



Univerzitet u Novom Sadu
Fakultet tehničkih nauka



**XXII Savetovanje
Energetska elektronika Ee 2023**

Zbornik radova



Novi Sad, Beograd, Srbija
25 - 28.10.2023.



**POWER ELECTRONICS SOCIETY
NOVI SAD, REPUBLIC OF SERBIA**

**DRUŠTVO ZA ENERGETSKU ELEKTRONIKU
NOVI SAD, REPUBLIKA SRBIJA**

XXII Savetovanje Energetska elektronika - Ee 2023

Zbornik radova

25 - 28. 10. 2023.

**NOVI SAD - BEOGRAD,
REPUBLIKA SRBIJA**



**POWER ELECTRONICS SOCIETY,
NOVI SAD**



**SERBIAN ACADEMY OF SCIENCES
AND ARTS, BELGRADE**



**ELECTROTECHNICAL INSTITUTE
"NIKOLA TESLA", BELGRADE**



**UNIVERSITY OF NOVI SAD,
FACULTY OF TECHNICAL SCIENCES,
NOVI SAD**

PUBLISHED BY - IZDAVAČI

POWER ELECTRONICS SOCIETY,
Novi Sad



DRUŠTVO ZA ENERGETSKU
ELEKTRONIKU, Novi Sad

ELECTROTECHNICAL INSTITUTE
"NIKOLA TESLA", Belgrade



ELEKTROTEHNIČKI
INSTITUT "NIKOLA TESLA",
Beograd

FACULTY OF TECHNICAL
SCIENCES,
Novi Sad



FAKULTET TEHNIČKIH
NAUKA,
Novi Sad

SRPSKA AKADEMIJA NAUKA I
UMETNOSTI
Beograd



SERBIAN ACADEMY OF
SCIENCES
AND ARTS, Belgrade

EDITOR - UREDNIK

Prof. dr Vladimir Katić

TECHNICAL SUPPORT & DESIGN - TEHNIČKA OBRADA I DIZAJN

Zoltan Čorba
Dragomir Nikolić
Jadranka Galić

COVER DESIGN – DIZAJN KORICA

Assoc. Prof. Ivan Pinčjer

UNDER AUSPICES OF: - POD POKROVITELJSTVOM:

- Ministry of Science, Technological Development and Innovation of the Republic of Serbia, Belgrade
- Provincial Secretariat for Higher Education and Scientific Research Activity of the AP Vojvodina, Novi Sad
- Matica srpska, Novi Sad



- Ministarstvo nauke, tehnološkog razvoja i inovacija Republike Srbije, Beograd
- Pokrajinski sekretarijat za visoko obrazovanje i naučno - istraživačku delatnost AP Vojvodine, Novi Sad
- Matica srpska, Novi Sad

TECHNICAL COSPONSORS - STRUČNI POKROVITELJI

- IEEE Power Electronics Society, Piscataway, USA
- IEEE Industrial Electronics Society, Piscataway, USA
- IEEE Industry Applications Society, Piscataway, USA
- IEEE - Serbia and Montenegro Section, Belgrade, Serbia
- IEEE Joint Chapter IAS/IES/PELS, Novi Sad, Serbia
- European Power Electronics and Drives Association, Brussels, Belgium
- European Center for Power Electronics, Nuremberg, Germany
- PEMC Council, Budapest, Hungary
- Society for Electronics, Telecommunications, Computers, Automatic Control and Nuclear Engineering, Belgrade, Serbia



- IEEE Društvo za energetska elektroniku, Piskatavej, SAD
- IEEE Društvo za industrijsku elektroniku, Piskatavej, SAD
- IEEE Društvo za industrijske primene, Piskatavej, SAD
- IEEE – Sekcija Srbija i Crna Gora, Beograd, Srbija
- IEEE zajednička podružnica IAS/IES/PELS, Novi Sad, Srbija
- Evropsko udruženje za energetska elektroniku i pogone, Brisel, Belgija
- Evropski centar za energetska elektroniku, Nuremberg, Nemačka
- PEMC udruženje, Budimpešta, Mađarska
- Društvo za Elektroniku, Telekomunikacije, Računarstvo, Automatiku i Nuklearnu tehniku, Beograd, Srbija

PARTNER - PARTNER

- Science and Technology park Novi Sad, Serbia



- Naučno-tehnološki park Novi Sad, Srbija

SUPPORTED BY - PODRŽAN OD

- ZF Serbia, Pančevo, Serbia



GOLDEN SPONSORS - ZLATNI SPONZORI

- Tajfun HIL d.o.o., Novi Sad, Serbia



- Bosch, Belgrade, Serbia

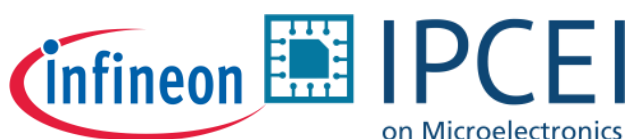


SILVER SPONSORS - SREBRNI SPONZORI

- Brose d.o.o., Pančevo, Serbia



- Infineon, Villach, Austria



EXHIBITORS - IZLAGAČI

- Continental, Novi Sad, Serbia



- MIND park, Kragujevac, Serbia



- Origin, Belgrade, Serbia / Nova Zona, Pančevo, Serbia



- Electrical Institute Nikola Tesla, Belgrade, Serbia



- Department of power, electronic and telecommunication engineering, Novi Sad, Serbia



ORGANIZED BY - ORGANIZATORI



Power Electronics Society - Društvo za energetska elektroniku
21000 Novi Sad, Fruškogorska 11, Serbia
Phone-Tel. 021/485-4547,
www.dee.uns.ac.rs E-mail: dee@uns.ac.rs



Electrotechnical Institute "Nikola Tesla" - Elektrotehnički institut "Nikola Tesla"
11000 Beograd, Koste Glavinića 8a, Serbia
Phone-Tel. 011/36-91-447, Fax 011/36-90-823
www.ieent.org E-mail: info@ieent.org



University of Novi Sad - Univerzitet u Novom Sadu
Faculty of Technical Sciences - Department for Power, Electronics & Telecom. Eng.
Fakultet tehničkih nauka - Departman za energetiku, elektroniku i telekomunikacije
21000 Novi Sad, Fruškogorska 1, Serbia
Phone-Tel. +381 21 485 4501,
www.ftn.uns.ac.rs E-mail: ftndean@uns.ac.rs



Serbian Academy of Sciences and Arts – Srpska Akedmija nauka i umetnosti,
Kneza Mihaila St. 35, Belgrade, Serbia
www.sanu.ac.rs E-mail: sasadir@sanu.ac.rs

GENERAL CHAIRS - PREDSEDAVAJUĆI

Prof. Dr. Vladimir Katić

University of Novi Sad, Faculty of Technical Sciences,
Novi Sad, Serbia

Academ. Prof. Slobodan Vukosavić

University of Belgrade and
Serbian Academy of Sciences and Arts, Belgrade, Serbia

Prof. Dushan Boroyevich

Virginia Tech, Blacksburg (VA), United States

TECHNICAL CHAIRS – PREDSEDAVAJUĆI PROGRAMSKOG ODBORA

Asst. Prof. Miroslav Vasić

Universidad Politecnica de Madrid, Center for Industrial Electronics
Madrid, Spain

Prof. Jelena Popović

The University of Twente, Twente, The Netherlands

Dr. Dusan Graovac

Infineon Technologies AG,
Neubiberg, Germany

Dr. Žarko Janda

University of Belgrade, Institute Nikola Tesla,
Belgrade, Serbia

PUBLICATION CHAIR – PREDSEDAVAJUĆI ZA IZDAVAŠTVO

Assist. Prof. Aleksandar Stanisavljević
University of Novi Sad, Faculty of Technical Sciences,
Novi Sad, Serbia

TRESURER & ORG. COMM. CHAIR - BLAGAJNA & PREDSEDNIK ORG.ODBORA

Assoc. Prof. Zoltan Corba
University of Novi Sad, Faculty of Technical Sciences,
Novi Sad, Serbia

EXHIBITION CHAIRS – PREDSEDAVAJUĆI ZA IZLOŽBU

Assoc. Prof. Stevan Cvetičanin
University of Novi Sad, Faculty of Technical Sciences,
Novi Sad, Serbia

Assist. Prof. Nikola Vukajlović
University of Novi Sad, Faculty of Technical Sciences,
Novi Sad, Serbia

INFORMATION CHAIR – PREDSEDAVAJUĆI ZA INFORMISANJE

Dragomir Nikolić, MSc
University of Novi Sad, Faculty of Technical Sciences,
Novi Sad, Serbia

INTERNATIONAL PROGRAMME COMMITTEE - MEĐUNARODNI PROGRAMSKI KOMITET

1. Kouzou Abdellah, University of Djelfa, Algeria
2. Vanja Ambrozic, University of Ljubljana, Slovenia
3. Goce L. Arsov, SS Cyril and Methodius University, Skopje, Macedonia
4. Seddik Bacha, Grenoble Alpes University/G2Elab and Supergrid Institute, France
5. Drago Ban, University of Zagreb, Zagreb, Croatia
6. Pavol Bauer, Delft University of Technology, Netherlands
7. Milan Bebić, University of Belgrade, Belgrade, Serbia
8. Frede Blaabjerg, Aalborg University, Denmark
9. Branko Blanuša, University of Banja Luka, Banja Luka, B&H
10. Ion Boldea, University Politehnica of Timisoara, Romania
11. Dushan Boroyevich, Virginia Tech, Blacksburg, Virginia, USA
12. Sergio Busquets-Monge, Universitat Politecnica de Catalunya, Spain
13. Mihai Cernat, "Transilvania" University of Brasov, Brasov, Romania
14. Ilhami Colak, Nisantasi University, Istanbul, Turkey
15. Sergio Cruz, University of Coimbra, Portugal
16. Željko Despotović, University of Belgrade, Mihajlo Pupin Institute, Serbia
17. Sasa Djokic, The University of Edinburgh, United Kingdom
18. Branko Dokić, University of Bajnje Luka, Banja Lika, B&H
19. Martin Doppelbauer, Karlsruhe Institute of Technology, Karlsruhe, Germany
20. Dinu Dragan, University of Novi Sad, Novi Sad, Serbia
21. Jasna Dragosavac, Institute Nikola Tesla, Belgrade, Serbia
22. Drazen Dujic, EPFL, Lausanne, Switzerland
23. Viliam Fedak, Technical University of Kosice, Slovakia
24. Dusan Gajic, University of Novi Sad, Novi Sad, Serbia

25. Ilya Galkin, Riga Technical University, Latvia
26. Dusan Graovac, Infineon Technologies AG, Germany
27. Stevan Grabic, University of Novi Sad, Novi Sad, Serbia
28. Adrian Graur, "Stefan Cel Mare" University of Suceava, Suceava, Romania
29. Petar Grbović, University of Innsbruck, Innsbruck, Austria
30. Boguslaw Grzesik, Silesian University of Technology, Gliwice, Poland
31. Marc Hiller, University in Karlsruhe, Karlsruhe, Germany
32. Žarko Janda, Institute Nikola Tesla, Belgrade, Serbia
33. Borislav Jeftenic, University of Belgrade, Belgrade, Serbia
34. Dejan Jerkan, University of Novi Sad, Serbia
35. Gojko Joksimović, Univerzitet Crne Gore, Podgorica, Crna Gora
36. Milutin Jovanović, Northumbria University, Newcastle, UK
37. Vladimir Katić, University of Novi Sad, Novi Sad, Serbia
38. Jovan Knezevic, BMW Group, Germany
39. Johann W. Kolar, Swiss Federal Institute of Technology, ETH Zentrum, Switzerland
40. Emil Levi, Liverpool John Moores University, Liverpool, UK
41. Leo Lorenz, University of Ilmenau and ECPE, Nuremberg, Germany
42. Slobodan Lubura, University of East Sarajevo, East Sarajevo, B&H
43. Darko Marčetić, University of Novi Sad, Novi Sad, Serbia
44. Petar Matic, University of Banja Luka, Banja Luka, Republic of Srpska, B&H
45. Luis Martinez-Salamero, Rovira i Virgili University, Tarragona, Spain
46. Jovica Milanović, The University of Manchester, Manchester, UK
47. Miro Milanovič, University of Maribor, Maribor, Slovenia
48. Čedomir Milosavljević, University of East Sarajevo, BIH
49. Slobodan Mircevski, SS Cyril and Methodius University, Skopje, Macedonia
50. Nebojša Mitrović, University of Niš, Niš, Serbia
51. Valentin Oleschuk, Academy of Sciences of Moldova, Moldova
52. Denis Pelin, University of Osijek, Croatia
53. Milutin Petronijevic, University of Nis, Serbia
54. Juan Peracaula, Polytechn. University of Catalonia, Barcelona, Spain
55. Aleksandar Prodić, University of Toronto, Toronto, Canada
56. Jovan Radaković, EPS, Subotica, Serbia
57. Lepasava Ristić, University of Belgrade, Belgrade, Serbia
58. Marco Rivera, Universidad de Talca, Talca, Chile
59. Milan Radmanović, University of Niš, Niš, Serbia
60. Miran Rodič, University of Maribor, Slovenia
61. Pedro Rodriguez-Ayerbe, CENTRALESUPELEC, France
62. Alfred Rufer, EPFL, Lausanne, Switzerland
63. Mincho Simeonov, Technical University of Gabrovo, Gabrovo, Bulgaria
64. Aleksandar Stanisavljevic, University of Novi Sad, Novi Sad, Serbia
65. Aleksandar M. Stanković, Tufts University, Boston, USA
66. Vojislav Stefanović, V-S Drives, New York, USA
67. Mariusz Stepien, Silesian University of Technology, Gliwice, Poland
68. Djordje Stojic, Institute Nikola Tesla, Belgrade, Serbia
69. Milomir Šoja, University of East Sarajevo, East Sarajevo, B&H
70. Alberto Tassarolo, University of Trieste, Trieste, Italy
71. Miroslav Vasic, Universidad Politecnica de Madrid, Center for Industrial Electronics, Madrid, Spain
72. Vladimir Vukić, Institute Nikola Tesla, Belgrade, Serbia
73. Slobodan Vukosavić, University of Belgrade and SANU, Belgrade, Serbia
74. Yongheng Yang, Aalborg University, Denmark

ORGANIZING COMMITTEE –ORGANIZACIONI KOMITET

1. **Assoc. Prof. Zoltan Čorba, University of Novi Sad, Serbia, Chairman**
2. Prof. Vladimir Katić, University of Novi Sad, Novi Sad, Serbia, Co-chairman
3. Academ, Prof. Slobodan Vukosavić, University of Belgrade & SANU, Belgrade, Serbia, Co-chairman
4. Dr Žarko Janda, Institute Nikola Tesla, Belgrade, Serbia
5. Nebojša Drakulić, Science Technology Park, Novi Sad, Serbia
6. Prof. Borislav Jeftenić, Power Electronics Society, Serbia
7. Prof. Nebojša Mitrović, University of Niš, Serbia
8. Prof. Darko Marčetić, University of Novi Sad, Serbia
9. Prof. Dragan Simić, University of Novi Sad, Novi Sad, Serbia
10. Assoc. Prof. Boris Dumnić, University of Novi Sad, Novi Sad, Serbia
11. Assis. Prof. Aleksandar Stanisljević, University of Novi Sad, Serbia
12. Assoc. Prof. Marko Vekić, University of Novi Sad, Novi Sad, Serbia
13. Assoc. Prof. Stevan Cvetičanin, University of Novi Sad, Novi Sad, Serbia
14. Assoc. Prof. Stevan Grabić, University of Novi Sad, Novi Sad, Serbia
15. Assist. Prof. Ivan Todorović, University of Novi Sad, Novi Sad, Serbia
16. Assist. Prof. Bane Popadić, University of Novi Sad, Novi Sad, Serbia
17. Assoc. Prof. Dejan Jerkan, University of Novi Sad, Serbia
18. Milica Banović, Ph.D. student, University of Belgrade, Serbia
19. Kristina Vujkov, Ph.D. student, University of Novi Sad, Serbia
20. Barbara Vujkov, University of Novi Sad, Serbia
21. Mladen Vučković, University of Novi Sad, Serbia
22. Dragomir Nikolić, University of Novi Sad
23. Ljubinka Buba Gerić, University of Novi Sad

Reviewers

International Programme Committee

Technical Support

Assoc. Prof. Zoltan Čorba

Web Master and E-Publishing

Dragomir Nikolić

Exhibition

Assoc. Prof. Stevan Cvetičanin

Finances

Ljubinka Gerić

Ee 2023 - Sekretariat

*Ms Ljubinka-Buba Gerić, Ms Jadranka Galić,
Mr Dragomir Nikolić, Assoc.Prof. Zoltan Čorba*

University of Novi Sad
Faculty of Technical Sciences
21000 Novi Sad
Trg Dositeja Obradovića 6
Serbia

Recenzenti

Međunarodni programski odbor

Tehnička podrška

van.prof. dr Zoltan Čorba

Vebsajt i e-izdavaštvo

Dragomir Nikolić

Izložba

vanr.prof. dr Stevan Cvetičanin

Finansije

Ljubinka Gerić

Ee 2023 – Sekretarijat

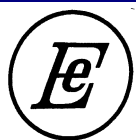
Univerzitet u Novom Sadu
Fakultet tehničkih nauka
21000 Novi Sad
Trg Dositeja Obradovića 6
Srbija

Tel.: +381 21 485 4504

E-mail: dee@uns.ac.rs, URL: www.dee.uns.ac.rs

Publishing of this Book of Abstracts & Electronics proceedings on USB was supported by Ministry of Education, Science and Technological Development of Republic of Serbia, Belgrade, and Provincial Secretariat for Higher Education and Scientific Research Activity, AP Vojvodina, Novi Sad

Štampanje ovog zbornika apstrakata i elektronskog zbornika radova na USB-u finansijski je pomoglo Ministarstvo prosvete, nauke i tehnološkog razvoja, Republike Srbije, Beograd i Pokrajinski sekretarijat za visoko obrazovanje i naučno-istraživačku delatnost, AP Vojvodine, Novi Sad



Symposiums on Power Electronics

Simpozijumi/Savetovanja Energetska elektronika

1. 1973 - I Savetovanje Energetska Elektronika - Beograd
2. 1975 - II Savetovanje Energetska Elektronika - Beograd
3. 1978 - III Savetovanje Energetska Elektronika - Zagreb
4. 1981 - IV Savetovanje Energetska Elektronika - Sarajevo
5. 1984 - V Savetovanje Energetska Elektronika - Ljubljana
6. 1986 - VI Savetovanje Energetska Elektronika - Subotica
7. 1988 - VII Savetovanje Energetska Elektronika - Beograd
8. 1995 - VIII Simpozijum Energetska Elektronika - Novi Sad
8th Symposium on Power Electronics
9. 1997 - IX Simpozijum Energetska Elektronika - Novi Sad
9th Symposium on Power Electronics
10. 1999 - X Simpozijum Energetska Elektronika - Novi Sad
10th Symposium on Power Electronics
11. 2001 - 11th International Symposium on Power Electronics - Novi Sad
XI Međunarodni simpozijum Energetska Elektronika
12. 2003 - 12th International Symposium on Power Electronics - Novi Sad
XII Međunarodni simpozijum Energetska Elektronika
13. 2005 - 13th International Symposium on Power Electronics - Novi Sad
XIII Međunarodni simpozijum Energetska Elektronika
14. 2007 - 14th International Symposium on Power Electronics - Novi Sad
XVI Međunarodni simpozijum Energetska Elektronika
15. 2009 - 15th International Symposium on Power Electronics - Novi Sad
XV Savetovanje Energetska Elektronika
16. 2011 - 16th International Symposium on Power Electronics - Novi Sad
XVI Savetovanje Energetska Elektronika
17. 2013 - 17th International Symposium on Power Electronics - Novi Sad
XVII Savetovanje Energetska Elektronika
18. 2015 - 18th International Symposium on Power Electronics - Novi Sad
XVIII Savetovanje Energetska Elektronika
19. 2017 - 19th International Symposium on Power Electronics - Novi Sad
XIX Savetovanje Energetska Elektronika
20. 2019 - 20th International Symposium on Power Electronics - Novi Sad
XX Savetovanje Energetska Elektronika
21. 2021 - 21st International Symposium on Power Electronics - Novi Sad
XXI Savetovanje Energetska Elektronika
22. 2023 - 22nd International Symposium on Power Electronics - Novi Sad
XXII Savetovanje Energetska Elektronika



XXII Savetovanje Energetska elektronika Ee 2023

PREDGOVOR

Savetovanje/Simpozijum Energetska elektronika obeležava 50 godina od svog prvog okupljanja u Beogradu daleke 1973. god. Ova duga tradicija pokazuje da je zajednica energetske elektronike u Srbiji aktivnai da ima značajne rezultate, vredne širom sveta. Prva konferencija održana je na srpskom jeziku kao savetovanje, a prezentovano je 47 referata iz bivše Jugoslavije. Uvedena je popularna naslovna skraćenica Ee(od Energetska elektronika). Sledeće konferencije održane su u Beogradu 1975. god. sa 50 referata, Zagrebu 1978. god. sa 94 rada, Sarajevu 1981. god. sa 95 referata, Ljubljani 1984. god. sa 104 rada, Subotici 1986. god. sa 126 referata i Beogradu 1988. god. sa 109 referata.

Posleduže pauze, usled nemilih događaja i raspada Jugoslavije, Energetska elektronika je oživela i nastavila 1995. god. u Novom Sadu, sa 79 radova. Počeo je kao naučni simpozijum sa izložbom, pa je za mesto održavanja izabran Međunarodni sajam elektronike i informatike Sledećisimpozijumi održanis u Novom Sadu 1997. god. sa 98 referata i 1999. god. sa 82 rada. Značajno učešće stranih autora rezultiralo je nadogradnjom simpozijuma u međunarodni, koji je 2001. god. okupio 107 radova, 2003. god. 101 rad, 2005. god. 94 rada, 2007. god. 101 rad, a 2009. god. 105 radova. Simpozijum je 2011. god. uključen u novu manifestaciju šireg obima „Dani energije” u Master konferencijskom centru Novosadskog sajma i privukao je102 rada, dok je Ee2013 imao 69 radova Međutim učešće industrije na izložbi je oslabilo, pa je odlučeno da se mesto održavanja premesti na univerzitet Sledećj Ee 2015 simpozijum održan je u Centralnoj zgradi Univerziteta u Novom Sadu, na kome je prezentovan 71 rad.

19. Međunarodni simpozijum o energetskoj elektronici Ee 2017 organizovan je po standardima vrhunske svetske naučne konferencije. Bio je to prvi tehnički kosponzorisan od IEEE Power Electronics Society (PELS) and IEEE Industrial Electronics Society (IES), the European Power Electronics (EPE) Association, i od the European Centre for Power Electronics (ECPE), kao i od IEEE Serbia and Montenegro Section and IEEE Joint Chapter PELS/IES/IAS of Serbia and Montenegro Section. Ovo snažno angažovanje IEEE donelo je promene u procesu pregleda i prihvatanja radova, koji su obavljani po IEEE standardima, pa je predstavljeno 75 radova i predavanja 248 autora iz 29 zemalja. Svi predstavljeni radovi su uključeni u IEEE Xplore bazu podataka i citirani u bazama Web of Science, Scopus i Google Scholar. 20. jubilarni simpozijum nastavljen uz IEEE tehničko kosponzorstvo i uz uključnje IEEE Industry Application Society, Ee 2019, okupio je u Novom Sadu 73 rada i predavanja, koje je napisalo 235 autora i koautora iz 23 zemlje. Nedavna pandemija virusa COVID-19 2020. god. i tada uvedena ograničenja putovanja, primorali su Organizacioni odbor da 21. međunarodni simpozijum o energetskoj elektronici - Ee 2021 organizuje u virtuelnoj formi (online). Ipak, 234 autora iz 27 zemalja pripremlilo je ukupno 81 rad i predavanja.

Godina 2023. donosi još jedan jubilej, 50 godina od prve konferencije. Organizacioni odbor 22. međunarodnog simpozijuma o energetskoj elektronici Ee 2023 odlučio je da unese neke izmene u organizaciji. Konferencija se po prvi put organizuje na dve lokacije, u Beogradu u Srpskoj akademiji nauka i umetnosti (SANU) i u Novom Sadu u salama Naučno-tehnološkog parka (NTP). Ideja je bila da se oda počast osnivačima Ee simpozijuma, srpskim akademikima, profesorima i naučnicima, pa je otvaranje, proslava jubileja i deo uvodnih predavanja zakazan u Svečanoj sali SANU u Beogradu, kao i da se oživi učešće vrhunskih tehnoloških kompanija, pa je naučni deo i ponovo oživljena izložba organizovana u salama i atrijumu NTP u Novom Sadu. Simpozijum je okupio 88 radova i predavanja (55 vrhunskih radova, uključujući 4 pozvana i 1 Keynote referat, 6 Keynote predavanja, 2 pozvana predavanja, 15 industrijskih prezentacija, 3 tutorijala, 1 istaknuto predavanje i 6 radovana nacionalnom savetovanju), koji su napisani od 280 autora i koautora iz 24 zemlje. Svi radovi su prošli kroz process dvostruke “slepe” revizije od strane Međunarodnog programskog komiteta i tehničkog prilagođavanja od strane Sekretarijata. Od 67 pristiglih radova za međunarodni simpozijum, 55 (82%) je prihvaćeno za predstavljanje na uvodnim, pozvanim i redovnim sesijama. Pored toga, organizovane sui tri industrijske sesije, jedno predavanje uglednog profesora i tri tutorijala.

Ovom prilikom želim da odam priznanje za veliki rad i trud kopredsedavajućinsimpozijuma prof. Dušanu Borojeviću sa Virginia Tech, SAD, i akademiku prof. Slobodanu Vukosaviću iz SANU/Univerzitet u Beogradu, te prof. dr Miroslavu Vasiću sa Politehničkog univerziteta u Madridu Španija prof. Aleksandru Prodićusa Univerziteta u Torontu, Kanada, dr Žarku Jandi iz Elektrotehničkog Instituta Nikola Tesla, Srbija, prof. Jeleni Popovićsa Univerziteta Tvente, Holandija i dr. Dušanu Graovcu iz Infineon Technologies, Nemačka/Austrija, koji su okupili veliki tim stručnjaka za energetsku elektroniku kao voditelje tema i recenzente, pozvali poznate uvodničare i vrhunske predavače i organizovali tutorijale, što je rezultiralo visokim kvalitetom programa simpozijuma Takođe zahvaljujemi prof Aleksandru Stanisavljeviću koji je uspeo da prođe kroz složenu procedure pripreme osnova za uvrštavanje svih prezentovanih radova u IEEE Xplore digitalnu biblioteku, te Web of Science, Scopus i Google Scholar baze citiranja. Njihov rad je veoma cenjen.

Predstavljeni radovi prikazuju najnovije rezultate istraživanja, nove tehnologije i trendove, kao i dostignuća industrije. Na Simpozijumu je da proceni značaj ovih doprinosa. Za tačnost rezultata, iskaza i zaključaka odgovorni su sami autori.

Paralelno, održava se XXII Savetovanje Energetska elektronika (na srpskom jeziku) i godišnja skupština Društva za energetsku elektroniku Srbije.

Prof. dr Vladimir Katić
Predsedavajući simpozijuma Ee 2023 i Predsednik Društva za
Energetsku elektroniku Srbije

FOREWORD

The Power Electronics Symposium is celebrating 50 years from its first gathering in Belgrade way back in 1973. This long tradition shows that the power electronics community in Serbia is active and has significant results, valuable worldwide. The first conference was held in the Serbian language as a national one, and 47 papers from all over ex-Yugoslavia were presented. It introduced the popular title abbreviation **Ee** (abbreviated from the Serbian name *Energetska elektronika*). The next conferences were held in Belgrade in 1975 with 50 papers, Zagreb in 1978 with 94 papers, Sarajevo in 1981 with 95 papers, Ljubljana in 1984 with 104 papers, Subotica in 1986 with 126 papers, and Belgrade in 1988, with 109 papers.

After a long break, due to unfortunate events in ex-Yugoslavia, Power Electronics revived and continued in 1995 in Novi Sad, with 79 papers. It started as a scientific symposium with an exhibition, so for the venue, the International Fair on Electronics and Informatics was chosen. The next symposiums were held in Novi Sad – in 1997, with 98 papers, and in 1999, with 82 papers. Significant participation of foreign authors resulted in an upgrade of the symposium into an international one, which in 2001 gathered 107 papers, in 2003 101 papers, in 2005 94 papers, in 2007 101 papers, and in 2009 105 papers. In 2011 the symposium was included in the new wider-scope event „Energy Days” in the Master Conference Center of Novi Sad Fair and attracted 102 papers in 2011 and 69 papers in 2013. However, the industry participation at the exhibition weakened, so it was decided to move into academia. The next, 2015 symposium was held in the Central Building of the University of Novi Sad, where 71 papers have been presented. The average number of participants was between 150 and 200 of which a significant portion were students and industry experts.

The 19th International Symposium on Power Electronics *Ee 2017* was organized according to the standards of the top World scientific conference. It was the first one technically co-sponsored by the IEEE Power Electronics Society (PELS) and IEEE Industrial Electronics Society (IES), the European Power Electronics (EPE) Association, and the European Centre for Power Electronics (ECPE), as well as by IEEE Serbia and Montenegro Section and IEEE Joint Chapter PELS/IES/IAS of Serbia and Montenegro Section. This strong involvement of IEEE brought changes in the paper review and acceptance process, which were performed according to IEEE standards, so 75 papers and lectures by 248 authors from 29 countries were presented. All presented papers were included in the IEEE Xplore database and cited in Web of Science, Scopus, and Google Scholar. The 20th jubilee symposium continued with IEEE technical sponsorship and included the IEEE Industry Application Society, as well. It gathered at *Ee 2019* in Novi Sad 73 papers and lectures, which were written by 235 authors & co-authors from 23 countries. The famous pandemic virus COVID-19 in 2020 and the travel restrictions introduced at that time, forced the Organizing Committee to organize the 21st International Symposium on Power Electronics *Ee 2021* in virtual form (online). Still, 234 authors from 27 countries prepared in total 81 papers and lectures.

The 2023 brings another jubilee, 50 years from the first conference. The Organizing Committee of the 22nd International Symposium on Power Electronics – *Ee 2023* decided to bring some changes to the organization. For the first time, the conference is organized at two locations, in Belgrade at the Serbian Academy of Sciences and Arts (SASA) and in Novi Sad at the halls of the Science and Technology Park (STP). The idea was to make a tribute to the founders of the *Ee* symposiums, Serbian academicians, professors, and scientists, so the opening, jubilee celebration, and some Keynotes are scheduled in the Ceremonial Hall of the SASA in Belgrade, and to revive the Hi-Tech industry participation, so the scientific part and reestablished exhibition are programmed in the Halls and Atrium of the STP in Novi Sad. The symposium gathered 88 papers and lectures (55 top-quality papers including 4 invited and 1 Keynote paper, 6 Keynote lectures, 2 invited lectures, 15 industry presentations, 3 tutorials, 1 distinguished professor lecture, and 6 papers at national conference) prepared by 280 authors and co-authors from 24 countries. All papers have passed through a double-blind reviewing process by the International Program Committee and technical adjustment by the Secretariat. From 67 submitted full papers for the international symposium, 55 (82%) have been accepted and will be presented in Keynote, Invited, and Regular sessions. Additionally, three industry sessions, one distinguished professor lecture, and three tutorials will be organized.

I would like to acknowledge the great work of the symposium co-chairs Prof. Dushan Boroyevic, from Virginia Tech, USA, and Academician Prof. Slobodan Vukosavic, from SASA/University of Belgrade, Serbia, the symposium Technical Chairs Prof. Miroslav Vasic, from the Universidad Politecnica de Madrid, Spain, Prof. Aleksandar Prodic, from University of Toronto, Canada, Dr. Zarko Janda, from Electrical Engineering Institute Nikola Tesla, Serbia, Prof. Jelena Popovic, from University of Twente, The Netherlands and Dr. Dushan Graovac, from Infineon Technologies, Germany/Austria, who gathered a large team of power electronics experts as topic chairs and reviewers, invited famous key-note speakers and high expert presenters and organized the tutorials, which resulted in high quality of the symposium program. Also, the Publication Chair Prof. Aleksandar Stanisavljevic managed to go through a complex procedure of preparing fundamentals for post-conference inclusion of all presented papers in the *IEEE Xplore* digital library and *Web of Science*, *Scopus*, and *Google Scholar* citation bases. Their work is highly appreciated.

The presented contributions show the latest research results, new technologies, and trends, as well as achievements of the industry. It is to the Symposium to evaluate the significance of these contributions. The authors themselves are responsible for the accuracy of the results, statements, and conclusions.

As parallel events, the XXII National Conference *Energetska elektronika* (in the Serbian language) and the annual assembly of the Serbian Power Electronics Society will be held.

Prof. Dr. Vladimir Katić

Ee 2023 Chairman &
President of the Serbian Power Electronics Society