
# 2016 IEEE AWARDS

IEEE
Advancing Technology for Humanity

*Dear IEEE Members, Honorees, Colleagues, and Friends:*

*It is with great pleasure that we welcome you to the 2016 IEEE Honors Ceremony. This year's theme, "Igniting the Future," was inspired by all of our award recipients—the men and women who create, educate, and, yes, ignite further innovation… who stood on the shoulders of giants to accomplish the work they did and on whose shoulders other technology innovators will stand to drive their work further into the future.*

*The 1957 recipient of the Nobel Prize in Literature and French philosopher, Albert Camus, said "Real generosity towards the future lies in giving all to the present." This year's recipients have done just that, with extraordinary achievements and future-igniting contributions to the fields of broadband and wireless communications, information theory, automotive technology, medical diagnostic imaging, engineering education, artificial intelligence, semiconductors, signal processing, next-generation transistors, real-time systems, and much, much more.*

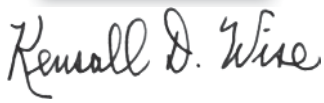
*IEEE and its members continue to propel the continuum of technological progress and the advancement of technology for humanity, but the future includes significant challenges. By many estimates there will be another 2–3 billion people on Earth by the middle of this century, and the nonrenewable resources we have relied upon for centuries are of finite supply.*

*In order to sustainably feed, power, transport, hydrate, and shelter a global community of 9–10 billion people, to safeguard their health, improve their quality of life, and facilitate their rapidly expanding communication requirements, groundbreaking technological advances will be required. As has been the case for more than 132 years, the expertise, determination, and ingenuity of IEEE members and their colleagues will drive these necessary advancements.*

*On behalf of IEEE's Board of Directors and some 420,000 members worldwide, we would like to extend sincere thanks to our generous awards sponsors and to all of the nominators, endorsers, volunteers, and staff who make our Awards Program possible.*

*As evidenced by the work and forward-looking vision of the award recipients we honor in New York this year, IEEE members continue to provide the technological spark to ignite a bright, prosperous future for coming generations of humankind.*

*Barry L. Shoop, Ph.D., P.E.*
*IEEE President and CEO*



*Kensall D. Wise*
*IEEE Awards Board Chair*

# PRESENTATION OF AWARDS AT IEEE HONORS CEREMONY

Saturday, 18 June 2016
Gotham Hall
New York, NY

*OPENING REMARKS—IEEE President and CEO Barry L. Shoop & IEEE President-Elect Karen Bartleson*

## CORPORATE RECOGNITIONS

IEEE Spectrum Technology in the Service of Society Award ..... NeuroPace, Inc.
IEEE Spectrum Emerging Technology Award ..... MC10, Inc.
IEEE Corporate Innovation Award ..... Intel Corporation
IEEE Ernst Weber Managerial Leadership Award ..... David Fairbank Welch

## SERVICE AWARDS

IEEE Richard M. Emberson Award ..... Stephen Weinstein
IEEE Haraden Pratt Award ..... Moshe Kam

## HONORARY MEMBERSHIP

IEEE Honorary Membership ..... Serge Haroche
IEEE Honorary Membership ..... Rodolfo Zich

## MEDALS

IEEE Alexander Graham Bell Medal ..... Roberto Padovani
IEEE Edison Medal ..... Robert Brodersen
IEEE Richard W. Hamming Medal ..... Abbas El Gamal
IEEE Medal for Innovations in Healthcare Technology ..... Charles A. Mistretta
IEEE Jack S. Kilby Signal Processing Medal ..... Louis Scharf
IEEE/RSE James Clerk Maxwell Medal ..... Geoffrey Hinton
IEEE James H. Mulligan, Jr. Education Medal ..... Simon Haykin
IEEE Jun-ichi Nishizawa Medal ..... Masayoshi Esashi
IEEE Robert N. Noyce Medal ..... Takuo Sugano
IEEE Dennis J. Picard Medal for Radar Technologies and Applications ..... Nadav Levanon
IEEE Medal in Power Engineering ..... Arun G. Phadke
IEEE John von Neumann Medal ..... Christos H. Papadimitriou
IEEE Medal for Environmental and Safety Technologies ..... Masahiko Miyaki, Yukihiro Shinohara, Katsuhiko Takeuchi
IEEE Simon Ramo Medal ..... John P. Lehoczky, Ragunathan Rajkumar, Lui Sha
IEEE Medal of Honor ..... G. David Forney, Jr.

IEEE Awards proudly acknowledges its 2016 Technical Field Award sponsors. These are some of the world's leading organizations, societies, and individuals whose generous support helps to recognize and promote technological advances for the benefit of humanity. Our partners include:

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**Dr. Kiyo Tomiyasu**
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**IEEE Circuits and Systems Society**
**IEEE Computational Intelligence Society**
**IEEE Computer Society**
**IEEE Control Systems Society**
**IEEE Education Society**
**IEEE Electromagnetic Compatibility Society**
**IEEE Electron Devices Society**
**IEEE Engineering in Medicine and Biology Society**
**IEEE Geoscience and Remote Sensing Society**
**IEEE Industry Applications Society**
**IEEE Industrial Electronics Society**
**IEEE Instrumentation and Measurement Society**
**IEEE Intelligent Transportation Systems Society**
**IEEE Life Members Fund**
**IEEE Microwave Theory and Techniques Society**
**IEEE Nuclear and Plasma Sciences Society**
**IEEE Photonics Society**
**IEEE Power & Energy Society**
**IEEE Power Electronics Society**
**IEEE Robotics and Automation Society**
**IEEE Signal Processing Society**
**IEEE Solid-State Circuits Society**
**IEEE Standards Association**
**IEEE Vehicular Technology Society**

The awards presented at the 2016 IEEE Honors Ceremony Gala are supported by the generosity of the following organizations and societies.

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## IEEE MEDALS, AWARDS & RECOGNITIONS

*The following awards are presented at the annual IEEE Honors Ceremony Gala*



## IEEE TECHNICAL FIELD AWARDS & PRIZE PAPERS

*The following awards are presented at 2016 IEEE technical conferences*

## IEEE Spectrum Technology in the Service of Society Award

*Sponsored by IEEE Spectrum*

NEUROPACE

The RNS® System is an award-winning technology developed and manufactured in Silicon Valley that has been recognized for its innovation. Similar to a pacemaker that monitors and responds to heart rhythms, the RNS System is the first and only medical device that can monitor and respond to brain activity. It constantly monitors brainwaves—including during sleep—looking for unusual activity that may lead to a seizure.

The device is personalized to recognize the electrical patterns specific to a recipient's brain, rapidly identifying unusual activity that can lead to a seizure. Within milliseconds of detecting unusual activity, the device sends brief pulses to instantly disrupt this activity and normalize brainwaves, often before seizure symptoms are felt.

The RNS® System consists of a small, implantable neurostimulator connected to leads (tiny wires) that are placed in up to two seizure onset areas. It comes with a simple remote monitor that recipients use at home to wirelessly collect information from the neurostimulator and then transfer it to the Patient Data Management System (PDMS). The doctor can log into the PDMS at any time to review accurate, ongoing information about seizure activity and treatment progress. This helps the doctor learn more about the recipient's seizures and improve care. Find out more about Neuropace online at www.neuropace.com.

## IEEE Spectrum Emerging Technology Award

*Sponsored by IEEE Spectrum*

mc10®

MC10 uses cutting-edge technology to create the most intelligent, flexible platform for biometric healthcare analytics. Our hardware and software systems are uniquely designed to minimize burden and maximize health insights.

Traditional electronic devices are rigid, bulky, and fundamentally mismatched to the properties of the human body. MC10 products are thin and flexible, and built to stretch, bend, and twist seamlessly with our bodies and the world around us.

MC10's software platform consists of a complete end-to-end system with mobile interfaces, cloud storage, and analytical tools. Lean, agile software development allows us to create robust systems to support the high volume of data gathered by the BioStamp® and WiSP™ platforms. Using the most powerful tools in big data analytics and machine learning, MC10's software translates the body's data into a language understandable to humans.

MC10's technology empowers all of us to better understand our bodies and work towards improving human health.

MC10 is a private company backed by a strong syndicate of financial and strategic investors that is improving human health through digital healthcare solutions. The company combines its proprietary ultra-thin, flexible body-worn sensors with advanced analytics to unlock health insights from physiological data.

MC10 has received widespread recognition for its revolutionary technology and was recently named in Fast Company's Most Innovative Companies in 2016 as a leader in healthcare. MC10 is headquartered in Lexington, MA, USA. Visit MC10 online at www.mc10inc.com.

## IEEE Corporate Innovation Award

*Sponsored by IEEE*

## Intel Corporation

**For pioneering the use of high-k metal gate and tri-gate transistor technologies in high-volume manufacturing**

Leading the semiconductor industry in developing revolutionary transistor technologies and achieving early high-volume manufacturing of microprocessor products, Intel's high-k metal gate and tri-gate transistor innovations have allowed the continuation of Moore's Law and enabled products with improved performance and lower power consumption. The semiconductor industry had been scaling metal-oxide-semiconductor field-effect-transistors (MOSFETs) for more than four decades until the early 2000s, when further scaling of traditional silicon dioxide/polysilicon materials presented leakage problems. New materials and structures would be needed for continued progress, and Intel's Technology and Manufacturing Group was first to meet the challenge with its introduction of high-k metal gate transistors and then with its tri-gate (FinFET) technology. Intel replaced most of the traditional dielectric MOSFET materials with a high-k hafnium-based dielectric to reduce leakage power, and metal gate electrode materials replaced doped polysilicon to provide improved transistor performance. Intel was the first to manufacture and ship these high-k metal gate transistors, beginning with its 45 nm technology in 2007. Intel then overcame the manufacturing challenges of using tri-gate transistors to surpass the limitations of planar MOSFETs. Tri-gate transistors feature channels on tall and narrow silicon fins instead of a planar surface. With a steeper subthreshold slope, tri-gate transistors result in lower power leakage and can operate at lower voltage for lower active power consumption. Intel was the first to ship microprocessors using tri-gate transistors in 2011 with its 22-nm technology. Intel's manufacturing success with these transistor technologies fundamentally changed the direction of the semiconductor industry. Other semiconductor companies have followed Intel's footsteps in developing high-k and tri-gate products, and foundry companies have accelerated efforts to meet the fabrications needs of their customers.

Headquartered in Santa Clara, CA, USA, Intel's Technology and Manufacturing Group is led by Sohail U. Ahmed, senior vice president and general manager, and Ann B. Kelleher, corporate vice president and general manager.

*Scope:* For an outstanding and exemplary innovation by an industrial entity, governmental or academic organization, or other corporate body, within the fields of interest to the IEEE.

## IEEE Ernst Weber Managerial Leadership Award

*Sponsored by IEEE*

## David Fairbank Welch

**For leadership in enabling the growth of cloud-based services and the Internet in optical transport networks**

A leader in driving technology innovations from concept to commercial success, David Fairbank Welch's contributions to optical devices for telecommunications networks have enabled the growth of the Internet and cloud-based services, providing faster communications for service providers, businesses, and consumers around the world. As chief technology officer and vice president of corporate development for Spectra Diode Labs, Welch played a critical role in launching the first commercially available 980-nm semiconductor pump laser for optical amplifiers. His design became the standard for pump lasers and enabled the proliferation of dense-wave-division-multiplexed systems for long-haul communications networks that allowed service providers to increase network capacity to meet the demanding bandwidth requirements of emerging Internet applications. In addition, Welch led the design, development, and commercialization of high-power semiconductor lasers and solid-state lasers for a diversity of materials processing applications. Welch has proven that his vision of photonic integration improves performance and reliability while reducing cost in telecommunication systems. He cofounded Infinera in 2001 and led the company in the architecture and development of the most widely deployed photonic integrated circuit (PIC) in industry. PICs are highly functional optical subsystems on a chip that overcome the data communications bottleneck between users and servers in the cloud. Welch then led Infinera's next-generation technology, which now serves as the foundation for the DTN-X optical transport networking platform. Where the entire transmission capacity of the Internet in 2005 was less than 9 terabits (Tb), DTN-X allows 9 Tb per second of long-haul capacity on a single optical fiber. As president of Infinera, since 2013 Welch introduced several new systems that make it easier for network operators to automate the digital switching and optical transport layers of the multi-Tb transport systems, including the industry's first super-channel reconfigurable optical add drop multiplexer and the first 500G flexible-grid super-channels.

An IEEE Fellow and recipient of the Institution of Engineering and Technology's J.J. Thomson Medal for Electronics (2013), the Optical Society's John Tyndall Award (2011), and elected to the U.S. National Academy of Engineering (2016), Welch is president of Infinera Corporation, Sunnyvale, CA, USA.

*Scope:* For exceptional managerial leadership in the fields of interest of the IEEE.

## IEEE Richard M. Emberson Award

*Sponsored by the IEEE Technical Activities Board*


### Stephen Weinstein

**For contributions to IEEE publications, awards, and globalization**

Known for inspiring others to always give their best in each of their IEEE volunteer activities and to pursue increasing involvement, Stephen Weinstein's contributions to IEEE have strengthened the Institute's global reach, its publications, and its awards program. A communications engineer with over 45 years of experience, Weinstein served as president of the IEEE Communications Society (ComSoc) in 1996-97, was a member of the IEEE Board of Directors in 2002-03, and was Vice Chair of the IEEE Awards Board in 2010-12. To encourage globalization of IEEE and extend the reach of ComSoc, while ComSoc president Weinstein initiated "sister society" agreements with the Korean Institute of Communications Society (KICS) and the Russian A.S. Popov Society and traveled to Vietnam and Germany to initiate sister society negotiations. He also was dedicated to developing numerous joint international technical initiatives and conference events. His efforts resulted in ComSoc becoming the first IEEE Society to have non-U.S. membership exceed U.S. members. Weinstein's contributions to publications include cofounding *IEEE Communications Magazine* and the *IEEE/ACM Transactions on Networking.* He also helped establish the *Journal of Communications Networks* as an English-language journal of the KICS technically cosponsored by ComSoc, served as its first editor-in-chief, and established a prestigious editorial board with global representation. His contributions as member and Vice Chair of the IEEE Awards Board included redefining corporate recognitions as major IEEE awards, which was critical to enhancing the importance of IEEE's awards to industry. As chair of the Awards Policies and Procedures Board, he significantly improved the clarity and value of the guidelines for finding and rewarding excellent award candidates.

An IEEE Life Fellow and recipient of the IEEE Communications Society Exemplary Global Service Award (2007), Weinstein is president of Communication Theory and Technology Consulting, New York, NY, USA.

*Scope:* For distinguished service to the development, viability, advancement, and pursuit of the technical objectives of IEEE.

## IEEE Haraden Pratt Award

*Sponsored by the IEEE Foundation*


### Moshe Kam

**For original and high-impact contributions to IEEE's Educational Activities, expanding IEEE's global reach and effectiveness**

Moshe Kam has dedicated his career to breaking down the barriers that limit access to the engineering profession, and to helping people from all backgrounds understand what engineers do. As an IEEE volunteer he has transformed IEEE's educational activities to spur interest in engineering by new audiences and facilitate the pursuit of engineering as a career path by young students worldwide. In 2005 Kam spearheaded TryEngineering.org, IEEE's most popular and successful online education program. This portal serves as the predominant source of pre-university engineering education for students, parents, and school counselors. The success of TryEngineering.org led to the development of the IEEE's TryNano.org and TryComputing.org portals. Kam also championed the development of IEEE's version of the Engineering Projects in Community Service (EPICS) project. Developed by Purdue University but originally implemented mostly in the United States, EPICS provides students with the opportunity to create technological solutions for their communities in cooperation with nongovernmental organizations and humanitarian groups. Using IEEE's resources and working with fellow volunteers, Kam expanded EPICS' reach around the world with over 40 projects, including a project that supplied reliable electricity to rural schools in Uruguay and a joint industry–IEEE venture to provide solar-energy-heated water for an orphanage in South Africa. Kam has also expanded the IEEE Teacher-in-Service Program, which trains IEEE volunteers to work with pre-university teachers on lesson plans in engineering and engineering design, thereby bringing hands-on engineering activities into the classroom. Another area where Kam induced change was IEEE's participation in accreditation of engineering programs outside the United States. Going beyond the traditional IEEE educational workshops on accreditation, he played a pivotal role in developing training programs for program evaluators in Peru, assisting accreditation programs in China, and creating a new accreditation body for Caribbean nations.

An IEEE Past President, IEEE Fellow, and recipient of the IEEE Third Millennium Medal (2000), Kam is dean of the Newark College of Engineering at the New Jersey Institute of Technology, Newark, NJ, USA.

*Scope:* For outstanding service to IEEE.

## IEEE Honorary Membership

*Sponsored by IEEE*

### Serge Haroche

**For the development of cavity quantum electrodynamics, leading to fundamental quantum physics studies and to a wide range of applications**

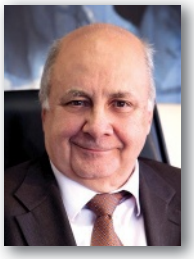
A Nobel-Prize-winning physicist who pioneered the discipline of cavity quantum electrodynamics (CQED), Serge Haroche has pushed the frontiers of CQED toward new achievements leading to practical applications in quantum optics and laser physics. With CQED, which involves studying the interaction of atoms with the quantum radiation field confined in highly reflective cavities, Haroche led a revolution in quantum electronics that brought quantum engineering into reality and has given substance to quantum thinking beyond what had been possible before. Building on Purcell's proposal from the 1940s that the atomic spontaneous emission rate could be enhanced at will by a resonant cavity, Haroche opened the modern era of experimental CQED during the 1980s. He explored the strong coupling regime in which the atom field interaction overwhelms the dissipative process. He demonstrated spectacular effects of quantum mechanics, such as the modification of atomic spontaneous emission by properly engineering the vacuum field boundary conditions and the observation of atomic superradiance in a cavity. Haroche made photon-by-photon observations possible, giving scientists the ability to watch a quantum measurement unfold in real time. During the 1990s, Haroche was the first to investigate the decoherence of a mesoscopic quantum superposition, which is essential in the quantum measurement process and also provides an explanation of the lack of quantum superposition at the macroscopic scale. Haroche's most recent work has focused on improving the quality of superconducting microwave cavities to enable real-time observation of quantum jumps of light through a quantum nondemolition photon counting process, which has opened new lines of research and helped realize quantum feedback loops.

A recipient of the 2012 Nobel Prize in Physics and member of the European Physical Society, Haroche is a professor and chair of quantum physics with the Collège de France, Paris, France.

*Scope:* For those who have rendered meritorious service to humanity in IEEE's designated fields of interest and who are not members of IEEE.

## IEEE Honorary Membership

*Sponsored by IEEE*



### Rodolfo Zich

**For leadership in the global integration of electrical and electronics engineering education and research**

A leading scientist in the area of electromagnetic wave scattering and antennas, Rodolfo Zich has continuously worked to expand international collaborations in electronics and telecommunications by establishing university exchange programs and international conferences that have promoted research and higher education in information and communications technology engineering around the world. While president of the Politecnico di Torino, the leading technical university of Italy, he worked tirelessly to greatly strengthen the cooperation with industry, increase the competition in European research space, develop joint teaching and research programs with several European institutions, and to create a worldwide network of cooperative efforts with over 50 universities from all continents. Zich was instrumental in transforming the Politecnico into an international venue of excellence for engineering research and education, increasing the foreign student population to 20% and attracting some of the best electronics researchers in the world. He developed graduate-level student-exchange programs with several European and U.S. universities that have been in effect for over 20 years. In 1992 he created and directed a network to provide remote education at the master's level, the first in Italy and one of the most advanced in Europe. To further promote international collaborations in diverse areas of electronics and communications, Zich established (in 1989) and has expanded the International Conference on Electromagnetics in Advanced Applications (ICEAA). The ICEAA has become a prestigious venue for international scientists and engineers held each year in different locations around the world. Zich also founded and has been chairing both the Istituto Superiore Mario Boella in Torino and the Torino Wireless Foundation, which are devoted to research and dissemination of advanced wireless technologies.

Zich is president of the Torino Wireless Foundation and president of the Istituto Superiore Mario Boella, Torino, Italy.

*Scope:* For those who have rendered meritorious service to humanity in IEEE's designated fields of interest and who are not members of IEEE.

## IEEE Alexander Graham Bell Medal

*Sponsored by Nokia Bell Labs*


### Roberto Padovani

**For innovations enabling efficient, wideband, wireless access to the Internet, that is central to all third-generation cellular networks**

The third-generation (3G) cellular technology enabled by the vision and leadership of Roberto Padovani is transforming lives around the word by supporting voice and wireless Internet access via mobile devices to over 3 billion people. Padovani provided key leadership in developing and commercializing code-division-multiple-access (CDMA) technology during the 1980s and 1990s to substantially increase circuit-switched voice capacity and enable efficient high-data-rate (HDR) packet-switched communications. His work has formed the basis for all 3G cellular systems and has also influenced fourth-generation long-term evolution (LTE) systems. Padovani later adapted CDMA technology, which was originally heavily tuned for voice services, to support data services. To overcome the challenges of asymmetry in data traffic in the up- and downlinks and the bursty nature of data, Padovani developed innovations including the scheduling of high and low rate users, variable modulation and code rate, and power control strategies for more efficient Internet data transfer, resulting in the HDR technology. He realized early on that, for packet data, symmetric performance across uplink and downlink and equal grade of service across users could be relaxed to improve total system throughput, in contrast to voice designs that focused on giving all users equal service in all conditions. Slow to be accepted by operators who were primarily concerned only with voice capacity, the demand for HDR communications grew as mobile phones began to support e-mail and Internet services. HDR evolved into the 1X EVDO system, which paved the way for high-speed data services on 3G systems. The availability of packet-switched Internet access made possible by Padovani's innovations has impacted business, safety, entertainment, navigation, social networking, education, and health in developed and especially developing countries around the world.

An IEEE Fellow and member of the U.S. National Academy of Engineering, Padovani is executive vice president and fellow with Qualcomm Technologies, San Diego, CA, USA.

*Scope:* For exceptional contributions to the advancement of communications sciences and engineering.

## IEEE Edison Medal

*Sponsored by Samsung Electronics Co., Ltd.*

### Robert Brodersen

**For contributions to integrated systems for wired and wireless communications, including wireless connectivity of personal devices**

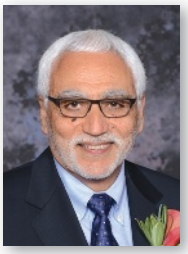
With the vision that wireless technology would fundamentally change the way we interact with information, Robert Brodersen has been at the forefront of introducing innovative technologies that are changing the wireless landscape even today. Focusing on using standard low-cost complimentary metal-oxide semiconductor (CMOS) technologies for integrated systems, Brodersen's work has enabled higher data rates, better energy efficiency, and better spectrum utilization critical to wireless devices. A testament to Brodersen's vision was the development of the Infopad as the first wireless tablet during the early 1990s. A complete integrated system, the project demonstrated the potential of cloud computing, broadband wireless connectivity, and low-power mobile computing well before the true emergence of the Internet and wireless networks. It took technology 15 years to catch up to his concept with the emergence of devices like the iPad, but the proliferation of personal devices we now take for granted shows that Brodersen's vision was spot on. Before energy efficiency of devices was an issue, Brodersen was one of the first to demonstrate that improving energy efficiency was critical to the continued scaling of digital circuitry. His combination of concurrency with voltage scaling in 1992 radically changed the way we build computer systems, making possible the multicore paradigms that fuel today's high-performance and mobile computing systems. He later extended this concept to include dynamic voltage scaling, which allows processors to scale energy efficiency proportional to the requested performance. In the late 1970s Brodersen also pioneered the idea of using switched capacitors for monolithic integrated filters. Originally used for single-chip realizations of pulse code modulation interfaces for wired telephony, switched-capacitor circuits have been the preferred choice for the efficient implementation of on-chip filters for the past four decades.

An IEEE Fellow and member of the U.S. National Academy of Engineering, Brodersen is a Professor Emeritus with the University of California, Berkeley, CA, USA.

*Scope:* For a career of meritorious achievement in electrical science, electrical engineering or the electrical arts.

## IEEE Richard W. Hamming Medal

*Sponsored by Qualcomm, Inc.*

### Abbas El Gamal

**For contributions to network multi-user information theory and for wide-ranging impact on programmable circuit architectures**

Abbas El Gamal's lasting contributions to information theory, wireless networks, field programmable gate arrays (FPGAs), and digital imaging have immensely impacted a wide variety of information technology applications critical in today's society. His early work formed the basis for several new areas in multi-user information theory, paving the way to capacity results integral to today's communications networks. He determined the capacity of the product of Gaussian broadcast channels and of deterministic interference channels leading to recent advances in multi-antenna and interference-limited wireless networks. Together with Thomas Cover, he established the first upper and lower bounds on the capacity of the three-node relay network. This work introduced the cut-set upper bound for networks, which is widely used in information theory today, as well as the compress-forward and decode-forward schemes, which continue to be the dominant relaying techniques. His recent work has involved the creation of coding schemes for sending multiple sources over noisy networks, and significant contributions to wireless networks through characterizing their optimal delay-throughput tradeoff and devising schemes for energy-efficient packet transmission scheduling. His book *Network Information Theory* (Cambridge Press, 2011) with Young-Han Kim provides the first unified and comprehensive coverage of the field. El Gamal's contributions to hardware design include the development of integrated circuit fabrics and tools that significantly reduce design time and cost of systems used in computing, communication, and signal-processing applications. In 1986, he cofounded Actel, where he coinvented the routing architecture used in all commercial FPGAs today. He subsequently pioneered the use of FPGAs in teaching digital system design, which has become standard in all electrical engineering programs.

An IEEE Fellow and member of the U.S. National Academy of Engineering, El Gamal is a professor and chair in the Department of Electrical Engineering at Stanford University, Stanford, CA, USA.

*Scope:* For exceptional contributions to information sciences, systems, and technology.

## IEEE Medal for Innovations in Healthcare Technology

*Sponsored by the IEEE Engineering in Medicine and Biology Society*


### Charles A. Mistretta

**For the development of imaging instrumentation and techniques that have transformed the diagnosis and treatment of vascular disease**

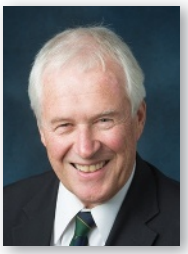
The pioneering accomplishments and vision of Charles A. Mistretta in developing digital subtraction angiography (DSA), time-resolved magnet resonance angiography (MRA), and accelerated imaging algorithms have transformed diagnostic radiology. During the 1970s, screen film X-rays were the standard for radiography and angiography. However, film angiograms were limited due to interference from overlying anatomy. Mistretta recognized the importance that electronic subtraction in imaging could play in providing vascular images that were free of obscuring anatomy. Incorporating a hand-made, custom-designed digital image processor, Mistretta introduced his DSA technique. He went on to refine and optimize DSA to provide virtually real-time visualization of vascular structures without obstructions, revolutionizing angiography with a safer and more effective technology that is now found in practically every medical center. DSA is also considered an enabling technology that made minimally invasive vascular therapeutic procedures such as angioplasty and stenting possible. During the 1990s, Mistretta applied DSA technology to overcome the limitations of slow magnetic resonance data acquisition in contrast-enhanced MRA techniques. He developed the time-resolved imaging of contrast kinetics (TRICKS) method for three-dimensional visualization of previously difficult-to-image vascular beds. TRICKS provides clinicians with dynamic vascular information and eliminates the timing uncertainty associated with single-image contrast-enhanced MRA. This radiation-free MRA method uses less toxic contrast material and is performed intravenously rather than intra-arterially for enhanced safety and effectiveness. Mistretta's recent efforts include work on image acceleration. His highly constrained reconstructions from projections (HYPR) method provides rapid accelerations of dynamic or parametric imaging by using imaging data acquired over a short time interval to weight an image acquired over a much longer time interval.

A member of the U.S. National Academy of Engineering, Mistretta is a professor with the Department of Medical Physics, Radiology, and Biomedical Engineering at the University of Wisconsin-Madison, Madison, WI, USA.

*Scope:* For outstanding contributions and/or innovations in engineering within the fields of medicine, biology, and healthcare technology.

## IEEE Jack S. Kilby Signal Processing Medal

*Sponsored by Texas Instruments, Inc.*

### Louis Scharf

**For pioneering and sustained contributions to statistical signal processing and its practice.**

Pioneering and introducing the use of statistical invariance for the design of detectors and estimators, Louis Scharf has profoundly impacted the way statistics are used in modern signal processing to provide solutions for a wide range of engineering problems. Scharf is most known for his work on modal analysis, invariance theories for subspace signal processing, dimension reduction in subspaces for managing performance metrics, and for his recent work on coherence statistics for space-time signal processing. His work on modal analysis is being applied to mode tracking in power systems to identify and track low-frequency modes of oscillation that reveal vulnerabilities to system instabilities. He introduced invariance as an important principle for designing optimal detectors, which has resulted in matched and adaptive subspace detectors for radar, sonar, and hyper-spectral imaging. These detectors adaptively find tell-tale signatures in broadband multisensor time series while maintaining invariance to unknown channel variations that cannot be modeled or estimated. Scharf's work on coherence is bringing attention to the commonality of a variety of seemingly disparate problems in detection and estimation theory. He also pioneered the geometric approach to interpreting signal processing problems and their solutions, leading to the application of problem-solving tools such as subspace projections (orthogonal and oblique), canonical coordinates, and principal angles between subspaces. His early work on the geometrical point of view provided a pathway for future researchers resulting in new insights and useful ways of approaching and solving problems. Scharf's *Statistical Signal Processing: Detection, Estimation, and Time Series Analysis* (Addison Wesley, 1991) is considered a definitive text on the subject.

An IEEE Life Fellow and recipient of an IEEE Third Millennium Medal (2000) as well as a Technical Achievement Award (1995) and Society Award (2004) from the IEEE Signal Processing Society, Scharf is Research Professor of Mathematics and Emeritus Professor of Electrical and Computer Engineering, Colorado State University, Fort Collins, CO, USA.

*Scope:* For outstanding achievements in signal processing.

## IEEE/RSE James Clerk Maxwell Medal

*Sponsored by IEEE*

### Geoffrey Hinton

**For pioneering and sustained contributions to machine learning, including developments in deep neural networks**

Driven by the desire to understand the mechanisms of cognition in the human brain and how to apply them to machines that learn, Geoffrey Hinton is considered the leading authority on machine learning. Hinton's development of the backpropagation algorithm was key to the resurgence of the machine learning field during the 1980s. He realized and demonstrated that, in addition to performing nonlinear regression and classification, backpropagation allowed neural networks to develop their own internal representations. The backpropagation algorithm has been used successfully in applications including speech and visual object recognition, fraud detection, plant monitoring, and automated check verification. His early work on the Boltzmann machine during the 1980s introduced many of the concepts that have remained at the forefront of neural network learning. Boltzmann machines were initially considered too slow for widespread application. However, as computing power improved, Hinton was able to develop a specific Boltzmann machine that provides much faster training properties than the earlier general machines. The ability to pre-train each of the layers of neural networks having up to 20 layers of parameters ushered in the era of deep-learning neural networks. Hinton demonstrated that deep networks, which partition the neural network into many layers, can be trained using mostly unsupervised learning, level by level, with each level learning to represent slightly more abstract concepts than the previous level, by composing those concepts represented by the previous levels. Hinton's work on deep learning has completely revolutionized the field of machine learning, especially impacting machine vision applications including image classification, medical diagnostics, law enforcement, computer gaming, and enhanced vehicle safety.

A Fellow of the Royal Society (U.K.) and recipient of the IEEE Neural Network Pioneer Award (1998), Hinton is a Distinguished Emeritus Professor with the Department of Computer Science at the University of Toronto, Toronto, Ontario, Canada, and a Distinguished Researcher at Google Inc., Mountain View, CA, USA.

*Scope:* For groundbreaking contributions that have had an exceptional impact on the development of electronics and electrical engineering or related fields.

## IEEE James H. Mulligan, Jr. Education Medal

*Sponsored by MathWorks, Pearson, and the IEEE Life Members Fund*

### Simon Haykin

**For contributions to engineering education in adaptive signal processing and communication**

With a passion for ensuring that education and research regularly reinforce each other, Simon Haykin is among the most influential electrical engineering educators of our generation. A prolific writer of textbooks, Haykin believes that, whenever possible, an author should make sure that the teacher adopting the textbook and the student studying from the book both feel comfortable in reading the textbook. This belief has been key to the success of his many landmark books on signal processing, adaptive filtering, communications (both analog and digital), neural networks, and learning machines that have made him well known throughout the world. The use of his textbooks is so widespread that many if not most of today's practicing engineers learned their fundamentals in communications, radio, and radar from Haykin. In 2015, it was estimated that over 14,000 students at over 120 universities in the United States and Canada alone were using one of Haykin's textbooks. He continues to define new topics that bring together signal processing, communications, controls, machine learning, and cognitive science. Haykin's current focus is devoted to a new way of thinking about human cognition from an engineering perspective. He has written books on cognitive networks and the fundamentals of cognitive radio and is currently working on what he considers his most important text, *Cognitive Dynamic System Theory*. This book builds on the teaching of cognitive dynamic systems at the graduate level and beyond by mimicking the brain and complementing it with engineering fundamentals. Haykin was the founding director of McMaster University's Communications Research Laboratory, which has distinguished itself for contributions to signal processing, adaptive filtering, radar, and communications.

An IEEE Life Fellow, Fellow of the Royal Society of Canada, and recipient of many international awards, Haykin is a Distinguished University Professor with the Electrical and Computer Engineering Department at McMaster University, Hamilton, Ontario, Canada.

*Scope:* For a career of outstanding contributions to education in the fields of interest of IEEE.

## IEEE Jun-ichi Nishizawa Medal

*Sponsored by the Federation of Electric Power Companies, Japan*


### Masayoshi Esashi

**For pioneering contributions to micro-electro-mechanical systems (MEMS), and their uses in automobiles, cellular phones, industrial equipment, and medical devices**

Masayoshi Esashi has been a pioneering force of micro-electro-mechanical systems (MEMS) technology for over 40 years, developing and bringing to market the tiny sensors and actuators that provide advanced functionalities in today's automobiles, cellular phones, industrial equipment, and medical devices. Esashi's key contributions to biomedical microsensors began in the 1970s, where his work on an ion-sensitive field-effect transistor (ISFET) led to the development of medical catheters for in-vivo pH and $PCO_2$ monitoring. During the 1980s, Esashi developed many MEMS and integrated circuit (IC) devices including a servo-type accelerometer, networked tactile sensor, multifreedom active catheter, and a monolithically integrated capacitive pressure sensor that was commercialized by Toyoda Machine Works. The microfluidic system developed by Esashi during the 1990s, which featured microchannels, flow sensors, valves, and pumps on a silicon wafer, provided the foundation for the micro total analysis system/lab-on-a-chip technologies of today. To provide the often-lacking tools needed for continued innovation of MEMS-based devices, Esashi used his IC research and development experience to help develop etchers, deposition machines, and special lithography and evaluation tools. His development of an ion-reactive etcher enabled the fabrication of deep trenches in silicon, which was critical to the commercialization of inertial sensors now used in over 1 million automobiles for active safety control. Another hallmark of Esashi's career has been his belief in "open innovation" collaboration. He established the Micro System Integration Center where companies can work together to advance MEMS technologies. This has resulted in wafer-level-based hetero-integrated devices such as piezoelectric MEMS switches for mobile phones, monolithic tunable filters for cognitive radios, MEMS-on-IC networked tactile sensors for human-friendly robots, and massively arrayed electron beam emitters for maskless high-speed nanolithography.

An IEEE Member and recipient of the Medal with Purple Ribbon from the government of Japan, Esashi is a professor with Tohoku University, Sendai, Miyagi, Japan.

*Scope:* For outstanding contributions to material and device science and technology, including practical application.

## IEEE Robert N. Noyce Medal

*Sponsored by the Intel Foundation*


### Takuo Sugano

**For contributions to and leadership in the research and development of the science and technology of semiconductor devices**

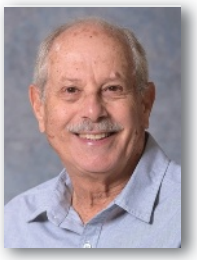
Takuo Sugano has dedicated his career to strengthening the understanding of semiconductor materials to enable progress in developing advanced silicon-based electronic devices and the continued growth of the industry. During the 1960s, he tackled instability issues in silicon metal-oxide-semiconductor field-effect transistors (MOSFETs) caused by sodium contamination. Using radio-activation analysis, Sugano demonstrated the physical mechanism of prevention of sodium ions from moving in the dielectric, leading to more stability and enabling more reliable and high-performance MOSFETs. Assuming that chemical bonds between silicon and oxygen or silicon at silicon dioxide-silicon interfaces are stretched, he also proposed a novel model on the origin of the U-shaped energy distribution of density of trap state at silicon dioxide-silicon interfaces. His work on electron transport in the silicon inversion layer highlighted the effect of surface quantization of carriers in MOSFET channels at room temperature to improve the dynamic characteristics of silicon MOSFETs. The resulting improvement in performance helped move the commercial application of silicon MOSFETs beyond personal calculators. To further improve MOSFET reliability, Sugano then focused his efforts on electron and hole trapping in silicon dioxide films that were thermally grown in an ultra-dry or conventional oxidizing atmosphere on the surface of silicon substrates and the generation of interface trap states by electron or hole injection. Also important to increasing the understanding of semiconductor materials was Sugano's role in establishment of a class-100 clean room in 1975 at the University of Tokyo at a time when clean rooms were not popular at universities. Sugano has also made pioneering contributions to III–V semiconductors, superconducting (Josephson junction) devices, and single-electron transistors. He developed an anodic oxidation process for III/V compound semiconductors in inductively coupled plasma and demonstrated its usefulness for fabricating gallium arsenide insulated-gate FETs. He also has made important contributions to plasma processes for fabrication of silicon large-scale integrated circuits, including plasma etching, plasma cleaning, and plasma oxidation.

An IEEE Life Fellow and recipient of the Person of Cultural Merit award (2006) from the government of Japan, Sugano is a Professor Emeritus with the University of Tokyo, Tokyo, Japan.

*Scope:* For exceptional contributions to the microelectronics industry.

## IEEE Dennis J. Picard Medal for Radar Technologies and Applications

*Sponsored by the Raytheon Company*



### Nadav Levanon

**For contributions to radar signal design and analysis, pulse compression, and signal processing**

With a central research theme of waveform design and analysis, Nadav Levanon is considered one of the world's foremost experts on radar theory and practice with many contributions to techniques that have become fundamental practices in radar signal processing. Levanon is most known for his development of the periodic ambiguity function (PAF), which is an important extension of Woodward's ambiguity function. PAF is the main tool for analyzing and designing continuous-wave radar waveforms and periodic pulsed waveforms. Levanon's early work on multicarrier waveforms for radar provides waveform variability and separability, which are of concern to advanced multiple-input, multiple output (MIMO) coding and are explored by the radar community. His recent work on noncoherent pulse compression has enabled coding concepts normally used in coherent radar to be applied to noncoherent radar such as laser radar. Making use of the laser's natural on-off keying technique, these radars can operate using extremely low-peak optical power, which is important for low-cost operation and stealth applications. Levanon designed and built his first radar during 1968-69 as part of his Ph.D thesis. Hundreds of these balloon-borne radar altimeters flew for months on meteorological balloons that provided data used to enhance the early Antarctic ice elevation maps. His radar was later adapted for aircrafts as the Sperry AA100 Radar Altimeter. He also headed a team that developed the first bird-borne beacon for the ARGOS satellite tracking system that was used to locate and gather information on migrating birds. Levanon also developed the user location concept of Qualcomm's GLOBALSTAR satellite communication system. Levanon's *Radar Principles* (Wiley, 1988) and *Radar Signals* (Wiley, 2004) are important books in the field that have educated two generations of radar students and experts.

An IEEE Life Fellow and Fellow of the Institution of Engineering and Technology, Levanon is a Professor Emeritus of the Faculty of Engineering with Tel Aviv University, Tel Aviv, Israel.

*Scope:* For outstanding accomplishments in advancing the fields of radar technologies and their applications.

## IEEE Medal in Power Engineering

*Sponsored by the IEEE Industry Applications, Industrial Electronics, Power Electronics, and Power & Energy Societies*


### Arun G. Phadke

**For contributions to synchrophasor technology for monitoring, control, and protection of electric power systems**

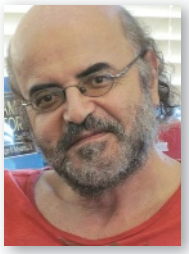
The pioneering work of Arun G. Phadke on computer-based protection equipment for providing precise, real-time data on power transmission system conditions has provided the backbone for today's wide-area measurement and control systems used to ensure power grid reliability and prevent disruptions from leading to large-scale blackouts. Phadke developed synchrophasors for measuring the flow of electricity through the power grid. Synchrophasors are time-synchronized numbers that represent both the magnitude and phase angle of the sine waves found in electricity and are time-synchronized for accuracy. Phadke also developed the phasor measurement unit (PMU) for measuring synchrophasors. PMUs have proven to be the main tool for the monitoring, protection, and control of the grid and are considered a quantum leap over analog technology, quickly providing the information needed to maintain grid stability over a wide region. During the 1990s, Phadke helped develop the concept of adaptive relaying. Using the computing and communications capability of computer relays, this concept allows for automatic adjustment of protective relay characteristics to match prevailing power system conditions to avoid unnecessary trips of equipment as a catastrophic power system event evolves. Phadke's efforts on advancing computer-based protective relaying began in the early 1970s when his implementation of protective algorithms in an IBM minicomputer and its subsequent installation in a 138-kV substation near Roanoke, Virginia, represented the world's first communicating relay and fault recorder. Also, his digital symmetrical component distance relay was a significant contribution to the distance protection of transmission lines. His early work on Fourier transforms for voltage and current calculation serves as the foundation for most of the digital relays installed throughout the world today.

An IEEE Life Fellow and member of the U.S. National Academy of Engineering, Phadke is a University Distinguished Research Professor with the Faculty of Engineering at the Virginia Polytechnic Institute and State University, Blacksburg,VA, USA.

*Scope:* For outstanding contributions to the technology associated with the generation, transmission, distribution, application, and utilization of electric power for the betterment of society.

## IEEE John von Neumann Medal

*Sponsored by IBM Corporation*

### Christos H. Papadimitriou

**For providing a deeper understanding of computational complexity and its implications for approximation algorithms, artificial intelligence, economics, database theory, and biology**

Christos H. Papadimitriou is a leader in providing an understanding of how computational complexity can be used as a tool for understanding limits and solving problems within the broader scientific community, pioneering connections and collaborations between computer science and other disciplines. Papadimitriou has been the key player in the development of our understanding of "NP total search problems," which are computational challenges where solutions are guaranteed to exist but may be hard to find. He has been very influential in developing algorithmic game theory, which involves the convergence of computer science and economic theory. His work on computing and determining the computational complexity of the Nash equilibrium has provided important insights for game theory and economics. He studied the algorithmic complexity of computing game-theoretic solutions to cooperative and noncooperative game scenarios, which has had important implications for economics and gauging the health of the Internet amid the risks caused by congestion. He defined the "price of anarchy," which provides a measure of the degree of inefficiency of equilibrium in a game, and is important for quantifying loss due to uncoordinated behavior of selfish agents within networks such as the Internet. Papadimitriou has also demonstrated how computational complexity can be applied to natural processes such as biology, describing the algorithmic aspects of protein structure. His novels *Turing* and *Logicomix* have been very successful in reaching the broader public and exposing many people to some of the fundamental principles and ideas of mathematics and computer science.

A member of the U.S. National Academy of Sciences, the National Academy of Engineering, the American Academy of Arts and Sciences, and an ACM Fellow, Papadimitriou is the C. Lester Hogan Professor of Electrical Engineering and Computer Science with the University of California, Berkeley, CA, USA.

*Scope:* For outstanding achievements in computer-related science and technology.

## IEEE Medal for Environmental and Safety Technologies

*Sponsored by Toyota Motor Corporation*



### Masahiko Miyaki, Yukihiro Shinohara, and Katsuhiko Takeuchi

**For development of electronic multipoint fuel-injection systems, enabling fuel-efficient and low-emission diesel engines**

The development of electronic multipoint fuel-injection technology by Masahiko Miyaki, Yukihiro Shinohara, and Katsuhiko Takeuchi has revitalized the popularity of diesel engines by enabling high-power operation with better fuel efficiency and lower emissions than conventional injector technology. The trio's concept of common rail direct fuel injection featured an electronically controlled multi-fuel injection system (ECMFIS) to overcome the limitations of common rail system prototypes of the 1960s. Incorporating an electronically controlled injector and sensors for speed, cylinder identification, and pressure, they were the first to successfully commercialize the diesel common rail system in 1995. Prior to their work, the popularity of conventional diesel engines was waning, due to significant black smoke emissions from poor atomization of fuel caused by low injection pressure. Their system allowed high fuel injection pressure, even at low engine speeds, for finer atomization resulting in less unburned fuel and fewer particulates. The first-generation ECMFIS reduced emissions of nitrogen oxides and particulates by half and cut combustion noise by as much as 10 dB. Their fourth-generation common rail system (2013) cuts emissions by 80% and further reduces combustion noise. They also developed an innovative feedback control system that can compensate for aging deterioration of the fuel injectors to ensure clean emissions and high drivability throughout the lifespan of the engine.

A Fellow of the Japan Society of Mechanical Engineers, Masahiko Miyaki is executive vice president; Yukihiro Shinohara is executive director of electric systems; and Katsuhiko Takeuchi is head of the diesel business unit—all at DENSO Corporation, Kariya-shi, Japan.

*Scope:* For outstanding accomplishments in the application of technology in the fields of interest to IEEE that improve the environment and/or public safety.

## IEEE Simon Ramo Medal

*Sponsored by Northrop Grumman Corporation*



### John P. Lehoczky, Ragunathan Rajkumar, and Lui Sha

**For technical leadership and contributions to fundamental theory, practice, and standardization for engineering real-time systems**

The groundbreaking work of John P. Lehoczky, Ragunathan Rajkumar, and Lui Sha on developing the generalized rate-monotonic scheduling (GRMS) theory has revolutionized the modern practice of real-time system design by ensuring that critical tasks can be guaranteed across a wide range of real-world applications. Building upon the RMS theory introduced by Liu and Layland in 1973, the trio developed and refined GRMS theory over two decades to provide predictability, efficiency, and flexibility in scheduling complex concurrent real-time tasks that regular RMS could not satisfy. GRMS transformed the development of real-time systems from what was traditionally a hand-crafted, error-prone process into a scientific engineering discipline for building real-time systems that are pervasive in applications including aerospace, defense systems, transportation, process control, manufacturing, and medical systems. Their work made it possible to compute both the average-case and worst-case behaviors with useful mathematical precision. Not only does GRMS contribute to keeping development costs in check, it also helps assure that expensive mission failures do not occur. GRMS has been incorporated into IEEE real-time software standards and hardware standards.

An IEEE Member, John P. Lehoczky is the Thomas Lord University Professor of Statistics and Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA, USA. An IEEE Fellow, Ragunathan Rajkumar is the George Westinghouse Professor with the Department of Electrical and Computer Engineering, Carnegie Mellon University, Pittsburgh, PA, USA. An IEEE Fellow, Lui Sha is the Donald B. Gillies Chair Professor of Computer Science, University of Illinois at Urbana-Champaign, Urbana, IL, USA.

*Scope:* For exceptional achievement in systems engineering and systems science.

## IEEE Medal of Honor

*Sponsored by the IEEE Foundation*


### G. David Forney, Jr.

**For pioneering contributions to the theory of error-correcting codes and the development of reliable high-speed data communications.**

In a career spanning more than 50 years, G. David Forney, Jr., has influenced virtually every major advance in the field of coding theory, providing practical solutions that have enabled high-speed data communications for systems ranging from wired to wireless and from electrical to optical. Forney introduced concatenated codes in 1965 as error-correcting codes constructed of two or more simpler codes to achieve good performance with reasonable complexity in detecting and fixing errors during data transmission. His concatenated method became widely used for space communications, and the approach is widely practiced today for satellite communications, mobile telephony, and digital video broadcasting. Forney joined Codex Corporation to develop practical implementations of coding theory, where he designed the first coding system to go into space—a convolutional code with sequential decoding for a NASA Pioneer deep-space mission in 1968. Considered the founder of the modern modem, in 1970 Forney brought quadrature amplitude modulation (QAM) to the marketplace by designing the first high-speed [9,600 bits per second (bps)] QAM telephone-line modem. This became the foundation of Codex's commercial success, and it revolutionized the industry, providing the foundation for the international V.29 9,600 bps modem standard.

Forney also introduced the now universally used concept of trellis diagrams to describe the Viterbi algorithm, and he is considered the first to recognize the Viterbi algorithm as an optimum sequence detector rather than just a proof technique. His Forney algorithm (FA) is employed by all practical decoders for Reed-Solomon (RS) codes for computing error values after error locations in a received code word have been determined. The FA continues to be widely used in many physical-layer transmission systems and optical/magnetic storage devices, which employ RS coding for outer-layer error control. Another important contribution by Forney is the minimum-phase whitened matched filter for maximum-likelihood sequence decoding of modulation symbols in the presence of intersymbol interference and noise. When turbo codes were introduced in 1993, Forney demonstrated that they could be described as "codes on graphs." In 2001, with what are now known as "Forney-style factor graphs," he showed that one graph can simultaneously describe both a code and its dual, which provides for new, efficient decoding algorithms. Forney continues to contribute to error-correcting coding techniques with recent work focusing on tail-biting trellis realizations using Forney-style factor graphs.

An IEEE Life Fellow and member of the U.S. National Academy of Engineering and U.S. National Academy of Sciences, Forney is currently an adjunct professor with the Department of Electrical Engineering and Computer Science and the Laboratory for Information and Decision Systems, Massachusetts Institute of Technology, Cambridge, MA, USA.

*Scope:* For an exceptional contribution or an extraordinary career in IEEE fields of interest.

This is an excerpt from IEEE Spectrum May 2016 print issue as "Modem Maestro."

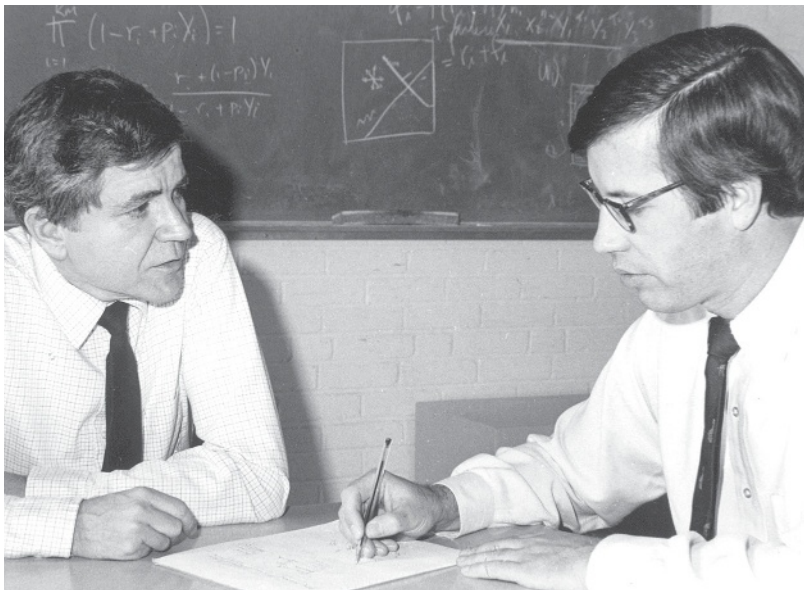
# Modem Maestro

G. David Forney Jr., the 2016 IEEE Medal of Honor recipient, turns **information theory** into practice

BY MARK ANDERSON

**IT CAN SOMETIMES SEEM AS THOUGH** there's a gaping chasm between theory and reality. But G. David Forney Jr., the recipient of this year's IEEE Medal of Honor, masterfully straddles both realms, his colleagues say. A key figure in the development of the high-speed modem, a device that opened up the Internet and all its associated world-changing technologies, Forney has balanced the practical and the theoretical throughout his career. Over the years, he has not only made critical contributions to communications and information theory but also put some of this recondite mathematical theory into practice. And as a result, he can claim a key role in the greatest communications revolution in modern history. • "He's one of the people who gets to the heart of abstract subjects very quickly," says Thomas Kailath, an emeritus professor of engineering at Stanford and the 2007 IEEE Medal of Honor recipient. "But uniquely, when needed, he also designed and built circuits, wrote code, and got things working. Everything Dave does, he does well." • And yet, as

PHOTOGRAPH BY **Mike McGregor**



**PUSHING THE LIMITS:** Forney [right] and Robert Gallager confer at MIT. This photograph was taken around 1965, Forney says.

an underclassman at Princeton in the late 1950s, Forney wasn't necessarily set on a career in engineering. He did ultimately decide to pursue a bachelor of science in engineering, but not out of any burning desire to invent or design.

"I thought, 'I'll keep my options open,' but without any great intention to become an engineer," Forney recalls, relaxing in the sunny sitting area off the kitchen of his Cambridge, Mass., home one December afternoon last year. But an elective course in thermodynamics taught by John Archibald Wheeler stirred a sense of discovery in him.

"I really liked his approach," Forney says of the legendary physicist's down-to-earth teaching style. "It was much more of an engineering course than a physics course. And he [assigned] a term paper instead of a final exam."

For the paper, Forney decided to read Léon Brillouin's 1956 book, Science and Information Theory. The book tackled thermodynamics in the context of information theory, then a fledgling field, founded about a decade earlier with a groundbreaking paper by Claude Shannon. In that 1948 paper, "A Mathematical Theory of Communication," Shannon laid out the mathematical foundation for the transmission of information (the centenary of his birth is being celebrated this year).

Forney says he was struck by Brillouin's resolution of the problem of Maxwell's demon, a thought experiment in which energy appears to be created for free by sorting molecules by their speed. Brillouin noted that every physical system contains information, and extracting that information—in the case of Maxwell's demon, the speed of particles—always costs energy, enough to precisely satisfy the laws of thermodynamics. "Information isn't free; it comes at a cost," Forney says, in summary. "Probably I could poke holes in that now. But certainly as an undergraduate this was all very interesting."

He carried this interest to graduate school at MIT, in 1961, where he found a whirlwind of research activity. Shannon himself had recently arrived from Bell Labs, and a research group was trying to extend his work and find practical uses for it.

In a master's thesis on information theory and quantum mechanics, and a doctoral dissertation on error-correcting codes, Forney displayed a bloodhound's nose for finding the right problems and the right questions to ask about those problems. The 1990 IEEE Medal of Honor recipient, Robert Gallager, a young faculty member in the mid-1960s and now an emeritus professor at MIT's Research Laboratory of Electronics, singles out Forney's doctoral thesis as a leap forward in the field.

At that time, digital technology was taking off, and researchers were hunting for coding schemes—ways of transforming those 1s and 0s into a form that could be carried from place to place with little power and few errors. In his celebrated 1948 paper, Shannon had already worked out the ultimate limit to such efficiency, a maximum achievable error-free data rate for any communications channel. But reaching that limit was easier said than done.

Disturbances during transmission will flip bits at random. To tackle errors, Shannon proposed adding redundant bits to a sequence of data before transmission to create an encoded packet. The longer the packet, the less likely it would be corrupted to look like another potential sequence. This approach could push transmission to its limits, but it posed a practical challenge at the decoding stage. The straightforward, brute-force approach would compare the incoming sequence with every possible transmitted sequence to find the most likely one. This process could work for relatively short packets, Forney says. But longer packets, which would be needed to obtain very low error rates, would quickly exhaust the computational power of a decoder, even with today's technology.

Researchers proposed various coding schemes to try to achieve data rates close to the Shannon limit with low error rates and reasonable decoding complexity. But there was no single code that could do it all.

Forney had another idea. Why not break the problem down and use multiple, complementary codes to encode and decode data, one operating on the outcome of the other? A simple inner code operating directly on the input and output of a communications channel could achieve a moderate error rate at data rates near Shannon's limit. An outer code, used before data enters the inner code and after exiting it, could drive error rates down further using a

powerful but less computationally complex algorithm.

Forney showed that this approach, dubbed concatenation, could achieve a much better trade-off between data rates and computational complexity, and that it would in principle let existing modems transmit and receive all the way up to Shannon's limit. "Today, almost every coding scheme for transmission is in some form a concatenated scheme," says colleague Gottfried Ungerboeck. "You can transmit information faster and more reliably with the same power and bandwidth."

Coming out of graduate school in 1965, Forney recalls that information theory was a field brimming with ideas and yet-to-be-realized applications. Any such IT field today might have launched a dozen startups, with angel investors hovering to pounce on possible secondary spin-off opportunities. But at the time, startups weren't really part of the culture, Forney says. Smart and capable grads who didn't intend to stay in academia typically sought out big companies.

Forney submitted applications to some of the usual suspects—IBM and Bell Labs. But on the advice of Gallager, Forney also applied to the recently formed Codex Corp. The Massachusetts-based company gave Forney the lowest offer. But he was sold. "They were in business to try to make information theory practical, to make coding practical. Nobody else was doing that," he says.

Forney became the 13th employee in the company, which would be bought by Motorola in 1977 and ultimately employ thousands. One of his first projects was a communications contract for NASA, creating coding and decoding algorithms for some of the agency's Pioneer spacecraft.

But the project that put Codex—and Forney—on the map was a 9,600-bit-per-second modem that became the basis of the company's commercial success. The company had devised the first such modem in 1968, Forney says, and it sold for more than US $20,000 to big firms with international data networks, such as banks and airlines. But, like its competitors, the modem turned out to be unreliable owing to a previously unrecognized problem with the telephone networks that added "phase jitter"—random variation in the phase of the signal-carrying waves traveling across them.

Following up on a suggestion made by Gallager, Forney designed a family of modems that used a modulation scheme called quadrature amplitude modulation. This approach, which could better handle phase shifts, produced a more reliable and successful modem. The design eventually became the basis of the international V.29 9,600-bit-per-second modem standard.

But this early practical success didn't lure Forney away from the fundamentals. After his modem work in 1970 and 1971, he spent a sabbatical year at Stanford. And when he returned, he set out to write up some thoughts he'd had on how an algorithm proposed in 1967 by Andrew Viterbi might be applied to signal decoding.

The result was a landmark 1973 paper in the Proceedings of the IEEE that popularized the Viterbi algorithm by introducing a visualization technique called the "trellis diagram." The algorithm can be used to recover data from a patchy or noisy signal. Today, it is used in an extraordinary range of disparate technologies, including modems, wireless communications, and voice and handwriting recognition, as well as DNA sequencing.

To explain how the Viterbi algorithm works, Forney gives a handwriting recognition example. Reading in the letters for the word "hand," the computer might initially determine that the second letter looks more like a q than an a. But a recognizer running the Viterbi algorithm will also factor in the fact that "hand" is a much more likely English word than "hqnd." "It finds the most likely sequences, taking into account both raw likelihood and sequence constraints," Forney says.

Viterbi-algorithm decision trees can be plotted in a latticelike trellis diagram, an approach Forney and his colleagues say is much simpler than writing out formulas and logical if-then statements. Trellis diagrams "laid things out graphically, which appeals to people more than just a collection of equations [does]," says Stanford's Kailath. "They provided a tool for engineers to appreciate what the Viterbi algorithm could do and make extensions of it."

From 1975 to 1985, Forney served as an R&D executive for Codex and then Motorola, after the company's acquisition. In the 1980s, Forney was inspired by trellis-coded modulation, a new signaling scheme developed by Ungerboeck that was rapidly adopted in modems, and he was drawn back into research. In the decades since, he has worked extensively on codes, with an eye toward continuing to raise the efficiency of data transmission. A number of his papers, as with his work on trellis diagrams, reintroduced key concepts into the field that other researchers could then apply.

Forney retired from Motorola in 1999. He has been an adjunct professor in the department of electrical engineering and computer science and the Laboratory for Information and Decision Systems at MIT since 1996.

Regarding his contributions, Forney says modestly, "I'm just the guy who comes along at the end of the circus parade." After a discovery has been made, he'll add to it, he says. In a sentence he sums up these insights: "You know, the right mathematical language to talk about this invention is this."

Filling out the framework around a new theory or algorithm might not be the kind of work that garners headlines, but it's still critical to progress, Gallager says. "Researchers 'keep score' by counting inventions and weighting them by their popularity," he says, but "what makes a research field grow and evolve is the context, relations, and connection to reality." Forney has created this "context in the information theory and communication technology fields to a greater extent than almost anyone else," Gallager says.

And in the ever-evolving world of engineering, the ability to draw from theory to push the limits of what's practical is one skill that will never go out of style. ●

## IEEE Biomedical Engineering Award

*Sponsored by the IEEE Circuits and Systems Society, IEEE Computational Intelligence Society, and IEEE Engineering in Medicine and Biology Society*

### K. Kirk Shung

**For contributions to ultrasound imaging and transducer technology**

A world-renowned leader of biomedical ultrasound technology, K. Kirk Shung's pioneering discoveries have contributed significantly to the health and welfare of society. His early work involving the interaction of ultrasound and blood has set the standard for research activities and the development of diagnostic ultrasound equipment. His study led to a thorough understanding of the origin of echogenicity of biological tissues in an ultrasonic image. Shung is also credited for developing the world's first high-frequency linear array at 30 MHz for imaging, an important technological breakthough in the field. His recent inntovations include applying high-frequency ultrasound beams to trap microparticles and cells and in assessing cellular responses to ultra-high-frequency ultrasound stimulation.

An IEEE Life Fellow, Shung is the Dean's Professor in Biomedical Engineering at the University of Southern California, Los Angeles, CA, USA.

## IEEE Cledo Brunetti Award

*Sponsored by the Brunetti Bequest*

### Akira Toriumi

**For contributions to CMOS device design from materials engineering to device physics**

Akira Toriumi's pioneering contributions to understanding advanced gate dielectrics and device physics are driving the continued miniaturization of components needed for current and future electronic devices. His early work on random dopant fluctuation-induced threshold voltage variation and its effect on device reliability addressed an important source of variation facing device design when trying to further scale power supply voltage. In the area of high-k silicon dielectrics, Toriumi demonstrated some of the thinnest reliable dielectrics to date to enable high-k gate stacks. He has also pioneered the investigation of using germanium as an alternative channel material for high-performance complimentary metal-oxide semiconductor (CMOS), which will be critical to providing the reduced power supply voltages needed for even smaller future technology generations.

An IEEE Senior Member, Toriumi is a professor with the Department of Materials Engineering at the University of Tokyo, Tokyo, Japan.

## IEEE Components, Packaging, and Manufacturing Technology Award

*Sponsored by the IEEE Components, Packaging, and Manufacturing Technology Society*

### Michael Pecht

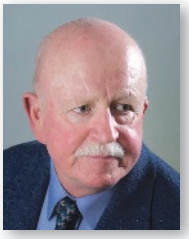
**For visionary leadership in the development of physics-of-failure-based and prognostics-based approaches to electronic packaging reliability**

A world leader in electronics packaging reliability, Michael Pecht has developed prediction tools that enable manufacturers to make their products safer and more operationally available. As an alternative to flawed handbook-based reliability prediction methods, Pecht developed the physics-of-failure (PoF) approach to electronics reliability. The PoF approach provides greater accuracy by taking into account the actual failure mechanisms of the device in the operating conditions that the device would likely face in the field. He also developed prognostics-based health assessment methods that have been adopted by industry to predict reliability for critical systems such as vehicle batteries, avionics, and alternative energy sources. Pecht also founded the Center for Advanced Life Cycle Engineering.

An IEEE Fellow, Pecht is director of the Center for Advanced Life Cycle Engineering at the University of Maryland, College Park, MD, USA.

## IEEE Control Systems Award

*Sponsored by the IEEE Control Systems Society*



### Arthur J. Krener

**For contributions to the analysis, control, and estimation of nonlinear control systems**

Arthur J. Krener's foundational work on nonlinear control provided the definitive treatment on controllability and observability of time-variant, real-world systems and has spurred tremendous progress in the development of nonlinear control theory. Krener's work during the 1970s set the cornerstone for control of nonlinear systems and the resulting research paper was selected by the IEEE Control Systems Society as one the 25 Seminal Papers of the 20th Century for its far-reaching importance. Krener's work on a bifurcation-based approach to controlling models of rotating stall and surge has been invaluable to the U.S. Air Force's study of jet engine instabilities. He has also been a leader in developing software tools for implementing the latest methods of nonlinear control.

An IEEE Life Fellow, Krener is a research professor with the Department of Applied Mathematics at the Naval Postgraduate School, Monterey, CA, USA.

## IEEE Electromagnetics Award

*Sponsored by the IEEE Antennas and Propagation Society, IEEE Electromagnetic Compatibility Society, IEEE Geoscience and Remote Sensing Society, and IEEE Microwave Theory and Techniques Society*

### Giorgio Franceschetti

**For leadership in the academic world, teaching, research, and scientific activities in advanced electromagnetics**

Giorgio Franceschetti has helped advance the field of electromagnetics through innovative research and high-level teaching covering diverse areas ranging from electromagnetic propagation in complex environments to wireless transmission power. Franceschetti introduced the study of electromagnetic fields and waves to Italian universities in 1965 and established an outstanding research community. His contributions to synthetic aperture radar technologies have been successfully used for imaging the Earth's surface from space. His work on the degrees of freedom involving scattering fields has enabled more accurate sampling, which has impacted electromagnetic imaging. As recognition of his long-lasting impact on electromagnetics, the November/December 2014 issue of the *Forum for Electromagnetic Research Methods and Application Technologies* (Vol. 6, NEWS&VIEWS) was dedicated to Franceschetti and contains a salute and a tribute to his accomplishments.

An IEEE Life Fellow, Franceschetti is a Professor Emeritus with the University Federico II, Naples, Italy.

## IEEE James L. Flanagan Speech and Audio Processing Award

*Sponsored by the IEEE Signal Processing Society*

### Takehiro Moriya

**For contributions to speech and audio coding algorithms and standardization**

Considered one of the most innovative speech and audio coding researchers in the world, the technologies and standards developed by Takehiro Moriya are used internationally for the practical transmission of speech signals over digital networks. His many contributions to standardized coding techniques include the pitch synchronous innovation scheme adopted by the Japanese digital cellular phone system, which is recognized as the lowest bit-rate standard for public telephone service in the world. His speech coder implemented in the ITU-T G.729 standard has become the default technique for VoIP systems, cellular phones, and voice recording devices. Moriya also made a significant contribution to establishing MPEG audio lossless coding (ALS), which has been selected as one of the techniques for the next generation of super-high-definition broadcasting in Japan.

An IEEE Fellow and NTT Fellow, Moriya is head of the Moriya Research Lab, NTT Communication Science Laboratories, Atsugi, Kanagawa, Japan.

## IEEE Fourier Award for Signal Processing

*Sponsored by the IEEE Circuits and Systems Society and the IEEE Signal Processing Society*

### Bede Liu

**For foundational contributions to the analysis, design, and implementation of digital signal processing systems**

Bede Liu's cutting-edge research has profoundly impacted the digital processing of images and video by enabling signal processing systems that feature lower circuit count, minimal power consumption, and reduced design cost critical to today's mobile multimedia devices. His revolutionary concept of incorporating a fixed number of shift-adds for multiplier-free filters provided a 3-to-1 savings in computation time over the traditional use of full multipliers. Liu's proposal to use 1-bit coefficients on oversampled data achieved significant savings in chip area and power. He also proposed a highly efficient motion vector search method for video coding, providing better accuracy and substantial time savings compared to prior approaches.

An IEEE Life Fellow, Liu is a Professor Emeritus with the Department of Electrical Engineering, Princeton University, Princeton, NJ, USA. He is a member of U.S. National Academy of Engineering, an Academician of Academia Sinica, and a Foreign Member of Chinese Academy of Sciences.

## IEEE Andrew S. Grove Award

*Sponsored by the IEEE Electron Devices Society*

### Carlos H. Díaz

**For sustained contributions to and leadership in foundry advanced CMOS logic transistor technology**

The innovations in logic transistor technology developed by Carlos H. Díaz have revolutionized the foundry industry and provided semiconductor companies the ability to bring devices to market more quickly and cost effectively. Díaz has successfully developed multiple generations of foundry technology from 0.18 µm forward. He has demonstrated that it is possible to provide a flexible high-density transistor technology platform that supports multiple device segments with minimal burden on manufacturing. Of note is his work on the 28-nm generation, which meets the needs of both high-performance and low-power applications. The 28-nm high-k/metal-gate transistor technology has set the foundry industry standard in performance-power space coverage on a wide range of devices such as cellular/mobile computing, graphics processors, field-programmable-arrays, and central processing units.

An IEEE Fellow, Díaz is the director of Logic Technology Advanced Development Division with Taiwan Semiconductor Manufacturing Co., Hsinchu, Taiwan.

## IEEE Herman Halperin Electric Transmission and Distribution Award

*Sponsored by the Robert and Ruth Halperin Foundation, in memory of Herman and Edna Halperin, and the IEEE Power & Energy Society*

### George J. Anders

**For contributions to advances in computational methods for the thermal rating of electric power cables**

George J. Anders' expertise has contributed toward setting the standard for rating electric power cables, which has provided significant economic benefits to the power industry. His computational techniques using analytical and finite element methods enable engineers to accurately rate cable circuits. He also developed optimization techniques for selecting the most economic conductor sizes, providing accurate calculations to avoid costly oversizing of buried cables. The software for steady-state and emergency ratings of underground cables, which he developed, is used throughout the world and is considered the industry standard for power cable rating calculations. Anders' contributions to early leak detection methods are also helping to reduce the costs of detection, location, clean up, and repair related to cable leaks.

An IEEE Fellow, Anders is currently president of Anders Consulting, Ltd., Woodbridge, Ontario, Canada.

## IEEE Masaru Ibuka Consumer Electronics Award

*Sponsored by Sony Corporation*

### Steven J. Sasson

**For designing and building the first digital still camera**

Steven J. Sasson's development of the first digital still camera and contributions to groundbreaking digital technologies have revolutionized photography, making it easier and less expensive to capture and share photos. His patented work at Kodak during the 1970s involved using a fast charge-coupled device to capture images to a digital buffer memory and transfer them to a nonvolatile digital storage medium. Sasson saw the potential of emerging memory chips and analog-to-digital converters and decided to store four digital bits per pixel on a cassette tape instead of using traditional analog video circuits. During the 1980s, he also developed the first megapixel digital camera incorporating discrete cosine transform compression for storing images on memory cards.

A recipient of the 2009 U.S. National Medal of Technology and Innovation, Sasson is currently president of Steven J. Sasson Consulting, LLC, Hilton, NY, USA.

## IEEE Internet Award

*Sponsored by Nokia Corporation*

### Henning Schulzrinne

**For formative contributions to the design and standardization of Internet multimedia protocols and applications**

The multimedia-capable Internet that we now take for granted was made possible by Henning Schulzrinne's fundamental contributions to the development of network protocols, applications, and algorithms for the effective transport of audio and video signals. He helped migrate the Internet from a medium containing primarily text and images to one featuring both real-time and on-demand audio/video. Key to the success of the Internet was Schulzrinne's Real-Time Transport Protocol, which became an Internet full standard in 2004. He also developed the Real-Time Streaming Protocol to control delivery of audio and video streams, which is supported by major consumer streaming architectures. And his Session Information Protocol became the standard for Internet telephony and conducting real-time interactive multimedia sessions.

An IEEE and ACM Fellow, Schulzrinne is a professor with the Department of Computer Science at Columbia University, New York, NY, USA and serves as a Technology Advisor to the Federal Communications Commission (FCC) in Washington, DC, USA.

## IEEE Richard Harold Kaufmann Award

*Sponsored by the IEEE Industry Applications Society*

### G.S. Peter Castle

**For developments of applied electrostatic devices and processes in industry, agriculture, and environmental protection**

One of the founders of modern applied electrostatics research, G.S. Peter Castle has developed tools for addressing real-world issues impacting manufacturing, agriculture, and the environment. His work on electrostatic precipitators including two-stage precipitation and space charge suppression has improved air-cleaning applications. He also developed processes for electrostatic liquid painting and powder coating, which have provided more cost-effective and environmentally friendly solutions compared to conventional industrial painting systems. Castle's induction charging concept has enhanced liquid deposition of pesticides on leaves, reducing the amount of chemicals that need to be sprayed for improved crop protection. His research concerning contact charging for electrostatic separation of plastics is benefitting the recycling industry.

An IEEE Life Fellow, Castle is a Professor Emeritus and adjunct research professor with the Department of Electrical and Computer Engineering at the University of Western Ontario, London, Ontario, Canada.

## IEEE Joseph F. Keithley Award in Instrumentation and Measurement

*Sponsored by Keithley Instruments, Inc. and the IEEE Instrumentation and Measurement Society*

### Samuel P. Benz

**For creating and disseminating quantum-based superconducting voltage standards that form the basis for worldwide precision voltage measurements**

Considered the premier researcher in developing and applying superconducting quantum voltage standards, Samuel P. Benz has provided industries around the world with the ability to perform precision measurements. Benz advanced the capabilities of Programmable Josephson Voltage Standard (PJVS) systems that provide improved voltage stability and noise immunity compared to conventional JVS technology. Accuracy is achieved because these voltage standards are based on superconducting Josephson junctions incorporating quantum mechanics, which ensures that the voltage does not drift with time or from environmental conditions. He also helped develop the Quantum Watt, which uses a PJVS for best ever power calibration critical to the electric power industry. The NIST alternating current (ac) JVS produces quantum-accurate ac waveforms and also significantly reduces uncertainties.

An IEEE Fellow, Benz is also a NIST Fellow and leads the Superconductive Electronics Group at the National Institute of Standards and Technology, Boulder, CO, USA.

## IEEE Gustav Robert Kirchhoff Award

*Sponsored by the IEEE Circuits and Systems Society*

### P.P. Vaidyanathan

**For fundamental contributions to digital signal processing**

Considered to be one of the pioneering contributors to multirate signal processing research, P.P. Vaidyanathan has heavily influenced the research directions in filter banks and multirate systems. He is most well known for developing the general theory of filter banks with perfect reconstruction, as well as orthonormal filter banks, which have impacted digital communications, audio, and image coders. One of his earliest contributions was in the area of low-sensitivity digital filter structures. He showed how such structures can be designed directly in discrete time, without the need for transforming electrical circuits into the digital domain. An early proponent of applying signal processing methods to genomics, Vaidyanathan developed methods to computationally predict the location of protein coding genes and noncoding genes. His work on coprime and nested arrays is expected to have major impact on applications such as direction finding and radar systems.

An IEEE Fellow, Vaidyanathan is a professor at the California Institute of Technology, Pasadena, CA, USA.

## IEEE Leon K. Kirchmayer Graduate Teaching Award

*Sponsored by the Leon K. Kirchmayer Memorial Fund*

### K.J. Ray Liu

**For exemplary teaching and curriculum development, inspirational mentoring of graduate students, and broad educational impact in signal processing and communications**

K.J. Ray Liu's students aren't just individuals pursuing graduate degrees in signal processing—they become his "extended family." They can attest to how Liu's passion for teaching and mentoring for their professional development goes beyond the classroom, beyond graduation. He is always there for them. Many have gone on to become leaders in academia and industry. Both a world-class researcher and excellent educator who pioneered and cross-pollinated various fields, Liu built the University of Maryland's signal processing program practically from scratch beginning in 1990 and has shaped it into one of the most well-respected graduate programs in the world. He also revamped the University's master's program in telecommunications, creating a unique identity resulting in a scholarly and financially successful program.

An IEEE Fellow, Liu is the Christine Kim Eminent Professor of Information Technology at the University of Maryland, College Park, MD, USA.

## IEEE Koji Kobayashi Computers and Communications Award

*Sponsored by NEC Corporation*

### Leandros Tassiulas

**For contributions to the scheduling and stability analysis of networks**

Leandros Tassiulas has revolutionized how scheduling and stability analysis are performed in communications networks, providing dynamic resource allocation tools to improve performance of wireless networks and Internet switches. Developing control algorithms based on a sound mathematical foundation as an alternative to heuristic approaches, Tassiulas introduced the Max-Weight scheduling algorithm for achieving maximum throughput in systems with conflicting resources as well as the Backpressure routing algorithm for end-to-end traffic forwarding. His Maximum Connected Queue algorithm introduced the concept of opportunistic scheduling that became part of most wireless standards since 3G. Together, these three algorithms provide the basis for cross-layer network design in today's wireless networks.

An IEEE Fellow, Tassiulas is the John C. Malone Professor in the Electrical Engineering Department and the Institute for Network Science at Yale University, New Haven, CT, USA.

## IEEE William E. Newell Power Electronics Award

*Sponsored by the IEEE Power Electronics Society*

### Johann W. Kolar

**For contributions to the advancement of three-phase pulse-width modulation (PWM) converter systems and power electronics education**

A visionary leader in the field of power electronics, Johann W. Kolar has a distinguished record of providing industry with key innovations for ensuring high power quality and saving energy. He has driven advances in three-phase pulse-width modulation rectifier and matrix converter technology, including the Vienna Rectifier and the Sparse Matrix Converter, over the past two decades. Offering outstanding performance concerning efficiency, power density, harmonic distortions, and costs, the Vienna Rectifier is widely employed for power supply of data centers and industry processes, as well as actuators of electric aircraft. Furthermore, Kolar has spearheaded the introduction of multi-objective optimization as a fundamentally new research approach into power electronics and has proposed a revolutionary new approach for education in power electronics that is used today in academia and industry all over the world.

An IEEE Fellow, Kolar is a full professor and chair of the Power Electronic Systems Laboratory at ETH Zurich, Zurich, Switzerland.

## IEEE Daniel E. Noble Award for Emerging Technologies

*Sponsored by the Motorola Solutions Foundation*

### Mark G. Allen

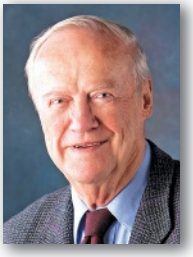
**For contributions to research and development, clinical translation, and commercialization of biomedical microsystems**

An international leader in the field of micro-electro-mechanical systems (MEMS), the innovations of Mark G. Allen are playing a major role in improving patient care and reducing healthcare costs. His development and commercialization, together with coworkers, of a fully implantable wireless sensor technology for monitoring heart pressure, known as the CardioMEMS Heart Failure System, allows physicians to better regulate patient activity and adjust medication regimes. Allen's innovation represents the first MEMS sensor approved by the U.S. Food and Drug Administration for permanent implantation in humans. Clinical studies of Allen's sensor have demonstrated a 37% reduction in hospital admissions and a 78% reduction in re-admissions, providing better quality of life for patients.

An IEEE Fellow, Allen is the Alfred Fitler Moore Professor with the Department of Electrical and Systems Engineering at the University of Pennsylvania, Philadelphia, PA, USA.

## IEEE Donald O. Pederson Award in Solid-State Circuits

*Sponsored by the IEEE Solid-State Circuits Society*



### Miles A. Copeland

**For contributions to the design and application of switched-capacitor and RF signal processing circuits**

Miles A. Copeland's 31-year career is marked by the strength of his achievements as a university teacher, inventor, researcher, and mentor. His innovative approach to industry-university collaboration supported the rapid development of the telecommunication and microelectronics industries in Canada. He coauthored, with Northern Telecom (Nortel), a groundbreaking paper on the use of switched capacitors as resistor equivalents, which demonstrated that filter RC time constants on-chip could depend on the ratio of capacitor sizes. This results in much better integration, repeatability, and accuracy when implementing analog filters on chip than is possible with ordinary resistors. The "filter codec" developed subsequently at Nortel used switched-capacitor filtering. With this innovation the company became an early leader in the shift to fully electronic switching networks. Other research work done by Miles' graduate students included much cited studies of the matching of on-chip capacitors and transistors.

An IEEE Fellow, Copeland is a Professor Emeritus with Carleton University, Ottawa, Ontario, Canada.

## IEEE Frederik Philips Award

*Sponsored by Philips Electronics N.V.*

### Kelin J. Kuhn

**For technical leadership in the development and implementation of breakthrough CMOS technology**

Kelin J. Kuhn's leadership in turning next-generation complimentary metal-oxide semiconductor (CMOS) technology into reality has been critical to enabling the continued miniaturization of transistors required for smaller but more powerful and efficient electronic devices. While working for Intel, Kuhn was responsible for navigating CMOS technology from minimum dimensions of 130 nm to 22 nm. Her involvement with introducing the high-k/metal-gate process was a breakthrough that enabled increased performance with lower power dissipation in electronic devices. She also made significant contributions to enabling the mass production of the TriGate transistor, which facilitates lower operating voltage for a substantial reduction in chip power consumption. These innovations are considered two of the most transformative changes in the history of silicon-based technology.

An IEEE Fellow, Kuhn is a professor with the Materials Science and Engineering Department at Cornell University, Ithaca, NY, USA.

## IEEE Photonics Award

*Sponsored by the IEEE Photonics Society*

### Mark E. Thompson

**For scientific and technical leadership in the conception, demonstration, and development of phosphorescent materials in organic light-emitting diode (OLED) displays**

The highly efficient photonic materials developed by Mark E. Thompson have advanced organic light-emitting diode (OLED) technology from a laboratory curiosity to a booming commercial success, providing low-power, high-resolution displays for mobile devices and the newest generation of flat-panel televisions. With a previous device efficiency of only 25%, OLED performance was severely limited. During the late 1990s, Thompson overcame the limitations by introducing iridium and platinum as materials for electrophosphorescent emitters, which through further development now provide practically 100% device efficiency. Less than 10 years after Thompson's introduction, electrophosphorescent OLEDs were commercialized and are now featured in the very popular Samsung Galaxy smartphones, among other products.

An American Association for the Advancement of Sciences and National Academy of Inventors Fellow, Thompson is a professor with the Department of Chemistry at the University of Southern California, Los Angeles, CA, USA.

## IEEE Robotics and Automation Award

*Sponsored by the IEEE Robotics and Automation Society*

### Raffaello D'Andrea

**For pioneering contributions to design and implementation of distributed, cooperative robotics and automation systems for commercial applications**

Spanning academics, business, and the arts, Raffaello D'Andrea's career is built on his ability to bridge theory and practice. He was the faculty advisor and system architect of the Cornell Robot Soccer Team, four-time world champions at the international RoboCup competition. He was one of the first in the controls community to use a multi-vehicle testbed for research. At ETH Zurich, his research redefines what autonomous systems are capable of. He is cofounder of Kiva Systems, a robotics company that revolutionized material handling by deploying thousands of autonomous mobile robots in warehouses. He recently founded Verity Studios, a company developing a new breed of interactive and autonomous flying machines.

An IEEE Fellow, D'Andrea is professor of dynamic systems and control at ETH Zurich, Zurich, Switzerland.

## IEEE Frank Rosenblatt Award

*Sponsored by the IEEE Computational Intelligence Society*

### Ronald R. Yager

**For contributions to the theory of fuzzy sets and systems**

With almost 40 years of groundbreaking contributions, Ronald R. Yager is one of the most highly cited researchers in the field of computational intelligence. Of major impact has been Yager's introduction of the Ordered Weighted Averaging operator that has been applied to multicriteria decision making, information fusion, database retrieval, and pattern recognition. His methodology for finding linguistic summaries of large data collections makes data easier to understand and has been integral to data mining applications. He also developed a generalized class of logical "and" operators, known as the Yager family of t-norms, that have been widely used to model the intersection of fuzzy sets. Yager's pioneering work on fuzzy-set-based approaches for social network and recommender systems has been important to web applications.

An IEEE Life Fellow, Yager is a professor with the Machine Intelligence Institute at Iona College, New York, NY, USA.

## IEEE David Sarnoff Award

*Sponsored by SRI International Sarnoff*

### Hiroyuki Matsunami

**For contributions to the development of silicon carbide (SiC) crystals and devices for advanced power electronics**

Recognizing early on the potential that silicon carbide (SiC) held for outperforming conventional semiconductor materials in advanced power electronics, Hiroyuki Matsunami has developed many critical breakthroughs to provide SiC-based energy-saving devices. Important to the adoption of SiC for power devices was Matsunami's step-controlled epitaxial growth technique, which enabled single-crystal growth and overcame the barrier of polytype mixing problems. His demonstration of the first high-voltage SiC Schottky barrier diodes for reducing power dissipation during energy conversion is considered a milestone in SiC power device development. Matsunami also played a pioneering role in establishing SiC power metal-oxide semiconductor field-effect transistor technologies. The devices made possible by Matsunami's innovations are being utilized today in trains, high-speed elevators, and hybrid vehicles and are realizing huge energy savings benefitting the environment.

An IEEE Life Fellow, Matsunami is a Professor Emeritus with Kyoto University, Yawata, Kyoto, Japan.

## IEEE Marie Sklodowska-Curie Award

*Sponsored by the IEEE Nuclear and Plasma Sciences Society*

### Simon R. Cherry

**For contributions to the development and application of in vivo molecular imaging systems**

Simon R. Cherry's expertise in developing molecular imaging systems incorporating positron emission tomography (PET) is driving advances in biomedicine and healthcare. Cherry created the first microPET scanner to evaluate radiopharmaceuticals and drugs in small animals. Overcoming the challenges of imaging small animals has been instrumental in allowing researchers and clinicians to gain a better understanding of diseases and potential human therapies. He also developed the first hybrid PET/magnetic resonance imaging (MRI) scanners for even more powerful preclinical imaging applications. His discovery that many radionuclides used in biomedical research produce Cerenkov luminescence and can be imaged using optical cameras has created one of the fastest-growing areas in molecular imaging. Cherry is currently working on developing the first total-body human PET scanner.

An IEEE Fellow, Cherry is a professor with the Departments of Biomedical Engineering and Radiology at the University of California, Davis, CA, USA.

## IEEE Innovation in Societal Infrastructure Award

*Sponsored by Hitachi, Ltd., and the IEEE Computer Society*

### William H. Sanders

**For the assessment-driven design of trustworthy cyber infrastructures for electric grid systems**

A leading cybersecurity expert, the groundbreaking contributions of William H. Sanders have made the electric power grid more safe, secure, reliable, and available. He did so by developing tools and techniques to make the grid more resilient to attacks that may occur as well as methods for quantitatively assessing its cyber security and resiliency. He has worked in every part of the field, from the distribution-side, including smart meters, to long-haul transmission networks. Among other contributions, he is the co-developer of the NP-View software to test NERC-CIP compliance of process control networks, which has changed the way utilities audit their networks.

An IEEE Fellow, Dr. Sanders is a Donald Biggar Willett Professor of Engineering and Head of the Department of Electrical and Computer Engineering at the University of Illinois at Urbana-Champaign, Urbana, IL, USA.

## IEEE Charles Proteus Steinmetz Award

*Sponsored by the IEEE Standards Association*

### Hermann Koch

**For leadership in and contributions to the development, standardization, and global impact of gas-insulating technology for substations (GIS) and high-voltage lines (GIL)**

Hermann Koch's dedication to advancing gas-insulating switchgear (GIS) and line (GIL) technology for the power industry is enabling the safe transmission of high electric power over greater distances and into space-constrained environments where overhead power lines are not viable. Working with Siemens AG, Koch developed new insulating gas mixtures for high-voltage systems, adopted pipeline laying technology to electrical systems, and was responsible for the installation of the first GIL system using these new techniques in 2001. Koch has helped increase global access to GIS and GIL technology by promoting improved standardization efforts between the International Electrotechnical Commission (IEC) and IEEE. He influenced IEEE to develop standards for high- and medium-voltage GIS and GIL and promoted IEC positions while a member of the IEEE Standards Activities Board.

An IEEE Fellow, Koch is a principle expert with the Energy Management Division at Siemens AG, Erlangen, Germany.

## IEEE Nikola Tesla Award

*Sponsored by Wolong Electric Group Co., Ltd., the IEEE Industry Applications Society, and the IEEE Power & Energy Society*

### Bruno Lequesne

**For contributions to the design and analysis of actuators, sensors, and motors for automotive applications**

The patented work of Bruno Lequesne has driven advances leading to the realization of "more electric automobiles" that use electrical and electromechanical systems for improved fuel economy, reduced greenhouse emissions, and better safety. With innovations recognized by multiple awards from industry leaders such as Delphi and General Motors, Lequesne's work on linear actuators provided closed form solutions to identify the best configurations for engine-valve motion or suspension. His work on encoders for brushless motors helped overcome torque ripple in electric power steering systems, contributing to a fuel-saving feature now standard in most vehicles. His camshaft and crankshaft position sensors for engine control help to reduce emissions, and his wheel speed sensors for anti-skid braking have made vehicles safer. He also developed one of the first induction belt-driven starter generators, which has enabled start-stop functionality to help eliminate idling losses in engines.

An IEEE Fellow, Lequesne is president of E-Motors Consulting, LLC, Menomonee Falls, WI, USA.

## IEEE Eric E. Sumner Award

*Sponsored by Nokia Bell Labs*



### Shuo-Yen Robert Li, Raymond W. Yeung, and Ning Cai

**For pioneering contributions to the field of network coding**

The pioneering contributions of Shuo-Yen Robert Li, Raymond W. Yeung, and Ning Cai to network coding have laid the foundation of the field. Their seminal work on linear network coding has changed the landscape of the information technology by demonstrating an improvement of transmission rates over traditional routing techniques in communication networks. Linear network coding has become one of the fastest-growing areas in communication theory. It is now being actively investigated for applications to mobile/wireless, network infrastructure and protocols, cloud storage, content distribution networks, and video streaming.

An IEEE Fellow, Li is a Distinguished University Professor with the University of Electronic Science and Technology of China, Chengdu, China and Professor Emeritus of the Chinese University of Hong Kong. An IEEE Fellow, Yeung is the Choh-Ming Li Professor of Information Engineering with the Chinese University of Hong Kong, Hong Kong, China. An IEEE Fellow, Cai is a Distinguished Professor with the State Key Laboratory of Integrated Services Networks (ISN), Xidian University, Xi'an, Shaanxi, China.

## IEEE Kiyo Tomiyasu Award

*Sponsored by Dr. Kiyo Tomiyasu, the IEEE Geoscience and Remote Sensing Society, and the IEEE Microwave Theory and Techniques Society*

### Yonina Eldar

**For development of the theory and implementation of sub-Nyquist sampling with applications to radar, communications, and ultrasound**

Yonina Eldar's pioneering work on sub-Nyquist sampling and reconstruction of sparse analog signals has demonstrated the potential to improve radar, medical imaging, communication, and storage systems. Bridging the gap between theory and real-world applications, Eldar developed the concept of "Xampling" for sub-Nyquist sampling and built hardware prototypes to demonstrate how the technique works in practical settings. The ability to sample signals at rates significantly lower than the standard Nyquist rate, but without the distortion normally associated with such techniques, positively impacts power consumption, storage memory, size, and digital signal processing rates in analog-to-digital converters. Eldar's innovations will enable portable ultrasound machines for emergency and rural medicine, radar systems with improved resolution, and better wireless capabilities for cognitive (intelligent) radio transmission and reception.

An IEEE Fellow, Eldar is a professor with the Technion-Israel Institute of Technology, Haifa, Israel.

## IEEE Transportation Technologies Award

*Sponsored by the IEEE Industry Applications, Industrial Electronics, Intelligent Transportation Systems, Microwave Theory and Techniques, Power Electronics, Power & Energy, and Vehicular Technology Societies*

### Petros Ioannou

**For contributions to the design, analysis, and implementation of adaptive cruise-control systems**

The pioneering innovations of Petros Ioannou have been instrumental in making adaptive cruise control (ACC) a practical reality and spurring its commercial adoption by the automotive industry. Using forward-looking sensors such as radar, ACC systems automatically adjust a vehicle's speed to maintain a safe driving distance based on vehicles ahead of it. Unique to Ioannou's work was implementing a time-headway approach to vehicle spacing instead of the popular belief of using vehicle-to-vehicle communications. By avoiding the complications of vehicle-to-vehicle communications, manufacturers such as Ford were able to bring ACC technology to market quickly. Ioannou's ACC systems also provide smoother acceleration and speed response, which have demonstrated positive effects on traffic flow, fuel economy, and the environment.

An IEEE Fellow, Ioannou is a professor with the University of Southern California, Director of the Center for Advanced Transportation Technologies, and Associate Director of Research of the University Transportation Center METRANs, Los Angeles, CA, USA.

## IEEE Undergraduate Teaching Award

*Sponsored by the IEEE Education Society*

### Terri Fiez

**For innovative undergraduate engineering and computing curriculum development fostering student engagement and retention**

Terri Fiez has helped ensure that engineering students are well prepared for their careers not only technically but in terms of leadership, teamwork, and communication. While at Oregon State University, Fiez implemented a learner-centered program called TekBots where freshman students develop an autonomous robot and build upon this platform during their four-year curriculum. By engaging students with a real system that does something interesting, students experience the frustration of getting real systems to work and the satisfaction of accomplishing the task. By graduation, students not only have a robot that they've customized, they also fully understand how it works and how it got there. Fiez also launched the first online post-baccalaureate program to provide computer science degrees for students with degrees from nonengineering disciplines.

An IEEE Fellow, Fiez is currently vice chancellor for research at the University of Colorado, Boulder, CO, USA.

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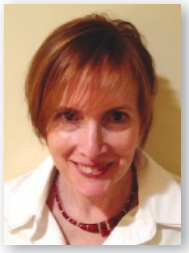
## IEEE Eric Herz Outstanding Staff Member Award

*Sponsored by IEEE*



### Susan Hassler

**For enhancing the global impact of IEEE by creating the distinctive publication *IEEE Spectrum*, which exemplifies the highest values of science, technology, and engineering journalism**

Susan Hassler has transformed IEEE's flagship member magazine *IEEE Spectrum* into an internationally renowned source for insightful and understandable coverage of science, technology, and engineering. She has repositioned the magazine and extended its digital platform strategy, establishing *IEEE Spectrum* as an essential member benefit while also expanding the visibility of IEEE among the larger technology community and general public by developing outlets for the magazine's material beyond IEEE. Hassler developed a mobile-friendly state-of-the art website and introduced a very popular video series and podcast service. Under her leadership, *IEEE Spectrum* has won numerous awards for both its print and online efforts, including three Grand Neal Awards and a National Magazine Award for General Excellence in the Thought Leader Category (2012).

An IEEE Member, Hassler is currently editor-in-chief of *IEEE Spectrum*, New York, NY, USA.

## Joyce E. Farrell IEEE Staff Award

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### Ken Gilbert

**For demonstrating distinguished job performance and serving as a role model to IEEE professional staff**

Entering his 20th year at IEEE, Ken Gilbert has learned a thing or two about how to manage a staff that really *works* together, and he knows just how influential and diverse IEEE really is. Starting his IEEE career as an accounting director, Gilbert moved over to Technical Activities Operations, where he is senior director. With a knack for maximizing the many different strengths that his staff members possess, his skills as a team builder are well known. He works to understand each person's abilities and interests to find the best organizational fit, bringing the employee with the right skills to a task rather than based just on a job description. He receives great satisfaction in assembling and maintaining diverse teams that complement each other, knowing that when his staff members feel that they are involved and making a difference, good things are accomplished.

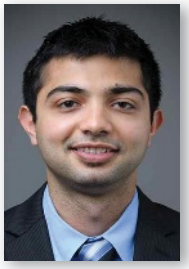
Gilbert is the senior director of IEEE Technical Activities Operations, Piscataway, NJ, USA.

## IEEE Donald G. Fink Award

*Sponsored by the IEEE Life Members Fund*

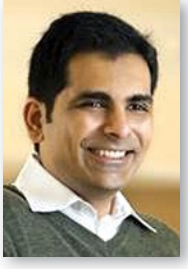











## Timothy York, Samuel B. Powell, Shengkui Gao, Lindsey Kahan, Tauseef Charanya, Debajit Saha, Nicholas W. Roberts, Thomas W. Cronin, Justin Marshall, Sanuel Achilefu, Spencer P. Lake, Baranidharan Raman, and Viktor Gruev

**For the paper, "Bioinspired Polarization Imaging Sensors: From Circuits and Optics to Signal Processing Algorithms and Biomedical Applications"**

Representing an integration of work in biology, mathematics, optics, materials science, and electronics, Timothy York and his colleagues present recent developments in bioinspired polarization imaging sensors and their applications to biomedicine in their paper "Bioinspired Polarization Imaging Sensors: From Circuits and Optics to Signal Processing Algorithms and Biomedical Applications." To emulate the highly efficient sensory systems found in biology to better detect features that are hard to see with the human eye, the paper, which appeared in the October 2014 issue of the *Proceedings of the IEEE* (vol. 102, no. 10, pp. 1450–1469), presents a bioinspired complimentary metal-oxide semiconductor (CMOS) current-mode polarization imaging sensor based on the compound eye of the mantis shrimp. The work presented in the paper has important implications for applications such as noninvasive neural recording, tissue evaluation, and tumor detection.

Timothy York is an IEEE Member and assistant professor with the Department of Electrical and Computer Engineering at Southern Illinois University, Edwardsville, IL, USA. Samuel B. Powell is a Ph.D. student with the Department of Computer Science and Engineering, Debajit Saha is a postdoctoral fellow with the Department of Biomedical Engineering, Samuel Achilefu is director of the Optical Radiology Lab, Spencer P. Lake is an assistant professor with the Department of Mechanical Engineering and Materials Science, Baranidharan Raman is an assistant professor with the Department of Biomedical Engineering, and Viktor Gruev is an IEEE Senior Member and associate professor with the Department of Computer Science and Engineering at Washington University, St. Louis, MO, USA. Lindsey Kahan is a research assistant with the Washington University School of Medicine, St. Louis, MO, USA. Shenkui Gao is an electrical engineer with Apple, Inc., Cupertino, CA, USA. Tauseef Charanya is a management consultant with Boston Consulting Group, Toronto, Canada. Nicholas W. Roberts is director of research with the School of Biological Sciences at the University of Bristol, Bristol, UK. Thomas W. Cronin is a professor with the Department of Biological Sciences at the University of Maryland Baltimore County, Baltimore, MD, USA. Justin Marshall is a professor of neuroscience and marine biology at the Queensland Brain Institute, University of Queensland, Brisbane, Australia.

The grade of IEEE Fellow recognized exceptional distinction in the profession. It is conferred by the IEEE Board of Directors upon a person with an extraordinary record of accomplishments in any of the IEEE fields of interest. The total number of IEEE Fellows elevated in any one year must not exceed one-tenth of one percent of the total voting membership of the IEEE on record as of 31 December of the preceding year. In 2016, 297 IEEE Fellows were elevated. To learn more about the Fellow program or to nominate, visit: www.ieee.org/fellows.

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University of Queensland
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for contributions to software tools for high performance, parallel, and distributed computing

**Vassilios Agelidis**
University of New South Wales
Sydney, NSW, Australia
for contributions to power electronics, renewable energy conversion and integration with electricity grid

**Kiyoharu Aizawa**
University of Tokyo
Tokyo, Japan
for contributions to model-based coding and multimedia lifelogging

**Ozgur B. Akan**
Koc University
Istanbul,Turkey
for contributions to wireless sensor networks

**Alin Albu-Schaeffer**
Technical University Munich
Oberpfaffenhofen-Wessling, Germany
for contributions to compliant and lightweight robots

**Massimo Alioto**
National University of Singapore
Singapore, Singapore
for contributions to energy-efficient VLSI circuits

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GE Global Research
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for contributions to dynamic security assessment and load forecasting in power systems

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University of Minnesota
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Lancaster University
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for contributions to neuro-fuzzy and autonomous learning systems

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Osaka University
Osaka, Japan
for contributions to micro manipulators and sensors, and applications to cellular biology

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University of South Florida
Tampa, FL, USA
for contributions to spectrum sensing in cognitive radio networks

**David Atienza**
EPFL- École polytechnique fédérale de Lausanne
Lausanne, Switzerland
for contributions to design methods and tools for multiprocessor systems on chip

**Ronald Azuma**
Intel Laboratories
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General Motors Global R&D
Detroit, MI, USA
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for contributions to multimedia data hiding and forensics

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for contributions to the development of novel devices for low power applications

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for development of electromagnetic sensors and actuators for automotive applications

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for application of robust optimization to power systems

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for contributions to evolutionary optimization

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for leadership in the technology and standards for rectifier, inverter and harmonic-mitigating transformers

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for contribution to circuits and architectures for power-efficient microprocessors

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for contributions to modeling signal and power integrity in 3D integrated circuits

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for contributions to III-V light emitter technology

**Hitoshi Kiya**
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for contributions to filter structure, data hiding, and multimedia security

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for contributions to sensors and instrumentation for high-speed imaging applications

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for contributions to the development of wide bandgap semiconductor laser diodes and ultraviolet LEDs

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for contributions to theory, simulation and software development for industrial plasma

**Avinoam Kolodny**
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for contributions to VLSI design and automation tools

**Danica Kragic**
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for contributions to vision-based systems and robotic object manipulation

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for leadership in laser science and technology

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for contributions to the technology of multi-antenna wireless communications

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for contributions to development and characterization of bulk multiple-gate field effect transistors

**Inkyu Lee**
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Seoul, Korea
for contributions to multiple antenna systems for wireless communications

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for leadership in parallel and distributed computing

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for contributions to the analysis and modeling of integrated circuits and systems

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for leadership in development of broadband wireless networks

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for contributions to Petri nets and their applications to automated manufacturing systems

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for contributions to power conversion for lighting and sustainable energy

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for contributions to perceptual modeling and processing of visual signals

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for contributions to algorithmic paradigms for database technology

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for contributions to the understanding of magnetotransport effects and magnetization reversal in nanostructures

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for contributions to low-voltage microarchitecture and approximate computing

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for leadership in the development of microwave transducers for biomedical application

**Fa-Long Luo**
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**Jian-Guo Ma**
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for leadership in microwave electronics and RFIC applications

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for contributions to block transmissions over wireless fading channels

**Souvik Mahapatra**
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for contributions to CMOS transistor gate stack reliability

**Gabriele Manganaro**
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for leadership in the design of high-speed converters

**Dimitris Manolakis**
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for contributions to signal processing education, algorithms for adaptive filtering, and hyperspectral imaging

**Jonathan Manton**
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for contributions to geometric methods in signal processing and wireless communications

**Joao Marques Silva**
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for contributions to biomedical microelectromechanical systems

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