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| **UČNI NAČRT PREDMETA / COURSE SYLLABUS** | | | | | | | | | | | | | | | | | |
| **Predmet:** | | | Merilna dinamika in tehnike elektromagnetne kompatibilnosti | | | | | | | | | | | | | | |
| **Course title:** | | | Measurement dynamics and techniques of electromagnetic compatibility | | | | | | | | | | | | | | |
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| **Študijski program in stopnja**  **Study programme and level** | | | | | **Študijska smer**  **Study field** | | | | | | | | **Letnik**  **Academic year** | | **Semester**  **Semester** | | |
| doktorski študijski program tretje stopnje Elektrotehnika | | | | | Ni smeri | | | | | | | | 1 | |  | | |
| 3rd cycle: doctoral study programme Electrical Engineering | | | | |  | | | | | | | | **1** | |  | | |
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| **Vrsta predmeta / Course type** | | | | | | | | | | | | Izbirni / Elective | | | | | |
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| **Univerzitetna koda predmeta / University course code:** | | | | | | | | | | | | 64870 | | | | | |
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| **Predavanja**  **Lectures** | **Seminar**  **Seminar** | | | **Vaje**  **Tutorial** | | | **Klinične vaje**  **work** | | | | **Druge oblike študija** | | | **Samost. delo**  **Individ. work** | |  | **ECTS** |
| **30** | **60** | | |  | | |  | | | |  | | | **35** | |  | **5** |
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| **Nosilec predmeta / Lecturer:** | | | | | Izr. prof. dr. Dušan Agrež | | | | | | | | | | | | |
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| **Jeziki /**  **Languages:** | | **Predavanja / Lectures:** | | | | slovenski/Slovene  angleški/English | | | | | | | | | | | |
| **Vaje / Tutorial:** | | | |  | | | | | | | | | | | |
| **Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** | | | | | | | | |  | **Prerequisits:** | | | | | | | |
| Vpis v doktorski študij.  Obveznih pogojev ni. Priporočeno predznanje obsega osnovno poznavanje s področja meritev, merilne instrumentacije ter osnov sistemov in signalov. | | | | | | | | |  | Enrolment in the program.  There are no compulsory prerequisites. Recommended prior knowledge comprises basic topics of measurements, measurement systems, and fundamentals of the system theory and signals. | | | | | | | |
| **Vsebina:** | | | | | | | |  | | **Content (Syllabus outline):** | | | | | | | |
| Amplitudna in časovna dinamika posplošenega merilnega kanala: prireditev signala, vzorčenje in kvantizacija. Principa nedoločenosti: časovno-frekvenčni, amplitudno-časovni. Princip končnega upadanja signalov in učinek iztekanja. Analiza značilnih vrednosti merilnih signalov in sistemov v časovnem, frekvenčnem in informacijskem prostoru. Merjenje in vrednotenje osnovnih parametrov periodičnih signalov (frekvence, amplitude in faze) v časovnem in frekvenčnem prostoru ob prisotnost šuma in primerjava merilnih negotovosti s teoretično dosegljivimi Cramer-Rao mejami.  Elektromagnetna kompatibilnost sistema, izvori in odpravljanje motilnih signalov. Obravnava občutljivosti procesnih merilnih sistemov na merilne, vplivne in motilne veličine. Vrste motenj in mehanizmi vnosa v merilni krog, galvanski vnos, kapacitivni, induktivni in elektromagnetni vnos. Ukrepi za izboljšanje odziva merilnih sistemov z aparaturno in programsko opremo z upoštevanje merilne dinamike. Ukrepi z aparaturno opremo: oblikovanje odzivov vhodnih stopenj, simetriranje, oklaplanje in ozemljevanje elementov merilnega sistema. Ukrepi z obdelavo signalov: filtriranje, postopki povprečenja, uporaba modulacije in analiza z DFT.  Izbrana poglavja iz dinamike aparaturne in programska opreme za pridobivanje, pretvorbo in ovrednotenje procesnih veličin. Avtomatsko zajemanje merilnih podatkov in predelava ter vrednotenje z računalniki. | | | | | | | |  | | Amplitude and time dynamics of the generalized measurement channel: signal conditioning, sampling, and quantization. Uncertainty principles: the time-frequency uncertainty and the time-amplitude uncertainty. The principle of the limited signal decreasing and leakage effect. Analysis of the characteristic parameters of the measurement signals and systems in the time, frequency, and information domain. Measurement and estimation of the basic periodic parameters (frequency, amplitude, and phase) in the time and frequency domain in the presence of noise. Comparison of the measurement uncertainties with the theoretically achievable Cramér-Rao bounds.  Electromagnetic compatibility of system, sources and suppression of disturbances. The process measurement system sensitivity to measurement, influence, and disturbance quantities. Coupling mechanisms to external sources: galvanic, capacitive, inductive, and electromagnetic coupling. Methods of improving the response of the measurement systems with hardware and software. Hardware approach: shape the impulse response of the front stages, symmetry of the inputs, shielding and grounding in the measurement systems. Software approach: filtering, averaging, modulation, and analysis with discrete Fourier transformation.  Selected topics on hardware and software dynamics for acquisition, conversion and estimation of the process quantities. Automatic acquisition of the measurement data and their processing with computers. | | | | | | | |

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| **Temeljni literatura in viri / Readings:** | | | | | |
| [1] A. V. Oppenheim, A. S. Willsky, S. Hamid, Signals and Systems (2nd Edition), Pearson Education Lim. 2014.  [2] J. Štremfelj, D. Agrež, "'Nonparametric estimation of power quantities in the frequency domain using Rife-Vincent windows", *IEEE Transactions on Instrumentation and Measurement*, vol. 62, no. 8, pp. 2171-2184, Aug. 2013.  [3] F. J. Harris, "On the Use of Windows for Harmonic Analysis with the Discrete Fourier Transform", Proceedings of the IEEE, vol. 66, no. 1, pp. 51-83, January 1978.  [4] B. Widrow, I. Kollar, Quantization Noise, Cambridge University Press, Cambridge, New York, 2008.  [5] H. W. Ott, Electromagnetic Compatibility Engineering, John Willey&Sons, 2009.  [6] J.G. Webster, H. Eren, Measurement, Instrumentation, and Sensors Handbook, Second Edition: Two-Volume Set, CRC, Springer, IEEE Press, 2014. | | | | | |
| **Cilji in kompetence:** | |  | | **Objectives and competences:** | |
| Poglobiti znanje in seznaniti študente z najnovejšimi spoznanji s področja merilne dinamike ter možnostmi zmanjšanja vpliva motenj v merilnih sistemih in s tem izboljšati elektromagnetno kompatibilnost. | |  | | To upgrade the knowledge of the measurement science and introduce students to the state-of-the-art topics of the measurement dynamics. Provide approaches how to reduce the disturbances in the measurement systems and improved electromagnetic compatibility. | |
| **Predvideni študijski rezultati:** | | |  | **Intended learning outcomes:** | |
| Razumevanje zakonitosti merilne dinamike in možnosti izboljšanja merilnega rezultata z obdelavo signalov.  Razumevanje problematike elektromagnetne kompatibilnosti in zmanjševanje motilnih signalov v merilnih sistemih. | | |  | Understanding of fundamentals of measurement dynamics and possibilities of improving the measurement result by signal processing.  Understanding of electromagnetic compatibility and suppression of disturbind signals in the measuring systems. | |
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| **Metode poučevanja in učenja:** | | |  | **Learning and teaching methods:** | |
| Predavanja, seznanjanje s teoretičnimi osnovami merilne dinamike s pomočjo analize prispevkov aktualnih referenc v obliki seminarskih nalog, v drugem delu tudi reševanje kompleksnejše naloge v obliki projektnega dela na fakulteti, raziskovalnem inštitutu ali podjetju. Za specifična področja, sodelovanje z mednarodno priznanimi strokovnjaki na tem področju v okviru mednarodne organizacije IMEKO - International Measurement Confederation (sekcija TC4 – Merjenje električnih veličin). | | |  | Lectures, an introduction to theoretical basis of measurement dynamics and electromagnetic compatibility with analysis of actual papers and books in the form of seminar work. In the second part, solving of more complex problem in the project work on faculty, research institute or company. For specific topics, possible collaboration with experts in this field under international organization IMEKO - International Measurement Confederation (section TC4 – Measurement of electrical quantities). | |
| **Načini ocenjevanja:** | Delež (v %) /  Weight (in %) | | | | **Assessment:** |
| * Pisni in ustni izpit * ali seminar na koncu semestra predstavitev rezultatov dela na način, ki je uveljavljen na mednarodnih strokovnih konferencah. | **50%**  **50%** | | | | * Writing and oral examination * or seminar work with presentation of results at the end of semester in the way, which is a standard for presentation on international conferences. |
| **Reference nosilca / Lecturer's references:** | | | | | |
| Agrež D (2002) Weighted multi-point interpolated DFT to improve amplitude estimation of multi-frequency signal. IEEE Trans. Instrum. Meas. 51(2): 287-292  Agrež D (2007) Dynamics of frequency estimation in the frequency domain. IEEE Trans. Instrum. Meas. 56(6): 2111-2118  Agrež D (2011) Estimation of parameters of the weakly damped sinusoidal signals in the frequency domain. Comp. Stand. & Inter. 33(2): 117-121  Štremfelj J, Agrež D (2013) Nonparametric estimation of power quantities in the frequency domain using Rife-Vincent windows. IEEE Trans. Instrum. Meas. 62(8): 2171-2184  Agrež D (2014) A/D Conversion with non-uniform differential quantization. In: P.Carbone et all (eds.) Design, Modeling and Testing of Data Converters, Springer-Verlag Berlin Heidelberg, pp. 277-306 | | | | | |