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| **UČNI NAČRT PREDMETA / COURSE SYLLABUS** | | | | | | | | | | | | | | | | | |
| **Predmet:** | | | Elektronika v avtomatiki | | | | | | | | | | | | | | |
| **Course title:** | | | Electronics in Automation | | | | | | | | | | | | | | |
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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:** | | | | | | | | | | | | 64131 | | | | | |
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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** |
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| **Nosilec predmeta / Lecturer:** | | | | | Boštjan Murovec | | | | | | | | | | | | |
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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):** | | | | | | | |
| Analogna elektronika senzorskih in vgrajenih sistemov.  Operacijski ojačevalniki in z njimi izvedena vezja analognega prevajanja in procesiranja signalov: napetostni primerjalnik, napetostni sledilnik, neinvertirajoči in invertirajoči napetostni ojačevalnik, seštevalnik, odštevalnik, instrumentacijski ojačevalnik, vezja za prilagajanje napetostnih območij, tokovno-napetostni pretvornik, dajalnik temenske napetosti, Schmittov prožilnik, izvedba napetostnih referenc. D/A in A/D pretvorniki: tipi in uporaba v vezjih. Upori, kondenzatorji, vgrajeni in parazitni RC in CR členi ter diode.  Vsa vezja so ilustrirana s primeri uporabe. Obravnava je izrazito neidealizirana, poudarjene so realne karakteristike in njihov parazitni vpliv na delovanje vezij. Neidealnosti so analizirane in ilustrirane s konkretnimi podatki proizvajalcev. Demonstrirane so razlike med izbranimi modeli operacijskih ojačevalnikov. Podan je zajem signalov napetostnih, tokovnih in uporovnih senzorjev na praktičnih primerih.  Celostno so obravnavane neidealnosti, ki največkrat otežujejo izvedbo preciznih senzorskih sistemov: napetostni premik, vhodni mirovni tok, tokovni premik, vhodna in izhodna notranja upornost, vpliv končnega ojačenja, frekvenčna meja, rejekcijski faktor, nestabilnost napajalne napetosti, omejena hitrost spreminjanja izhodne napetosti, vpliv kapacitivnosti bremena, lezenje, šum, temperaturne odvisnosti. Podani so principi kompenzacije napetostnega premika in vhodnih tokov ter večanje rejekcijskega faktorja. Obravnavana je uporaba dveh operacijskih ojačevalnikov v zanki in popravljanje frekvenčnih karakteristik. Pri neidealnostih AD in DA pretvornikov je poudarek na premiku ničle, premiku polnega območja, napaki ojačenja ter integralni in diferencialni nelinearnosti. Meritve spektrov signalov in opazovanje popačenj.  Analogne lastnosti digitalnih sklopov s poudarkom uporabe pri vgrajenih sistemih. Izhodna notranja upornost, vhodna notranja impedanca, poraba energije v povezavi s frekvenco preklopov, vpliv kapacitivnih bremen, tipi digitalnih izhodov (totem pole, open drain). Izvedbe oscilatorjev za mikroprocesorske sisteme. Analogna stikala in multiplekserji z uporabo in neidealnostmi.  Praktični vidiki realizacije vezij: problem neidealne mase in napajalnih linij, uporaba blokirnih kondenzatorjev, koncept in uporaba sponk FORCE, SENSE in REF, DC in AC sklopitev signalov, osnove linijskih pojavov. | | | | | | | |  | | Analog electronics for sensors and embedded systems.  Operational amplifiers and circuits for analog signal conditioning and processing: voltage comparator, voltage follower, inverting and non-inverting voltage amplifier, adder, subtractor, instrumentation amplifier, adjustment of voltage ranges, current-to-voltage converter, peak detector, Schmitt trigger, voltage references. D/A and A/D converters: types and their use in circuits. Resistors, capacitors, built-in and parasitic RC and CR combinations, diodes.  All circuits are illustrated with examples. Analyses and descriptions are highly non-idealized, and they highlight the real characteristics and their parasitic influence on the functioning of the circuits. Non-idealities are analyzed and illustrated with datasheets from manufacturers. Demonstrated are differences between the selected models of operational amplifiers. Described is capturing of signals from voltage, current and resistive sensors with practical examples.  Non-idealities, which tend to hamper precision sensor systems, are thoroughly analyzed: offset voltage, input bias current, input offset current, input and output internal resistances, impact of non-infinite amplification, frequency limit, common-mode rejection, unstable power supply, slew rate, impact of load capacitance, drift, noise, temperature dependence. Outlined are compensations of offset voltage and input bias current, presented are methods for increasing of common-mode rejection ratio. Explained is the use of two operational amplifiers in the loop and correction of frequency characteristics. The most thoroughly discussed non-idealities of AD and DA converters are zero and full-range offset, gain error, integral and differential non-linearity. Demonstrated are measurements of signals’ spectra and observations of distortion.  Analog characteristics of digital circuits with an emphasis on the use in conjunction with embedded systems: output resistance, input impedance, power consumption in conjunction with switching frequency, the influence of capacitive loads, types of digital outputs (totem pole, open drain). Oscillators for microprocessor systems. Analog switches and multiplexers together with their non-idealities.  Practical aspects of circuit realization: non-ideal ground and power lines, the use of blocking capacitors, the concept and use of connections FORCE SENSE and REF, DC and AC coupling, basics of transmission lines. | | | | | | | |

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| **Temeljni literatura in viri / Readings:** | | | | | |
| 1. Jung W. , Op Amp Applications Handobook, Analog Devices, 2005.  2. Kester W., The Data Conversion Handbook, Analog Devices, 2005.  3. Zumbahlen H., Linear Circuit Handbook, Analog Devices, 2008.  4. Kitchin C., Counts L., A Designer's Guide to Instrumentation Amplifiers (3rd edition), Analog Devices, 2006.  5. Toumazou C., Trade-offs in Analog Circuit Design, Kluwer Academic corp., 2002.  6. Horowitz P., Hill W., The Art of Electronics, Cambridge University Press, 1996.  7. Kordyban T., Hot Air Rises and Heat Sinks, ASME Press, 1998. | | | | | |
| **Cilji in kompetence:** | |  | | **Objectives and competences:** | |
| Osvojitev konceptov in delovanja analognih vezij, ki se uporabljajo pri realizaciji senzorskih in vgrajenih sistemov. Obravnava ni idealizirana, ampak so poudarjena odstopanja realnih karakteristik od idealiziranih ter s tem povezane težave, ki nastopajo v praksi. | |  | | Mastering the concepts and operation of analog circuits for realization of sensor and embedded systems. Treatment is highly non-idealized and with highlight on deviations from the idealized characteristics and the associated problems that occur in practice. | |
| **Predvideni študijski rezultati:** | | |  | **Intended learning outcomes:** | |
| Zasnova kakovostnih in robustnih vezij avtomatike, senzorskih in vgrajenih sistemov. Koncepti in temeljne zakonitosti prenosa in ojačevanja nizkofrekvenčnih električnih signalov. Prehod med digitalno in analogno obliko signalov ter s tem povezane težave. Seznanitev z neidealnostmi in njihovo odpravljanje. | | |  | The design of high-quality and robust automation circuits, sensors and embedded systems. Concepts and basic rules of conditioning and processing of low-frequency sensor signals. The transition between digital and analog signals as well as related problems. Acquaintance with non-idealities and their handling. | |
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| **Metode poučevanja in učenja:** | | |  | **Learning and teaching methods:** | |
| Teoretično znanje obravnavane tematike pridobijo študenti na predavanjih, ki so vsebinsko tesno povezana z vajami. V okviru vaj študenti v praksi spoznajo reprezentativne primere obravnavanih vezij, njihove lastnosti in neidealnosti. | | |  | Lectures give students theoretical knowledge. Laboratory courses are tightly coupled with lectures, and give true hands-on experience of the lectured topics. Demonstrated is the working of discussed circuits, their non-idealities and methods for their handling. | |
| **Načini ocenjevanja:** | Delež (v %) /  Weight (in %) | | | | **Assessment:** |
| Pogoj za pristop k izpitu so opravljeni izpiti Osnove elektrotehnike I in II, Polprevodniška elektronika ter pozitivna skupna ocena tedenskih kolokvijev, na katerih se preverja snov predavanj v povezavi z vajami. Ocene so 6-10 (pozitivno) oziroma 1-5 (negativno).  Izpit je sestavljen iz pisnega in ustnega dela. ki je zopet ocenjevan z oceno 6-10 (pozitivno) oziroma 1-5 (negativno). Končna ocena je sestavljena iz povprečne ocene kolokvijev ter uspeha na pisnem in ustnem izpitu. V primeru solidnega razumevanja snovi na ustnem izpitu se končna ocena ustrezno poveča. V primeru negativno ocenjenega izpita ostane pozitivna ocena kolokvijev veljavna.  Ocenjevalna lestvica: nezadostno (od 1 do 5), zadostno (6), dobro (7), prav dobro (8), prav dobro (9), odlično (10).  Prispevki k oceni:  pisni izpit: 50 %  ustni izpit: 50% | 50%  50% | | | | A passed exam of Fundamentals of electrical engineering I and II, and Semiconductor electronics are prerequisites for the exam.  Before taking an exam students must achieve a cumulative positive assessment of weekly colloquia, in order to verify the comprehension and understanding of lectures in combination with exercises. Ratings are 6-10 (positive) or 1-5 (negative).  Exam consists of a written and an oral part, which again is measured by assessing grades 6-10 (positive) or 1-5 (negative). The final score is the average grade of colloquia and success in the written and oral examination. A solid understanding of the topics in the oral exam results in grade increase. In the case of a negative exam score the positive grades of colloquia remain valid.  Grading scale: insufficient (1 to 5), adequate (6), good (7), very good (8), very good (9), excellent (10).  Contributions to final grade:  written exam: 50 %  oral examination: 50 % |
| **Reference nosilca / Lecturer's references:** | | | | | |
| 1. MUROVEC, Boštjan, PERŠ, Janez, MANDELJC, Rok, SULIĆ KENK, Vildana, KOVAČIČ, Stanislav. Towards commoditized smart-camera design. Journal of Systems Architecture, ISSN 1383-7621, Nov. 2013, no. 10, part A, str. 847-858.  2. MUROVEC, Boštjan, KOCIJANČIČ, Slavko. A USB-based data acquisition system designed for educational purposes. The international journal of engineering education, ISSN 0949-149X, 2004, vol. 20, no. 1, str. 24-30.  3. MOČNIK, Jure, GORNIK, Miha, MUROVEC, Boštjan, ŽEMVA, Andrej. A concept to optimize power consumption in smart homes based on demand-side management and using smart switches. Elektrotehniški vestnik, ISSN 0013-5852, 2013, letn. 80, št. 5, str. 217-221.  4. MUROVEC, Boštjan, TIEDJE, James M., STRES, Blaž. DNA encoding for an efficient 'Omics processing. Computer methods and programs in biomedicine, ISSN 0169-2607, 2010, vol. 100, no. 2, str. 175-190.  5. NAGODE, Klemen, MUROVEC, Boštjan. A complex hydro-power plant dynamic model integrated into the electrical network. *Elektrotehniški vestnik*, ISSN 0013-5852, 2015, letn. 82, št. 4, str. 183-190. | | | | | |