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| **NAČRT PREDMETA / COURSE SYLLABUS** | | | | | | | | | | | | | | | | | |
| **Predmet:** | | | Industrijski krmilni in regulacijski sistemi | | | | | | | | | | | | | | |
| **Course title:** | | | Industrial Control Systems | | | | | | | | | | | | | | |
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| **Študijski program in stopnja**  **Study programme and level** | | | | | **Študijska smer**  **Study field** | | | | | | | | **Letnik**  **Academic year** | | **Semester**  **Semester** | | |
| Univerzitetni študijski program prve stopnje Elektrotehnika | | | | | **Avtomatika** | | | | | | | | 3. | | letni | | |
| 1st cycle academic study programme Electrical Engineering | | | | | **Control Systems** | | | | | | | | **3.** | | **summer** | | |
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| **Vrsta predmeta / Course type** | | | | | | | | | | | | Obvezni - strokovni/ compulsory professional | | | | | |
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| **Univerzitetna koda predmeta / University course code:** | | | | | | | | | | | | 64132 | | | | | |
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| **Predavanja**  **Lectures** | **Seminar**  **Seminar** | | | **Vaje**  **Tutorial** | | | **Klinične vaje**  **work** | | | | **Druge oblike študija** | | | **Samost. delo**  **Individ. work** | |  | **ECTS** |
| **45** |  | | | **45** | | |  | | | |  | | | **85** | |  | **7** |
|  | | | | | | | | | | | | | | | | | |
| **Nosilec predmeta / Lecturer:** | | | | | Igor Škrjanc | | | | | | | | | | | | |
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| **Jeziki /**  **Languages:** | | **Predavanja / Lectures:** | | | | slovenski | | | | | | | | | | | |
| **Vaje / Tutorial:** | | | | slovenski | | | | | | | | | | | |
| **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):** | | | | | | | |
| Uvod, življenjski cikel sistemov vodenja, razdelitve, zvezno in diskretno vodenje.  Zvezno vodenje. Zahtevnejši pristopi pri načrtovanju PID reg. sistemov: računalniška optimizacija, avtomatsko nastavljanje in prilagajanje. Praktični problemi - filtriranje, brezudarni preklop ročno/avtomatsko, integralski pobeg.  Večzančne regulacijske metode: uvedba krmiljenja v regulacijo, kaskadna regulacija, regulacija razmerja.  Analiza in načrtovanje s pomočjo frekvenčnih karakteristik in diagrama lege korenov. Stabilnost regulacijskih sistemov: ojačevalni in fazni razloček, Nyquistov stabilnostni kriterij. Prehitevalna in zakasnilna kompenzacija.  Uporaba programskega orodja MATLAB z dodatkom Control System Toolbox in Optimization Toolbox pri analizi in načrtovanju sistemov vodenja.  Diskretno vodenje. Načrtovalski pristopi – lestvični diagram, sekvenčni funkcijski diagram. Kombinacijska krmilja in sekvenčna krmilja. Standardni programski jeziki programirljivih logičnih krmilnikov. Izvedbe nekaterih krmilij. | | | | | | | |  | | Introduction, life cycle of control systems, continuous and discrete control.  Continuous control. Complex approaches to design of PID controllers: optimization, self-tuning and adaptation. Practical problems – filtering, bump-less transfer manual/automatic, anti-wind up.  Multi-loop control methods: feed-forward, cascade control systems.  Analysis and design in frequency domain: Bode diagram, root locus diagram. Stability of control systems. Nyquist stability criteria. Lead and lag compensators.  Practical work with MATLAB environment and Control System Toolbox and Optimization Toolbox in analysis and design of control systems.  Discrete control. Design, ladder diagram, functional diagram. Standard program languages of programmable logic controllers. Realization. | | | | | | | |

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| **Temeljni literatura in viri / Readings:** | | | | | |
| 1. B. Zupančič. Zvezni regulacijski sistemi 1. del, 2. izdaja, Univerza v Ljubljani, Fakulteta za elektrotehniko, 1996.  2. B. Zupančič. Zvezni regulacijski sistemi II. del, 2. izdaja, Univerza v Ljubljani, Fakulteta za elektrotehniko, 1995.  3. S. Strmčnik, R.Hanus, Đ. Juričić, R. Karba, Z. Marinšek, D.Murray-Smith, H. Verbruggen, B. Zupančič, Celostni pristop k računalniškemu vodenju procesov, 1. izdaja, Univerza v Ljubljani, Fakulteta za elektrotehniko, 1998.  4. R. C. Dorf, H. Bishop: Modern Control Systems, Pearson Education, Inc., Publishing As Pearson Prentice Hall, Tenth Edition, 2004.  5. B. C. Kuo, F. Golnaraghi: Automatic Control Systems, 7th Edition, Prentice Hall, 2004.  6. K. Ogata, Modern Control Engineering, 4th edition, Prentice Hall, 2002.  7. J. Stenerson, Fundamentals of programmable logic controllers, sensors, and communications, 3rd ed., Pearson Prentice Hall, 2004.  8. R. W. Lewis, Programming industrial control systems using IEC 1131-3, Revised ed., London, The Institution of Electrical Engineers, 1998**.** | | | | | |
| **Cilji in kompetence:** | |  | | **Objectives and competences:** | |
| podati zahtevnejše postopke pri načrtovanju PID regulacije,  podati večzančne regulacijske metode,  podati analizo in načrtovanje v frekvenčnem prostoru in s pomočjo diagrama lege korenov,  obravnava vodenja s programirljivimi logičnimi krmilniki | |  | | complex approaches to design of PID controllers,  multi-loop control methods,  analysis in frequency domain  control by programmable logic controllers | |
| **Predvideni študijski rezultati:** | | |  | **Intended learning outcomes:** | |
| Poglobljena znanja iz zveznega in diskretnega vodenja | | |  | Advanced knowledge of continuous and discrete control | |
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| **Metode poučevanja in učenja:** | | |  | **Learning and teaching methods:** | |
| Predavanja in laboratorijske vaje | | |  | Lectures and laboratory exercises | |
| **Načini ocenjevanja: pisno/ustno** | 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 | 10%  45%  45% | | | | 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. KARER, Gorazd, ŠKRJANC, Igor. Interval-model-based global optimization framework for robust stability and performance of PID controllers. *Applied soft computing*, ISSN 1568-4946. [Print ed.], 2015, vol. , str. 1-18.  2. PREGLEJ, Aleksander, REHRL, Jakob, SCHWINGSHACKL, Daniel, STEINER, Igor, HORN, Martin, ŠKRJANC, Igor. Energy-efficient fuzzy model-based multivariable predictive control of a HVAC system. *Energy and buildings*, ISSN 0378-7788. [Print ed.], Oct. 2014, vol. 82, str. 520-533.  3. ZDEŠAR, Andrej, CERMAN, Otta, DOVŽAN, Dejan, HUŠEK, Petr, ŠKRJANC, Igor. Fuzzy control of a helio-crane : comparison of two control approaches. *Journal of intelligent & robotic systems*, ISSN 0921-0296, Dec. 2013, vol. 72, no. 3/4, str. 497-515.  4. DOVŽAN, Dejan, ŠKRJANC, Igor. Control of mineral wool thickness using predictive functional control. *Robotics and computer-integrated manufacturing*, ISSN 0736-5845. [Print ed.], Jun. 2012, vol. 28, no. 3, str. 344-350.  5. OBLAK, Simon, ŠKRJANC, Igor. Continuous-time Wiener-model predictive control of a pH process based on a PWL approximation. *Chemical Engineering Science*, ISSN 0009-2509. [Print ed.], Mar. 2010, vol. 65, no. 5, str. 1720-1728. | | | | | |