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| **UČNI NAČRT PREDMETA / COURSE SYLLABUS** | | | | | | | | | | | | | | | | | |
| **Predmet:** | | | Modul C: Programirljivi krmilni sistemi | | | | | | | | | | | | | | |
| **Course title:** | | | Module C: Programmable 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 | | | | | Vse smeri | | | | | | | | 3. | | poletni | | |
| 1st cycle academic study programme Electrical Engineering | | | | | All fields | | | | | | | | 3. | | summer | | |
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| **Vrsta predmeta / Course type** | | | | | | | | | | | | Izbirni – splošni / elective general | | | | | |
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| **Univerzitetna koda predmeta / University course code:** | | | | | | | | | | | | 64139 | | | | | |
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| **Predavanja**  **Lectures** | **Seminar**  **Seminar** | | | **Vaje**  **Tutorial** | | | **Klinične vaje**  **work** | | | | **Druge oblike študija** | | | **Samost. delo**  **Individ. work** | |  | **ECTS** |
| **30** |  | | | **30** | | |  | | | |  | | | **65** | |  | **5** |
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| **Nosilec predmeta / Lecturer:** | | | | | David Nedeljković | | | | | | | | | | | | |
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| **Jeziki /**  **Languages:** | | **Predavanja / Lectures:** | | | | slovenski / Slovenian | | | | | | | | | | | |
| **Vaje / Tutorial:** | | | | slovenski / Slovenian | | | | | | | | | | | |
| **Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** | | | | | | | | |  | **Prerequisits:** | | | | | | | |
| Vpis v letnik študija. | | | | | | | | |  | Enrolment in the year of the course. | | | | | | | |
| **Vsebina:** | | | | | | | |  | | **Content (Syllabus outline):** | | | | | | | |
| Kratka zgodovina krmilij in predstavitev področij, kjer srečamo značilne krmilne naloge (industrija, energetika, promet...).  Pregled najpomembnejših logičnih funkcij kot gradnikov krmilij: binarne, pomnilne, časovne in števne.  Uporaba senzorjev in aktuatorjev: diskretnih, analognih; poudarek na tistih, ki jih najpogosteje srečamo v močnostni elektrotehniki.  Osnutek, projekt in razvoj krmilja na preprostejših zgledih. Ponazoritev krmilja s funkcijskim načrtom. Kombinacijska in koračna krmilja. Upoštevanje varnostnih zahtev.  Zasnova programirljivih krmilnikov, njihova zgradba in različne izvedbe strojne opreme. Vhodni in izhodni signali na krmilniku. Naslavljanje, podatkovni tipi. Princip obdelovanja uporabniškega krmilnega programa na krmilniku.  Načini pisanja uporabniškega krmilnega programa: ukazi, lestvični diagram, funkcijski načrt. Podrobna seznanitev z najpomembnejšimi ukazi in funkcijami.  Orodja za razvoj krmilnega programa in uporabniškega vmesnika. Sistemi SCADA.  Komunikacija med več krmilniki ter med krmilnikom in inteligentnimi perifernimi enotami. | | | | | | | |  | | A brief history of control systems.  Areas of programmable logic control application (industry, energetics, traffic...)  Fundamental and other logical functions: binary, memory, timer, counter.  Application of digital and analog sensors and actuators.  Flowchart and types of control: combination control, step control.  Safety measures.  Concepts and structures of PLCs. Input and output signals, addressing, data types.  Methods of user control software development: statement list (STL), ladder diagram (LAD), function block diagram (FBD). Most important instructions and functions.  Software development tools for user control program development and user interface design. Supervisory Control And Data Acquisition (SCADA) systems.  Communication among PLCs and other intelligent peripherals. | | | | | | | |

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| **Temeljni literatura in viri / Readings:** | | | | | |
| 1. Vanja Ambrožič, David Nedeljković: Uvod v programirljive krmilne sisteme, Univerza v Ljubljani, Fakulteta za elektrotehniko, 2011. 2. Hans Berger: Automating with SIMATIC : controllers, software, programming, data communication, operator control and process monitoring, Publicis Publishing, Erlangen, 2009. 3. Heinrich Lepers: SPS-Programmierung nach IEC 61131-3. Mit Beispielen für CoDeSys und Step 7, Franzis PC und Elektronik, 2007. 4. Vanja Ambrožič: Mikroračunalniki v močnostni elektroniki, Univerza v Ljubljani, Fakulteta za elektrotehniko, Ljubljana, 2001. 5. Hans Berger: Automating with STEP7 in STL and SCL, Publicis MCD Verlag, Erlangen, 2000. | | | | | |
| **Cilji in kompetence:** | |  | | **Objectives and competences:** | |
| Študent bo spoznal najpomembnejše gradnike krmilnih sistemov in njihove lastnosti. Za reševanje krmilnih nalog se bo naučil uporabljati sodobne programirljive krmilnike, za katere bo s pripadajočimi razvojnimi orodji izdelal krmilno programsko opremo in uporabniški vmesnik. S sistematičnim pristopom bo preprečil nastanek zastojev v krmiljenem procesu in vestno poskrbel za izpolnitev vseh varnostnih zahtev. Zavedal se bo nujnosti dobrega dokumentiranja, jasnega postavljanja zahtev in učinkovite komunikacije med sodelavci na projektu. | |  | | The student will learn about programmable control system components and their features. He will accomplish knowledge to solve control problems by using programmable logic controllers (PLCs), where proper hardware selection/configuration, control software development and user interface are needed.  With systematic approach he will reduce occurrence of deadlocks in controlled process and carefully address all safety issues. As well, student will become aware of necessity of clear requirements, perfect documentation and efficient communication among the project team. | |
| **Predvideni študijski rezultati:** | | |  | **Intended learning outcomes:** | |
| **Znanje in razumevanje:**  Študent se bo seznanil z gradniki krmilnih sistemov, razumel bo koncept programirljivih krmilnikov in njihove zmogljivosti, spoznal pa bo tudi različne načine razvoja krmilne programske opreme (nabor ukazov, lestvični diagram, funkcijski načrt).  **Uporaba:**  Pri avtomatizaciji tehnološkega procesa bo študent izbral ustrezno strojno opremo (programirljivi krmilnik s pripadajočimi moduli, senzorji in aktuatorji), glede na zahteve procesa z ustreznim razvojnim orodjem napisal pripadajoči krmilni program in izdelal uporabniški vmesnik za posluževanje procesa.  **Refleksija:**  Pri snovanju krmilnega sistema bo študent celovito in enoumno definiral zahteve v procesu, s čimer se proces izogne nepredvidenim zastojem zaradi pomanjkljivega krmilja. Odgovorno in z vso zavzetostjo bo na prvo mesto postavil zahteve glede varnosti.  **Prenosljive spretnosti:**  Študent se bo pri izvajanju laboratorijskih vaj navajal na sistematični pristop, ustrezno dokumentiranje idej in rešitev ter učinkovito komunikacijo z naročnikom (tehnologom), sodelavci in podizvajalci. Znanja, pridobljena pri tem predmetu, bo študent lahko nadgradil in uporabil za realizacijo najzahtevnejših krmilnih sistemov. | | |  | **Knowledge and understanding:**  The student will be acquainted with the elements of control systems. He/she will understand the concept of programmable logic controllers and their capabilities, as well as a variety of ways to develop control software (statement list, ladder diagram, function block diagram).  **Application:**  The student will choose the proper hardware (programmable controller with associated modules, sensors and actuators) for the automation of a technological process. According to the process requirements, he/she will write the corresponding control program using the appropriate development tools. To provide an efficient operation and supervision of the process, he/she will develop a suitable user interface (HMI).  **Reflection:**  In designing the control system, the student will carefully and unambiguously define the process requirements, thus avoiding some unforeseen delays due to deficient control. He/she will responsibly and with full commitment consider the safety requirements.  **Transferable skills:**  Through laboratory work, the student will accustom a systematic approach, appropriate documentation of ideas and solutions and effective communication with the client (technologists), co-workers and subcontractors. The student will be able to upgrade the knowledge, obtained within this course, for the realization of the most demanding control systems. | |
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| **Metode poučevanja in učenja:** | | |  | **Learning and teaching methods:** | |
| Predavanja (30 ur) in laboratorijske vaje (30 ur); opcija: projektno delo na nalogah, ki potekajo v Laboratoriju za regulacijsko tehniko in močnostno elektroniko. | | |  | Lectures (30 hours) and laboratory work (30 hours); optional: project work on R&D activities within the Laboratory of Control Engineering and Power Electronics. For foreign students: consultations in English and project work. | |
| **Načini ocenjevanja:** | Delež (v %) /  Weight (in %) | | | | **Assessment:** |
| Za pristop k izpitu mora kandidat imeti uspešno opravljene laboratorijske vaje in izdelano poročilo z le-teh.  Pisni in ustni izpit. Kandidat, ki na pisnem izpitu zbere vsaj 50 % možnih točk, lahko pristopi k ustnemu izpitu. Končna ocena se oblikuje na podlagi rezultata pisnega izpita in ustnega zagovora, pri čemer se upošteva tudi poročilo z laboratorijskih vaj.  Kandidatom, ki se vključijo v projektno delo in nalogo uspešno zaključijo, ni treba opravljati pisnega in ustnega izpita, temveč se jim ocena poda na podlagi njihovega angažiranja na projektu in pri tem osvojenih znanj.  Ocenjevalna lestvica:  nezadostno (od 1 do 5), zadostno (6), dobro (7), prav dobro (8), prav dobro (9), odlično (10). | Pisni izpit 50%, ustni izpit 50%  /  Written exam 50%, oral exam 50% | | | | The candidate can take the exam after accomplished laboratory work and written report on his/her laboratory work.  Written and oral exam. The candidate who passes the written exam with at least 50% of possible points can take the oral examination. The final assessment is based on the result of written examination and oral examination, taking into account the candidate's written report on the laboratory work.  The grade for the candidates involved in the project work that successfully accomplish their task can be formed on the basis of student's knowledge acquired during his/her engagement within the project.  Grading scale:  poor (1 to 5), adequate (6), good (7), very good (8), very good (9), excellent (10). |
| **Reference nosilca / Lecturer's references:** | | | | | |
| 1. KONTARČEK, Andraž, BAJEC, Primož, NEMEC, Mitja, AMBROŽIČ, Vanja, NEDELJKOVIĆ, David. Cost-effective three-phase PMSM drive tolerant to open-phase fault. IEEE transactions on industrial electronics, ISSN 0278-0046. [Print ed.], Nov. 2015, vol. 62, no. 11, str. 6708-6718.  2. SLADIĆ, Saša, SKOK, Srđan, NEDELJKOVIĆ, David. Efficiency considerations and application limits of single-phase active power filter with converters for photoenergy applications. International journal of photoenergy, ISSN 1110-662X, 2011, vol. 2011, str. 1-8.  3. AMBROŽIČ, Vanja, NEDELJKOVIĆ, David. Uvod v programirljive krmilne sisteme. 2. izd. Ljubljana: Fakulteta za elektrotehniko, 2011.  4. NEMEC, Mitja, DROBNIČ, Klemen, NEDELJKOVIĆ, David, FIŠER, Rastko, AMBROŽIČ, Vanja. Detection of broken bars in induction motor through the analysis of supply voltage modulation. IEEE transactions on industrial electronics, ISSN 0278-0046. [Print ed.], Aug. 2010, vol. 57, no. 8, str. 2879-2888.  5. NEDELJKOVIĆ, David, NASTRAN, Janez, VONČINA, Danijel, AMBROŽIČ, Vanja. Synchronization of active power filter current reference to the network. IEEE transactions on industrial electronics, ISSN 0278-0046. [Print ed.], 1999, vol. 46, no. 2, str. 333-339. | | | | | |