The Instrumentation and Measurement Magazine, April issue, 2008

Standard 1451.1

From the Editor's Bench

Kim Fowler

1451 Sensors and Distributed Measurements

This issue of the magazine focuses on distributed measurements and the 1451 standard for smart sensors. Dr. Kang Lee is the guest editor; he invited and organized the articles for this issue. His guest editorial follows.

Kang will present a tutorial on the 1451 standard and sensors at I^2MTC 2008 in Victoria, Canada. Kang will also present an extended amount of material at the Instrumentation Measurement University (IMU) this July in Italy. (See the advertisement later in this issue for IMU – it's quite a good deal for anyone who might consider attending!)

It's Been a Good Run

It is time for change for the magazine. After nine years of editing the magazine, I am handing over the editorial reins of the magazine to Dr. Shlomo Engelberg. Shlomo is Chairman of the Department of Electronics at the Jerusalem College of Technology; he is deeply involved in researching and teaching instrumentation and measurement to university students.

I began editing the magazine in the summer of 1999 and helped produce the Fall 1999 issue. My effective participation ends with the October 2008 issue. With the support of the I&M AdCom (Administration Committee) and much help from Mrs. June Sudduth, my editorial assistant, we have made a number of changes to the magazine over the years to be responsive and to serve the readership better. It's been quite a collaborative effort; here is what we have accomplished together:

- We went from four issues per year to five issues in 2005 to six issues per year in 2006.
- We have added special issues – AUTOTESTCON selected papers for the August issue and the student focus in the October issue.
- We added the tutorial series of articles that introduces instrumentation and measurement for people who might be new to the field or for those who want a refresher.
- We added a number of new columns including TC News and Membership Reports.
- We moved the composition and publishing to Allen Press to save money for the society.
- We increased advertising to help offset some of the costs of publishing the magazine.
- We added the magazine website to summarize each issue and to provide membership information in a more timely fashion.

Each one of these changes has been well received.

One important goal for the magazine has been to introduce other fields and disciplines through instructive articles and tutorials. Another goal has been to keep you, the readers, current with the activities of the society. These goals remain.

The magazine has been a very good experience for me, primarily because I have been blessed to work with outstanding people – June, the columnists, the authors of articles and

tutorials, and the people on the AdCom who supported the magazine. The good news is that these people remain onboard and contributing to the magazine. Shlomo, who has been a columnist and always prompt, accurate, and careful with submissions, is very able to take over the editorship. He is already a year ahead with his plans. He will also edit and handle the June and December issues this year.

The magazine has long lead times, its deadlines are five months before mailing each issue, so by the time you receive this magazine, June and I will be finishing the October issue. Shlomo will be taking over. I move on to other responsibilities within the Instrumentation & Measurement Society – I am the Executive Vice President this year and will be involved in many new activities. I will still see many of you at the conferences and will keep contact through my columns in the magazine.

I've enjoyed this magazine very much and enjoyed working with you and for you.kimf@ieee.org

Kim

Guest Editor Editorial

Smart and Wireless Sensor Standards for Distributed Measurements

Kang Lee

Sensors are ubiquitous. They are used in a variety of measurement and control applications that touch our lives everyday, ranging from industrial automation to intelligent transportation systems to health care to smart appliances to homeland defense. Computer-based instrumentation has existed a long time and has become very complex due to a massive amount of cabling when hundreds and thousands of sensors need to be connected together. Networking sensors has emerged as an effective way for connecting sensors, similar to the way personal computers are connected.

Sensor networks have come a long way since their appearance in the early 90s. Specifically, smart sensor networks with self-identification and plug-and-plug capabilities and wireless sensor networks with ad-hoc networking capability have emerged. Today smart and wireless sensor networks have created a very exciting atmosphere in the developer as well as user communities. Wireless sensors with ad-hoc networking capability will free sensors from cumbersome wires. They can relay information from one sensor to another distributed over a large area. In the near future, they are expected to operate with submicrowatts of battery power, or energy scavenged from the environment, for instance, converting into electricity from vibration or heat energy generated on machinery operating in a factory. Through these distributed wireless and wireline sensor networks, tens of thousands of sensors can be connected to communicate and share sensor data and information among users and applications. As an example, in the case of homeland security, government agencies and private enterprises can share information in order to effectively protect people and property.

The diversity of sensor networks and system requirements and the need to accommodate unknown future systems have driven toward sensor applications that can support heterogeneous, multi-vendor networks. Thus, a framework for interoperability is needed to accommodate these

systems and networks. Open sensor interfaces, standardized sensor data formats, and messaging standards are needed to enable the integration, access, fusion, use, and delivery of sensor-derived data for these applications. The suite of IEEE 1451 Smart Transducer Interface Standards for Sensor and Actuators are the focus of this issue of the Instrumentation and Measurement Magazine. These standards help guide developers in building networks and systems that can effectively discover, access, and use sensor-derived data using both wireline and wireless networks. In sensing applications where timestamping of sensor data in a distributed system are important, the IEEE 1588 Precision Clock Synchronization Protocol Standard can help to address the interoperability issues because it defines a protocol to synchronize independent clocks running on separate nodes of a networked measurement and control system to a high degree of accuracy and precision better than a submicrosecond. These two standards are developed by the Instrumentation and Measurement Society's Technical Committee on Sensor Technology

Since there is a great interest in network-centric, distributed, and plug-and-play sensors, and a need to coordinate various sensor and related standards in government agencies and standards development organizations, a Sensor Standards Harmonization Working Group is convened regularly at the National Institute of Standards and Technology. A plugfest has been initiated in the group to provide a forum for interoperability testing of standardized wireline and wireless sensor networks. Any interested party from government, industry, and academia who wish to participate is welcome. (kanglee@nist.gov)

Kang

The President's Perspective

Alessandro Ferrero

Knowing Each Other

As you probably guessed while reading my column in the February issue, I assign great importance to knowledge. When we belong to a community, like our I&M Society, if we want to strengthen the cooperation between members and between members and the Society governance, we should all know about each other; our interests and our expectations about how the Society can best serve our needs.

This is not an easy task. We're a true world-wide community of thousands of people, and we have few chances of meeting unless it is during conferences and meetings. However, we can communicate through our publications. This Magazine that was started years ago is a virtual forum through which we can meet and discuss topics of common interest. We're all involved with measurements and we know that good data are the basis of knowledge. So, let me provide you a few data about our membership, and let's use these data to start introducing us to each other.

At the end of November 2007, while I am preparing this column, the I&M Society counts 7,905 members divided into

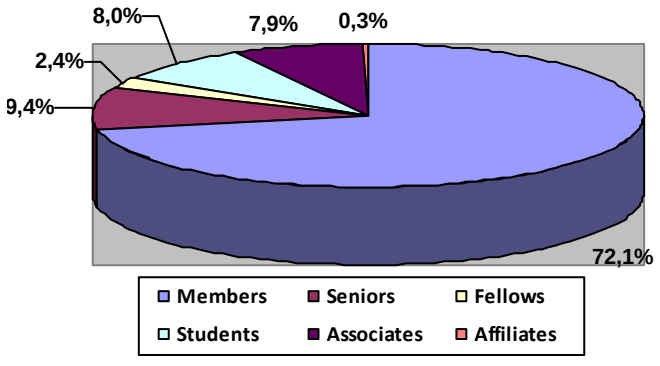

Fig. 1. IMS members by grade

the different grades, shown in the pie-chart of Fig. 1.
We represent the 2.1% of the total IEEE members (374,767 total members, found in the IEEE Annual Report, 2006), and our size is above the median size of the IEEE Societies.

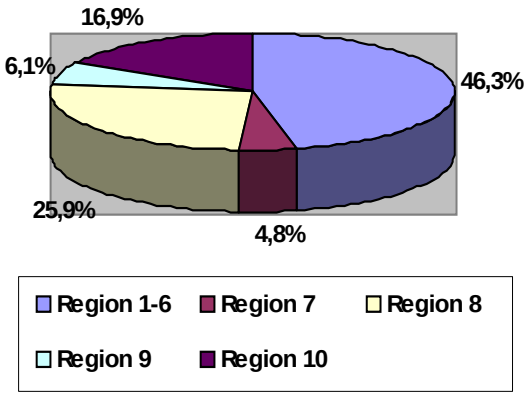

Fig. 2. Geographical distribution of the IMS members

We have more Senior and Fellow Members than the IEEE average (9.4% vs. 7.8% of Senior Members and 2.4% vs. 1.6% of Fellow Members), but we have less Student Members (8%) than the IEEE average (21.5%). The geographical distribution is shown in the pie-chart of Fig. 2.

If we compare this distribution with the general distribution of all IEEE members, we find again some differences. We have less members from the United States (Regions 1-6): 46.3% vs. the 57.6% of the whole IEEE. We have more members from Region 8 (Europe, Middle East and Africa): 25.8% vs. the 16.2% of the whole IEEE. The other regions have approximately the same percentage as the whole IEEE.
It is also interesting to note that the 28.4% of our members comes from the Academia (20.6% is the IEEE value), the 49.2% from Industry (51.3% is the IEEE value) and the 4.2% from Government Institutions (9.9% is the IEEE value).

These figures are not totally surprising, if we consider the core of the I&M field: instrumentation, on one side, and measurement, that is theory and methodology, on the other side. Despite modern instruments have become more and more user friendly, their correct use and the correct interpretation of the measurement results implies a deep knowledge of the theoretical involvements. Hence, the high number of academicians among our members is not a surprise. The geographical distribution, with the majority of academicians coming from Region 8 and the majority of members from Industry coming from Regions 1-6, is also not unexpected. The majority of the manufacturers of measuring instruments are located in the USA, and it is quite logical that members coming from this region belong to the industrial world. On the other hand, Europe has a solid background in the analysis of the theoretical implications of the scientific experimental activity that goes back to Galileo and that represents the fundamentals of the measurement science: no wonder, hence, that the majority of the members from Region 8 are academicians. No wonder also that the 48% of the paper accepted for publication in our Transactions, in 2007, comes from Region 8 authors.

We've the data, and we've a good, logically sound interpretation of these data. Is this enough? Should we try to learn something more from these data, in order to set the optimal course for the I&M Society? In my opinion we have much more to learn from these data. Let's start with a few additional considerations.

Looking at the above data, measurement theory and practical applications seem to stay, literally, an Ocean apart. Is this useful to the I&M community? I don't think so. This Society is the virtual bridge across this ocean, though, probably, it is still a narrow bridge. What can we do to widen it, so that the different visions of I&M can effectively merge together? Are our publications and conferences properly aimed at this target, or shall we make some adjustments?

The above data show us also a limited involvement of Region 9 and Region 10 in the Society activity. Apparently, there is no reason for this. Metrology is well developed in Latin America, and Far East Countries have important manufacturers of measuring instruments and gave significant contributions to the advancement of the measurement science. Why are we not attracting more members from these Regions?

The last important issue opened by the analysis of the above data is related to our Student Members. We have significantly less members than the IEEE average, and this really worries me. Today Student Members are tomorrow Members. Today Students are tomorrow I&M engineers and scientists, and if we fail to attract them, we fail to plan our own future. The Society AdCom is fully aware of this problem, and we've already started many actions: we've appointed students' representatives in the AdCom, we give awards to the Best Student Papers in our major conferences and we've organized the International Measurement University devoted to students and young scientists and engineers that wish to refine their competence in the I&M field. Will these efforts bring more Student Members to the Society?

During the last years, the Society's AdCom has worked hard to find good, coordinated answers to these questions and tune the Society's strategic plans to be best serve our Members. The recent increase of our membership, compared with the general decrement of the Societies' membership, is seemingly showing that we're heading the right direction. The way is still long, and a constant tuning and monitoring of the Society's strategy is in the future AdCom plans and in my own plans.

The opinion of all of you is, once again, invaluable to help us keep the right course and hit the target. As always, your comments are welcome. (alessandro.ferrero@polimi.it)

Alessandro

Membership Notes – April 2008

Ruth A. Dyer

As of December 31, 2007, my tenure as Vice President of Membership ended. I have been very privileged to have had the opportunity to work with an outstanding Membership Committee over the last two years. These individuals include James Becker, Jorge Daher, Joe Lopez, Shreekanth Mandayam, and Kristen Muñoz. Joe and Kristin were the student representatives to the I&M Administrative Committee during my role as VP, and their ideas and efforts have been invaluable as we have worked to establish new connections with and enhance the involvement of the student members of our society. James, Jorge and Shreekanth have each spent many hours to develop and implement new initiatives designed to better serve our members and our chapters. Thus, I want to extend my warmest thanks to all of them for their extraordinary contributions to the work of this committee and to let them know how much fun it has been to work alongside them.

It is my distinct pleasure to introduce the new Vice President of Membership, Jorge Daher (j.daher@ieee.org). Jorge lives in Uruguay and is a representative for Siemens. Jorge has been instrumental in the success of our membership development efforts, serving as the I&M

Chapter Liaison for the past two years. I feel confident that the I&M Society's positive trends will continue under his capable leadership!
Warmly,
Ruth

Meet with Chapters or those interested in creating new Chapters
Members of the I&M Administrative Committee (AdCom) are available to meet with currently existing Chapters or with groups of members who are interested in creating new chapters. For instance, two AdCom members visited with members in Hyberadad, India during November to share information on starting a chapter, and funding opportunities for chapters. Please contact Jorge Daher, the Chapter Chair Liaison, to let him know of your interest in arranging for a visit by an AdCom member.

New I & M Senior Members:
September: Kyle Iverson, Kent Lundberg, Vikass Monebhurrun, Ralf Prien, Dan Rosenthal
October: Vibhav Pathak, Simona Salicone

I&M Distinguished Lecturers:
Abed (Abdulmotaleb) El Saddik
University of Ottawa, Ontario, Canada
abed@mcrlab.uottawa.ca
Area of expertise: Haptics Technologies: Theory and Applications

Kang Lee
National Institute of Standards and Technology, Gaithersburg, MD, USA
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Area of expertise: IEEE 1451: Empowering the Smart Sensor Revolution

Pawel Niewczas
University of Strathclyde, Glasgow, UK
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Area of expertise: Advanced Optical Sensors for Power and Energy Systems' Applications

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Srinivas, T.K.	tks@ieee.org	New Jersey Coast Section Joint Chapter

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Column Summaries

By the Numbers

Stephen A. Dyer and Justin S. Dyer

Numerical Integration *(Summary)*

Integration is a smoothing operation, and numerical integration is, in its essence, a stable operation. Many formulas (or rules) exist. The most basic of these is the so-called rectangular rule, which effectively amounts to a Riemann sum with finite n (or, equivalently, fixed T). Perusal of any elementary text on numerical analysis would uncover several other classical formulas, such as the trapezoidal rule and Simpson's rule. Some other rules include the midpoint rule, the corrected trapezoidal rule, Tick's rule, Simpson's three-eighths rule, and Bode's rule. And the list goes on.

While some would argue that basic rules such as these are generally of only historical interest, with the possible exception of extended (or composite) versions of the simpler formulas, comparing various of the rules can help develop intuition. And, besides, there indeed remain situations, especially in various instrument designs, that beg for the implementation of some of these basic integration rules.

This column will discuss: numerical integration as recursive digital filtering; difference equations for the various integration rules; find the transfer function, the impulse response, and the frequency response of the trapezoidal rule; compare the relative performance of a given numerical-integration rule with true integration and; which integrator to choose.

Instrumentation Notes *(Summary)*

Distributed Measurement Systems – a Web System Approach: Part 1

Andrzej Kalicki, Łukasz Makowski,
Andrzej Michalski, Zbigniew Staroszczyk

The February 2007 "Instrumentation Notes" column of *The I&M Magazine* described a wireless hydrocarbon pollution measuring and monitoring system [1]. That column focused on the hardware solution of the sensor side of the country-wide measuring system and introduced the software. The system was developed at the Warsaw University of Technology and gives Internet access to the network of sensors which monitor hydrocarbon pollution in sensitive areas of Poland.

The system has the ability to track 20 different regions (i.e. water reservoir of a city, petrochemical plant, oil ship at the port) that are monitored by up to 10 mobile observation points (MOPs). MOPs are the measurement devices. The MOPs communicate through the Global System for Mobile Communications/General Packet Radio Service (GSM/GPRS) links with the central server. The central server provides a database service for Supervisory Clients (SvClient) who have access by Internet browsers. It offers great flexibility of solutions.

This column presents two groups of software systems used in the monitoring system and their main advantages and disadvantages. The graphical user interface (GUI) is also discussed. The GUI allows the SvClient to access the system data and control. From the user's point of

view, the system is the Internet/Web application of the distributed measuring system [2]. The terminals are the autonomous MOPs [3]. The third software application in a server solution that is based on free and open source software will be described in the December 2008 issue of the I&M Magazine.

A Look Back and Now

Quality and Reliability Facilitator- FMEA *(Summary)*

Bernie Gollomp

Failure Modes and Effects Analysis (FMEA) includes stress, reliability, environment, quality and duty-cycle factors, regardless of the application goal. During design, the FMEA primary objectives are to identify failure modes and to mitigate those failures through changes in design, processes, and materials. The standards presented emphasize the broad commitment to the practice of FMEA from system design initiation to product end of life. FMEA proficiency, like other design tools, should be an organization goal.

Remember that realizing Six Sigma and other quality goals require rigorous FMEA practice. This column briefly explains the history and importance of FMEA and why entropy is the typical cause of failures during a product's lifetime.

New Products

Robert Goldberg

(Summary)

Miniature High-Temp Accelerometer, by Endevco Corporation
Model 67-100 - structural and component testing and monitoring in environments up to 175°C.
www.endevco.com.

Automated Optical Inspection (AOI) platform, by Agilent Technologies Inc
Agilent Medalist sj5000 AOI solution for post-reflow inspection
www.agilent.com/find/sj5000

Oxygen and Carbon Dioxide Analyzer, by iWorx
The GA-200 uses laser diode absorption technology and infrared detection
www.iworx.com.

4-Channel 50 MS/S 8-Bit Digitizer/Oscilloscope, by Strategic Test Corp
The UF2e-2020 and UF2e-2021 has simultaneous sampling in many modes
www.strategic-embedded.com

Accurate Temperature Measurement via the Internet, by Measurement Computing Corp.
The WEB-TEMP and WEB-TC- allow Web-enabled temperature input devices and users to take measurements and monitor them via the Internet.
www.mccdaq.com.
Chilled Mirror Hygrometer, by GE Sensing & Inspection Technologies
The OptiSonde™ humidity indicator, transmitter and data logger
www.gesensing.com

8 and 10kVA UPS for Sensitive Scientific and Lab. Instruments, by Falcon Electric, Inc
FN Series double-conversion online Uninterruptible Power Supplies (UPSs)
www.falconups.com.

Enhanced Moisture Measure, by Moisture Register Products, a div. of Aqua Measure Instr. Co.
BSP-901 near infrared (NIR) Continuous On-line Moisture measure and Control System
www.moistureregisterproducts.com.

Hand Crimp Tool to Attach Unisex Connector, by ETCO Inc.
A compact hand crimp tool to properly position the unisex connector's open barrel ear section
www.etco.com

Harmonic Phase Reference Generator, by NMDG
The 20 GHz, NM200 Enables Accurate Characterization of HF Components and Signals
www.nmdg.be

New Software for convenient EMI measurements
R&S ES-SCAN from Rohde & Schwarz is a cost-effective Windows software tool for EMI precompliance measurements
visit www.rohde-schwarz.com

G315 operator interface panel adds to Data Management Platform,by Red Lion Controls, Inc**.**
A 15" (38.1cm) XGA (1024 x 768) display touch screen panel
www.redlion.net

Omniview^{tm} Technology, from Cognex
For high-speed, non-stop inspection of randomly oriented cylindrical containers
www.cognex.com/omniview/

Next Generation of Tunable Diode Lasers, by TOPTICA Photonics

The DL pro 780 is an external cavity diode laser (ECDL)
www.toptica.com.

Article Summaries

Understanding IEEE 1451 – Networked Smart Transducer Interface Standard *(Summary)*

Eugene Y. Song, Kang Lee

"Sensors and actuators are ubiquitous. They are used in a variety of applications that touch people's lives every day, ranging from industrial automation to environmental condition monitoring and control; [from] intelligent transportation systems to homeland defense.

"In response to [the] industry's need for a set of standardized sensor interfaces, the Institute of Electrical and Electronic Engineers (IEEE)… has sponsored the development of a suite of smart transducer interface standards for sensors and actuators, known as the IEEE 1451." This article dives into the technology behind these sensors and what advancements they offer, as well as a breakdown of the entire IEEE 1451 Family of Standards.

These quotes are taken from the first and third paragraph in the article.

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Networked Sensor Monitoring using the Universal IEEE 1451 Standard *(Summary)*

Darold Wobschall

As the use of smart sensors climbs in all technological fields, it is becoming more apparent that a widely accepted standard is required to further communication between incompatible applications. This brings about the proposal of the IEEE 1451 Standard. The standard ensures that products manufactured by different companies will work together smoothly through self-configuration, as well as allows data transducers to communicate regardless of the sensor physical layer. Furthermore, compliance with the 1451 Standard would make any

registered and authorized sensor internet-accessible, and would create a nationwide sensor network. A standard for digital sensor protocol, particularly the 1451 Standard, has the potential to be a significant breakthrough in the world of technology.

This summary was written by Caitlin Woody

The Need for Smart Transducers, An Aerospace T&E Perspective *(Summary)*

Lee H. Eccles

Proving vehicle safety and performance is arguably the most complex task in airplane production. The amount of required materials is growing, therefore cost and labor is going up; internal systems are becoming more complex, and so become more easily disrupted; and the problem surrounding signals and time synchrony is never-ending. Although not without their cons, smart transducers offer solutions to these key problems.

Smart transducers can reduce the amount of materials needed, thereby reducing the intricate set-up and modification these materials require. Data collected by these sensors is made available for real-time evaluation and processing so the systems may run more smoothly and also is stored for post-test analysis. Finally, these transducers offer sensor synchronization, boasting uncertainties within 100 nanoseconds. The author compares standards proposed by IEEE 1452 working groups and the roles they would play in the Aerospace Test and Evaluation community.

This summary was written by Caitlin Woody

A Contribution for the IEEE STD. 1451.2 Revision with Time Synchronization *(Summary)*

Helena Geirinhas Ramos

"The IEEE 1451 standard focuses on simplifying transducer connectivity to existing control and transmission networks. During the past 20 years, a number of instrument buses, sensor control networks, sensor buses, and fieldbuses have been promoted and implemented worldwide.

"This article gives a background history for the 1451 standard and proposes enhancements for the IEEE 1451 set of standards for Smart Transducers. It describes implementation of the… Precision Time Protocol (PTP) in a distributed network to synchronize real time clocks included in the IEEE 1451 devices… that constitute the network."

These quotations were taken from the article as the summary.

Tutorial # 13
A Brief Tutorial on the IEEE 1451.1 Standard *(summary)*

Vitor Viegas, Miguel Pereira, Pedro Girão

The integration of microprocessors in the transducer body has opened the opportunity for adding intelligence to the transducer and for making it pluggable to digital communication networks. From the manufacturer's viewpoint, the work of adding intelligence to transducers is a good investment because it adds value to the device itself. On the other hand, interfacing transducers with the wide variety of fieldbuses currently available, each with its own protocol specifications, is a huge headache. For this reason, manufacturers tend to choose a particular fieldbus and work around it. Others decide to create a new, customized fieldbus for their products. This diversity of fieldbuses and network protocols leads a manufacturer to closed, less-flexible and generally more expensive solutions.

The 1451 family of standards tries to solve this problem by proposing a set of standardized hardware and software interfaces that act as "plugs" where heterogeneous components can be connected and work together. This article focus on the 1451.1 Std [1], which defines a software interface suitable to represent any networked smart transducer.

The quoted parts of this summary are from the first and third paragraphs of the article.