

History of IMEKO TC4 – Second Part

Mario Savino¹, Janusz Mindykowski²

¹*Electrical and Information Engineering Department, Politecnico di Bari, Via Re David 200, Bari, Italy, mario.savino@poliba.it*

²*Marine Electrical Power Engineering Department, Gdynia Maritime University, 81-225 Gdynia, Poland, j.mindykowski@we.am.gdynia.pl*

Abstract – This paper is a logical and complementary carrying on of the previous history of IMEKO Technical Committee on “Measurement of Electrical Quantities” (TC4) from 1979 to 2002, written by Mario Savino and presented during the TC4 Symposia in Kosice, Slovak Rep., 8-10 September 2010 and in Natal, Brazil, 27–30, September 2011. After a brief summary of the beginning of the IMEKO TC4 and of its genesis, this paper deals with the scientific and organizational progress in IMEKO TC4 from 2003 to 2016. The paper considers all the TC4 Symposia and World Congresses organized in those years, with a glance at the historical events in the world. Particularly, it was important the decision of several new countries to join the European Community. This choice influenced the development and promoted new trends in measurement of electrical quantities.

Keywords – *History of IMEKO TC4 – Second Part*

I. INTRODUCTION

The official establishment of IMEKO TC4 occurred in 1984 and from then it has organised at least one Symposium each year and has actively co-operated in the success of the IMEKO World Congresses. The first merit of TC4 was to bring together the experts from eastern and western countries to improve the development and use of electrical and electronic instruments for measuring, monitoring and recording electrical signals. It is incredible that just in September 2007, during the Symposium in Iasi, Mario Savino promised to write the history of TC4 for allowing young researchers to know the development of our TC. The history, the teacher of life, is important for reconnecting the past to the present, and building the future. In three previous papers, [1] [2] [3] it is detailed the history of TC4, from 1979 to 2002. The reader will learn the mission of TC4, its scope, and objectives. In another paper, [4] there is an overview of the measurement, of electrical quantities within IMEKO from 2003 to 2015. After summarizing the history of TC4, from 1979 to 2002, the present paper discusses and comments all the TC4 Symposia and IMEKO World

Congresses from 2003 to 2016. The importance of these events and in general of measurement for the development of information society is well known and recently underlined in the report on Engineering Technology Education. In fact, ABET (Accreditation Board for Engineering and Technology Incorporation), which accredits post-secondary education programs in applied science, computing engineering and engineering technology, requires that engineers have an ability to design and conduct experiments, as well as to analyse and interpret data. In particular, Technology Engineers must have an ability to conduct standard tests and measurements, to analyse and interpret experiments, and to apply experimental results to improve processes.

1. The beginning

In May 1979 Giuseppe Zingales, at that time the Italian delegate to IMEKO General Council, during the 8th World Congress held in Moscow, USSR, admitted the absence of a committee relevant to electrical measurements in spite of the presence of many experts in that field at IMEKO Symposia and Congresses. In May 1982 during the 9th IMEKO World Congress, held in Berlin West, a group of colleagues, Adam Fiok, Wladimir Kneller, Giuseppe Zingales and in particular Jean Weiler, at that time Treasurer of Confederation, shared the basic idea of creating a Technical Committee (TC) on Electrical Measurements. The TC4 concerning microwave measurements had operated until 1984 when it was dissolved as the result of inactivity. Adam Fiok, on behalf of Polish Member Organisation, officially presented the proposal of changing the name of TC4 from “Microwave Measurements” to “Electrical Measurements” in May 1983 during the 26th session of IMEKO General Council in Prague. In May 1984 during the TC7 Symposium “Measurement and Estimation” in Bressanone, the commission, with the joining of Italo Gorini, had a long meeting during the Symposium. The commission shared the text containing the TC4 topics, which the General Council approved in the version published in the IMEKO Address Book. The IMEKO General Council, in the resolution concerning the foundation of the new TC4, together with its scope, also approved its membership. Jean Weiler (Switzerland) was

elected the first Chairman of the Committee and Adam Fiok (Poland) the Scientific Secretary.

2. *The first Symposia and Congresses*

The venue for the 1st Symposium on “Noise in Electrical Measurement” in 1986 was Villa Olmo in Como, a beautiful town on the lake with the same name in North Italy. Giuseppe Zingales asked Arnaldo Brandolini from the “Politecnico di Milano” to organize the conference in the same place as the Italian “Day of Measurement”. Several topics concerned the noise for characterisation, diagnostics, and measurement and reduction techniques in analog and digital signal processing. The 2nd Symposium has been held in Warsaw, POLAND, May 26-28, 1987 with the title of “Industrial Measurement of Electrical and Electronic Component and Equipment”. Adam Fiok, the TC4 Scientific Secretary, was the organizer. For the first time Linus Michaeli presented a paper on ADC. In 1988, the 11th World Congress in Huston, Texas, USA, took place in conjunction with the 43rd Annual Conference and Exhibition of ISA, the Instrument Society of America. The Congress also celebrated the jubilee of the strain gauge. During the Congress Jean Weiler for the TC4 organized a Round Table on “Electrical Quantities with special emphasis on Harmonic, Inter-Harmonics and Transients”. The venue of the 3rd Symposium on “Measurement in Electrical and Electronic Power Systems” was Zurich, SWITZERLAND, September 20-22, 1989, organized by Jean Weiler. During the TC4 meeting Jean, as he had promised in Como, left the Chairmanship to Adam Fiok and unanimously the Committee appointed him TC4 Honorary Chairman. Varna, BULGARIA was the venue of the 4th Symposium on “Intelligent Measurement of Electrical and Magnetic Quantities” in November 15-17, 1990. In spite of some logistical problems, the Symposium was a success. In 1991 for the first time, an IMEKO event, the 12th World Congress, was organized in China from 5 to 10 September. In that period, China began to open up to the international free market. During the Congress, there were two sessions devoted to TC4, with particularly emphasis to the keynote written by Fiok and Weiler [5]. The 4th Symposium on “Electrical Measuring Instruments for Low and Medium Frequencies” was held in Vienna, AUSTRIA, April 8-10 1992, organized by W. Wehrmann. The chairmanship of Adam Fiok brought the spectrum of frequency in topics to be enlarged. The 6th Symposium on “Intelligent Instrumentation for Remote and On-Site Measurements” was held in Brussels, BELGIUM, May 12-13 1993. The official organizer of the Symposium, which had a good success, was Christian Eugene. The venue of 13th World Congress was Torino, organized by Zingales and Sergio Sartori. During the TC4 meeting, the committee accepted the proposal of a Workshop on the ADC in Slovenia. The 7th Symposium on “Modern Electrical and Magnetic

Measurement” was held in Prague, CZECH REPUBLIC, September 13-14 1995. Milos Sedlacek organized the Symposium and all of the TC4 members stressed the importance of three very interesting invited lectures presented by H Schumny [6], S. Dado [7] and Jean Weiler [8]. After the decision made in Torino, the 1st Workshop on “ADC Modelling” was held in Smolenice Castle, SLOVAKIA, May 7-9 1996, organized by Linus Michaeli. This was the first great event of a Working Group on ADC, known and appreciated in the world. The 8th Symposium on “New Measurements and Calibration Methods of Electrical Quantities and Instruments” was held in Budapest, HUNGARY, September 16-17 1996, organized by István Zoltán and István Kollár. Mario Savino opened the Symposium with an invited paper on “Trends in digital measuring instruments”. The TC4 meeting approved the “European Project for a proposal of ADC Standardization” and nominated Harald Schumny and Pasquale Arpaia co-ordinators. The 2nd IMEKO Workshop on ADC Modelling and Testing was held during the 14th World Congress in Tampere, Finland, June 1-2 1997. The Workshop was a success with a final Round Table on European projects. During the TC4 meeting Jean Weiler proposed, Mario Savino as “Acting Chairman” of TC4, Milos Sedlacek and Antonio Serra respectively as Deputy Chairman and Scientific Secretary of TC4. The 9th Symposium on “Electrical Instruments in Industry” was held in Glasgow, SCOTLAND, September 8-9 1997, organized by Ian A. Henderson and Joseph McGhee. Mario Savino concluding the Symposium said that Lord Kelvin would be happy for the results obtained. The venue of the 10th Symposium “Development in Digital Measuring Instrumentation” was Naples, ITALY, September 17-18 1998. The success was due to the active collaboration of Massimo D’Apuzzo e Antonio Langella. The working Group on ADC and DAC, according to the political European integration proposed a European Project for ADC-based device Standardization (EUPAS). During the TC4 meeting, Mario Savino, Milos Sedlacek and Antonio Serra were elected respectively Chairman, Deputy Chairman and Scientific Secretary of TC4. Adam Fiok was nominated Honorary Chairman. The list of the TC4 members included: Olli Aumala; Harald Schumny; Philippe Marchegay and Pasquale Daponte. During the World Congress in Osaka, Japan (June 13-18 1999), we commemorated the death of Jean Weiler. He was the Swiss delegate to the IMEKO General Council from 1972 to 1996, Treasurer for twenty years and the Father of TC4. The 4th Workshop on “ADC Modelling and Testing” was held in Bordeaux, FRANCE, September 09-10 1999. The Workshop was organised by Philippe Marchegay and Dominique Dallet. It was the first TC4 IMEKO event in France. The 5th Workshop on “ADC Modelling and Testing” was held during the 15th World Congress in Wien, AUSTRIA, September 26-28 2000. The European Commission, Research DG, Human

Potential Programme, High-Level Scientific Conferences HPCF-CT-2000-00036 supported the Workshop. We came back to Wien after eight years and commemorated the death of Adam Fiok. Mario Savino described Adam Fiok's activities for both creation and improvement of the TC-4. The 11th Symposium on "Trends in Electrical Measurements and Instrumentation" was held in Lisbon PORTUGAL, September 13-14 2001. The Symposium was scheduled two days after the twin towers tragedy (Days of Terror). Antonio Serra was worried, but all members overcame the fear and they participated in the Symposium that was a success. The 7th Workshop on "ADC Modelling and Testing" was held in Prague, CZECH REPUBLIC, June 26-28 2002. Vladimir Haasz was able to organise the joint 7th Workshop on ADC Modelling and Testing and 4th ADDA Conference. During the meeting L. Michaeli reported the positive results of the 2nd Summer School on Data Acquisition Systems, held in June at the Technical University of Kosice, in the framework of Socrates Program in collaboration with the Technical University of Budapest (Hungary), University of Calabria (Italy), Technical University of Prague (Czech Republic), and University of Sannio (Italy). The tradition of annual Summer schools started in 2001. The 12th International Symposium on "Electrical Measurements and Instrumentation" took place in Zagreb, CROATIA, September 25-27 2002, organized by Mladen Borsic. IMEKO TC4 Board declared Milos Sedlacek as new Chairman, Antonio Serra as new Deputy Chairman, and Pasquale Daponte as new Scientific Secretary, for the successive three years.

3. *The 17th IMEKO World Congress in CROATIA, 2003*

The venue of the 17th World Congress on "Metrology in the 3th Millennium" was Dubrovnik, CROATIA, on June 22-27 2003, organized by Mladen Borsic. The measurement and assessment of Power Quality (PQ) was one of the most important topics. Alessandro Ferrero discussed very well this subject in his invited paper [9]. During the presentation of a paper on the fundamentals of electrical PQ assessment [10], there were two electrical energy failures. Some participants thought that it was a trick of the session chairpersons, for underlining the importance of power quality. Really, the use of numerous air conditioning devices, at the same time, caused the faults. It was a hot summer indeed. For the first time, in the long IMEKO history, the whole Congress in Croatia used Internet for its organization. The TC4 contribution to the Congress was really significant and documented by 64 papers presented in 12 oral sessions and 57 papers presented in three poster sessions, considering the total number of the 489 Congress papers. In 2003, Paolo Carbone organized the VIII IMEKO TC4 Workshop on ADC Modelling and Testing (IWADC 2003) in Perugia, ITALY, on September 8-10 2003. It was an event also technically sponsored by IEEE and by Italian Group of

Electric and Electronic Measurements (GMEE). With seventeen different countries represented in the workshop and three special sessions, the scientific program included 65 papers, out of the 80 abstracts submitted, 2 plenary talks and 1 round table. In the same year, Linus Michaeli and Jan Saliga organized the third Summer School on "Data Acquisition System" in Kosice, SLOVAKIA, 29 June - 11 July 2003. Around 20 MSc degree and PhD students from partners involved in the WG "ADC and DAC Metrology" spent two weeks long stay at the Technical University of Košice. Since 2003, the ERASMUS program sponsored the Summer School on "Data Acquisition Systems".

4. *The 13th TC4 International Symposium in GRECE, 2004*

During the 13th TC4 International Symposium on "Measurements for Research and Industry Applications", calibration metrology and standards, automated tests for traditional and virtual measurement systems had a large emphasis. The venue of Symposium was Athens, GREECE, from the 29th September to the 1st October 2004, with the 9th International Workshop on ADC Modelling and Testing, organized under the chair of Eleptherios Kayafas and Vassilios Loumos. The celebration of the 20th anniversary of the TC4 foundation fell in that year. During the plenary session, Van Biesen, Kemeny and Roske [11] presented an invited paper, concerning the non-governmental cooperation in measurement and instrumentation, and provided important information on the age of the knowledge based society, on globalization of research and on engineering education.

5. *The 14th TC4 International Symposium in POLAND, 2005*

Janusz Mindykowski organized, on September 12-15 2005, the 14th TC4 International Symposium on "New Technologies in Measurement and Instrumentation" together with the 10th Workshop on ADC Modelling and Testing, held in Gdynia and Jurata, POLAND. An opening plenary session paper reported the state of art in ADC and DAC modelling and testing, presented by Cruz Serra, Daponte and Michaeli [12]. The working sessions of the Symposium and IWADC Workshop took place in Jurata, a resort situated on the Hel Peninsula on the Gulf of Gdansk on the Baltic Sea.

One of the most fascinating events during the Symposium was a sea voyage on board of the seagoing tall ship "Dar Młodzieży", under the full sail from Gdynia to Hel and back. The scientific topics were very similar to those in Athens 2005, only "Power Quality Measurement" changed in "Power Quality Assessment", and "Time and Frequency Measurement", changed in "Optical Wavelength Metrology". Many areas explored in Athens had extension, development and analysis in

Gdynia. Due to the aforementioned similarity of the topics and of presented papers from one side, and the Measurement journal auspices from the other, this journal published, in a special issue [13], the extended and updated versions of the papers from Athens and Gdynia/Jurata. The 3rd and 4th Summer School, on "Data Acquisition Systems", took place in Kosice, SLOVAKIA, 14 - 25 June 2004 and Benevento, ITALY, 19 June - 2 July 2005, organized by Linus Michaeli and Jan Saliga, and Pasquale Daponte, respectively.

6. *The 18th IMEKO World Congress in BRASIL, 2006*

Rio de Janeiro, BRAZIL was the venue of the XVIII IMEKO World Congress on "Metrology for a Sustainable Development" together with the 11th IMEKO TC4 Workshop on ADC Modelling and Testing (IWADC 2006), on September 17-22, 2006, organized by Gelson Rocha. For the first time in the IMEKO history, the Congress took place in the America Latina. The general theme of the Congress was a kind of response for the challenges concerning a need of sustainable development of countries, regions and continents, and the possibility to understand and recognize the role of metrology in this context. The Congress was scientifically very interesting and gave the opportunity of admiring the beauty of Brazil, and Rio de Janeiro.

The most important conclusion of the Congress was the consideration that sustainability is not a brake on the growth and the development of the society, but a smart way to organize the work according to proper economic and energetic standards on the road of good design. To define these standards, the metrology will play a role more and more significant.

Sustainability should be a dynamic process able to allow constant expansion or contraction depending on markets and resources, with the respect to the environment and standards agreed within international politics.

During the TC4 Board meeting, the Chairman Antonio Cruz Serra informed that the TC4 representatives had the highest number of papers and the widest activity among all the IMEKO Technical Committees. During the meeting, the Honorary Chairman Mario Savino communicated the election of Antonio C. Serra as the IMEKO President for the following three years. In the next step, the Committee nominated Linus Michaeli and Janusz Mindykowski as new TC-4 Deputy Chairman and Scientific Secretary, respectively (under a proposal of Pasquale Daponte).

Since 2006, another university, involved in the TC4 WG, organized the Summer School for the period of three years. In addition, the main objective of the Summer School changed according to the present hot topic in the field of the virtual instrumentation.

7. *The 15th TC4 International Symposium in ROMANIA,*

2007

The venue of the 15th IMEKO TC4 International Symposium on "Novelties in Electrical Measurements and Instrumentation" together with the 12th IMEKO TC4 Workshop on ADC Modelling and Testing was Iasi, ROMANIA, 19 - 21 September 2007, organized by Alexandru Salceanu and Mihai Cretu. This TC4 Symposium was running simultaneously with the 1st IMEKO TC19 International Symposium on "Measurement and Instrumentation for Environmental Monitoring" and the 3rd Technical Meeting on "Remote Instrumentation in Next-Generation Grids". The environment received a particular attention, with its influence on our life, climate changes and the protection issue. Another topic was that of energy, confirming the interest in the study of savings, safety and economic efficiency. The programme of Symposium and Workshop consisted of the opening ceremony and plenary lecture, 17 working sessions under the TC4 topics, five working sessions under the TC19 topics, a special GRID session, poster session and closing session. J. Mindykowski emphasized several issues of the title of the Symposium "Novelties in Electrical Measurements and Instrumentation" [14]. There was a large number of submissions to the ADC Workshop, oriented to such topics as Σ - Δ ADC for general application, ADC testing, ADC/ADC modelling and ADC standardization. The theme of the plenary paper presented by prof. Christos Christopolus titled "The Role of Simulations in Support of Measurements at High-Frequencies" [15]. For completion of the TC4 activity in 2007, the 7th Summer School on "ADC & DAC Metrology" continued in Benevento, ITALY, organized by Pasquale Daponte and Sergio Rapuano.

8. *The 16th TC4 International Symposium in ITALY, 2008*

Devoted to these topics and organized by Marcantonio Catelani, the 16th IMEKO TC4 International Symposium on "Exploring New Frontiers of Instrumentation and Methods for Electrical and Electronic Measurements" integrated with the 13th International Workshop on ADC modelling and testing, took place in Florence, ITALY, on September 21-24, 2008. During the Workshop, there was an interesting contemporary metrological event: the IEEE TC10 Technical Meeting on "Waveform Generation Measurement and Analysis". It was a further initiative of cooperation between the IEEE and IMEKO bodies, and with other IMEKO Committees. Franco Pavese (Italy) organized the IMEKO TC4-TC21 Joint Session, focusing on typical aspects of measurement and instrumentation for electrical quantities as well as on mathematical tools for measurements. The participants at the Symposium admired the Italian art in Florence. Maurice G. Cox presented the plenary IMEKO TC4 lecture entitled "Systematic-error modelling, with an application to

complex permittivity measurement” [16], dedicated to the fond memory of friend and colleague Professor Gaetano Iuculano, who strongly wanted that the meeting could take place in Florence and unfortunately passed away in 2007. A significant innovation of the Symposium was to introduce interdisciplinary, multi-subject special sessions. The titles of those sessions give a very good overview of the current development trends in the domain of metrology [17] covered by the IMEKO TC4 and IWADC. C. Lyded from Analog Devices, Cork, Ireland delivered the IMEKO IWADC opening lecture titled “A brief history of the Analog Digital Converter” [18]. The lecture illustrated how recent main architectures evolved in the context of the most important driving applications of the time and of the available manufacturing technology. The IMEKO TC4 Symposium in Florence, 2008, together with the related metrological events had the highest number of presented papers (193) in the history of TC4 Symposia. The year of the Symposium(2008) corresponded to the 50th anniversary of the IMEKO founding, as underlined and expressed in the paper “IMEKO - the Instrumentation and Measurement Confederation” [19] presented by A. Serra and L. Van Biesen, IMEKO President and IMEKO Past President, respectively. By closing the picture of IMEKO TC4 activity in 2008, the 8th Summer School on “Distributed Measurement Systems” took place for the three consecutive years in Gavle, SWEDEN. Peter Handel and Niclas Bjoersel organized it as a two-week-event at the turn of June and July 2008, 2009 and 2010, respectively.

9. *The 19th IMEKO World Congress in PORTUGAL, 2009*

The venue of XIX IMEKO World Congress on “Fundamental and Applied Metrology” together with the 14th IMEKO TC4 Workshop on ADC Modelling and Testing was Lisbon, PORTUGAL, on September 6 - 11, 2009, organized by Pedro Silva Girão and Pedro Ramos. The subjects of the five invited talks gave emphasis to Fundamental and Applied Metrology. The Congress program had scheduled 82 oral and 4 poster sessions. One workshop dealt with “Measuring the impossible: Measurement of Characteristics Related to Human Perception and Interpretation”. In this context, G. Battista Rossi and B. Berglund presented a paper on “Measurement Related to Human Perception and Interpretation - state of The Art and Challenges” [20], an example of interdisciplinary between technical and psychological subjects. On a total number of 551 full Congress papers, the contribution of TC4 was significant with 116 published papers. One of the workshops was composed of four sessions, dedicated to analogue-to-digital converters and organized under the umbrella of TC4 by P. Daponte and L. Michaeli.

10. *The 17th TC4 International Symposium in SLOVAKIA, 2010*

Linus Michaeli and Jan Saliga organized from September 8th through September 10th, 2010, the 17th IMEKO TC4 Symposium on “Instrumentation for the Information and Communication Technology Era”, together with the 3rd IMEKO TC19 Symposium and the 15th International Workshop on ADC Modelling and Testing, in Kosice, SLOVAKIA - European City of Culture in 2013. A new topic concerned the “Advanced Instrumentation Based on Micro and Nano Technologies”. Themes linked to EU Research Projects regarded “EMC Testing and Outcomes of International Research Projects”. Mario Savino for the first time presented [1] the beginning of history of the TC4, summarising many years of TC4 activities, looking at the past and recognizing new possible challenges. Many participants appreciated this presentation, because they had the opportunity to refresh remembrances and past undertakings. He completed the recollection of the past, during the gala dinner, showing several photos taken from beginning of TC4 to the year 1988.

11. *The 18th TC4 International Symposium in BRASIL, 2011*

Mario Savino presented the second part of the TC4 history, from 1989 to 2002 [2], during the successive 18th IMEKO TC4 International Symposium on Measurement of Electrical Quantities, (part of Metrologia 2011, together with the VI International Congress on Electrical Metrology - IX SEMETRO), which took place in Natal, BRASIL, 27-30 September 2011, organized by Gelson Rocha. Mario Savino was also author of an invited talk “Energy policies and renewable energy systems monitoring”.

Klaus von Klitzing presented his discovery on the quantized Hall Effect in an invited lecture. He received the 1985 Nobel Prize in Physics. The new fundamental constant, called von Klitzing constant, together with the Josephson constant is the base for the precision measurement of all electrical quantities. Klaus showed the photos of Nobel ceremony, when he received the prize of Royal Swedish Academy of Sciences from the hands of His Majesty the King. For many TC4 members was difficult to take place in the IMEKO TC4 Symposium in Brazil, especially for travel and accommodation expenses. For this reason, more members preferred to be present in the 16th IMEKO TC4 International Workshop on ADC Modelling and Testing - Data Converter Design, Modelling and Testing (IWADC) organized together with IEEE ADC Forum in Orvieto, ITALY, 30 June-01 July 2011, by Paolo Carbone. The event was a success. A good cooperation of TC4 IMEKO and TC10 IEEE on common themes was the benefit of this workshop.

12. The 20th IMEKO World Congress in KOREA, 2012

Energy security, climate change and environmental conservation require a worldwide co-operation. These themes were the topics of XX IMEKO World Congress on “Metrology for Green Growth” held in Busan, REPUBLIC of KOREA, in September 9 - 14, 2012, organized by Sam-Yong Woo with support of Dae-Im Kang, in that time President of IMEKO. Busan was the third host city of a World Congress in Asian region after Beijing (1991) and Osaka (2001). The Congress had a great success, thanks to the organisational quality and its venue. The IMEKO TC4 contribution to the success of the Congress was large. Just during the XX IMEKO World Congress, the new Working Group “Electrical Metrology in Nano- and Micro Technology” started its activity. This new initiative had a strong support by Asian metrologists and another TC4 partner. The TC4 Board Meetings made pressure to IMEKO MOs (member organisations) for inclusion of the IMEKO proceedings and journals in the Web of Science (Web of knowledge database system), and also to support the efforts of the IMEKO community members towards the indexing in the SCOPUS database system. In Busan, the TC4 Board elected Janusz Mindykowski from Poland (Chairman), Dominique Dallet from France (Deputy Chairman) and Pedro M. Ramos from Portugal (Scientific Secretary) for the successive three-year term of office 2012-2015. In 2012, the 12th Summer School on “Distributed Data Acquisition Systems”, took place in Cosenza, ITALY, 23 - 28 July 2012, organized by Domenico Grimaldi. A focus of that Summer School was “Advancements in Signal Processing” and their influence on development of the related algorithms, procedures and instrumentation.

13. The 19th TC4 International Symposium in SPAIN, 2013

The venue of the 19th IMEKO TC4 Symposium on Measurements of Electrical Quantities together with the 17th TC4 IWADC Workshop on ADC and DAC Modelling and Testing was Barcelona, SPAIN, 18 - 19 July 2013, organized by Joaquin del Rio and Antoni Manuel. The Symposium looked into traditional TC4 topics, oriented in the context of the so-called society of knowledge. A novelty of the Symposium was to expand subjects with the issues related to marine technologies and applications. Two papers presented some new ideas concerning the aforementioned areas, addressed to precision timing in TDMA-based Wireless Sensor Network [21] and to measuring system and power management for underwater research [22]. During the TC4 Board Meeting, the traditional way of IMEKO journals’ editorial supporting process continued, and, at the end, Dominique Dallet and Joaquin del Rio for Measurement and Alexandru Salceanu and Spartacus Gomariz for ACTA IMEKO, respectively, had the charge of the Guest Editors. During the same TC4 Board

Meeting, Pasquale Daponte presented another crucial issue, concerned the IMEKO Indexing System, as an important factor stimulating a scientific evaluation process in many countries. In 2013, the 13th Summer School on “Distributed Data Acquisition Systems” preceded the 19th TC4 Symposium, still organized by Joaquin del Rio in Vilanova la Geltru/Barcelona, 15 - 19 July 2013, and was an important forum for young researchers in the field of metrology.

14. The 20th TC4 International Symposium in ITALY, 2014

Benevento in Italy, from 15 to 17 September 2014, was the venue of the 20th IMEKO TC4 Symposium on “Research on Electrical and Electronic Measurements for the Economic Upturn” and of the 18th IMEKO TC4 International Workshop on ADC Modelling and Testing. The historical buildings of Benevento University were the frame for the two events, organized by Pasquale Arpaia and Sergio Rapuano (TC4 Symposium) and Pasquale Daponte (IWADC), respectively. The most important news concerning the IMEKO activity in 2014 are in [23]. The motto of the Symposium referred to the global economic situation, which requires innovative solutions also in the area of measurement technologies. Mario Savino, a co-author of the paper [24], presented a new multi-utility network for energy sustainability, giving innovative solutions in the area of measurement technologies. That year, the organizers of the Symposium introduced in the programme a new type of organisation, viz. numerous special sessions – mainly application-oriented sessions dedicated to transdisciplinary research. Among the highlights of the Symposium, the two keynote plenary lectures should be mentioned, i.e.: “The Higgs boson and beyond: the physics of the Large Hadron Collider experiments at CERN” [25] by Giuseppe Iacobucci from the University of Geneva and CERN, and “Pulse metrology” by Nicholas G. Paultier from NIST. The first of them opened a new horizon for many participants of the metrology meetings. The Benevento Workshop on ADC Modelling and Testing focused mainly on new methods for non-conventional ADC architectures. A half-day session devoted to software for ADC testing, combining hands-on experience with five lectures, was an innovation of that Workshop. The TC4 events in Benevento attracted 228 attendees, including 20 organising committee members. The book of proceedings contained 210 papers, selected out of 243 submitted manuscripts, and 5 invited lectures, by authors coming from 38 countries. The same 2014 was also the year for the Summer School. Some differences are relevant in respect to many previous ones. First, it was 3 weeks long Summer School and organized with the different formula traditionally used in ERASMUS programme. Due to the efforts of Joaquin del Rio from Universitat Politècnica de Catalunya, a successful grant application created the possibility to organize the IP Martin Summer School on

Marine Technology, Instrumentation, in Vilanova i la Geltru / Barcelona, SPAIN, on June 29 - July 18 2014. Looking at the wide and multi-disciplinary marine technology instrumentation oriented programme, it was a good chance for graduate students from seven countries, to develop their knowledge and professional skills related to the innovative nature of the project under consideration.

15. *The 21st IMEKO World Congress in CZECH REPUBLIC, 2015*

Prague, CZECH REPUBLIC, was the venue of the XXI IMEKO World Congress on “Measurement in Research and Industry” from the 30th August to the 4th September 2015, organized by Jaromir Volf with a significant contribution of Vladimir Haasz and Jan Holub. An invited lecture concerned a new subject, that of Emotion Detector [26]. The contribution of the TC4 was significant with four oral and two poster sessions, a Special Session on Advanced Magnetic and Electric Current Measurement, and the Round Table on Measurement Challenges for Future Energy Networks. This Round Table had arisen from the paper [24], presented in Benevento 2014, and discussed during the related TC4 Board meeting. There was the leading paper [27], presented by Carmine Landi, being an introduction to the new theme concerning the metering advancements for future energy networks. During the TC4 Board Meeting in Prague, a deep discussion concerned the enlargement of the TC4 areas of activity. Some TC4 Members were of the opinion, that TC4 should be more concentrated on the traditional scope. On the contrary, the majority of the present members put attention to the necessity to extend the vision of the TC4 activity to other fields. During the Congress in Prague, Janusz Mindykowski recommended the TC4 officers for the next three-year term, particularly Dominique Dallet from France as Chairman, Pedro Ramos from Portugal as Vice-Chairman and Alexandru Salceanu from Romania as Scientific Secretary. To close the TC4 activity in 2015, the 15th Summer School on “Distributed Data Acquisition Systems” took place in Vilanova i la Geltru from the 29th June to the 3rd July, organized by Joaquin de Rio. It was the last one, because of missing support by the ERASMUS program, the tradition of regular Summer Schools finished in 2015.

16. *The 21st TC4 International Symposium in HUNGARY, 2016*

The venue of the 21st IMEKO TC-4 International Symposium on “Understanding the World through Electrical and Electronic Measurement”, and the 19th International Workshop on ADC Modelling and Testing, was Budapest. TC4 Symposium, a forum for discussing on new trends of measurements and sensors, came back to this beautiful European metropolis after twenty years.

Unfortunately, the chairman of the Symposium, Prof. István Kollár passed away one month before the beginning of the event. Prof. Tamás Dabóczy the Head of Department Measurement and Information Systems in Budapest University of Technology and Economics decided to dedicate the Symposium for his memory. Mario Savino, during the opening ceremony, recalled the figure of István. They met each other in 1988 during the 11th World Congress in Huston. Mario said that István has been one of the more studious and precise scientists among his colleagues, following all the sessions of TC4 Symposia and IMEKO Congresses with high attention and he directed his questions to the lecturers towards the attainment of the improvement of the measurement science. The scientific program included a very interesting plenary lecture “System Identification in the real world” by Johan Schoukens, Vrije Universiteit of Brussel, as well as contributed lectures and poster presentations.

II. CONCLUDING REMARKS

The Authors would like to thank all the colleagues who asked them to write this historical retrospect through their recollections. Taking into account the period from 2003 to 2015, some observations are necessary. First of them, the TC4 field of activity, although still focused on electrical and electronic instrumentation, has assumed its inter- and trans-disciplinary dimension. A second point regards the necessity of stronger links between scientist engineers and industry representatives to solve the most important problems relevant to energy, security, climate changes and environmental protection issues. A third point concerns the increase of administrative and formal limitations, unknown in the past, when the scientists were interested mainly in scientific activities. The next remark concerned the confirmation of the TC4 to be of exceptional importance for the IMEKO, with, not only, its contribution of TC4 Symposia and at IMEKO Congresses, but also with the TC4 International Workshop on ADC and DAC Modelling and Testing and TC4 Summer Schools. With their success, these great events were fundamentally important to attract young people to the circle of TC4 followers, proponents and participants.

III. ACKNOWLEDGMENT

Any opinions, conclusions or recommendations expressed in this paper are those of the authors and not necessarily reflect the views of IMEKO bodies. The authors thank all the members of TC4 for their contribution to this history.

REFERENCES

- [1] M. Savino, *The History of the Technical Committee 4 of IMEKO on Measurement of Electrical Quantities. The first*

- part, Proceedings of the XVII IMEKO TC-4 International Symposium and XV International Workshop on ADC Modeling and Testing, Kosice, Slovak Rep., 8-10 September 2010.
- [2] M. Savino, *The History of the Technical Committee 4 of IMEKO on Measurement of electrical quantities, from 1989 to 2002, invited talk*, Proceedings of the 18th IMEKO TC4 International Symposium on Measurement of Electrical Quantities, Natal, BRASIL, 27-30 September 2011
 - [3] M. Savino, *An overview of the measurement of electrical quantities from 1979 to 2002*, Measurement 45 2012, pp. 2185-2193
 - [4] J. Mindykowski, M. Savino, *An overview of the measurement of electrical quantities within IMEKO from 2003 to 2015*, Measurement, 2005
 - [5] A. Fiok, J. Weiler, *New approaches in the measurement of electrical systems, in: XII IMEKO World Congress*, China, September 5–10, 1991.
 - [6] H. Schumny, *Digital measurement systems*, Proc. of the 7th IMEKO TC-4 Int. Symp. on “Modern Electrical and Magnetic Measurement” Prague, CZECH REPUBLIC, September 13-14, 1995
 - [7] S. Dado, *Will sensors always be a bottleneck in measurement systems?*, Proc. of the 7th IMEKO TC-4 Int. Symp. on “Modern Electrical and Magnetic Measurement” ibidem
 - [8] J. Weiler, *Can measurement be taught?* Proc. of the 7th IMEKO TC-4 Int. Symp. on “Modern Electrical and Magnetic Measurement” ibidem
 - [9] A. Ferrero, *Electric power quality measurement, invited paper*, Proceedings of the XVII IMEKO World Congress on Metrology in the 3rd Millenium, Dubrovnik, Croatia, June, 2003
 - [10] J. Mindykowski, *Fundamentals of electrical power quality assessment*, Proceedings of the XVII IMEKO World Congress on Metrology in the 3rd Millenium, Dubrovnik, Croatia, June, 2003
 - [11] L. Van Biesen, T. Kemeny, D. Roske, *Non-governmental cooperation in measurement and instrumentation, plenary paper*, Proceedings of the 13th IMEKO TC4 International Symposium on Measurements for Research and Industry Applications and the 9th International Workshop on ADC Modelling and Testing, Athens, Greece, September / October, 2004
 - [12] A. Cruz Serra, P. Daponte, L. Michaeli, *ADC and DAC modelling and testing - state of the art, plenary paper*, Proceedings of the 14th IMEKO TC4 International Symposium on New Technologies in Measurement and Instrumentation and the 10th International Workshop on ADC modelling and Testing, Gdynia / Jurata, Poland, September 2005
 - [13] J. Mindykowski, E. Kayafas, *Innovative design and paradigms in instrumentation and measurements*, Editorial, Measurement 41, 2008, pp. 219-221.
 - [14] J. Mindykowski, *Novelties in electrical measurements and instrumentation in the wake of IMEKO TC4 & TC19 Symposia and ADC Workshop in Iasi, Romania*, September 2007, Metrology and Measurement Systems, Vol. XIV, 4 (2007), pp. 639-641.
 - [15] Ch. Christopoulos, *The role of simulations in support of measurements at High-Frequencies*, plenary paper, ibidem
 - [16] M. G. Cox, *Systematic - error modelling, with an application to complex permittivity measurement, plenary opening lecture*, Proceedings of the 16th IMEKO TC4 International Symposium on Exploring New Frontiers of Instrumentation and Methods for Electrical and Electronic Measurement and the 13th International Workshop on ADC Modelling and Testing, Florence, Italy, 2008.
 - [17] J. Mindykowski, *Exploring new frontiers of instrumentation and methods for electrical and electronic measurements in light of the IMEKO TC4 Symposium in Florence, Italy, September 2008*, Metrology and Measurement Systems, Vol. XV, 4 (2008), pp. 613-616.
 - [18] C. Lyded, *A brief history of the Analog Digital Converter, IWADC opening lecture*, Proceedings of the 16th IMEKO TC4 International Symposium on Exploring New Frontiers of Instrumentation and methods for Electrical and Electronic Measurement and the 13th International Workshop on ADC Modelling and Testing, Florence, Italy, September, 2008
 - [19] A. Cruz Serra, L. Van Biesen, *IMEKO - the Instrumentation and Measurement Confederation*, Proceedings of the 16th IMEKO TC4 International Symposium on Exploring New Frontiers of Instrumentation and methods for Electrical and Electronic Measurement and the 13th International Workshop on ADC Modelling and Testing, Florence, Italy, September, 2008
 - [20] G. B. Rossi, B. Berglund, *Measurement related to human perception and interpretation - state of the art and challenges*, Proceedings of the XIX IMEKO World Congress on “Fundamental and Applied Metrology”, Lisbon, PORTUGAL, September 2009.
 - [21] D.M. Toma, Joaquin del Rio, A. Manuel, *Precision timing in IDMA – based. Wireless Sensor Network through IEEE 1588 Standard*, In: Proceedings of the 19th TC4 Symposium on Measurements of Electrical Quantities & the 17th TC4IWADC Workshop on ADC and DAC Modelling and Testing, Barcelona, Spain, 18- 19 July 2013.
 - [22] I. Masmitja, J. Gonzalez, S. Gomariz, *Measuring system and power management of the Guanay II AUV*, In: Proceedings of the 19th TC4 Symposium on Measurements of Electrical Quantities & the 17th TC4 IWADC Workshop on ADC and DAC Modelling and Testing, Barcelona, Spain, 18–19 July 2013.
 - [23] R. Z. Morawski, J. Mindykowski, 2014: IMEKO in Benevento, Measurement. Automation Monitoring, Vol. 61, 1 (2015), pp. 24 – 25.
 - [24] A. Di Nisio, M. Savino, M. Spadavecchia, *Challenges in monitoring toward a new multi-utility network for energy sustainability*, Proceedings of the 20th IMEKO TC4 International Symposium on Research on Electrical and Electronic Measurement for the Economic Upturn and the 18th TC4 International Workshop on ADC and DCA Modelling and Testing, Benevento, ITALY, September 2014.
 - [25] G. Iacobucci, *The Higgs boson and beyond: the physics of the Large Hardon Collider experiments at CERN*, Keynote plenary lecture, Proceedings of the 20th IMEKO TC4 Symposium on Research on Electrical and Electronic Measurements for the Economic Upturn and the 18th IMEKO TC4 International Workshop on ADC and DCA Modelling and Testing, Benevento, ITALY, September 2014.
 - [26] A. Kamcka, *Uncertainties caused by human factors - can an emotion detector help?*, invited talk, Proceedings of the XXI IMEKO World Congress on Measurement in Research and Industry, Prague, CZECH REPUBLIC, August / September 2015.
 - [27] C. Landi, *Introduction: Metering advancements for future energy networks, opening paper to related Round Table*, Proceedings of the XXI IMEKO World Congress on Measurement in Research and Industry, Prague, CZECH REPUBLIC, August / September 2015