FACULTY OF ELECTRICAL ENGINEERING

BANJA LUKA

X International Symposium

INDUSTRIAL ELECTRONICS

INDEL – 2014

SYMPOSIUM PROGRAM

Banja Luka

November 6-8, 2014

Organized by

FACULTY OF ELECTRICAL ENGINEERING
BANJA LUKA
Patre 5
78000 Banja Luka
Republika Srpska
Bosnia and Herzegovina
www.etfbl.net

Under the auspices of
Ministry of Science and Technology, Republic of Srpska Government

Technical co-sponsor
The Institute of Electrical and Electronics Engineers - IEEE

Symposium Chairman

Branko Dokić, University of Banja Luka, Banja Luka, Republic of Srpska, Bosnia and Herzegovina

Program Committee

Dimitar Alexiev, Technical University of Sofia, Bulgaria
Goce Arsov, University St. Cyril and Methodius, Skopje, Macedonia
Zdenka Babić, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Narcis Behlilović, University of Sarajevo, Federation of Bosnia and Herzegovina, Bosnia and Herzegovina
Petar Biljanović, University of Zagreb, Croatia
Branko Blanuša, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Milorad Božić, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Dražen Brđanin, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Zlatko Bundalo, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Branko Dokić, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Gordana Gardašević, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Cvetan Gavrovski, University St. Cyril and Methodius, Skopje, Macedonia
Vladimir Katić, University of Novi Sad, Serbia
Tom Kazmierski, University of Southampton, United Kingdom
Branko Kovačević, University of Belgrade, Serbia
Igor Krčmar, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Božidar Krstajić, University of East Sarajevo, Republic of Srpska, Bosnia and Herzegovina
Mirza Kušljugić, University of Tuzla, Federation of Bosnia and Herzegovina, Bosnia and Herzegovina
Vančo Litovski, Nis Cluster of Advanced Technologies, Serbia
Duško Lukač, University of Applied Sciences, Koeln, Germany
Danilo Mandić, Imperial College, London, United Kingdom
Dragan Mančić, University of Niš, Serbia
Darko Marčetić, University of Novi Sad, Serbia
Petar Marić, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Slavko Marić, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Petar Matić, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Octavio Nieto-Taladriz Garcia, Polytechnic University of Madrid, Spain
Vojin Oklobdžija, New Mexico State University, Las Cruces, New Mexico, USA
Predrag Pejović, University of Belgrade, Serbia
Tatjana Pešić-Brđanin, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Predrag Petković, University of Niš, Serbia
Nikola Rajaković, University of Belgrade, Serbia
Predrag Rapajić, University of Greenwich, London, United Kingdom
Miran Rodič, University of Maribor, Slovenia
Ferid Softić, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Goran Stojanović, University of Novi Sad, Serbia
Milić Stojić, University of Belgrade, Serbia
Nikola Teslić, University of Novi Sad, Serbia
Slobodan Vukosavić, University of Belgrade, Serbia
Čedomir Zeljković, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Volker Zerbe, University of Applied Sciences of Erfurt, Germany
Miloš Živanov, University of Novi Sad, Serbia

Organizing Committee

Branko Dokić, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Petar Marić, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Zoran Đurić, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Tatjana Pešić-Brđanin, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Igor Radojičić, National Assembly of the Republic of Srpska, Bosnia and Herzegovina
Duško Torbica, ELNOS, Republic of Srpska, Bosnia and Herzegovina
Dragan Praštalo, Mikroelektronika, Republic of Srpska, Bosnia and Herzegovina
Dragoljub Davidović, The union of energy professionals of Republic of Srpska, Bosnia and Herzegovina
Željko Jungić, Adviser to the Director of strategy department at Telekom Srpske a.d., Republic of Srpska, Bosna and Herzegovina
Branko Blanuša, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Petar Matić, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Igor Krčmar, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Čedomir Zeljković, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Željko Ivanović, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Mladen Knežić, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina

Technical Secretaries

Đorđe Lekić, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Predrag Mršić, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Vanja Todorović, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Milosava Radonjić, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina
Bojana Trbić, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina

www.indel.etfbl.net
indel@etfbl.net

Plenary session

Friday, November 7, 2014, 10:00, Room 110
Co-chairs: Tom Kazmierski and Predrag Pejović

Tamás Ruzsányi

NEW GENERATION OF PUBLIC TRANSPORT VEHICLES FOR REPLACING DIESEL BUSES

Abstract *− The big cities all over the word are suffering from the permanent traffic jams and the increasing air pollution generated by the vehicles driven by combustion engines. The obsolete diesel buses serve as the base of the public transport facilities and mostly they are responsible for the majority of the air pollution. The new technologies for substituting the old fleets with less emission rate and lower energy consumption are available but the financial resources for the change are very limited and there are more different conditions that can influence the selection of the right public transport systems. The lecture has a short overview on the history of the electric vehicles and introduces the latest technologies with comparison, as well as, the possibility of their application in environment-friend rubber wheel vehicles. At the end there is an outlook to the expected trends in public transport.*

• • •

Vladimir Katić

PLUG-IN ELECTRIC VEHICLES – STATE OF TECHNOLOGY AND MARKET PERSPECTIVES

Abstract *– Transportation sector is contributing in great percentage (23%) to GHG emission in EU countries. In order to reach EU 202020 targets significant efforts to reduce vehicles´ exhausting gases have been made. Plug-in vehicles are foreseen as a part of solution, as it is expected that their share in GHG emission will be decreased below 10% in 2050. In the paper, an overview of plug-in vehicles technologies is presented. All systems are classified and details of electric power processing units are given. Special attention is placed to market perspectives of presented solutions. A review of present state in plug-in passenger cars production and prediction for coming years are given.*

• • •

Milos Pilipovic, Danijel Spasojevic, Ivan Velikic and Nikola Teslic

TOWARD INTELLIGENT DRIVER-ASSIST TECHNOLOGIES AND PILOTED DRIVING: OVERVIEW, MOTIVATION AND CHALLENGES

Abstract *− In this paper we present an extensive literature review on the research progresses in Intelligent Driver-Assistance Systems (IDAS). IDAS monitor the car's environment and driving behaviour to identify and avoid a potentially dangerous situations at an early stage without human input. Based on intelligent sensor fusion technology with full or partial context-aware autonomy in decision-making IDAS aim to combat obstacles in a traffic scene using various advanced control systems such as Adaptive Cruise Control, Collision Avoidance System, Driver Drowsiness Detection System, Parking Assistance System, Lane Departure Warning System. Several adaptive safety*

control systems have been proposed and discussed as well as their interoperability issues to address different aspects in road situation analysis. Any autonomous advanced control system manufacturers launches should be selectable by the driver. In addition, the implementation complexity is analyzed. At the end of the paper we envision some research directions. To the best of our knowledge series-built vehicles with a piloted driving function will be technically feasible this decade over the next two to three years period.

T-01: Materials and components

Friday, November 7, 2014, 17:00, Room 104

Chair: Goce Arsov

Zoran Jakšić

OPTICAL CHEMICAL SENSORS FOR INDUSTRIAL APPLICATIONS

Invited Paper

Abstract *– The market for accurate and inexpensive sensors of chemical compounds in gases and liquids is increasing at a steady pace and it is expected that in 2015 the global demands should reach a level of more than US$ 17 billion. Industrial applications of optical chemical sensors include process and quality control, as well as environmental pollution measurements in different fields that include process industry, automotive, biomedical industry, power engineering, oil and gas industry and food industry. Optical sensing methods offer some distinctive advantage over other approaches, including the applicability in dangerous, flammable and explosive environments, high sensitivities, compact design and insensitivity to external interference. They can be used to recognize trace amounts of a wide range of different chemicals, are compatible with the existing control systems and can be used for multianalyte detection. This work first shortly reviews different schemes utilized for all-optical chemical sensing in gases and liquids. These include various planar and fiber-optic waveguide systems that utilize absorption, transmission or reflection spectroscopy, fluorescence measurements that may be applied to propagating or evanescent waves. Affinity sensing is considered, where the optical sensor surface or a special intermediate receptor layer binds the targeted analyte, which in turn causes physicochemical transformations that modulate the optical properties of the system. The most part of the presentation is dedicated to sensors utilizing surface plasmon polaritons in metal-dielectric nanocomposites. These devices offer label-free, real-time and multianalyte operation with sensitivities even reaching single molecule level. Different schemes are considered including the use of optical metamaterial structures for adsorption-based sensing. The advantages and disadvantages of these sensing schemes are considered.*

• • •

Goce Arsov

PARAMETRIC SPICE MODEL FOR STATIC INDUCTION TRANSISTOR (SIT) IN TRIODE MODE OF OPERATION

Abstract *– The static induction transistor (SIT) is a device which belongs to the multichannel power FET family. Depending on its internal source resistance it can achieve triode or pentode like output characteristics. The purpose of this work is to present a simple model suitable for computer analysis and simulation of circuits containing SITs in triode-like mode of operation. The model is based on the SITs static and dynamic behaviour, and not on the physical structure and characteristics of the device. A possible method for extraction of the model parameters is proposed. The simulated static and frequency characteristics correspond well to the experimental results available from the references. The model has passed all performed tests. Although the proposed model is not yet an ideal solution it will help to start simulating circuits containing the static induction transistors for different applications.*

• • •

Vojislav V. Mitić, Ljubiša M. Kocić, Vesna Paunović and Vančo Litovski

BATIO3-CERAMICS IMPROVED CAPACITORS FRACTAL NATURE THIN FILM DIELECTRICS

Abstract *– The influence of fractal nature geometry on electronic components and deep level electronic circuit integration records a substantial increment in recent times. This contribution is an intention to suggest a methodic way for versatile class of new capacitors' shapes based on fractal curves and intergranular thin film ceramics dielectrics. Our experimental work is done mostly on BaTiO3 and silicates ceramics with additives (CeO2, Bi2O3, MnCO3, Nb2O5, CaZrO3, Dy, La, Er2O3, Yb2O3, Ho2O3 etc.). The advantage of this suggestion is its fair simplicity and flexibility in choice among practically unlimited set of forms and considerable increasing of capacity because of fractal surfaces growth impact on super microcapacitors energy and especially an energy storage. This is a new frontier door for fractal electronics.*

• • •

Miloš Marjanović, Vesna Paunović, Zoran Prijić, Aneta Prijić and Danijel Danković

ON THE MEASUREMENT METHODS FOR DIELECTRIC CONSTANT DETERMINATION IN NB/BATIO3 CERAMICS

Abstract *– In this paper the measurement methods for dielectric constant determination in Nb/BaTiO3 ceramics have been presented. The experimental results obtained using LCR meter with dielectric test fixture and the influence of ceramic microstructure on the accuracy of methods have been discussed.*

• • •

Karolina Kasaš-Lažetić, Dejana Herceg, Dragan Kljajić and Miroslav Prša

FREQUENCY DEPENDANT CURRENT DISTRIBUTION AND RESISTANCE COEFFICIENT OF ALUMINUM CONDUCTORS

Abstract *– Aluminum conductors, such as ACSR (Aluminum Conductor Steel Reinforced) or ACCR (Aluminum Conductor Composite Reinforced) are widely applied in electric power transmission and distribution systems. For that reason, we decided to investigate the behavior of those conductors, making an accent on current distribution inside them and resistance coefficient determination. In this paper we do present all calculation results for two ACSR and two ACCR, of similar characteristics, at frequencies up to 2500Hz. Obtained results, presented graphically, confirmed our expectations. The entire calculation was carried out applying COMSOL Multiphysics 3.5a computer program package.*

• • •

Dejana Herceg, Karolina Kasaš-Lažetić, Dragan Kljajić, Nikola Mučalica and Miroslav Prša

EDDY CURRENTS INSIDE PIPELINE BURIED BENEATH HV OVERHEAD POWER TRANSMISSION SYSTEM

Abstract *– Conductive pipes for liquids and gas transportation are frequently buried in the ground, in vicinity of a high voltage three-phase overhead electric power delivery system. The heating of the pipe, due to eddy currents, is of crucial importance.*

In this paper investigation of heating effect is performed at a real problem. First of all it was determined which voltage level power transmission system produces the most significant eddy currents. After that a model of real zinc coated steel pipe was positioned in vicinity of electric system. For nominal currents in electric power delivery system, external magnetic field and eddy currents were calculated, together with power of heating losses inside the pipe's wall.

All calculations were performed numerically, applying COMSOL Multiphysics 3.5a computer program, for the worst pipe position and minimal height of power delivery conductors from the ground, at eight different frequencies, up to 450 Hz. The calculation results, magnetic field distribution, induced current distribution and frequency dependent heating power, are given graphically.

All calculated results show that, for investigated type of power delivery system, currents induced in the pipe's walls are negligible, except in case when the pipe is extremely closed to the power delivery system, which cannot happen in practice.

T-02: Power electronics

Friday, November 7, 2014, 17:00, Room 105

Chair: Branko Blanuša

Miroslav Lazic, Dragana Petrovic, Skender Miodrag and Sandra Sovilj Nikić

THE USE OF MICROCONTROLLERS IN MODERN SOLUTIONS OF POWER ELECTRONICS

Invited Paper

Abstract *– The role of modern power electronics is to provide reliable and uninterruptible power supply for the consumers. Electric power stations are the most commonly used primary sources of energy. That energy is distributed to the consumers by large power distribution grid. Secondary power sources are usually some sort of alternative power sources or batteries. All power sources have to be controlled all the time. There have to be a system of power electronic devices that provides reliable and continuous power supply operation. Modern power electronic devices are switching type. The basic elements of a switching power supply are power electronics and control electronics. The control electronics are suitable for controling with logical circuits. Because of that, microcontrolles are now part of every modern power electronic devices. If the system has more than one power electronic devices controlled by the microcontroller then multiply microcontroles have to be coordinated to work as one. This paper describes an implemented solution of uninterrupted power supply for telecommunications equipment that uses either power distribution grid either alternative power source either storage battery. The microcontroller is a part of every power source that equipment uses. Also it controls and adjust all the power sources so that equipment has reliable and continuous power supply.*

• • •

Marko Vekic, Stevan Grabic, Evgenije Adzic, Zoran Ivanovic and Vlado Porobic

PMSG SYNCHRONIZATION CONTROL ALGORITHM BASED ON THE ACTIVE DAMPING PRINCIPLE

Abstract *– In this paper the modified active damping law was used to damp oscillations during the synchronization process of PMSG cascade. Due to the imposed capacity limit of the converter and exclusive reactive power injection, the damping ability is limited. Boundaries of the area which defines possible synchronization depend on PMSG initial speed and the difference between the grid and PMSG angle at the moment of connection. Exhaustive tests by means of the state of the art HIL emulation were performed to prove both the modified damping law and its area of application.*

• • •

Predrag Pejovic and Marija Glisic

CONDUCTION MODES OF A PEAK LIMITING CURRENT MODE CONTROLLED BUCK CONVERTER

Abstract *– In this paper, analysis of a buck converter operated applying a peak limiting current mode control is performed, focusing regions where the limit cycle is unstable. Normalized discrete time converter model is derived. Chart of operating modes is presented, and it is shown that the converter exhibits an infinite number of discontinuous conduction modes in an area where the continuous conduction mode would be expected assuming stable limit cycle. The converter is analyzed applying numerical techniques to determine period number of different discontinuous conduction modes and dependence of the output current on the output voltage and the limiting current. The numerical results agree with the analytical results in areas where the limit cycle is stable, and differ in regions where the*

limit cycle is unstable. Two different notions of stability, the limit cycle stability and the converter open loop stability, are clarified.

• • •

Srđan Lale, Milomir Šoja, Slobodan Lubura and Milan Radmanović

MODELING AND ANALYSIS OF NEW ADAPTIVE DUAL CURRENT MODE CONTROL

Abstract *– This paper proposes a new adaptive dual current mode control (ADCMC) approach which is modification of existing dual current mode control (DCMC). ADCMC introduces several significant advantages over DCMC, such as no peak-to-average error in the inductor-current signal, better transient response of inner current loop, improved line regulation and easier adjustment to different types of power electronics converters. Besides description of the working principles of ADCMC, this paper presents the development of small-signal model and transfer functions of ADCMC on the example of buck converter. Simulation results are presented which prove the derived analysis.*

T-03: Circuits and systems

Friday, November 7, 2014, 17:00, Room 106

Chair: Vančo Litovski

Miljana Milic and Vanco Litovski

PYTHON APPLICATION FOR ANALYZING ANALOG FILTERS' TRANSFER FUNCTION

Abstract *– Analog filter represent an inevitable block in modern telecommunications and electronics. They suppress the undesired spectrum components, regardless of their nature. An interactive Python application, developed for analyzing the analog filters' transfer function is described in this paper. The application calculates and draws most of the filter's characteristics such as: step and impulse response of the filter in the time domain, and, module, phase and group delay in the frequency domain. The application accepts transfer function of the filter described both using poles and zeros of the function, or polynomials of the numerator and denominator as inputs. A Python programming language is used as a development platform, since it is free, and offers large available online support, and since it supports object-oriented and functional programming style.*

• • •

Milena Stanojlović Mirković, Vančo Litovski, Predrag Petković and Dragiša Milovanović

FAULTS SIMULATIONS IN XOR/XNOR CELL RESISTANT TO SIDE CHANNEL ATTACKS

Abstract *– This paper describes simulation results of testing the No Short-circuit current Dynamic Differential Logic (NSDDL) XOR/XNOR cell which consist of two NSDDL AND cells and one NSDDL OR cell. The goal is to consider the impact of individual defects in such complex circuit. Fault dictionary will be created based on repetitive simulations preformed for defects inserted one by one. For a short circuit defects detection logical function and supply current will be exploited. All cells are designed in CMOS TSMC035 technology using Mentor Graphics design tools.*

• • •

Aleksandar Pajkanovic and Veljko Malbasa

BANDGAP VOLTAGE REFERENCE IN 130NM: DESIGN AND SCHEMATIC LEVEL SIMULATION

Abstract *– A bandgap voltage reference design based on a simple topology utilizing a current mirror and a complementary to absolute temperature voltage source is presented in the paper. Simulation results for implementation in 130 nm CMOS standard process show temperature variation of the output voltage within 5 mV over a temperature range of 165 K (from -40◦C up to 125◦C) in the nominal case, i.e. the absolute reference voltage temperature variation is 0.19 %, i.e. 11.5 ppm/◦C. The influences of supply voltage and process variations (including corner and Monte Carlo analysis) on the output reference voltage are presented and discussed. Time domain analysis shows that the circuit is fully operational within 112 ns. The results are obtained through the schematic level simulations using Spectre Simulator from Cadence Design System.*

• • •

Dejan Mirković, Predrag Petković, Ilija Dimitrijević and Igor Mirčić

OPERATIONAL TRANSCONDUCTANCE AMPLIFIER IN 350NM CMOS TECHNOLOGY

Abstract *– This paper presents transistor level design of operational transconductance amplifier in CMOS technology. Custom designed, circuit is to be built-in into the mixed-signal, switched capacitor circuit. Amplifier targets relatively high slew-rate and moderate open loop gain with megahertz order gain-bandwidth. Adopted architecture is discussed appreciating application in switched capacitor circuits. Circuit behavior is examined through set of simulations. Obtained results confirmed desired behavior. Target technology process is TSMC 350nm.*

• • •

Borisav Jovanovic, Dejan Mirkovic and Milunka Damnjanovic

THE DESIGN OF MCU'S COMMUNICATION INTERFACE

Abstract *– In this paper, the communication between a microcontroller IP block and external Base band microprocessor is examined. The microcontroller is a part of a complex integrated System-on-chip and uses standard 8051 instruction set. The paper describes the operation of embedded circuits that allow programming, software debugging and communication with external microprocessor. The communication is based on SPI interface.*

T-04: Electrical machines and drives

Friday, November 7, 2014, 17:00, Room 103

Chair: Petar Matić

Dejan Reljic and Dejan Jerkan

EXPERIMENTAL IDENTIFICATION OF THE MECHANICAL PARAMETERS OF AN INDUCTION MOTOR DRIVE

Abstract *– In order to obtain fast dynamic response performance of an induction motor drive, the identification of mechanical parameters such as the drive inertia and the coefficients of friction, with a good accuracy, is highly desirable. They are essential for the design of the high-performance induction motor drive speed, as well as position controllers and speed observers, since a drive response is influenced not only by load disturbances but also by these mechanical parameters. Moreover, they are of great importance for the accurate dynamic modeling and simulation of various high-performance induction motor control strategies. In this paper an experimental off-line method for the mechanical parameters identification is presented. The method uses speed-time curve, obtained during the retardation test on the drive, with an appropriate mechanical losses model of the drive, and the mean squared error performance function based on a genetic algorithm (GA) approach, to obtain unknown mechanical parameters of the tested drive. The proposed method is verified by experiments.*

• • •

Đorđe Lekić and Petar Matić

DESIGN OF TESLA'S TWO-PHASE INDUCTOR

Abstract *– This paper describes a new method for designing Tesla's two-phase inductor for demonstration of rotating magnetic field, based on the famous Tesla's Egg of Columbus experiment. The design is based on electromagnetic and thermal analytical models of the two-phase inductor and verified by computer simulation and FEM analysis.*

• • •

Marko Gecić, Mirna Kapetina, Vladimir Popović and Darko Marčetić

PARTICLE SWARM OPTIMIZATION BASED ENERGY EFFICIENCY METHOD FOR HIGH SPEED IPMSM DRIVES

Abstract *– This paper describe a novel method for increasing energy efficiency of interior permanent magnet synchronous motor (IPMSM) drives. In order to minimize the controllable electrical losses of IMPSM the dq-axes armature current is calculated based on particle swarm optimization (PSO). The method are tested for the wide speed range and different load condition. Simulation results of high speed IPMSM drives are presented and discussed.*

• • •

Vladimir Popovic, Marko Gecic, Veran Vasic, Djura Oros and Darko Marcetic

EVALUATION OF LUENBERGER OBSERVER BASED SENSORLESS METHOD FOR IM

Abstract *– System approach for analysis of Luenberger observer for vector-controlled induction motor drives without shaft sensor is presented in this paper. Important aspects of control algorithm for induction motor system were described in detail. Realization of control algorithm based on Luenberger*

observer calculation mehod for estimation of unknown induction motor states is performed within appropriate digital signal controller (DSC). Verification is given through simulation and experimental results of vector-controlled induction motor sensorless drive.

• • •

Dejan Jerkan, Marko Gecić and Darko Marčetić

IPMSM INDUCTANCES CALCULATION USING FEA

Abstract *– Accurate determination of interior permanent magnet synchronous machine's (IPMSM) inductances is very important issue, especially in areas of high-performance drives and systems. This paper presents the method for calculation of the direct and quadrature inductances of permanent magnet synchronous machine using finite element analysis (FEA), where the calculation of these parameters is based on the determination of flux linkages. Two types of IPMSMs are investigated, with tangentially and radially magnetized permanent magnets. The numerical results of the calculations are presented by diagrams and they are discussed and compared to each other.*

• • •

Vlado Porobic, Evgenije Adžić, Zoran Ivanović, Marko Vekić and Stevan Grabić

A SUPLEMENTARY TOOL TO THE STANDARD TEACHING METOD OF INDUCTION MOTOR DRIVE CONTROL

Abstract *– This paper demonstrates an modern approach to teaching motor drive control, which can be used as additional tool to the standard education methods or even completely self contained. Emulation-based virtual laboratory is proposed for control engineering education purpose. By using theexample of induction machine digital control, there is shown that emulation experiments can give students an industrially relevant educational experience. Both digital controller design steps and suitable emulated power stages, together with experiment results are presented in detail.*

T-05: Measurement methods and systems

Friday, November 7, 2014, 17:00, Room 107

Chair: Igor Krčmar

Mitar Simic

DESIGN OF MONITORING AND DATA ACQUISITION SYSTEM FOR ENVIRONMENTAL SENSORS

Abstract *– In this paper description of monitoring and data acquisition system for environmental sensors is described. Device can be used as standalone device but it also can be connected to the PC through serial communication. Color display is used for local graphical presentation of sensors readings while for online PC analysis specialized application was developed. Application provides alarm occurrence log with e-mail notifications. System is scalable and easily can be expanded with new sensors. System verification was done with SHT11 measurement device and system worked stable and reliable.*

• • •

Milan Simić, Dragan Živanović, Dragan Denić and Goran Miljković

SOFTWARE SUPPORTED PROCEDURE APPLIED TO TESTING OF INSTRUMENTS FOR HIGH-ORDER HARMONICS MEASUREMENT

Abstract *– Software supported procedure, applied for generation of the test voltage waveforms with certain level of the standard harmonic disturbances, is presented in this paper. Procedure is functionally based on the virtual instrumentation concept, which includes control application in LabVIEW software environment and data acquisition board NI PCIe 6343. Variation of the basic parameters for definition, presentation and signal generation is provided by various control functions and switches, implemented on front panel of the developed virtual instrument. For specific harmonic disturbances is possible to define percentage amounts of the harmonic amplitude levels, nominal frequency variations, amplitude fluctuations, start and stop times, rising and falling times of the disturbances. Described acquisition system is verified by testing of the three-phase power quality analyzer Fluke 435 Series II. By this generation system is possible to provide various voltage test waveforms with typical harmonic disturbances. In this specific case, for testing purpose are used some characteristic test waveforms with harmonic disturbances. Basic measurement results and some recorded voltage signals, obtained from testing procedure, are presented and analyzed in this paper.*

• • •

Djordje Obradovic, Miodrag Brkic, Viktor Dogan, Milos Zivanov and Barta Karoly

HARDWARE REALIZATION OF DATA LOGGER SYSTEM FOR INLAND EXCESS WATER

Abstract *– Inland excess water cause considerable economic, social and environmental problems. In northern parts of Vojovodina, where inland excess waters occurs regularly, continuous measurement of groundwater level on several measurement points over long periods of time is needed for realization of hydrodynamic models. With data collecting system management innovative geographic information methods and observation techniques these models can be developed to predict inland excess water. In this paper hardware realization of data logger is described in details. Data logger system was developed and used on locations of interest in northern Vojvodina.*

• • •

Boris Ličina, Dragan Pejić, Platon Sovilj and Vladimir Vujičić

APPLICATION OF DIGITAL STOCHASTIC MEASUREMENT OF DEFINITE INTEGRAL PRODUCT OF TWO OR MORE SIGNALS USING TWO-BIT A/D CONVERTER

Abstract *– Commonly used strategy in discrete digital measurements is to capture digital value of signal's magnitude at a chosen time instant. The mathematics in the background of this strategy is algebra, while the applied theory is the Theory of discrete signals and systems. An alternative measurement strategy, named "measurement over an interval", has been researched in three challenging areas: (i) measurement of fast-changing signals, (ii) measurement of noisy signals, and (iii) measurement that requires high accuracy and linearity. Numerous simulations, experiments and developed measurement instruments have proven the engineering/metrological applicability of this "measurement over an interval" strategy. This paper presents application of digital stochastic measurement over interval of the finite integral product of two or more signals using two-bit A/D converter. Error of this method is shown through a large number of simulations.*

T-06 and T-09: Signal processing and Information technologies

Saturday, November 8, 2014, 10:00, Room 104

Chair: Vladimir Risojević

Darko Brodic

SCRIPT RECOGNITION BY STATISTICAL ANALYSIS OF THE IMAGE TEXTURE

Invited Paper

Abstract *– The paper proposed an algorithm for the script identification using the statistical analysis of the texture obtained by script mapping. First, the algorithm models the script sign by the equivalent script type. The script type is determined by the position of the letter in the baseline area. Furthermore, the extraction of the features is performed. This step of the algorithm is based on the script type occurrence and co-occurrence pattern analysis. Then, the resultant features are compared. Their differences simplify the script feature classification. The algorithm is tested on the German and Slavic printed documents incorporating different scripts. The experiment gives the results that are promising.*

• • •

Nikola Stojanovic, Dragisa Milovanovic, Vidosav Stojanovic and Negovan Stamenkovic

DESIGN OF TWO-CHANNEL ANALYSIS PART OF HYBRID FILTER BANK

Abstract *– In the present paper a new design method for continuous-time power-symmetric active RC filters, which is suitable for two-channel hybrid filter bank realization, is proposed. Some theoretical properties of continious-time power-symmetric filters in a more general perspective are studied. This includes the derivation of a new general analytical form, and a study of poles and zeros locations in s-plane. In the proposed design method the analytic solution of filter coefficients is solved in s-domain using only one nonlinear equation Finally, the proposed approximation is compared to standard approximations. It was shown that attenuation and group delay characteristic of the prop.*

• • •

Jovan Galić, Slobodan Jovičić, Đorđe Grozdić and Branko Marković

CONSTRAINED LEXICON SPEAKER DEPENDENT RECOGNITION OF WHISPERED SPEECH

Abstract *– In this paper we present results on automatic speech recognition of isolated words with part of Whi-Spe database with female speakers, in speaker dependent fashion and constrained lexicon (50 words). Word recognition rate is calculated for four train/test scenarios, with modeling of context independent monophones, context dependent triphones and whole words. As a feature vectors, we used Perceptual Linear Prediction Coefficients and Mel Frequency Cepstral Coefficients. The HTK was used to implement isolated word recognizer. Further improvement is achieved with reduction in number of monophone units used for modeling. Due to very high deviation in performance among different speakers, influence of Signal to Noise Ratio of tested recordings on performance of recognizer is examined in particular.*

• • •

Milan Tucic, Dragan Topalovic, Milos Nikolic and Ivan Kastelan

SIMPLE ARCADE GAME FROM HARDWARE SIDE USING MICROBLAZE

Abstract *– This paper proposes reconstruction of the simple arcade game Pong using MicroBlaze soft core and explains hardware side of this process. Reconstruction is split into two time phases. In the first phase hardware is developed with functionalities which, as they are, are sufficient for game implementation. This means hardware part of system is made of simple graphic controller and paddle movement controller. The second phase covers system analysis and hardware made as a result of this analysis. All upgrades are done considering MicroBlaze's flexibility. This kind of approach and organization leads to better balance between hardware and software implementation, and demonstrates advantages of designing a system in which it is possible to monitor, analyze and influence the further evolution of the system.*

• • •

Marko Kovacevic, Branimir Kovacevic, Dejan Stefanovic and Vukota Pekovic

SYSTEM FOR AUTOMATIC TESTING OF ANDROID BASED DIGITAL TV RECEIVERS

Abstract *– With constant increasing of digital TV receivers complexity and constant need for reducing the product time-to-market - the development of reliable and effective system for automatic testing of digital TV receivers becomes highly desirable. This paper proposes system for automatic testing of Android based digital TV receivers which is able to cover the entire process of product testing – from requirement definition, through verification test plan creation, automatic test cases execution and testing reports generation. System consists of web tool responsible for requirement and test management and stand-alone application responsible for automatic tests execution based on Black Box Testing methodology.*

T-07: Modeling, identification and process control

Saturday, November 8, 2014, 10:00, Room 105

Chair: Milorad Božić

Aleksandar Ribić and Miroslav Mataušek

DESIGN AND TUNING OF PID OVERRIDE CONTROL SYSTEM BASED ON SIGNAL FILTERING

Abstract *– The proposed override control system consists of two anti-reset windup controllers, common actuator and a limiter, surrounded by pre and post biproper filters. Prefilter is inverse of the post-filter. The desired limit on the override variable and its set-point are defined by output of the limiter. Signal selector is not applied in the proposed structure. Other characteristic feature of the proposed solution, compared to standard one, is that the override variable response is obtained practically without overshoot. Procedure for adjusting parameters of the postfilter are defined and illustrated in detail. Simulation results are used to demonstrate the basic ideas. Experiment on a laboratory thermal plant with noisy measurements is used to confirm validity of the proposed solution.*

• • •

Marko Bošković, Tomislav Šekara, Milan Rapaić and Boris Jakovljević

RATIONAL APPROXIMATIONS TO DESIGN CONTROLLERS FOR UNSTABLE PROCESSES, INCLUDING DEAD-TIME

Abstract *– This paper addresses the problem of designing complex controllers for unstable industrial processes with transport delay under constraints on robustness and performance. The solution to the control design problem is obtain in a non-rational form which is rationalized using various methods. The paper also presents a comparative analysis of different approximation techniques. By means of numerical simulations it has been shown that proposed methods lead to adequate performance and robustness indices.*

• • •

Aleksandar Rakic and Petar Matic

ADAPTIVE TORQUE CONTROL FOR SENSORLESS INDUCTION MOTOR DRIVES IN WIDE-SPEED RANGE

Abstract *– In this paper, control structure is proposed to ensure desired performance of sensorless induction motor (IM) drives in both base speed range and field-weakening. Appropriate nonlinear IM model is utilized for derivation of adaptive slip manipulation based torque control law. In the base speed range, proposed solution reduces to IFOC, while in the field weakening it becomes voltage angle control with full dc bus utilization. Proposed solution is verified by means of simulation.*

T-08: Renewable energy and energy efficiency

Saturday, November 8, 2014, 10:00, Room 106

Chair: Vladimir Katić

Bane Popadic, Boris Dumnic, Dragan Milicevic, Vladimir Katic and Zoltan Corba

SOPHISTICATED RESEARCH AND DEVELOPMENT STATION FOR CONTROL OF GRID CONNECTED DISTRIBUTED ENERGY SOURCES

Abstract *– A sophisticated research and development station for control of the grid connected distributed energy sources has been developed at the Faculty of Technical Sciences. This research station should allow researchers to investigate the influence of grid connected converter control on the grid conditions and vice versa. Additionally, the control of the grid connected converter during grid disturbances can be investigated. In addition to its R&D features, this station will present students with the possibilities to get high quality knowledge in the respected area. This paper aims to present the research potential of the station, while displaying some of the many versatile features gained by the introduction of the grid emulator.*

• • •

Zoran Ivanovic, Evgenije Adzic, Stevan Grabic, Vlado Porobic and Vladimir Katic

LOW VOLTAGE RIDE-THROUGH CAPABILITY OF DISTRIBUTED GENERATOR CONNECTED TO THE GRID THROUGH THE BACK-TO-BACK CONVERTER

Abstract *– This paper deals with low voltage ride-through capability of distributed generator unit. Distributed generator, considered in this paper, is based on squirrel cage induction machine and it is connected to the grid through the back-to-back converter and LCL filter. With an increasing distributed generation grid connection requirements in almost every country require generation unit to stay connected to the grid and ensure active and reactive power injection. In this paper we proposed improved dual vector current controller to deal with the unbalance imposed by the electrical grid. Controller provides injection of active and reactive power to the grid, even if the voltages are lower than the nominal one. Results are validated using contemporary hardware-in-the-loop emulation platform, while controller is based on TMS320F2812 DSP.*

• • •

Vladimir Katic, Milan Pecelj and Ivan Todorović

EFFECTS OF INDIVIDUAL BATTERY CHARGER STATION ON POWER QUALITY

Abstract *– A number of new devices are entering the public grid in a form of battery charging station, either as individual units or as a group connected at the same grid. This paper addresses the question of the effect of individual charging station operation as non-linear unit on the local distribution grid power quality by investigating current and voltage spectrum, i.e. harmonics. Two type of charging modes are considered: Mode 3 (moderate speed charging) and Mode 4 (fast-charging) in case of three-phase AC chargers. The operation is tested on one of traditional topologies using computer simulations. Results showed low voltage distortion and rather high current one. Both distortions are in accordance with IEEE and IEC/EN standards. However, current distortion is very close to limits and in some cases may have effect on transformer overheating and resulted in its de-rating.*

• • •

Vladimir Katić, Ivan Todorović, Milan Pecelj, Zoltan Čorba, Boris Dumnić and Dragan Milićević

MULTIPLE BATTERY CHARGER STATIONS IMPACT ON POWER QUALITY

Abstract *– This paper addresses the question of the impact of the multiple battery charger stations on the local distribution grid power quality by investigating grid current and voltage spectrum. The case of station with multiple battery chargers of two types (mode 3 and mode 4) is considered. A Matlab/Simulink model has been developed and used for testing. The model parameters are selected in such a way to reflect real conditions in public grid. The results show that level of voltage harmonics is increased. Further on, the current harmonics are also high and above IEEE standard 519-1992 limits and IEC/EN 61000-3-4 levels. Still, as a result of harmonic cancelation and attenuation effect, the THDI is lower than in case of single charger operation.*

• • •

Duško Lukač, Miona Andrejević Stošović, Dragiša Milovanović and Vančo Litovski

REFERENCE ANALYSIS OF THE ANALOGOUS MODELS FOR PHOTOVOLTAIC CELLS BY COMPARISON WITH THE REAL PHOTOVOLTAIC MODULES

Abstract *– This paper is based on the research Project between Rheinischen Fachhochschule in Köln - University of Applied Sciences, Germany, and the University of Niš, Serbia in regard of modeling of photovoltaic cells of different technologies. Standard models used for modeling of photovoltaic cells give partially satisfactory results, which are mostly depending on the physical-mathematical model and on the technology of the photovoltaic cells used. In this work we compare Simulation results based on simplified diode model and one-diode model with the characteristics of three different real photovoltaic modules of different cell type based on different cell technology. We show the dependency of accuracy of the physical models by the choice of ideality factor and reverse saturation current, which at least often led to calculation of different efficiency factors of PV cells. Thus, the calculated data given by manufacturer can distinguish significantly in regard of cell efficiency compared with the measured data. By varying of ideality factor and reverse saturation current, the curve course of the simulated characteristic curve can be adjusted to show a very good correspondence with the curve course of the real cell. Furthermore, we show the differences in the quality factor according to the model used and give a reference in conclusion to the limits of the current based on different cell technology.*

• • •

Marko Ikic, Jovan Mikulovic and Zeljko Djurisic

IMPROVED MODEL FOR ESTIMATING PV SYSTEM PRODUCTION

Abstract *– In this paper is presented improved model for estimating the electricity production of photovoltaic (PV) systems. In the literature is known two kinds of models, theoretical one and one based on the measured data on horizontal solar insolation. In second one, solar insolation on panel surface, beside of other parameters, is determinate based on average value of slope factor. This paper gives improvements in model for estimating panel production, determining solar insolation on panel surface based on available data of average ten-minute solar insolation on horizontal surface and ambient temperature, and calculating slope factor for each ten-minute period. Experimental results obtained by the real photovoltaic system mounted on a roof of Faculty served as a verification of described improved model.*

T-10: Telecommunication technologies

Saturday, November 8, 2014, 10:00, Room 107

Chair: Gordana Gardašević

Gordana Velikic, Milan Bjelica, Nemanja Ignjatov, Mica Cetkovic and Ivan Kastelan

THE PERSONALIZATION OF A CLOUD ECOSYSTEM: ADDING DIMENSIONS TO SITUATIONAL AWARENESS

Invited Paper

Abstract *– The lack of easy to use environment to connect and manage the things is one of the obstacles that hold back multimodal personalized use of Internet of Things. We present a novel idea and a cloud framework with original elements that enable development of ecosystem for the user tailored deployment of things in the context of a personalized situational awareness. The benefits of the infrastructure are fortified with several use case scenarios that provide an insight to the platform's innovative possibilities.*

• • •

Jugoslav Joković, Tijana Dimitrijević, Aleksandar Atanasković, Nataša Maleš-Ilić and Bratislav Milovanović

TLM MODELING OF EMISSIONS FROM PRINTED CIRCUIT BOARD OF POWER AMPLIFIER MATCHING CIRCUITS

Abstract *– The paper considers an electromagnetic (EM) emission from a printed circuit board (PCB) representing impedance matching circuits on microwave amplifier. The analysis is based on Transmission Line Matrix (TLM) method including the basic physical features of the input and output impedance matching circuits realized using the microstrip. The ports are described through the TLM wire compact model while a simple equivalent transistor model based on S parameters is applied to account for the connection between the PCB elements. Since a rectangular metallic enclosure is typical closed environment for microwave amplifier, the EM emissions inside and outside the enclosure with aperture are compared with respect to engineering purposes.*

• • •

Stefan Panic, Djoko Bandjur, Branimir Jaksic, Ivana Dinic, Srboljub Zdravkovic and Dejan Jaksic

LEVEL CROSSING RATE OF MACRODIVERSITY SYSTEM OPERATING OVER GAMMA SHADOWED RICIAN FADING CHANNEL

Abstract *– Macrodiversity system with macrodiversity selection combining (SC) receiver and two microdiversity SC receivers is considered. Received signal is affected simultaneously to Gamma long term fading and Rician short term fading resulting in system performance degradation. Macrodiversity SC receiver reduces Gamma shadowing effects and microdiversity SC receivers reduce multipath fading effects on bit error probability. Closed form expression for average level crossing rate of macrodiversity SC receiver output signal envelope is evaluated. Numerical results are presented graphically to show the influence of Gamma long term fading severity, shadowing correlation and Rician factor on average level crossing rate.*

• • •

Ivana Savic, Milan Savic and Gordana Velikic

IMPLEMENTATION OF TR-069 CONNECTION REQUEST MECHANISM

Abstract *– This paper proposes and evaluates an approach for monitoring and controlling devices over a network based on TR-069 protocol. Protocol itself relies on communication between server and clients (devices). Main characteristic of this protocol is that all the communication is initiated from the device side. In order to allow server to initiate interaction, a connection request mechanism is defined. It serves as a notification system that informs the device to start interaction with the server. Depending on the network state, available resources at hand and security considerations, there are four types of connection request to choose from: connection request over TCP, connection request over TCP with port forwarding, Session Traversal Utilities for NAT (STUN) based connection request and Extensible Messaging and Presence Protocol (XMPP) based connection request.*

• • •

Igor Tomić and Nebojša Maletić

COMPARISON OF MODELS FOR SELF-SIMILAR NETWORK TRAFFIC GENERATION

Abstract *– In this paper, five models for self-similar network traffic generation are presented and compared: iterated chaotic maps, fractional Gaussian noise model, Pareto model and finite and infinite Markov chain model. The models are compared on the basis of Hurst parameter and mean value of generated sequences, and also on the basis of algorithm efficiency. R/S plot, Variance-Time plot and Periodogram method are used for the Hurst parameter estimation. According to simulation results, the model which gives sequences whose parameters are close enough to the given ones is fronted.*

• • •

Milena Milosevic, Krsto Lazic, Branimir Kovacevic, Nenad Jovanovic and Marko Kovacevic

OVERVIEW OF THE HBBTV COMPLIANT BROWSER UPGRADE ON ANDROID BASED DTV PLATFORM

Abstract *– Upgrade to the new version of software is resource and time consuming process. Manufacturers try to optimize this process in any way. This paper presents upgrade of the HbbTV software solution as a system which relies on web technologies. Since web browser is one of the platform dependent components of the HbbTV software solution, the paper focuses on the web browser's update on Android based DTV platform. With the Android upgrade, web browser also changes. These changes can be major changes and to achieve faster releases and better performances, manufacturers have to choose which browser to choose, existing or the upgraded one. Two default Android web browsers are analyzed and compared. Web browsers' overview of supported features and performances related to the HbbTV is given.*

F1: Poster session

Saturday, November 8, 2014, 12:00 -13:00
Chair: Čedomir Zeljković

Jovan Setrajcic, Sinisa Vucenovic, Blanka Skipina and Svetlana Pelemis

SUCCESSIVE ABSORPTION AND REFRACTION IN ULTRATHIN MOLECULAR NANO-FILMS

Abstract *– Based on the formed model of nano-film crystal structures, changes of optical properties due to the presence of borders for the case of symmetrical ultrathin films are theoretically investigated in this paper. Influence of five border parameters on the occurrence of localized exciton states is examined, as well as their relation with the effects of discretization and selection of resonant absorption of present electromagnetic radiation. Used combined analytical-numerical calculation to find the allowed energy states of excitons and their spatial distribution (per layers) along the axis perpendicular to surface planes. We determined permittivity for the observed models of these ultrathin dielectric films and explored the influence of boundary parameters on the occurrence of discrete and selective absorption.*

• • •

Nikola Lecic, Akhil Chandran Mukkattu Kuniyil, Goran Stojanovic and Aleksandar Pajkanovic

LOW-COST MULTI-PHASE DC/DC BUCK CONVERTER TEST CIRCUIT WITH SIMPLE CONTROL FOR TESTING MULTI-PHASE INDUCTORS

Abstract *– In this work six-phase DC/DC converter with simplified low-cost topology will be represented. Circuit control block has been developed as direct control concept, without control loop for output signal. Different operating modes are easily adjustable with DIP-4 switch. Duty cycle in all operating modes is 50%. Small resistance power resistor with 50 mΩ resistance has been positioned between ground point and load to provide possibility to circuit user to analyse transient response of test circuit. Operating frequency of circuit is externally adjustable with laboratory frequency counter. The circuit is simple for use and variable inductor topologies, single or multiphase inductors can be tested with this circuit.*

• • •

Srdjan Đorđević, Slobodan Bojanić and Marko Dimitrijević

SMART METER PRIVACY BY SUPPRESSION OF LOW POWER FREQUENCY COMPONENTS

Abstract *– This paper focuses on the problems associated with privacy protection in smart grid. We give an overview of a possible realization of a privacy-preserving approach that encompasses privacy-utility tradeoff into a single model. This approach proposes suppression of low power frequency components as a solution to reduce the amount of information leakage from smart meter readings. We consider the applicability of the procedure to hide the appliance usage with respect to the type of home devices.*

• • •

Bosko Mijatovic and Cedomir Zeljkovic

COMPUTER-ASSISTED PERFORMANCE ASSESSMENT OF OUTDOOR SUBSTATION GROUNDING SYSTEMS

Abstract *– The performance of grid grounding system is assessed by using a commercial software package. The most influential input variables are systematically varied and their impact on the system is observed and discussed. The corrective measures are suggested in order to bring the design parameters of the grounding system within their permissible limits.*

• • •

Predrag Mršić, Čedomir Zeljković and Nikola Rajaković

COST EFFECTIVENESS OF A CONTROL STRATEGY FOR GRID-CONNECTED PHOTOVOLTAIC SYSTEMS

Abstract *– The electricity customers may use photovoltaic systems supported by batteries in order to fulfill a fraction of their energy requirements and to decrease the peak demand. The achievable savings primarily depend on a system control strategy. In this paper, one algorithm based on a threshold control is described and tested. The sensitivity on the most important input variables is analyzed by extensive set of numerical simulations.*

• • •

Ivan Todorović, Petar Gartner, Vladimir Katić and Stevan Grabić

ULTRACAPACITORS AS AUXILIARY ENERGY SOURCE IN ELECTRIC VEHICLES

Abstract *– Recent and promising anticipated development in energy storage technologies demands adequate energy flow control strategies that will actuate opportunities spawned by this development. In this paper, energy management strategy that relies on fuzzy logic theory is proposed, i.e. controllers that govern functioning of the converters are designed using human reasoning and interrelated fuzzy logic rather than conventional PID controllers. It will be shown how the proposed energy management allows ultracapacitors to be used as an energy source that not only eliminates shortcomings of other sources but can also be used as a tool for optimization of system functioning as a whole.*

• • •

Bojan Erceg, Petar Matić and Čedomir Zeljković

REDUCING THE ACTIVE POWER LOSSES IN TRANSMISSION NETWORK BY USING PHASE SHIFTING TRANSFORMER

Abstract *– This paper analyses the possibility of decreasing the active power losses in 110 kV transmission network in BiH/RS by using phase shifting transformer. The network before and after connection of phase shifting transformer on the line with the largest power flow is simulated by a commercially available software package. The optimal phase shift required to minimize the overall losses in the transmission network is determined by a search through simulation results.*

AUTHOR INDEX

Adžić. E. 10, 15, 21
Andrejević Stošović, M. .22
Arsov, G. 7
Atanasković, A. 23
Bandjur, Dj. 23
Bojanić, S. 25
Bošković, M. 20
Bjelica, M. 23
Brkic, M. 16
Brodic, D. 18
Cetkovic, M. 23
Chandran Mukkattu Kuniyil, A. 25
Čorba, Z. 21, 22
Damnjanović, M. 13
Danković, D. 8
Denić, D. 16
Dimitrijević, I. 13
Dimitrijević, T. 23
Dimitrijević, M. 25
Dinic, I. 23
Dogan, V. 16
Dumnic, B. 21, 22
Đorđević, S. 25
Đurišić, Ž. 22
Erceg, B. 26
Galić, J. 18
Gartner, P. 26
Gecić, M. 14, 15
Glisic, M..... 10
Grabić, S. 10, 15, 21,26
Grozdić, Đ. 18
Herceg, D.. 8
Ignjatov, N. 23
Ikic, M. 22
Ivanović, Z. 10, 15, 21
Jakovljević, B. 20
Jakšić, D. 23
Jakšić, Z. 7
Jakšić, B. 23
Jerkan, D. 14,15, 23
Jovanović, B. 13
Jovanovic, N. 24
Jovičić, S. 18
Joković, J. 23
Kapetina, M. 14
Karoly, B. 16
Kasaš-Lažetić, K. 8
Kastelan, I. 19, 23
Katić, V. 5, 21, 22, 26
Kljajić, D. 8
Kocić, LJ. 8
Kovacevic, M. 19, 24
Kovacevic, B. 19, 24
Lale, S. 11
Lazic, K. 24
Lazić, M. 10
Ličina, B. 17
Lecic, N. 25
Lekić, Đ. 14
Litovski, V. 8, 12, 22
Lubura, S. 11
Lukač, D. 22
Malbasa, V. 12
Maletić, N. 24
Maleš-Ilić, N. 23
Marjanović, M. 8
Marčetić, D. 14, 15
Marković, B. 18
Mataušek, M. 20
Matić, P. 14, 20, 26
Mijatović, B. 26
Mikulovic, J. 22
Milicevic, D. 21, 22
Milic, M. 12
Milovanović, D. . 12,18, 22
Milovanović, B. 23
Milosevic, M. 24
Miljković, G. 16
Mirković, D. 13
Mirčić, I. 13
Mitić, V. 8
Mršić, P. 26
Mučalica, N. 8
Nikolić, M. 19
Oros, Đ. 14
Obradović, Đ. 16
Pajkanović, A. 12, 25
Panić, S. 23
Paunović, V. 8
Pecelj, M. 21, 22
Pejić, D. 17
Pejović, P. 10
Pelemis, S. 25
Petković, P. 12, 13
Petkovic, V. 19
Petrović, D. 10
Pilipovic, M.....5
Popadic, B. 21
Popović, V. 14
Porobić, V. 10, 15, 21
Prijić, A. 8
Prijić, Z. 8
Prša, M. 8
Radmanović, M. 11
Rakic, A. 20
Rapaić, M. 20
Rajaković, N. 26
Reljic, D. 14
Ribic, A. 20
Ruzsányi, T. 5
Savic, I. 24
Savic, M. 24
Setrajcic, J. 25
Simic, M. 16
Simić, M. 16
Skender, M. 10
Skipina, B. 25
Sovilj Nikić, S. 10
Sovilj, P. 17
Spasojević, D. 5
Stamenkovic, N. 18
Stanojlović Mirković, M. .12
Stefanović, D. 19
Stojanović, G. 25
Stojanović, N. 18
Stojanović, V. 18
Šekara, T. 20
Šoja, M. 11
Teslic, N. 5
Todorović, I. 21, 22, 26
Tomić, I. 24
Topalovic, D. 19
Tucic, M. 19
Vasic, V. 14
Vekic, M. 10, 15
Velikić, I. 5
Velikic, G. 23, 24
Vucenovic, S. 25
Vujičić, V. 17
Zdravkovic, S. 23
Zeljković, Č. 26
Živanović, D. 16
Živanov, M. 16