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S & YP+mentors+peace+love= science and growing

Giuseppe Buja, Zbigniew Krzemiński, Marek Adamowicz, Marek Jasiński

In this extraordinarily difficult time, we understand better that only peace, love and cooperation are the keys to growing in technology for humanity. Let us learn from our Mentors how they grow by their hard work and international cooperation. Thanks to prof. Giuseppe Buja and prof. Zbigniew Krzeminski, we have the unique schools of adjustable speed drives that are helping people to convert electrical to mechanical power and vice versa. Let's learn how it was possible:

Interview to Professor Giuseppe Buja

Professor Giuseppe Buja, let give us a glimpse on your research journey

My journey has begun in 1964 by enrolling in the electronic engineering course at the University of Padova (UNIPD) and complementing the electronic background with extra teachings from the electric engineering syllabus. Right after the "Laurea" degree, I joined UNIPD for an apprenticeship on semiconductor power circuits that at the time were composed of thyristor and diode devices. My first research involvement was in the mid-seventies when I developed the PWM control of power inverters. In the 80s, I focused my research on the implementation of the control of power converters in the high-processing microcomputers that had been introduced just at that time, in an intriguing coincidence with the power transistors. I still feel thrilled in thinking about when I programmed the first-marketed DSP (Intel 2020) to control a PWM inverter built with a three-phase Toshiba IGBT bridge. In 1992, I moved to the University of Trieste, where I did research on AC electric drives. At the turn of the 2000s, I returned to UNIPD and shifted my interests from the equipment to the systems. I founded the Laboratory of "Electric Systems for Automotive and Automation", giving it the mission of developing research and educational activities for mobility and energy systems by merging electric, electronics and informatics technologies. As the times were ripe for the penetration of electric systems into the vehicles, I directed the Lab research right away into the drive-by-wire systems and then, into the powertrains of the electric vehicles (EVs). The next step was the research on the EV battery charging, both wired and wireless type. Before retirement, I turned the Lab research towards the conversion systems enabling the grid integration of renewable sources. With a retrospective look, I can say that my research journey has constantly evolved, chasing my innate passion for new technologies and emerging topics.

Were your research-side activities equally lively?

Yes, really. Nowadays it is hard to imagine how bounded were the academic activities in the early 80s. Attendance to the conferences was typically limited at the annual domestic symposium, papers were mainly published in national journals, news on power electronics was taken almost exclusively from the library books (written, incidentally, by authors not of my country). A little at a time I realized that this context was not productive for my research and decided to shape it in an open and international way. Just to begin, I sent my research notes (by post, no email at that time!) to the author of one of my cult books on power electronics:

Prof. J. Murphy, University of Cork, Ireland. Much to my surprise, he invited me to his university, and this unique experience was the cornerstone of my research-side activities. I commenced attending conferences abroad, publishing papers in international journals and to visit renowned labs. As soon as I had the chance, I enjoyed the dual experience of inviting external researchers and tutoring foreign students in my Lab. An activity, however, makes me particularly proud even now. It was the attendance to conferences in the eastern European countries before the fall of the Wall. Despite the red tape to enter into them, I keep a vivid memory of the warm hospitality received by local researchers, subsequently turned into a still alive friendship. Further to this activity, I was honored to receive shortly after the invitation of Prof. I. Nagy, Budapest University, Hungary, to help him in promoting the Power Electronics and Motion Control (PEMC) Council and the PEMC conferences all around the world.

Let us now talk about your involvement in IEEE and, specifically, in IES?

My thinking is "if there were no IEEE, it would have to be invented". I am greatly indebted to it for many reasons. IEEE was like a gym for me as it trained me in research. Reading and deepening IEEE Transactions papers allowed me to stay up to date and hone my skills on my research issues. IEEE was also a springboard for me. Indeed, the publication of my first papers in the IEEE Transactions has opened the doors of many Labs to me, even in my country. Attendance at the IEEE conferences was another chance for me as I personally met scholars from every country and presented my research results to an international audience. It was also a chance to realize how much effective are the social events of the conferences in educating to respect different cultures and civilizations.

I approached IES in the late 70s, when the name of the Society was Industrial Electronics and Control Instrumentation (IECI). At that time, I was researching the microcomputer control of the power converters and was attracted by the IECI initiatives on this issue. In 1980, I attended for the first time the Society annual meeting that was publicized as the IECI Conference on Industrial Applications of Microcomputers. I had immediately a good feeling with the officers and, some years later, I got involved in technical and administrative tasks. This did not surprise me too much because the Society had been distinguished for many years by the inclusion of US-outside people in its bodies. So, in the late 80s, with the support of the President, Prof. F. Harashima, I organized two international workshops in my country on the microcomputer control of electric drives that were well-attended and honored by the presence of top researchers like Profs. B. K. Bose and K. Ohnishi. A few years later, the President, Mr. R. Begun, proposed me to chair the first European edition of IECON in 1994. I accepted it all at once, without weighing the relevant workload, because I was confident in the help of the IES officers and the local volunteers, such as Prof. C. Cecati to name one. Among the officers, I feel like expressing a heartfelt tribute to Prof. R. Niederjohn, an exquisite person who visited me before the Conference to bring me his strong encouragement. IECON'94 took place in Bologna, Italy; it was the top attended IECON until then and remained in the collective memory for the high level of the scientific contributions. Subsequently, I was appointed by the Society as the vice-president (VP) for Small Conferences (lately renamed for Workshops). It was a demanding and challenging assignment since there was a flourishing of new Workshops and Symposia in those years. In this regard, I am glad to talk about the conception of the International Symposium on Diagnostics for Electric Machines, Power Electronics and Drives

(SDEMPED). It occurred in 1996, at an airport room, while waiting for a delayed flight. I met there Prof. G. Capolino and we agreed on the increasing interest in the diagnostics for the power electronics equipment. At the end of the meeting, we laid out a plan to launch the SDEMPED Symposium, which happened a year later in the charming town of Carry-le-Rouet, France. For my VP duties, I had the opportunity to strictly work with the IES officers, especially President Prof. J.C. Hung; it was a very stimulating trial that enriched me greatly from the professional point of view. From the late 90s, I supported IES mainly in technical activities because of my increasing academic commitments and the efforts in running my Lab, charged with many research programs immediately after its start-up.

It is evident from my I said how much I am technically, professionally, and socially satisfied to be a member of IEEE and, specifically, of IES. It was therefore natural for me to encourage students and colleagues to join and participate in the life of the Institute and its Societies. About that, I am pleased to mention some students of mine who I have introduced in IES: M. Valla (Post-doc student), and R. Oboe and R. Keshri (Ph.D. students).

Did you have exciting experiences in performing your research-side activities?

Of course, especially while attending conferences. I would like to go off the technical rails and talk about two experiences that are engraved in my memory. The first one occurred in the 80s, after the gala dinner of a conference in the Tatra Mountains (Romania). I was tired after a hard trip to arrive at the conference site, and I decided to anticipate my colleagues in walking back to the hotel. On the way, I found myself in front of a bear. I was terrified but, instinctively, stood there with a tough face. The bear came up to me at a brisk pace and -maybe because I did not run away or had a tough face- it turned around and slowly went into the bush. When I go back with the mind to this event, I am convinced that the instinct helps solve some problems more than long reasoning. The other experience occurred to me in the 90s, at IECON in Maui, Hawaii. One day, I decided to have an afternoon of leisure and booked a tour in a submarine to enjoy the seabed around the island. When I took my place, I jumped on the seat like a scholar discovering that one of my idols, Prof. W. Leonhard, was sitting next to me. I introduced myself shyly while he greeted me warmly and put me at ease by saying that he knew my papers. To strike up the conversation with him, I asked about the implementation of the field-oriented control (FOC), but he diverted the talk and told me about him. So, while colored fishes passed in front of the portholes, I found out the genesis of the FOC theory, I came to know that he had practiced on the drives when he was in charge of the electric equipment of a submarine during the Second World War, and much more. I listened to him all along the tour and, when went ashore, I grasped how simple and friendly are the great scientists.

Have you some advice to give to a young researcher?

The choice to undertake a career as a researcher in the engineering field must be dictated by passion, a great passion. Indeed, a researcher must work on “a matter in the making”, not on an established one. This means that he must believe strongly in the force of his ideas to overcome the uncertainties that inevitably arise in carrying out a research task. It is equally important that he be strong enough in recognizing when an idea is wrong or unpractical, and in

starting over. He must be also conscious that, behind a good achievement, there are long times spent thinking and experimenting even if the idea was originated from an instant inspiration.
Another piece of advice to a young researcher is that he must go out from the comfort zone of their lab to gain a working experience, besides that of research, in abroad labs or in a company. Nowadays, there are a lot of opportunities that he should not miss. This helps him to grow in many ways such as in confronting his knowledge, assessing his competence, getting inspiration, and even discovering methodologies that advance his abilities. In this regard, I mention the research path of a student of mine, Prof. R. Oboe. Under my guidance, he spent part of his Ph.D. course in Japan, at the Laboratory of Prof. K. Ohnishi, and went back with a wealth of skills in the motion control field that he has deeply nurtured up to excel in the scientific community.
For their part, the tutors must be fair in helping and evaluating their students, and -first of all, must be masters of life by teaching, together with the science, the values of intellectual honesty, the behavioral correctness, and the conscious use of the research results.

How has retirement changed your life?

Much is changed. I continue to carry out research activities and to pursue my hobbies, but now timings are reversed as most are for hobbies. I like walking in the green, especially along the banks of the numerous rivers that pass through Padova, the city where I live; I like reading books of contemporary history and listening to pop music. The research activities are mainly aimed at supporting the work of students and colleagues with hints and discussions, but sometimes I inspire them with novel concepts, sticking to my motto that research is a state of mind.

IES President, Mr. C. Einholf, gives the E. Mittelman award to Prof. G. Buja.

Interview to prof. Zbigniew Krzeminski

Inspiring young engineers and scientists to take on great industrial challenges

Supporting an experienced mentor who will help for some time and reliably show directions for further development is very important for young scientists at the initial stage of their career. In our pages, we present the profiles of mentors who have had an extraordinary

impact on the development of the scientific career of young engineers and scientists. Among them, we would like to present Prof. Zbigniew Krzeminski from the Gdansk University of Technology (Gdansk TECH), Poland. Over the 47 years of his academic career, Prof. Krzeminski has mentored several dozen young professionals, including 15 promoted doctors in the field of automation, electronics, and electrical engineering. Some of them are already well-known professors, such as Prof. Haitham Abu-Rub from Texas A&M University at Qatar already known from our columns.

FIGURE 1- Prof. Krzeminski's university collaborators and mentees on the world's first prototype of a medium voltage power electronic transformer for the oil & gas industry [1]

In 2004 Prof. Krzeminski went beyond strictly academic activities and together with PhD students created the university start-up MMB Drives, which, going through the entire development cycle of start-ups, has become a professional technology company [2]. And just as in the scientific world, Professor's mentees successfully solve new scientific problems, in the industrial field a team of PhD students and doctors from MMB Drives has been uncompromisingly facing the greatest challenges in almost all industries, including the power industry, oil & gas, renewable sources, rail and sea transport, electromobility and, of course, the machine industry. The headquarters of the technology company MMB Drives is shown in Fig. 2. As befits a technological company, MMB Drives has its own power sources in the form of a wind farm, photovoltaic panels, and a heat pump.

FIGURE 2 - The headquarters of the technology company MMB Drives has its own power sources in the form of a wind farm, photovoltaic panels, and a heat pump.

It should be emphasized that during these 18 years MMB Team did not lose the competitive gene and last year won" The Grand Challenge: Energy" implemented as part of the Grand Challenge formula organized in Poland by the National Centre for Research and Development (NCBR). Figure 3 shows the winners, MMB Team, including Prof. Zbigniew Krzeminski (first from the right), who are involved daily in engineering power electronics and control systems for renewable energy and variable speed drives.

FIGURE 3 – MMB Team led by Prof. Zbigniew Krzeminski - the winners of the Grand Challenge: Energy competition 2021.

The Grand Challenge: Energy competition started close to 200 teams of constructors from all over Poland presented the work of the compact devices for individual applications, capable of converting wind energy into electricity, to store it and return it most effectively. The prototypes of wind turbines had to meet the parameters determined in the Participant Manual, i.a. their dimensions could not exceed a cube of 2 m and their weight 200 kg. Moreover, the systems were esthetic and silent. The wind power plant developed by Prof. Krzeminski's team has been equipped with a high-power factor wind with axial flux permanent magnet generator, SiC-based power converter system ensuring effective management of energy storage. The developed shape of the blades and the control algorithm ensured that during the competition the device could work without power limitations against strong winds and used maximal wind energy for low and high speeds.

The secret of the success of Professor Krzeminski consists in combining industrial and university experience. The beginning of the Professor's career dates back to the mid-1970s when Poland as a country of the so-called Socialist Bloc was behind the Iron Curtain in the area of influence of the Soviet Union. According to the Soviet doctrine, free contacts of scientists of socialist countries with Western scientists were then forbidden. Moreover, the financing support of scientific development in those years was highly ineffective due to the inefficiency and low effectiveness of the whole socialist bureaucratic machine. Therefore, scientific achievements in the field of power electronics and industrial electronics in Poland were based only on the determination of individual inventors and researchers and their direct cooperation with the industry. It was, therefore, necessary to develop such solutions needed for the industry which would at the same time inspire young doctoral students and scientists for the development of their careers.

FIGURE 4 – A joint social event of Professor Krzeminski's university associates and engineers and doctoral students from MMB Drives company

The first achievement of Prof. Krzeminski, when he was a doctoral student, was to develop a controlled thyristor drive with an electronic controller and two parallel operating stepper motors for the textile industry. Controlling two motors in parallel was aimed at increasing the power. The innovation of the solution was the use of the impulse splitter for thyristors with a flip-flop system which was resistant to the interference of control signals. Shortly thereafter, the Professor was ready to face the greatest life challenge, which was to develop an original nonlinear control of induction motor called multiscalar control [3]. This challenge was related to the implementation of the doctoral dissertation and, as a result, determined the entire future academic career of Professor.

It has just been a decade since Blaschke proposed Field Oriented Control (FOC) in 1972 [4], which enables one to control an induction motor like a separately excited dc motor. Field-oriented control, which was based on the decomposition of the instantaneous stator current into two components: flux current and torque-producing current, ensured in its first industrial applications precise control of variable-speed drives but assuming that the magnetic flux of the motor would be kept constant. Today, numerous modifications and developments of the field-oriented control, thanks to the decoupling members of the velocity and flux dynamics, allow for free adjustment of the induction motor excitation [5], but at that time new methods of non-linear control of induction motors were of particular interest.

The idea of nonlinear control was to apply the transformation of vector variables of the induction motor model to new variables, independent of the reference system, one of which was proportional to the motor torque, and then the use of linearization of the model and control obtained, which resulted in decoupling the dynamics of the regulated speed and flux of the induction motor. For the linearization of the nonlinear equations of the induction motor multiscalar model, Prof. Krzeminski used the theory of the structural synthesis of automatic control nonlinear systems developed by the Ukrainian scientist L. M. Boychuk [6]. In the multiscalar control according to Prof. Krzeminski, the regulation of torque and flux is no longer performed in a rotating coordinate system but using the cross and scalar products of stator current and rotor flux since the products contain the complete information about the mutual position of the stator current vector and rotor flux vector. The nonlinear feedback allows linearization and therefore simplification of the mechanical and electromagnetic control loops. In the second half of the 1980s, it became possible for Polish scientists to go to the West of Europe. Thanks to obtaining a Robert Bosch scholarship, Prof. Krzeminski was able to go to the IFAC (International Federation of Automatic Control) Congress in 1987, where he presented for the first time his proprietary method of non-linear control of induction motors [3].

The fall of the Berlin Wall and the liberation of Eastern Europe from the domination of the Soviet Union in 1989-1991 allowed scientists from Poland to communicate freely with their colleagues around the world. In the years 1998-2000 Prof. Krzeminski, in cooperation with the German company AvK SEG Kempen (later Woodward Kempen), together with his PhD student Andrzej Geniusz, actively participated in the development of multiscalar control for offshore wind turbines with double-fed induction generators [7], [8]. As a result of this cooperation, AvK SEG Kempen awarded Gdansk TECH an order to develop a control system for a high-power wind turbine generator. "We were invited to collaborate to develop an industrial sensorless control system for a double-fed machine used in high-power wind farms. It required the development of an original induction machine speed observer. The system was applied in practice, and the subject of cooperation was extended to the issues of generator stability in

conditions occurring in a wind farm "- says Prof. Krzemiński. Andrzej Geniusz, PhD student, currently works at Woodward Kempen as a specialist responsible for the Concycle® series of multiscalar converters. Today, Concycle® converters are installed in more than 15,500 wind turbines worldwide.

The interesting industrial challenge undertaken by the team of Prof. Krzeminski was the development of new generation variable speed drive solutions to reduce footprint and operating cost on the oil production platforms.

a) b)

FIGURE 5 – Prof. Krzeminski with his PhD student Janusz Szewczyk at the electric submersible pump (ESP) factory Alkhorayef Petroleum Company in Saudi Arabia (a); world first Power Electronic Transformer (PET) - based MV variable speed drive with ESP installed on the test rig (b) [1], [9].

For the first time in the world, Prof. Krzeminski used a megawatt-scale SiC-based power electronic transformer for supplying electric submersible pump drives. Prof. Krzeminski's team has also developed innovative downhole monitoring systems using high-temperature electronics (HTE) and developed a reduced diameter high efficiency permanent magnet motor for retrofitting existing production wells. Low voltage and medium voltage variable speed drives and control devices developed by MMB Drives have been used in over 900 production wells worldwide.

As Prof. Krzeminski emphasizes, the functioning of the team implementing projects in the field of modern electric drives and power electronic converters requires specialization and continuous improvement of the members of the research team. The current state of the theory of electric machines control enables to achieve high-quality regulation of selected quantities, provided that the latest achievements of electronics and power electronics are used which are developing very quickly. This creates special conditions for conducting research, consisting of continuous improvement of the developed solutions, and testing the possibility of using electronic systems with the highest parameters.

FIGURE 6 – High precision downhole monitoring system using high-temperature electronics developed by MMB Drives.

Carrying out research as part of every planned project requires the employment of a team of professionals with genuine scientific and research achievements, especially in the field of laboratory work. The role of the mentor, in this case, is to motivate the team to take up challenges that go beyond the achievements so far, but also to give a helping hand when the young specialist thinks that he has hit a dead end. "Despite the very rapid development of technology all over the world, young specialists are sure to face many challenges. New types of engines that will be able to use battery energy more efficiently, or more efficient hydrogen production technologies. We are also working on all of this at MMB Drives. At the same time, I inspire my younger colleagues to always be accompanied by the element of fun in achieving success" – says Prof. Krzeminski.

Also, thanks to prof. Buja and prof. Krzeminski the World divided by the Wall have been unified and freedom won. This is our role to make science in peace and respect others.

[1] Shanks D. S., Pietryka J., Szewczyk J., Samsel J., Krzeminski Z., Systems and methods of power transmission for downhole applications, U.S. Patent No. 10,968,726. Washington, DC: U.S. Patent and Trademark Office, 2021.
[2] Adamowicz Anna, Mazurek-Krasodomska Ewa, Krzeminski Zbigniew, Adamowicz Marek, Selected financial-economic aspects of R&D in renewable energy conversion technologies. The case of University Spin-off Company. In Fifth International Conference on Ecological Vehicles and Renewable Energies EVER, 2010.
[3] Krzeminski Z., Nonlinear control of induction motor. IFAC Proceedings Volumes, 20(5), 1987, 357-362.

[4] Blaschke Felix, Das Prinzip der Feldorientierung, die Grundlage fur die transvector-Regelung von Drehfeldmaschinen. Siemens-Z, vol. 45, 1971, 757-767.
[5] Kazmierkowski M. P., Krishnan R., & Blaabjerg F. (Eds.), Control in power electronics (Vol. 17). San Diego: Academic press, 2002
[6] Boychuk, L. M. An inverse method of the structural synthesis of automatic control nonlinear systems, Automation, Kiev: Naukova Dumka, No.6, pp. 7, 1966.
[7] Geniusz A., Krzeminski Z., Control system based on the modified multiscalar model for the Double Fed Machine. PCIM Europe, 2005.
[8] Geniusz A., Power control of an induction machine, U.S. Patent No 7,423,406, 2008.
[9] Zahrani A.M., Windiarto Y., Orlowski T., First Installation of NEMA 4 Medium Voltage Drive in Saudi Aramco Fields, SPE Middle East Conference "Artifical Lift", Manama, Bahrain, 26-27 November, 2014.