| **UČNI NAČRT PREDMETA / COURSE SYLLABUS** | | | | | | | | | | | | | | | | | |
| **Predmet:** | | | Digitalno vodenje | | | | | | | | | | | | | | |
| **Course title:** | | | Digital control | | | | | | | | | | | | | | |
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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 | | | | | Avtomatika in informatika, Robotika | | | | | | | | 1 | | 1 | | |
| 2nd cycle masters study programme in Electrical Engineering | | | | | Control systems and computer engineering, Robotics | | | | | | | | 1 | | 1 | | |
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| **Vrsta predmeta / Course type** | | | | | | | | | | | | Izbirni-strokovni /compulsory - professional | | | | | |
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| **Univerzitetna koda predmeta / University course code:** | | | | | | | | | | | | 64200 | | | | | |
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| **Predavanja**  **Lectures** | **Seminar**  **Seminar** | | | **Vaje**  **Tutorial** | | | **Klinične vaje**  **work** | | | | **Druge oblike študija** | | | **Samost. delo**  **Individ. work** | |  | **ECTS** |
| **45** |  | | | **30** | | |  | | | |  | | | **75** | |  | **6** |
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| **Nosilec predmeta / Lecturer:** | | | | | Sašo Blažič | | | | | | | | | | | | |
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| **Jeziki /**  **Languages:** | | **Predavanja / Lectures:** | | | | slovenski, v primeru večjega števila tujih študentov angleški / Slovene, in case of a large number of foreign students English | | | | | | | | | | | |
| **Vaje / Tutorial:** | | | | slovenski, v primeru večjega števila tujih študentov angleški / Slovene, in case of a large number of foreign students English | | | | | | | | | | | |
| **Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** | | | | | | | | |  | **Prerequisits:** | | | | | | | |
| Vpis v letnik. | | | | | | | | |  | Enrolment in the year of study. | | | | | | | |
| **Vsebina:** | | | | | | | |  | | **Content (Syllabus outline):** | | | | | | | |
| Osnovni koncepti sistemov digitalnega vodenja, bločna shema sistema digitalnega vodenja, časovna kvantizacija, kvantizacija po amplitudi.  Matematične osnove obravnave diskretnih sistemov, časovno diskretni signali, z- in inverzna z-transformacija, Parsevalov teorem, relacija med različnimi oblikami Fourierjevih transformacij, povezava med ravninama z in s, prenosna funkcija, diskretna konvolucija.  Spremenljivke stanja diskretnih sistemov, enačbe stanja in prenosna funkcija, relacija med odzivom sistema in lastnimi vrednostmi ter lastnimi vektorji, odziv sistemov kot funkcija sistemske matrike, fundamentalna matrika, metode za določevanje matrike prehajanja stanj, odziv nehomogenih linearnih sistemov, ravnotežna stanja sistemov.  Frekvenčni odziv diskretnih sistemov.  Diskretni ekvivalenti zveznih sistemov, diskretni ekvivalenti zveznih prenosnih funkcij, diskretni ekvivalenti zveznih sistemov, ki so opisani s spremenljivkami stanja, povezava med predstavitvami v zveznem in diskretnem prostoru, prevedba zveznih PID regulatorjev v diskretne.  Vodljivost in spoznavnost diskretnih sistemov, prevedba v kanonične oblike.  Stabilnost diskretnih sistemov. Kriteriji za ugotavljanje stabilnosti, stabilnost nelinearnih sistemov, direktna metoda Ljapunova.  Regulator stanj z opazovalnikom. Osnovni regulator stanj, optimalni regulator stanj, opazovalnik stanj, Kalmanov filter, princip dualnosti. | | | | | | | |  | | Basic concepts of digital control, schematic representation of a digital control system, quantisation of time, quantisation of the signal value.  Mathematical bases of discrete systems, sampled signals, z-transform, inverse z-transform, Parseval’s theorem, relations among different forms of Fourier transform, relation between z- and s-planes, transfer function, discrete convolution.  States of discrete systems, state-space representation and transfer function, relation between system response and system eigen-values and eigen-vectors, system response as a function of the system matrix, fundamental matrix, methods for determination of a state transition matrix, the response of non-homogenous linear systems, equilibrium states of the systems.  Frequency response of discrete systems.  Discrete equivalent of continuous systems, discrete equivalent of continuous transfer functions, discrete equivalent of continuous systems given by state-space representations, the relation between continuous and discrete representations, transformation of continuous PID controllers into discrete ones.  Controllability and observability of discrete systems, canonical forms.  Stability of discrete systems Stability criteria, stability of nonlinear systems, direct Lyapunov method.  State controller with a state observer. Basic state controller, optimal state controller, state observer, Kalman filter, duality principle. | | | | | | | |

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| **Temeljni literatura in viri / Readings:** | | | | | |
| 1. Sašo Blažič, Digitalno vodenje, Založba FE in FRI, Ljubljana, 2013. 2. Drago Matko, Diskretni regulacijski sistemi, Univerza v Ljubljani, Fakulteta za elektrotehniko, 1991. 3. Sašo Blažič, Diskretni regulacijski sistemi, Zbirka vaj, Univerza v Ljubljani, Fakulteta za elektrotehniko, 2007. 4. Drago Matko, Računalniško vodenje procesov, Univerza v Ljubljani, Fakulteta za elektrotehniko, 1995. 5. Gene F. Franklin, J. David Powell, Michael L. Workman, Digital Control of Dynamic Systems, Third Edition, Addison-Wesley, 1997. 6. Karl Johan Astrom , Bjorn Wittenmark, Computer-Controlled Systems: Theory and Design Third Edition, Prentice Hall 1997. 7. Gurvinder Singh Virk, Digital Computer Control Systems, Macmillan, 1991. 8. Rajko Svečko, Diskretni regulacijski sistemi, Univerza v Mariboru, Fakulteta za elektrotehniko, računalništvo in informatiko, Maribor 2003. | | | | | |
| **Cilji in kompetence:** | |  | | **Objectives and competences:** | |
| * prikazati področje diskretnih regulacijskih sistemov, to je sistemov, ki so zapisani v obliki, ki je primerna za digitalno vodenje, * podati zahtevnejše postopke za analizo in sintezo diskretnih sistemov, * podati metode pretvorb zveznih sistemov v diskretne, * podati moderne regulacijske algoritme za digitalno vodenje, * seznaniti slušatelje s problemi robustnosti digitalnega vodenja. | |  | | * To present the area of discrete control systems, i.e. the systems, given in a form suitable for digital control * To present complex methods of discrete systems analysis and design. * To show the methods of conversion of continuous systems into discrete form. * To present some modern control algorithms to be implemented in digital control. * To introduce the problems of digital control robustness. | |
| **Predvideni študijski rezultati:** | | |  | **Intended learning outcomes:** | |
| Znanje in razumevanje:  poglobljena znanja iz digitalnega vodenja | | |  | Knowledge and understanding:  Deeper understanding of digital control | |
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| **Metode poučevanja in učenja:** | | |  | **Learning and teaching methods:** | |
| predavanja in laboratorijske vaje | | |  | Lectures and laboratory work | |
| **Načini ocenjevanja:** | Delež (v %) /  Weight (in %) | | | | **Assessment:** |
| ocena laboratorijskih vaj  pisni izpit  ustno izpraševanje | 25%,  30%,  45% | | | | Laboratory work assessment  Written examination  Oral examination |
| **Reference nosilca / Lecturer's references:** | | | | | |
| 1. BLAŽIČ, Sašo*.* Digitalno vodenje. Ljubljana: Založba FE in FRI, 2013. ISBN 978-961-243-230-0. 2. BLAŽIČ, Sašo, Diskretni regulacijski sistemi, Zbirka vaj, Univerza v Ljubljani, Fakulteta za elektrotehniko, 2007. 3. BLAŽIČ, Sašo, MATKO, Drago, RODIČ, Tomaž, DOVŽAN, Dejan, MUŠIČ, Gašper, KLANČAR, Gregor. The design of observers for formation-flying control. Acta astronaut., 2013, vol. 82, no. 1, str. 60-68. 4. BOŠNAK, Matevž, MATKO, Drago, BLAŽIČ, Sašo. Quadrocopter control using an on-board video system with off-board processing. Robot. auton. syst., Apr. 2012, vol. 60, no. 4, str. 657-667. 5. BLAŽIČ, Sašo, ŠKRJANC, Igor, MATKO, Drago. Globally stable direct fuzzy model reference adaptive control. Fuzzy sets syst., 2003, vol. 139, no. 1, str. 3-33. | | | | | |