

UČNI NAČRT PREDMETA / COURSE SYLLABUS

Predmet:	Več-antenski sistemi
Course title:	Multiple-Antenna Systems

Študijski program in stopnja Study programme and level	Modul Module	Letnik Academic year	Semester Semester
Informacijske in komunikacijske tehnologije, 3. stopnja	Komunikacijske tehnologije	1	1
Information and Communication Technologies, 3 rd cycle	Communication Technologies	1	1

Vrsta predmeta / Course type Izbirni / Elective

Univerzitetna koda predmeta / University course code: IKT3-649

Predavanja Lectures	Seminar Seminar	Sem. vaje Tutorial	Lab. vaje Laboratory work	Druge oblike	Samost. delo Individ. work	ECTS
15	15			15	105	5

**Navedena porazdelitev ur velja, če je vpisanih vsaj 15 študentov. Drugače se obseg izvedbe kontaktnih ur sorazmerno zmanjša in prenese v samostojno delo. / This distribution of hours is valid if at least 15 students are enrolled. Otherwise the contact hours are linearly reduced and transferred to individual work.*

Nosilec predmeta / Lecturer: Prof. dr. Tomaž Javornik

Jeziki / Predavanja / Lectures: Slovenščina, angleščina / Slovenian, English
Languages: Vaje / Tutorial:

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:

Zaključen študij druge stopnje s področja informacijskih ali komunikacijskih tehnologij ali zaključen študij druge stopnje na drugih področjih z znanjem osnov s področja predmeta. Potrebna so tudi osnovna znanja matematike, računalništva in informatike.

Prerequisites:

Completed second cycle studies in information or communication technologies or completed second cycle studies in other fields with knowledge of fundamentals in the field of this course. Basic knowledge of mathematics, computer science and informatics is also requested.

Vsebina:

Osnove razširjanja radijskih valov:
 Osnovni mehanizmi razširjanja, več-potno razširjanje, presih, ozkopasovni in širokopasovni modeli radijskega kanala, profil zakasnitve moči, koherentna pasovna širina, Dopplerjeva razširitev, kotna razpršitev
 Pametne antene:
 antene s preklapljanjem snopa, prilagodljive antenske skupine, prostorsko porazdeljeni sodostop (SDMA), algoritmi za prilagajanje

Content (Syllabus outline):

Basics of radio wave propagation:
 basic propagation mechanisms, multipath propagation, fading, narrow band and broad band radio channel models, power delay profile, coherence bandwidth, Doppler spread, angular dispersion.
 Smart antennas:
 switched beam antennas, adaptive array antennas, space division multiple access (SDMA), algorithms for adaptation of antenna

uteži anten, algoritem MUSIC, uporaba pametnih anten

Sistemi MIMO z več vhodi in več izhodi: kanal MIMO, kapaciteta sistemov MIMO, prostorsko časovne kode, prostorsko časovno multipleksiranje

Porazdeljeni več-uporabniški in več-antenski sistemi:
porazdeljeni kanal MIMO, kanal z razpršeno oddajo in kanal s sodostopom uporabnikov (MAC), sodelujoči sistemi MIMO

Pregled več-antenskih sistemov v komunikacijskih sistemih 4G in naslednji generaciji: masivni MIMO, LTE kooperativni MIMO, CoMP, LTE Rele

weights, MUSIC algorithm, applications of smart antennas.

Multiple input multiple output MIMO systems: MIMO channel, capacity of MIMO systems, space time codes, space time multiplexing.

Distributed multi-user and multiple antenna systems:
distributed MIMO channel, broadcast channel (BC) vs multiple access channel (MAC), cooperative MIMO systems.

Overview of multi-antenna systems in 4G and beyond:
massive MIMO, LTE cooperative MIMO, CoMP,Relay

Temeljni literatura in viri / Readings:

Izbrana poglavja iz naslednjih knjig: / Selected chapters from the following books:

- S. Saunders, A. Zavala, *Antennas and Propagation for Wireless Communication Systems*, 2nd Edition, A John Wiley and Sons Ltd, 2007. ISBN 978-0-470-84879-0
- A. F. Molisch, *Wireless Communications*, John Wiley & Sons, Chichester, West Sussex, 2010. ISBN 978-0-470-74186-3
- C. Johnson, *Long Term Evolution in Bullets*, Johnson, 2012, ISBN 1478166177
- A. Paulraj, R. Nabar, D. Gore, *Introduction to space-time wireless communications*, Cambridge University Press, 2003. ISBN 0-521-82615-2
- C. A. Balanis, P. I. Ioannides, *Introduction to Smart Antennas*, Morgan & Claypool Publishers, Jan 1, 2007 - Technology & Engineering, ISBN 1598291769

Cilji in kompetence:

Cilj predmeta je posredovati študentom obstoječa znanja iz sodobnih več-antenskih telekomunikacijskih sistemov.

Študenti bodo seznanjeni z osnovnimi in z naprednimi koncepti pametnih anten, sistemov MIMO, vključno s prostorsko časovnim kodiranjem in prostorsko časovnim multipleksiranjem, s porazdeljenimi več uporabniškimi in več-antenskimi sistemi. Prikazali bomo tudi uporabo več-antenskih sistemov v sodobnih komunikacijskih sistemih.

Študenti bodo razvili sposobnost samostojnega raziskovalnega in razvojnega dela na področju več-antenskih sistemov, ki vključuje načrtovanje in preskušanje sistemov ter vrednotenje delovanja več-antenskih sistemov

Objectives and competences:

The objective of the course is to deliver to the students the existing knowledge of advanced multi antenna telecommunication systems.

Students will be acquainted with the fundamental and advanced concepts of the smart antennas, MIMO systems including space time coding and space time multiplexing, distributed multi-user and multiple antenna systems. At the end the applications of multiple antenna approach in communication systems are shown.

Students will develop the ability to solve independent research and development tasks in the field of advanced multiple antenna systems, including system design and testing, and system performance evaluation.

Predvideni študijski rezultati:

Študent, ki bo uspešno končal ta predmet, bo pridobil:

- znanja in razumevanje sodobnih in bodočih več-antenskih sistemov
- pregled novih konceptov in pristopov na področju več-antenskih sistemov
- sposobnost izbire ustreznega več-antenskega sistema glede na zahtevano zanesljivost in kapaciteto sistema ter razmere v radijskem kanalu
- pregled stanja raziskav in razvoja na področju več-antenskih komunikacijskih sistemov

Intended learning outcomes:

Students who complete this course successfully will acquire:

- knowledge and understanding of existing and future multiple antenna systems
- overview of new concepts and approaches in the field of multiple antenna systems
- the ability to choose the multiple antenna system according to required system reliability and its capacity, according to the conditions in radio channel.
- state-of-the-art in research, design and development of multiple antenna systems

Metode poučevanja in učenja:

Predavanja, seminar, konzultacije, individualno delo

Learning and teaching methods:

Lectures, seminar, consultancy, individual work

Načini ocenjevanja:	Delež (v %) / Weight (in %)	Assessment:
Seminarska naloga	50 %	Seminar work
Ustni zagovor seminarske naloge	50 %	Oral defense of seminar work

Reference nosilca / Lecturer's references:

- A. Hrovat, G. Kandus, **T. Javornik**, "A survey of radio propagation modeling for tunnels", *IEEE Communications surveys and tutorials*, vol. 16, no. 2, pp. 658-669, 2014
- M. Pesko, **T. Javornik**, L. Vidmar, A. Košir, M. Štular, M. Mohorčič, "The indirect self-tuning method for constructing radio environment map using omnidirectional or directional transmitter antenna", *EURASIP Journal on wireless communications and networking*, ISSN 1687-1499, [in press] 2015
- T. Celcer, G. Kandus, **T. Javornik**, "Adaptive utility-based scheduling algorithm for multiuser MIMO uplink", *EURASIP Journal on wireless communications and networking*, vol. 2011, no. 22, pp. 1-12, 2011
- A. Hrovat, G. Kandus, **T. Javornik**, "Four-slope channel model for path loss prediction in tunnels at 400 MHz". *IET Microwaves, Antennas & Propagation*. vol. 4, no. 5, pp. 571-582, 2010
- I. Jelovčan, G. Kandus, **T. Javornik**, "An adaptive zero forcing 2010, maximum likelihood soft input soft output MIMO detector", *IEICE Transactions on Communications*. vol. E92-B, no. 2, pp. 507-515. 2009