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| **UČNI NAČRT PREDMETA / COURSE SYLLABUS** | | | | | | | | | | | | | | | | | |
| **Predmet:** | | | Povečanje prenosne zmogljivosti elektroenergetskega sistema | | | | | | | | | | | | | | |
| **Course title:** | | | Increasing Power System Transmission Capacity | | | | | | | | | | | | | | |
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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 | | | | | Vse smeri | | | | | | | | 2 | | 1 | | |
| 2nd cycle masters study programme in Electrical Engineering | | | | | All study fields | | | | | | | | 2 | | 1 | | |
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| **Vrsta predmeta / Course type** | | | | | | | | | | | | Izbirni-splošni /elective general | | | | | |
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| **Univerzitetna koda predmeta / University course code:** | | | | | | | | | | | | 64309 | | | | | |
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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:** | | | | | Rafael Mihalič | | | | | | | | | | | | |
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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 predmeta | | | | | | | | |  | Enrolment in the year of the course | | | | | | | |
| **Vsebina:** | | | | | | | |  | | **Content (Syllabus outline):** | | | | | | | |
| Trendi razvoja sodobnih elektroenergetskih sistemov, problem ozkih grl v sistemu ENTSO-E, tehnične omejitve pri prenosu električne energije na dolge razdalje ter primerjava med parametri izmeničnega in enosmernega prenosa, povečanje prenosne zmogljivosti EES s sodobnimi koncepti, primeri preteklih neželenih dogodkov v EES in možne poti za preprečitev tovrstnih scenarijev, koncept fleksibilnega prenosnega sistema (FACTS), naprave FACTS - splošni principi, 1. generacija naprav FACTS, 2. generacija naprav FACTS, Paralelne naprave FACTS, serijske naprave FACTS, kombinirane naprave FACTS, visokonapetostni enosmerni prenos (HVDC), vpliv naprav FACTS na obratovalne parametre EES, možnosti aplikacij (dinamično preusmerjanje pretokov moči, dušenje nihanj, povečanje kotne stabilnosti, regulacija napetosti, preprečevanje napetostnega zloma), modeli naprav FACTS za potrebe izračunov pretokov moči, modeli naprav FACTS za uporabo v direktnih metodah za oceno stabilnosti in modeli naprav FACTS za simulacijo dinamičnih pojavov v EES. | | | | | | | |  | | Development concepts of modern electrical power systems (EPS), transmission congestion issues in ENTSO-E interconnection, technical limitations in long-distance electrical energy transmission, comparison between alternating current (AC) and direct current (DC) transmission, increasing EPS transmission capacity by following modern concepts, examples of past EPS events/disturbances with high impact on EPS operation and introduction of possibilities for their avoidance, Flexible AC Transmission System (FACTS) concept, FACTS devices – basic principles, first generation of FACTS devices, second generation of FACTS devices, shunt FACTS devices, series FACTS devices, combined series-shunt FACTS devices, high voltage direct current (HVDC) transmission, impact of FACTS devices on EPS operational parameters, FACTS applicability (dynamic load-flow control, oscillation damping, transient stability enhancement, voltage control, voltage collapse prevention), modelling of FACTS devices for load-flow studies, modelling of FACTS devices for direct stability assessment methods, modelling of FACTS devices for dynamic EPS phenomena studies. | | | | | | | |

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| **Temeljni literatura in viri / Readings:** | | | | | |
| 1. Flexible ac transmission systems (FACTS) / edited by Yong Hua Song and Allan T. Johns. – London : IEE, cop. 1999. – (IEE power and energy series ; Vol. 30). 2. E. Acha, C. R. Fuerte-Esquivel, H. Amirez-Perez, C. Angeles-Camacho: "FACTS - Modelling and Simulation in Power Networks", John Wiley & Sons, Chichester 2004. 3. Kalyan K. Sen, Mey Ling Sen: "Introduction to Facts controllers, IEEE Press, 2009. 4. Naran G. Hingorani, Laszlo Gyugyi: "Understanding FACTS", IEEE PRESS, New York 1999 | | | | | |
| **Cilji in kompetence:** | |  | | **Objectives and competences:** | |
| Poznavanje omejitev pri prenosu električne energije,  poznavanje osnovnih konceptualnih razlik med konceptoma prenosa električne energije preko izmeničnega oz. enosmernega prenosnega sistema (prednosti, slabosti, posebnosti enega, glede na drugega),  poznavanje konceptov in načinov usmerjanja pretokov moči po elektroenergetskem sistemu,  poznavanje koncepta FACTS. | |  | | Being familiar with and understanding the limitations of electrical energy transmission,  knowing basic conceptual differences between direct current (DC) and alternating current (AC) transmission: pros and cons, specifics of both concepts,  being acquainted with load-flow control possibilities in electric power systems and  Flexible AC transmission system concept. | |
| **Predvideni študijski rezultati:** | | |  | **Intended learning outcomes:** | |
| Slušatelj se seznani z omejitvami pri prenosu električne energije na dolge razdalje oz. skozi velike EES in z osnovnimi splošnimi koncepti razvoja sodobnih elektroenergetskih sistemov. Na konkretnih primerih iz preteklosti (razpadi sistemov) in ob predstavitvi osnovnih fizikalnih hipotetičnih možnosti za preprečitev tovrstnih dogodkov bo podana motivacija za analizo naprav, s katerimi bi lahko te možnosti udejanili (naprave FACTS). Slušatelj bo seznanjen z osnovnimi koncepti različnih tipov in različnih generacij naprav FACTS. Pri tem bo poudarek na tem, kako EES "čuti" take naprave in kaj ter na kak način (osnovni principi regulacije) je z njimi v EES možno doseči določene cilje. Ker gre za novo tehnologijo in predstavlja ustrezno modeliranje naprav FACTS velikokrat problem, bo poudarek na njihovem modeliranju pri analizi stanj v EES. | | |  | Student gets acquainted with long-distance transmission limitations that occur in EPS and basic principles of development of modern EPS. Based on actual past EPS events (blackouts) and assumptions of availability of hypothetical possibilities for blackout mitigation the motivation for studying appropriate devices (FACTS) that might be useful in the process of avoiding blackout is provided. Student becomes familiar with the concept of basic types and generations of FACTS devices. The mains stress is put on EPS’s point of view in the context of possible impacts of different FACTS devices control. Focus is put on FACTS devices modelling for different types of EPS studies, as FACTS is considered as relatively new technology. | |
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| **Metode poučevanja in učenja:** | | |  | **Learning and teaching methods:** | |
| Predavanja in laboratorijske vaje | | |  | Lectures and practical laboratory courses | |
| **Načini ocenjevanja:** | 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 | 50%  25%  25% | | | | 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. MIHALIČ, Rafael, GABRIJEL, Uroš. A structure-preserving energy function for a static series synchronous compensator. *IEEE transactions on power systems*, ISSN 0885-8950. [Print ed.], vol. 19, no. 3, str. 1501-1507. 2. MIHALIČ, Rafael, POVH, Dušan, ŽUNKO, Peter. Transient stability control. V: SONG, Yong Hua (ur.), JOHNS, Allan T. (ur.). *Flexible ac transmission systems (FACTS)*, (IEE power and energy series, Vol. 30). London: IEE, cop. 1999, str. 443-505. 3. AŽBE, Valentin, MIHALIČ, Rafael. The control strategy for an IPFC based on the energy function. *IEEE transactions on power systems*, ISSN 0885-8950. [Print ed.], nov. 2008, vol. 23, no. 4, str. 1662-1669. 4. AŽBE, Valentin, GABRIJEL, Uroš, POVH, Dušan, MIHALIČ, Rafael. The energy function of a general multimachine system with a unified power flow controller. *IEEE transactions on power systems*, ISSN 0885-8950. [Print ed.], aug. 2005, vol. 20, no. 3, str. 1478-1485. 5. GAŠPERIČ, Samo, MIHALIČ, Rafael. The impact of serial controllable FACTS devices on voltage stability. *International journal of electrical power & energy systems*, ISSN 0142-0615. [Print ed.], Jan. 2015, vol. 64, str. 1040-1048. | | | | | |