Power Electronics in Serbia – a look backward on 20 symposiums

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***Abstract* — Power Electronics in Serbia has passed rapid development in the last 50 years. It was result of collaboration and synergy between research institutes, industry and academia in Serbia (former Yugoslavia), but also of enthusiasm and devotion of research teams all over the country. Significant production program in industry was put into manufacturing process, and extensive experience and know-how has been gained. Such great interest was motivation to researchers of the Institute Nikola Tesla from Belgrade and the Serbian Academy of Sciences and Arts to establish in 1973 a national forum for exchange of scientific results, the Power Electronics conference. The conference started in Belgrade then it was organized in several major research centres of Yugoslavia, while finally sited in Novi Sad in 1995. Today it is a symposium, fully international, cosponsored by the IEEE with all papers included in the IEEE Xplore database and cited in the Web of Science, the Scopus and Google scholar. In this paper development of power electronics and main research results are followed as reflection of papers presented in the previous 20 Power Electronics conferences and symposiums. As huge number of papers has been presented, this overview will be devoted to progress of power electronics in Serbia, only. Theirs main researchers will be highlighted, as they made and are still making significant contribution to the Worlds´ power electronics community.**

Keywords — Power Electronics, Serbia, Symposium on Power Electronics

I. INTRODUCTION

The development of any scientific field is closely linked to the establishment and holding of scientific and research conferences, symposia and workshops. They are an important place for sharing novel scientific results, research directions, and practical experiences and for broad discussions. By following the topics, content of the papers, titles of sessions, panels, tutorials and other related activities, one can get an overview on development in a field.

In the field of electrical and electronics engineering in Serbia the first steps were made by the Serbian Committee of CIGRE (established as Yugoslav Committee of CIGRE), which organized the 1st National CIGRE conference in 1951, and by the Society for Electronics, Telecommunications, Computers, Automatic Control and Nuclear Engineering (ETRAN), which has started its conference activities in 1955.

The field of power electronics is related to application of electronics principles in processing power with maximum efficiency. By such approach it distinguished itself from electrical engineering, so at the beginning of the 20th century the first power electronics device based on vacuum-tube technology, mercury arc rectifier has been invented. The modern era in power electronics, but also in electrical and electronics engineering, started with introduction of thyristor (or Silicon Controlled Rectifier - SCR), a three terminal p-n-p-n semiconductor power device in 1957 by General Electric. This new device opened possibilities to design different power converters (AC/DC, AC/AC, DC/AC or DC/DC), with significant improvement in efficiency, so existing rotating converters became obsolete and were soon abounded. However, the device itself and implementation of these converters, effects on electric machines and industrial drives characteristics and operation, but also new control opportunities, and many other issues, opened many new questions and development crossroads or produced different solutions, so needs for conference dedicated to these issues have had aroused.

Thus, in June 1973, the first national Power Electronics conference (*Energetska elektronika* in Serbian) was organized in Belgrade, Serbia. It was result of significant activities of Serbian researchers and engineers, but also needs of industry, in framework of development in wider area of that time Yugoslavia and Eastern Europe, as well. Nowadays, after 46 years, the conference has strongly positioned itself as an important regional international event. The International symposium on Power electronics, popular Ee, is now in the 20th edition.

The aim of this paper is to present the development and achievements of power electronics in Serbia, to explain why its researchers made and are still making significant contribution to the Worlds´ power electronics community, and to show possible future directions, all of that through the visor, content, selection of authors, participant and other features of 20 conducted conferences or symposiums.

II. BACKGROUND

In the 50-ties and 60-ties of the 20th century intensive electrification and industrialization has been conducted all over the Serbia (Yugoslavia at that time). It was the time when new universities were established in Novi Sad, Niš, Kragujevac, apart from major one in Belgrade. Modern technology was implemented either by obtaining licences or by self-development in research institutions. Know-how transfer to industry and research were done mainly through several research institutes and some engineering faculties with long tradition. In the field of power engineering, the Institute Nikola Tesla in Belgrade, Faculty of Electrical Engineering and Faculty of Mechanical Engineering in Belgrade, were the leading ones.

978-1-7281-5067-3/19/$31.00 ©2019 IEEE

There were several other well-known research institutes in other major cities of former Yugoslavia (Zagreb, Ljubljana, and Sarajevo). They had very good teams and valuable results in implementing the modern technology in general. Also, they were successful in manufacturing power electronics converters in industry, in electric transportation, in electric power generation and other fields. Power electronics industry was not significant, as power converters with vacuum-tube technology devices have been assembled and handed-over to users by manufacturing units in these institutes. The main products were mercury-arc rectifiers for DC drives, battery chargers and uninterruptable power sources, together with various rotating converters.

III. Power Electronics Beginning in Serbia

In Serbia in the late 1950-ties electrical engineering industry was mainly related to electrical machinery and cables, while electronics industry dealt with low power vacuum-tube devices and consumer electronics (radio and TV sets, telephone sets, telephone exchanges, etc.). There was no industry or manufacturers with power electronics products.

The major breakthrough was made in 1967, when Prof. Petar Miljanić brought from Canada some samples of the first high power solid-state devices, the SCR or thyristor [1,2]. At that time, theory and some applications of the thyristor based converters were well-known and taught at the university, but there were no practical experiences. He initiated different solution for in control of the DC excitation of synchronous generators of the Djerdap hydro power plant in 1968 (commissioned in 1972 with installed capacity of 1.03 GW on Serbian side and 1.03 GW on Romanian side), i.e. application of thyristor rectifier with phase control. Furthermore, a young team of researchers, Petar Miljanić, Vladan Vučković, Djordje Kalić, Dejan Schreiber, and others, decided to use the new device for assembling power converters and starts solving practical problems in their industrial technical solutions. Such decision boosts research on solid-state converters and power electronics in general. The first current controlled variable speed induction motor drive with rectifier-inverter energy recuperation was produced at the Institute "Nikola Tesla", as results of collaboration with Electrical and Mechanical Engineering faculties in Belgrade and the Serbian Academy of Sciences and Arts. There were many other practical realizations, like thyristor sub-synchronous cascades for speed control of induction motor driving pumps in pumping stations and heating plants, thyristor DC/AC converter for UPS applications, AC/AC cyclo-converter, etc.

IV. The Early Conferences

Such significant achievements resulted in decision to organize the first national conference on Power Electronics by Serbian Academy of Sciences and Arts, and Institute "Nikola Tesla". The conference was held in the premises of the Serbian academy in 1973 with 47 papers presented and more than one hundred participants. Organizing committee included Prof. Petar Miljanić, Prof. Vladan Vučković (Fig.1) and Prof. Đorđe Kalić, while the Proceedings were edited by Đorđe Kalić.

The topic of the conference were devoted to power converters, especially to inverters for speed-control of AC drives or for uninterruptible power supplies, which were presented in several papers by researchers from the Electrotechnical Institute Nikola Tesla from Belgrade (dr P. Miljanić, dr V. Vučković, M. Daković, dr Đ.Kalić). Also, DC drives, modelling of devices, battery chargers, etc. were topics of the conference papers. An overview of different power electronics converters ("Task and Perspectives of Power Electronics") was presented at plenary session by Prof. Z. Plenković.

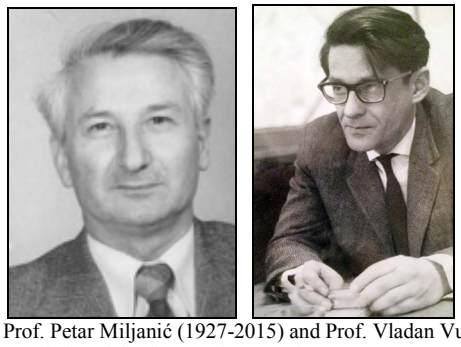

Fig.1. Prof. Petar Miljanić (1927-2015) and Prof. Vladan Vučković (1928-2006) – chairs of the first conference, the Ee ´73.
Sources: http://www.ains.rs/clanstvo/ains.web.pocasni/Miljanic.Petar.htm and https://sr.wikipedia.org/sr-el/Владан_Вучковић

The next conference was devoted to the 120th birthday of Nikola Tesla and held in Belgrade in 1975 with 50 presented papers. Application of thyristors dominated in all presented papers, with different solution, like AC/DC converters in DC drives, DC Chopper for electric vehicle drive, DC/AC converters for control of induction motors, etc. Most of the papers came from several research groups from the Institute Nikola Tesla and Faculty of Electrical Engineering from Belgrade. Many of papers were based on practical solutions, while new ideas had experimental verification. It should be noted that at that time new courses on Electric Power Converters (with this title or similar) started almost at all university centres in Serbia and Yugoslavia. At the Faculty of Electrical Engineering in Belgrade this course was introduced in 1978 by Prof. Petar Miljanić, which replaced the previous course on Mutators (Mercury-arc converters) toughed by Prof. Ilija Volčkov, At the University of Novi Sad, Faculty of Technical Sciences similar course was introduced by Prof. Vladan Vučković and a new course on Industrial Electronics by Prof. B. Pantić and Vladimir Katić.

Rapid rise in interest on power electronics and application area widening of power electronics devices and products in Serbia were obvious. Several teams in Serbia, at the research Institute Nikola Tesla, the Serbian Academy of Sciences and Arts, in industry (Copper Mill in Sevojno, Electronic industry of Niš, etc.) and at University of Belgrade and Novi Sad, have worked in research and development in this field. Similar cases were in other parts of Yugoslavia, so Yugoslav Coordination Committee has been established in 1978 to organize the next, the 3rd Power Electronics conference. The committee members were Izet Benca, Zvonko Benčić, Tomo Bosanac, Rafael Cajhen, Ahmet Gavranović, Mesud Ibrahimpašić, Petar Miljanić, Zvonko Plenković, Jože Pukl, Ljubiša Šipetić, Ilija Volčkov and Vladan Vučković, a mix of scientist from research institutes, industry and academia. They decided that conference should rotate through Yugoslavia, so next one is organized in Zagreb.

The "Rade Končar" company hosted the 3rd conference in Zagreb in 1978 with 94 papers. The main members of the Organizing Committee were Prof. Zvonko Benčić, Prof. Tomo Bosanac, Prof. Rafael Cajhen, Prof. Petar Miljanić and Prof. Zlatko Plenković (Fig.2). At that time, the first university text-book on power electronics in Yugoslavia was written by Z.Benčić and Z.Plenković: "Power Electronics, 1st part – Semiconductor Valves" (in Serbo-Croatian language, *School Book*, Zagreb, 1978). Serbian researchers presented several papers regarding various aspects of practical applications of DC/DC converter (chopper), and some new solutions of three-phase inverters for control of induction motor drive, induction heating and reluctance motors supply.

Prof. dr. sc. Zvonko Benčić | Acad. Tomo Bosanac (Bjelovar, 15 May 1918 – Zagreb, 12 August 2003), JAZU | Prof. dr. sc. Rafael Cajhen at the time when he retired in 1999 | Acad. Prof. dr. sc. Petar Miljanić (Belgrade, 1927 – Belgrade, 16 February 2015) | Prof. Zlatko Plenković (Podgora, 28 July 1917 – Zagreb, 25 March 2003)

Fig.2. Members of Power Electronics Yugoslav Coordination Committee.
Source: http://www.sveopoduzetnistvu.com/index.php?main=clanak&id=142

The "Energoinvest – IRCA and Energetska elektronika" company hosted the next, the 4th conference in Sarajevo in 1981. Total of 95 papers were presented and the Proceedings editor was Prof. Asif Šabanović. The plenary session paper "Modern tendencies in semiconductor converter design" by Z. Antonić and D. Šrajber presented the state-of-art in this field in Serbia. The direction toward utilization of higher frequencies (up to 100 kHz) switching devices in DC/AC and DC/DC converters showed capabilities of Serbian researchers and industry. However, the need to import some foreign devices and components, limited the cost-effectiveness of such solutions.

At that time microprocessors started to enter in control circuits of power electronics devices, so the first industrial variable-speed induction motor drive with transistor inverter and microprocessor control has been installed and put into operation in "Viskoza" company in Loznica in 1981. The drive was designed by Prof. Vladan Vučković and his team from the Institute "Nikola Tesla". He also transferred his new knowledge and experience on young academicians and students at the University of Belgrade and Faculty of Technical Sciences in Novi Sad and educated and influenced many future famous scientists and researchers, including one of the authors of this paper.

The 5th conference in Ljubljana in 1984 was supported by "ISKRA Avtomatika" company and organized by a new body – Inter-academy Board for Power Electronics of the Yugoslav Academies of Sciences - JAZU, AZU BIH, MANU, SANU and SAZU. The board members were S. Zimunjić (ANU BIH), A. Šabanović (ANU BIH), T. Bosanac (JAZU), Z. Benčić (JAZU), G. Demirovski (MANU), P. Miljanić (SANU), V. Vučković (SANU), L. Gyergyek (SAZU) and K. Jezernik (SAZU). The conference was organized in premises of the Ljubljana Fair and showed strong connection of research and industry and transfer of know-how from academia. In total, 104 papers were presented.

The conference was opened with an overview on the state in Power Electronics in Yugoslavia by Prof. Rafael Cajhen (University of Ljubljana). Researchers from Serbia presented their latest results in digital (microprocessor) control with different applications (for induction motor drive, DC/DC converters, Voltage regulators, etc.). This topic dominated at the conference, also, as the new technology was driving force of further developments in power electronics. Several new research groups from Slovenia (Maribor), Macedonia (Skopje), Bosnia and Herzegovina (Sarajevo) and Serbia (Novi Sad and Subotica) have emerged at that time, showing increased interest and significant achievements in Yugoslavia. Results of a group from Technical Faculty in Maribor, led by Prof. Karel Jezernik in advanced control of drives were especially impressive.

A young group from University of Novi Sad, Faculty of Technical Sciences (Radiša Jevremović, Emil Levi and Vladimir Katić) had it first appearance on the Power Electronics conferences by presenting the paper "Three-phase Natural Commutated Inverter for Induction Motor Drives". The paper analysed possibilities of application of naturally-commutated inverter and presents its characteristics using mathematical modelling and experimental testing.

Another group emerged in Subotica (Serbia). The researchers were employed by electric machines producing company "Sever", and had been working along a huge ERA (Electronics Regulation and Automation) project, together with the mentioned group from the University of Novi Sad, Faculty of Technical Sciences and some researchers from University of Belgrade. This project in particular, but several other power electronics related projects financed by the Republic of Serbia Ministry of Science and the Autonomous Province of Vojvodina research funds have launched some of the finest researchers nowadays, known Worldwide: Prof. Dushan Boroyevich (Faculty of Technical Sciences, now Virginia Tech, USA), Prof. Emil Levi (Faculty of Technical Sciences, now Liverpool John Moors University, U.K.), late Dr. Milan Jovanović (Faculty of Technical Sciences, later Delta Comp., USA), Prof. Slobodan Vukosavić (University of Belgrade, now SANU, also), Prof. Vladimir Katić (University of Novi Sad, Faculty of Technical Sciences), Prof. Jožef Varga (High Electrotechnical School, Subotica now Wolong-Sever, Hungary), Milan Adžić (Sever, now Polytechnic of Subotica, Serbia), Ištvan and Šandor Nađ (Sever, now in private business), Savo Mitrović (Sever, now ATB Sever), Jovan Radaković (Sever, now Elektrovojvodina ED Subotica), late Prof. Radiša Jevremović (University of Novi Sad, Faculty of Technical Sciences), Prof. Borislav Jeftenić (University of Belgrade, now retired) and many others.

This was the reason why the 6th conference was organized in Subotica in 1986, with significant support of the "Sever" Company. Later on it will be proved that this conference was the most successful one regarding the number of presented papers - 126 papers. The conference presented notable research results and practical solutions of Serbian researchers and industry. Induction motor (AC) drives and microprocessor inverter control again were in

focus of Serbian researchers, but also new high-power switching devices, powerful DC/DC converters (Choppers) for electric vehicles, applications for electric traction (locomotive propulsion), DC drives for steel-profiles production, and converters for solar generation and others.

The next conference, the 7th one was organized in Belgrade in October 1988 in the Sava Conference Centre completing the *Tour de Yougoslavie* of the conference host cities, but being the last one in former Yugoslavia, also. In Belgrade 109 papers were presented.

Besides papers which treated traditional topics in Serbian research laboratories, like uninterruptable power supplies, digital control of variable-speed AC and DC drives, and implementation in industry and transportation, some novel research tracks had been opened. The results achieved regarding operation of direct frequency changers or matrix converters (by Laslo Huber), power quality (harmonics) measurement and analysis (by Vladimir Katić), and high-power DC/DC converters had been reported. Very good overview and classification of basic types of power converters were presented by Dejan Šrajber (Institute Nikola Tesla). The characteristic of this conference was participation of foreign researchers, which had indicated that internationalization of the conference was imminent.

Fig. 3. Traditional logo of the Power Electronics conferences and Power Electronics Society of Serbia.
Source: Power Electronics Society of Serbia archive.

V. CONFERENCE IN TRANSITION

The unfortunate events that hit Yugoslavia in 1991-1995, the collapse of the Yugoslav industry and the dismantling of research institutes in Zagreb and Sarajevo, delayed the regular holding of the conference. *"At initial meeting at the Institute for Power Engineering and Electronics in Novi Sad, in January 1995, we had a dilemma whether we should go on and continue without these people. As is evident today, desire to continue with the tradition prevailed, since these reunions started here and were violently interrupted at the same place"* [2].

After 7 year pause, the conference continued in Novi Sad as an international symposium on Power Electronics and national conference (*Energetska elektronika*, in Serbian) in 1995 and further on as a biannual gathering. Although the format changed, the initial abbreviation "Ee", the next conference number and the logo (Fig. 3) remained as a legacy and continuity with previous conferences. The traditional industry support of the conference was significantly decreased, as electrical engineering industry in Serbia was destroyed in transition. Still, specific connection with industry and application of power electronics devices and apparatus remained.

The 8th symposium and national conference was organized by the Faculty of Technical Sciences of the University of Novi Sad, the Institute "Nikola Tesla" Belgrade and Novi Sad Fair in Novi Sad in September 1995. It was under auspices of the Serbian Academy of Sciences and Arts and the Ministry of Science and Technology of the Republic of Serbia. Total of 79 papers were presented, but repeated participation of foreign researchers had brought new significance to the symposium.

The renewal of the conference was generally well accepted and several exceptional invited papers have been presented by Prof. Vladan Vučković (Inst. N.Tesla, Serbia) [3], Prof. Petar Miljanić (SANU, Serbia), Prof. Vojislav Viktor Stefanović (VPEC, USA), Prof. Slobodan Mirchevski (UKIM, N.Macedonia), Prof. Dushan Boroyevich (VPEC, USA), Prof. Milić Stojić (Univ. of Belgrade, Serbia), Prof. Zoran Stoiljković (Univ. of Belgrade, Serbia) and Prof. Borislav Jeftenić (Univ. of Belgrade, Serbia). All these paper addressed current state of power electronics in Serbia and wider, advancement in electric motor digital control, industrial drives, applications of simulation tools, etc. The conference showed that research on power electronics is alive and spread all over the country and that many solutions are applied in the industry.

An especially well collaboration was established with colleagues from Republic of North Macedonia, Prof. Goce Arsov and Prof. Slobodan Mirchevski (see Fig.4).

Fig. 4. International collaboration – Prof. Goce Arsov, Prof. Slobodan Mirchevski, Prof. Branko Dokić,
Sources: https://www.researchgate.net/profile/Goce_Arsov
https://www.researchgate.net/profile/Slobodan_Mircevski
http://www.unibl.org/sr-lat/vesti

The 9th symposium was organized in Novi Sad in 1997 with new ambition and enthusiasm. The quality of papers was improved through strict review, so at the end, 98 papers has been accepted and presented. Special merit of the conference was several high quality invited papers presented by Prof. Emil Levi (Liverpool JM University, U.K.), Prof. Borislav Jeftenić (University of Belgrade, Serbia), and Prof. Petar Miljanić (SANU, Serbia). The novelty of conference were some papers with application of fuzzy logic, application of simulation tools in laboratories, increased interest in power quality issues and design/solutions of electric vehicles, including commercial ones.

Very important collaboration with our colleagues from Banja Luka (Bosnia and Herzegovina) has been established shaping future symposiums. It was agreed with Prof. Branko Dokić (Fig.4) that Industrial Electronics - INDEL conference, organized by University of Banja Luka and Power Electronics symposium will be harmonized and work together (Power Electronics will be organized in odd years and INDEL in even years). Furthermore, the best papers from the both conferences will be selected and printed in the *Electronics Journal*, published by Electrical Engineering Faculty of the University of Banja Luka.

During the 9th symposium in Novi Sad, in 1997, the Power Electronics Society of Serbia has been founded. The

society task was to organize future symposiums and coordinate all other activities in promotion and development of power electronics and surrounding fields. The logo of the conference was accepted as the official logo of the society. Prof. Vladimir Katić has been elected for the society president and Prof. Vladan Vučković for vice-president.

Fig. 5. Prof. Vladimir Katić and Prof. Vladan Vučković
Source: Power Electronics Society of Serbia photo archive.

"The jubilee, the 10th Symposium on Power Electronics Ee'99 was organized in time of the greatest temptations for our country, ... The question whether it is reasonable to organize a gathering with international participation in such conditions was raised in several occasions. ..... The members of Executive Board of Power Electronics Society have subordinated all above problems to the great interest and wishes of numerous scientists, engineers, manufacturers and students and managed to persist in symposium organization"[4].

The great efforts, which have been putted in preparation and organization of the 10th symposium in October 1999 proved to be worthwhile. Among the 82 accepted papers (out of 98 submitted), there were 28 papers (34.5%) of authors from foreign institutions, arriving from 8 countries. Six invited papers have been presented by Prof. Predrag Pejović & Dr. Žarko Janda, Prof. Emil Levi, Prof. Dragan Petrović, Prof. Mihai Cernat and Prof. Slobodan Vukosavić, while the symposium attracted around 150 participants. The symposium covered four main topics Power converters, Electrical drives, Electrical machines and Control & measurements. The content of the paper showed that power electronics in Serbia is in accordance with European trends.

VI. INTERNATIONAL SYMPOSIUMS

The 11th symposium became truly international in 2001 and since then it has attracted many famous professors or researchers from ex-yu region, EU and other countries to present their state-of-the-art results. 107 papers have been presented, among them 48 papers (45%) arrived from institution of 16 different countries. Eleven invited papers have been presented by authors from ABB, Switzerland (Dr. Nikola Čelanović), Ford Motor Co. and V-S Drives, USA (Dr. Viktor Stefanović), Semikron, Germany (Dejan Schreiber) and others, showing good connection of the Power Electronics society with industry. The IEEE – Yugoslavia Section was for the first time technical co-sponsor of the symposium.

Technical content of the symposium included new topic: Power electronics in telecommunications, which widened its scope. Also, first papers appeared at the conference covering new, emerging topics of distributed generation and renewable energy sources, like variable-speed wind turbines. These papers will have significant impact on later research in Serbia.

The 12th International Symposium on Power Electronics, organized in Novi Sad in 2003 had significant international participation. Out of 101 papers, 49 (48.5 %) were international ones. The symposium looked back into 100 years of the power electronics history [6] and celebrated its 30th birthday. A novelty was another new topic, Power quality, which has been introduced, as a consequence of great interest of participants. Also, invited papers on multi-phase multi-motor drive (by Prof. Emil Levi), on power quality state-of-the-art (by Prof. Jovica Milanović) and trends in automotive power electronics (by Dr. Dušan Graovac - see Fig.6) attracted significant attention.

Regular papers from Serbian researchers introduced results on control of wind turbines, on some solutions with DTC, on FPGA realization of space vector PWM control, on application of fuel-cells for electricity generation and power supply, and other advanced achievements.

Fig. 6. Dr. Dušan Graovac (Atena, Germany) is presenting its invited paper at the Ee2003 symposium.
Source: Power Electronics Society of Serbia photo archive.

The 13th International Symposium on Power Electronics was held in Novi Sad in 2005. It offered 87 scientific papers, 6 student papers and one tutorial by Prof. Jovica Milanović (The University of Manchester, U.K.), while attracted around 200 participants. Three invited paper from Dr. Dušan Graovac (Transtechnik GmbH @ Co., Germany), Prof. Slobodan Vukosavić and Prof. Čedomir Milosavljević gave the insight on the most advanced trends in power electronics. The symposium, under the lucky number 13, also had significant international participation – 45 papers (51.7 %) arrived from authors from 17 different countries. Alongside, a tutorial and 6 student papers were also in the program. The symposium brought some new items, again. The first one was new topic – Renewable Energy Sources, as a consequence of modern trends in development and application of power electronic devices. Then, the novelties were two student competitions: for the best student paper and for the best hardware-software solution "Hardware & Software 2005".

Serbian researchers among others, gave contributions in the field of wind turbine control under grid disturbances, application of fuel cells, presented new methods of MV and LV induction motor conditions diagnosis and showed other significant results.

In 2006, Prof. Vladan Vučković, the Serbian Power Electronics Society vice-president, passed away. This was a great loss to the society and all people who have known

him. Prof. Borislav Jeftenić, has been elected for this position (Fig.7).

Fig.7. Prof. Vladimir Katić and Prof. Borislav Jeftenić, president and vice-president of the Power Electronics Society of Serbia.
Source: Power Electronic Society of Serbia, http://www.dee.uns.ac.rs/PhotoAlbum/2007a/album/slides/Dsc_0050.html

The 14th *edition* of the International Symposium on Power Electronics was in Novi Sad in 2007. It had again significant international participation – 53 papers (52.5 %) out of 101 presented arrived from 20 foreign countries showing continuous interest for the conference. Six invited papers have been presented, among which two from University of Toronto, Canada, one of Prof. Aleksandar Prodić and the other from Prof. Wai Tung Ng (Fig. 8)

All papers were published in electronic form (CD-ROM), which also contains multimedia presentations of the organizers and commercial sponsors, facts about Power Electronics Society, as well as complete bibliography from all symposiums on Power Electronics (1973-2007). The 3rd "Hardware & Software 2007" student competition for the best mobile hardware-software solution was successful, as 6 student teams from the universities of Banja Luka, East Sarajevo, Timisoara, Niš and Novi Sad (2 teams) were in competition.

Fig. 8. Prof. Aleksandar Prodic (left) and Prof. Wai Tung Ng (right) both from the University of Toronto, Canada, speaking at the Ee 2007.
Source: Power Electronic Society of Serbia, Photo album 2007, http://www.dee.uns.ac.rs/PhotoAlbum/2007a/album/slides/Dsc_0050.html

The Ee 2009, the 15th International Symposium on Power Electronics, was held in Novi Sad in Oct. 2009. More than 200 participants attended the conference. At the symposium, 105 papers (8 invited) were presented from various institutions of 19 countries. The symposium highlighted the problems and practical or virtual solution in many fields: Distributed energy, Microgrids, Smart Grids, MW wind turbines, Automotive AC drives, Real-time digital simulations where some of them. Six decade of thyristor, as well as 125 years of IEEE, were addressed, also.

Fig. 9. Prof. Reza Iravani (University of Toronto, Canada) and Dr. Dejan Schreiber speaking at the Ee 2009.
Source: Power Electronic Society of Serbia, http://www.dee.uns.ac.rs/PhotoAlbum/Ee2007-1/album/slides/DSC_9536.html

For the 5th time the student's competition "Hardware & Software 2009" was organized by Prof. Miloš Živanov bringing in 6 competing teams. The novelty was special edition of the past proceedings of the Power Electronics Symposiums in the period of 10 years, from 1997 to 2007. Such compilation provided significant insight into development in the field of Power Electronics at the turn of the Millennium, during the past decade and an important overview for the young authors and symposium participants.

Fig.10. Student competition H&S 2009 presentation in front of the jury (Nataša Nešković, Vladimir Katić, Igor Kuzle, Đorđe Paunović).
Source: Power Electronic Society of Serbia, http://www.dee.uns.ac.rs/PhotoAlbum/Ee2007-1/album/slides/DSC_9536.html

Ee 2011 symposium (*the 16th*) hosted of 102 papers from research institutes, industry and university centers of 19 countries and gathered more than 200 participants (Fig.11). Nine invited papers were presented and as new event, two special sessions and one specialized workshop were organized.

The Serbian researchers presented their state-of-the-art results in exploring energy conversion systems for the next decade (Prof. Slobodan Vukosavić), in applying advanced Hardware-In-the-Loop (HIL) technology (Assis. Prof. Nikola Čelanović et al.), and Printed and Nano electronics (Prof. Goran Stojanović et al.). Also, some experience from industrial applications of power electronics, like retrofit power supply for electrostatic precipitator electrodes in coal-powered plants (Prof. Slobodan Vukosavić et al.), sensorless tension control for rewinder in paper industry

(Prof. Milan Bebić et al.), motor current signature analysis for preventing rotor failures (Dr. Žarko Janda et al.), self rechargeable wheel-chair (Mladen Kovačev et al.) and stand-alone PV system (Zoltan Čorba et al.) were presented.

Fig.11. Prof. Ištvan Varga, Prof. Slobodan Vukosavić and dr Žarko Janda during coffee break
Source: http://www.dee.uns.ac.rs/PhotoAlbum/Ee2007-2/album/

At the end, certificate of appreciations were handed over to the authors with repeated contributions at the symposium over the years. One of the laureate was Prof. Boguslaw Grzesik from Poland, who have been attended the symposium for more than 10 years (Fig.12).

Fig. 12. Prof. Boguslaw Grzesik receives certificate of appreciation
Source: http://www.dee.uns.ac.rs/PhotoAlbum/Ee2007-2/album/

VII. 40 YEARS OF THE SYMPOSIUM

After 40 years, the symposium is still active (Fig.13). It was held in October 2013 in Novi Sad. The economic crisis which influenced universities, and authors´ orientation to publish mostly in indexed journal (*Publish or Perish*) have affected on participation at this and at coming symposiums. In the year of jubilee, 69 papers have been accepted out of 90 submissions, but prepared by 239 co-authors coming from research institutes, industry and university centers of 26 countries. Three invited papers addressed the key issues in power electronics and also the 65th anniversary of transistor. Around 200 participants were present in the Master Conference center, mainly young researchers and students, bringing new life to the power electronics field and bright future for the symposium.

At that time researchers from Serbia continue to investigate different type of AC drives, improve digital control algorithms, analyze problem in electrical machines and explore power quality issues. Special results have been obtained in developing and using HIL technology and power electronics in a cloud idea.

As this was the 40 years jubilee symposium, special 2 volume DVDs was issued with electronic version of all papers presented at the Power Electronics Conferences/symposiums since the first one in 1973. This is valuable technical information for researchers in the field. Later on (in 2015) the Executive Board of the Power Electronics Society of Serbia decided that all papers should be available through the society web site, i.e. to have open access.

Fig. 13. Part of the organizing team and the 40 years jubilee logo of the symposium Ee2013.
Source: http://www.dee.uns.ac.rs/PhotoAlbum/Ee2007/album/

The next 18th symposium Ee 2015 was for the first time held in the new premises of the University of Novi Sad, its central building. The 71 symposium papers came from 269 authors & coauthors of 20 countries. International and Serbian researchers have jointed their teams and many results are presented together.

Specific achievements were in field of HIL applications, effects of voltage disturbances on PV inverters operation, new concept of power grids as cyber physical systems, and high-voltage DC/DC converters. The symposium proved high quality value of its papers, but needed further international recognitions.

It happened at the next, the 19th symposium Ee2017. It was another turning point in its history. For the first time it was organized as a truly IEEE co-sponsored event, in accordance with IEEE standards and reviewing rules. Two IEEE societies have technically co-sponsored the event (PELS and IES), together with the EPE Association and ECPE (European center for power electronics). Technical Chair Prof. Emil Levi (Fig.14) managed to assemble six distinguished Key note lecturers, invited three top researchers and also made very strict selection of the papers.

Fig.14. Prof. Emil Levi receiving Certificate of appreciation for his excellent work as Technical Chair of the symposium Ee2017.
Source: http://www.dee.uns.ac.rs/PastSymp/Ee2017/index.html

High quality presentations, panel sessions and excellent lectures of Prof. Frede Blaabjerg (Fig.15), Prof. Dushan Boroyevic (Fig.16), Dr. Victor Stefanovic (Fig.16), Prof. Pavel Bauer, Prof. Ion Boldea, Prof. Dragan Maksimovic, Prof. Jovica Milanovic, Prof. Vladimir Blasko, Dr. Ian Meyer, Prof. Jako Kilter, Prof. Igor Papic, Prof. Saša Djokić, Prof. Drazen Dujic and Dr. Jovan Knezevic, together with IEEE distinguished lecturer Prof. Ralf Kennel, and tutorials presenters Prof. Petar Grbović and Prof. Hose Cobos made this symposium probably the best one in the long history of Ee symposiums/conferences. This was a huge success and kind a template for organization of future symposiums. Furthermore, the Publication Chair Prof. Aleksandar Prodić managed to go through complex procedure of including the presented papers into IEEE Xplore digital library and later into the Web of Science, Scopus and Google Scholar data bases and citations. The symposium was well attended, especially by young researchers and students which gave especially pleasant atmosphere (Fig.17).

Fig.15. Prof. Frede Blaabjerg and Prof. Vladimir Katic chairing a session at the Ee2017.
Source: http://www.dee.uns.ac.rs/PastSymp/Ee2017/index.html

Fig. 16. Prof. Dushan Boroyevic and Dr. Victor Stefanovic at the gala dinner of the symposium Ee2017.
Source: http://www.dee.uns.ac.rs/PastSymp/Ee2017/index.html

Fig. 17. Participants of the Ee2017.
Source: http://www.dee.uns.ac.rs/PhotoAlbum/Ee2017/Ee2017.htm

Now, the 20th jubilee symposium, again celebrating its long history, is organized as the top regional conference by the IEEE PELS, the Power Electronics Society of Serbia and the Faculty of Technical Sciences of the University of Novi Sad. There are several technical co-sponsors, the IEEE PELS; IES and IAS societies, EPE Association, ECPE and ETRAN society. Technical chair Prof. Drazen Dujic has invited six Key note lecturers and five invited papers from academia and industry making the practical side more visible. Besides that, strictly selected 57 regular papers, together with two distinguished professors lectures (Prof. Krishna Shenai from University of Chicago, USA, and Prof. Petar Grbovic from University of Innsbruck, Austria) and two exceptional tutorials complete the program of the symposium. Total number of authors is 219 from 24 countries, making this conference truly international one and top regional place to meet experts in power electronics and to discuss actual problems and solutions.

Fig. 18. The logo and sponsors of the 20th symposium Ee2019.
Source: http://www.dee.uns.ac.rs/?r

VIII. Conclusion

The symposium on Power Electronics started way back in 1973 as a national conference named *Energetska elektronika* (In Serbian). After so many years, at the 20th edition it is still young, full of new ideas, but enriched with experience and tradition, representing excellent meeting place for researchers, university professors, engineers, manufacturers, students and other experts in the field of Power Electronics and surrounding areas.

It also reflects the work and results of Serbian researchers showing their place in the power electronics community and their achievements.

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