IEEE Wireless Power Transfer School at 2021 IEEE Wireless Power Week

Program Agenda
Virtual, June 1 2021

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Near Field WPT

- **Fundamentals of Near Field IPT**

  - **Duleepa Thrimawithana/ Grant Covic**, The University of Auckland, Auckland, New Zealand

  Abstract: Currently, there is a strong drive to electrify the transportation sector as a solution to the environmental and economic impacts of vehicles using internal combustion engines. However, to-date, limitations of battery technologies have hindered the uptake of electric vehicles (EVs). For example, the main drawbacks commonly associated with EVs are the limited range and long charging times, both of which are a direct result of the low energy and power densities of current battery technologies. These issues are further aggravated due to the fact that the EVs need to be plugged-in to refuel, as it can take many hours to fully-charge a depleted EV battery. Although, fast and extreme fast charging systems have been developed and deployed to help EV users refuel in a fraction of an hour, this is achieved at the expense of battery life and user safety. In contrast, wireless charging of stationary and in-motion electric vehicles promises a future where EVs are replenished organically, thus avoiding long charging times, range anxiety and battery degradation. An ubiquitous wireless charging infrastructure, especially one that is bi-directional, can be used to provide grid services, thus not only drastically improving the uptake of EVs, but also supporting grids with high penetration of renewable electricity.

  

  Bio: Duleepa J. Thrimawithana, received his BE in Electrical Engineering (with First Class Honors) in 2005 and his Ph.D. in power electronics in 2009 from The University of Auckland, Auckland, New Zealand. From 2005 to 2008, he worked in collaboration with Tru-Test Ltd. in Auckland as a Research Engineer in the areas of power converters and high-voltage pulse generator design. He joined the Department of Electrical and Computer Engineering at The University of Auckland in 2009 where he currently works as a Senior Lecturer. He has co-authored over 100 international journal and conference publications and holds 18 patent families on wireless power transfer technologies. In recognition of his outstanding contributions to engineering as an early carrier researcher, Dr. Thrimawithana received the Jim and Hazel D. Lord Fellowship in 2014. His main research areas include wireless power transfer, power electronics and renewable energy.

  

  Bio: Grant A. Covic (S'88-M'89-SM'04) is a full professor with the Electrical, Computer, and Software Engineering Department at The University of Auckland (UoA). He began working on inductive power transfer in the mid 90's, and by early 2000's was jointly leading a team focused on AGV and EV charging solutions. He has published more than 200 international refereed papers in this field, worked with over 30 PhDs and filed over 40 patent families, all of which are licensed to various global companies in specialised application fields. Together with Prof. John Boys he co-foundered HaloIPT and was awarded the NZ Prime Minister's Science Prize, amongst others for successful scientific and commercialization of this research. He is a fellow of both Engineering New Zealand, and the Royal Society of New Zealand. Presently he heads inductive power research at the UoA, is directing a government funded research program on stationary and dynamic wireless charging of EVs within the road, while also co-leading the interoperability sub-team within the SAE J2954 wireless charging standard for EVs.

- **An Introduction to MHz IPT**

  - **Paul Mitcheson,** Imperial College London

  Abstract: This tutorial will address the motivation for using higher frequencies for IPT, and investigate the properties and design of the magnetic link at such frequencies. We will then look at circuit

topologies (both inversion and rectification) that are suitable for high frequency operation and provide some examples of systems and applications for which MHz IPT has a role to play.

Bio: Paul Mitcheson received the MEng degree in Electrical and Electronic Engineering in 2001 and the PhD degree in 2005 both from Imperial College London. He is currently Professor of Electrical Energy Conversion in the Control and Power Research Group in the Electrical Engineering Department at Imperial and has research interests in energy harvesting systems, wireless power transfer and power electronics. He is a fellow of the higher education academy and senior member of the IEEE. He was general co-chair of PowerMEMS 2013, held in the Royal Society, London and of Wireless Power Week 2019, held at the IET Savoy Place, London. He sits on the Executive Committee of the UK Power Electronics Centre and is a co-founder of the Imperial College wireless-power spinout, Bumblebee Power Ltd.

- **Fundamentals of Capacitive WPT**
  - **Khurram Afridi**, Cornell University

Abstract: Near-field wireless power transfer (WPT) systems are of two types: inductive, which use magnetic field coupling between conducting coils, and capacitive, which use electric field coupling between conducting plates to transfer energy. For medium-range applications (such as electric vehicle charging), inductive WPT systems have traditionally been preferred. However, capacitive WPT systems have potential advantages over inductive systems because of the relatively directed nature of electric fields, which reduces the need for electromagnetic field shielding. Furthermore, because capacitive WPT systems do not use ferrites, they can be operated at higher frequencies, allowing them to be smaller and lighter. However, there are also challenges associated with capacitive WPT. This talk will cover the fundamentals of capacitance WPT, including the design of couplers, matching networks and high-frequency inverter/rectifiers, and will use results from prototyped systems to highlight the opportunities and challenges associated with capacitance WPT.

Bio: Khurram Afridi received the B.S. degree in electrical engineering from the California Institute of Technology (Caltech) in 1989 and the S.M. and Ph.D. degrees in electrical engineering and computer science from the Massachusetts Institute of Technology (MIT) in 1992 and 1998, respectively. During summers and between degrees he worked for JPL, Lutron, Philips, and Schlumberger. In 1997, he joined the founding team of Techlogix as Chief Technology Officer and became Chief Operating Officer in 2000. From 2004 to 2008 he also led the development of LUMS School of Science and Engineering (SSE) as Project Director, and was appointed Associate Professor and the Werner-von-Siemens Chair for Power Electronics in 2008. From 2009 to 2014 he was a Visiting Associate Professor in the Department of Electrical Engineering and Computer Science at MIT, and from 2014 to 2018 he was an Assistant Professor in the Department of Electrical, Computer and Energy Engineering at the University of Colorado (CU) Boulder. Since August 2018 he is an Associate Professor in the School of Electrical and Computer Engineering at Cornell University. His research interests are in power electronics and energy systems incorporating power electronic controls. He is an associate editor of the IEEE Journal of Emerging and Selected Topics in Power Electronics and the Technical Program Committee co-chair for WoW 2021. Dr. Afridi is a recipient of Caltech's Carnation Merit Award, CU Boulder's Goh Faculty Fellowship, the BMW Scientific Award, and the NSF CAREER Award. He is co-author of five IEEE prize papers.

- **EMC and EMF Safety Issues in Near Field Wireless Power Transfer Systems**
  - **Mauro Feliziani**, University of L'Aquila, Italy

Abstract: The objective of this presentation is to analyze aspects of electromagnetic compatibility (EMC) and electromagnetic field (EMF) safety of near-field wireless power transfer systems. In particular, the next generation of electric vehicles (EVs) equipped with WPT systems is being studied. WPT systems used to wirelessly recharge electric vehicle internal batteries are intentional sources of time-varying magnetic fields in and around electric vehicles. A major concern is therefore the compliance of emitted magnetic fields with EMC and EMF safety standards and regulations, also because the use of traditional magnetic field mitigation technique is not efficient, or can reduce the performance of the WPT systems. Additionally, the use of carbon fiber reinforced polymer (CFRP) for EV bodyshells increases public health concerns as CFRP is quite transparent to the magnetic field. The talk is primarily aimed at advanced models and methods for shielding, field mitigation, coil design, and human exposure. The evaluation of electromagnetic interference (EMI) of active implantable medical devices (AIMDs) in patients inside and outside electric vehicles is also presented. Finally some information is provided on dynamic WPT systems in urban and suburban areas.

Bio: Mauro Feliziani (M'91-SM'00) received the Laurea Degree in Electrical Engineering from Sapienza University of Rome, Rome, Italy, in 1983. From 1987 to 1994 he was with Sapienza University as a Researcher (1987-1992), and Associate Professor (1992-1994). In 1994 he joined the University of L'Aquila, Italy, as Full Professor of Electrical Engineering.

He is the author or co-author of more than 200 peer reviewed papers published in the fields of Electromagnetic Compatibility (EMC) and in electromagnetic field numerical computation. His current research interests include Wireless Power Transfer and Electromagnetic Field Safety. Prof. Feliziani received the Best Paper Award from the IEEE Transactions on Industry Applications - Electrostatics Process Committee 1995, from the EMC Europe Symposium 2000, Bruges, Belgium, and from Wireless Power Week conference, London, UK, 2019. He was also co-author of: Best Student Paper at the IEEE International Symposium on EMC, Honolulu, USA, 2007; Second Best Student Paper at the BEMS Annual Meeting, Cancun, Mexico, 2006; Best Poster Presentation at the IEEE CEFC 2014, Annecy, France. He received the 2020 Kanda Award for the paper with highest citations among all the IEEE Transactions on Electromagnetic Compatibility papers published in the last 5 years (2015-2019), and the 2020 IEEE EMC Society Technical Achievement Award. From 1995 to 2000, he was Associate Editor of the IEEE Transactions on Electromagnetic Compatibility. He was the Guest Editor of a Special Issues of the IEEE Transactions on Magnetics, May 2003; COMPEL, 2008; Energies, 2018; Energies, 2020. Currently he is an Associate Editor of "Electrical Vehicles" in Energies and an Academic Editor for Wireless Power Transfer (Cambridge-Hindawi) journal.

In 1994 he was co-founder of EMC Europe Symposium. He was the General Chair of the EMC Europe Symposium, Sorrento, Italy, in 2002, and of the EMC Europe Workshop, Rome, in 2005. He was the Technical Program Committee Chair of EMC Europe 2012, Rome, Italy. He was the President of the International Steering Committee of the EMC Europe Symposium in 2012-2015. He was the General co-Chair of the EMC Europe Symposium 2020, Virtual Conference.

Far Field WPT – Special Topic on Solar Power Satellite

- **Solar Power Satellite**
  - **Hooman Kazemi**, Raytheon, USA

    Abstract: The advent of a lower cost space launch together with the rise of the new micro/nano-satellites and other novel space vehicle technologies, provide the motivation to explore power and signal transmission through space, using directed energy technologies. The presentation focuses on possible applications that will benefit from wireless power beaming in space using directed energy technologies that span the spectrum from RF to optical wavelengths, allowing to power long-range space vehicles and sensors. The component and systems technologies needed to enable such applications, such as the ultra-compact solid state RF power modules and converters together with some of the optical high power sources, will also be discussed. Additionally the receiver technologies such as RF rectennas and their performance will be analyzed, highlighting options for conformal and low weight receiver architectures.

Bio: Dr. Hooman Kazemi (Senior Member, IEEE) received his B.S, M.S and Ph.D. from department of electrical and electronic engineering at University of Leeds, U.K. He is an Engineering Fellow at Raytheon Intelligence and Space business unit of Raytheon Corporation. He is part of the advanced concepts and technology systems and focus on developing advanced microwave and millimeter wave technologies. Key focus areas is high power directed energy portfolio systems including high power transmitters and high sensitivity receivers to provide new capabilities such as non-lethal repel effects, advanced biometrics, see thru clothing imaging. Another area of work has been high data rate communication using millimeter wave frequency range for multi-Gbps links on moving platforms towards ultra-low size weight and power (SWAP) systems. His recent focus is on developing millimeter wave wireless power systems including high power sources and high efficiency receivers delivering power at long range for a variety of applications. He currently developing high power Rectenna circuits and systems together with a variety of sources to enable stand-off wireless power beaming in various modalities of ground, air and space.. He is also a visiting Professor at the University of Hawaii advanced Wireless center focused on the next generation research into augmented wireless systems. He has published numerously and in receipt of multiple patents in the areas discussed.

- **Recent Advance of Beam Wireless Power Transfer for Solar Power Satellite in Japan**
  - **Naoki Shinohara**, Kyoto University, Japan

    Abstract : In Japan's "Basic Plan for Space Policy", which was established in 2008 and is revised in 2020, a Solar Power Satellite (SPS) is introduced as one of important space technologies and of hopeful national goals. The Japanese government METI (Ministry of Economy, Trade, and Industries) gave a roadmap for the development and implementation of the SPS by the 2050s in consideration with commercial wireless power transfer (WPT) systems as spin-off technology. In this talk, I introduce recent METI's R&D project toward the SPS and recent advance of R&D results, mainly the narrow beam WPT.

Bio: Naoki Shinohara received the B.E. degree in electronic engineering, the M.E. and Ph.D (Eng.) degrees in electrical engineering from Kyoto University, Japan, in 1991, 1993 and 1996, respectively. He was a research associate in Kyoto University from 1996. From 2010, he has been a professor in Kyoto University. He has been engaged in research on Solar Power Station/Satellite and Microwave Power Transmission system. He was IEEE MTT-S Distinguish Microwave Lecturer (2016-18), and is IEEE MTT-S Technical Committee 25 former chair, IEEE Wireless Power

Transfer Conference founder and advisory committee member, IEEE MTT-MGA regional coordinator, URSI commission D vice chair, and Wireless Power Transfer Consortium for Practical Applications (WiPoT) chair. His books are "Wireless Power Transfer via Radiowaves" (ISTE Ltd. and John Wiley & Sons, Inc., "Recent Wireless Power Transfer Technologies Via Radio Waves (ed.)" (River Publishers), and "Wireless Power Transfer: Theory, Technology, and Applications (ed.)" (IET), and some Japanese text books of WPT.

- **Overview of Power Beaming and Space Solar**
  - **Paul Jaffe**, Naval Research Laboratory

Abstract: This short course surveys the fundamentals of power beaming and space solar, including: overview and concepts of space solar; energy collection methods (photovoltaics, thermal engines, sun-pumped lasers); power beaming modalities (microwave, millimeter wave, laser, reflection); space solar implementation architectures; space systems design; large space structures and space robotics; phased array antennas, retrodirective beam control, rectenna theory and design; safety, regulatory, and societal issues; application contexts; and space and energy economics.

Bio: Paul Jaffe is an electronics engineer and researcher with over 25 years of experience at the U.S. Naval Research Laboratory (NRL). He has led or held major roles on dozens of space missions and on breakthrough technology development projects for civilian, defense, and intelligence community sponsors, including SSULI, STEREO, TacSat-1, TacSat-4, ORS, MIS, PRAM, CARINA, RSGS, PTROL, S2FOBs, and LEctenna. He was responsible for electrical system and spacecraft computer hardware development. He served as coordinator and editor of two solar power satellite study reports and was the principal investigator for a ground-breaking space solar research effort. His current roles include program management and systems engineering of a portfolio of projects. He serves as a lecturer for the Aerospace Engineering Department at the University of Maryland. He has over 50 journal, conference, and patent publications and is the recipient of numerous awards. Dr. Jaffe has made many international speaking and media appearances, including as a TEDx speaker, on MSNBC, and the Science Channel's "Through the Wormhole with Morgan Freeman." He is also active in educational and STEM outreach. Dr. Jaffe received a Bachelor of Science in Electrical Engineering from the University of Maryland, College Park and a Master of Science in Electrical Engineering at the Johns Hopkins University, graduating with honors. He earned a Ph.D. in Electrical Engineering at the University of Maryland, College Park.

- **Fundamental Technology and Prototype Experiment of MWPT & SSPS in China**
  - **Baoyan Duan**, Xidian University, China

Abstract: This presentation will give a comprehensive introduction about the development of fundamentals, technologies and prototype construction & experiment of microwave wireless power transfer and Space Solar Power Satellite (SSPS) in China. Firstly, the updated OMEGA innovative idea is developed and described in details. Secondly, the corresponding theory and technologies such as high solar energy collection, huge space flexible structural design, overall thermal problem solution, wireless microwave energy transfer and the corresponding transferring antenna and rectenna, and so on. Thirdly, the numerical simulation results of the above points are shown to demonstrate the project. Fourth, the experimental prototype, constructed in Xi'an, China, and experiment are given to demonstrate the updated innovative design project. And finally, the next plan and road map of Chinese development of SSPS are given too.

Bio: Baoyan Duan has been Academician of Chinese Academy of Engineering (CAE) (2011), President of Xidian University (XDU), Xi'an, China (2002 - 2012) and Full Prof of Electromechanical Egging, XDU, China. He received the B.S., M.S., and Ph.D. degrees in Electromechanical Engineering from XDU in

1981, 1984, and 1989 respectively. From 1991 to 1994, he studied as Postdoctoral Fellow at Liverpool University, U.K. and worked as Visiting Scientist at Cornell University, Ithaca, NY, in 2000. He is currently a full Professor in the School of Electromechanical Engineering at XDU where he founded the research institute on mechatronics about electronic equipment design. He is Chair of antenna industry alliance (AIA) of China, Chair of Electromechanical Engineering Society of China. He is Fellow of International Engineering and Technology (IET) and Chinese Institute of Electronics (CIE), Members of International Society for Structural and Multidisciplinary Optimization (ISSMO). He serves as editor-in-chief of Electromechanical Engineering of China, editor-in-deputy chief of Chinese Journal of Electronics, the Section editor in chief of CAE flagship magazine <ENGINEERING> and the editors of more than 10 other academic journals. His has been dedicating himself in research of electromechanical engineering and opened new area of electromechanical coupling (EMC) theory among electromagnetic, structural deformation and temperature fields of microwave electronic equipment (MEE). He has made known the influence mechanism (IM) of nonlinear mechanical parameters on electronic performance of MEE and developed the integrated design methodology of MEE based on EMC and IM. The above results have been successfully applied in national major engineering projects such as the deep space exploration, the Shenzhou spacecraft, the “Tiantong No.1”- space deployable antenna and so on, As the Chief Design Engineer, he led to design and was involved to implement an innovative dynamic-high-accuracy-positioning and ultra-light-weight design of feed-cabin-cable supporting system for the five hundred meters aperture spherical radio telescope (FAST500), which is in operation since 2016 and many new planets were observed for the first time. He was invited to give a keynote speech on this achievement at EuCAP’2018 in London.

He has published 200 papers and six books, authorized 40 patents of invention. He has received, as the first author, the 1st prize of national award for science and technology progress of China (STPC) 2020, and the 2nd prize of national award for STPC three times (2004, 2008 and 2013). In 2009, he was selected as science Chinese person. In 2012, he was issued Hong Kang HLHL prize of science and technology progress. In 2017, he received award for outstanding scientific and technological achievement from Chinese Academy of Science and the golden prize of “good design” of China. In 2018, he received the life achievement award from Asian Society of Structural and Multidisciplinary Optimization.

Emerging Technologies

- **WPT Patent Landscape**
  - **Fritz M. Fleming**

Abstract: On January 1, 2013, the United States Patent and Trademark Office (USPTO) moved from using the United States Patent Classification (USPC) system to the Cooperative Patent Classification (CPC) system, a jointly developed system with the European Patent Office (EPO). CPC has now been adopted by many countries throughout the world. This short course will provide an introduction to the Cooperative Patent Classification (CPC) system and where various WPT technologies are classified. The evolution of WPT patent classification will be discussed with an emphasis on the advantages of using CPC, as well as differences between CPC and IPC (International Patent Classification) used by WIPO (World Intellectual Property Organization). In CPC, WPT is primarily classified in H02J50, and each of the subgroups will be introduced, as well as a few areas outside of H02J50. Finally, to round out the WPT patent landscape, a graphical representation of patent publication trends will be considered. The end goal is not to make the audience an expert in patent classification, but to make the audience aware of the relevant areas of CPC for WPT.

Bio: Fritz M. Fleming is a registered patent agent working as a patent consultant with Henry Feiereisen LLC based in New York City, a well-established intellectual property services firm founded in 1983, specializing in the representation of German speaking clients in all phases of the patent prosecution process. Before becoming a registered patent agent, Fritz was on active duty with the United States Air Force at Hill AFB, Utah as an F-16A Instrumentation Engineer from 1985-1990. Fritz then joined the United States Patent and Trademark Office (USPTO) as a patent examiner in 1991, where he worked until he retired in 2019. While at the USPTO, Fritz primarily examined power distribution technologies (USPC 307, now CPC H02J), seeing his first WPT application in 1992. Over the decades to follow, the number of WPT filings steadily increased and he became very interested in WPT and saw the various WPT technologies and applications evolve during his tenure at the USPTO. In 2014, he went to the EPO in Munich as part of a USPTO delegation to discuss the switch from USPC to CPC and the need for a more detailed classification of WPT given the rapidly increasing filings in WPT. Fritz also served as a Quality Nominee (QN) and worked with EPO counterparts to make major revisions to the H02J schedule in CPC, including the addition of new subgroups for WPT in H02J50. During his time at the USPTO, he examined over 1600 patent applications, with over 160 of those being WPT related. He also taught WPT technology and classification to fellow examiners and the contractor responsible for re-classifying a large portion of WPT patent documents in H02J. He reviewed the work of many junior patent examiners and performed quality control over random samples of the contractor's reclassification work. While at the USPTO, Fritz also served as an advanced technology analyst in the United States Air Force Reserves at the Defense Intelligence Agency. Fritz graduated from Southern Methodist University, Dallas, Texas, in 1985 with a BSEE (Summa Cum Laude, Tau Beta Pi, and Eta Kappa Nu) and minors in German and Applied Mathematics. He has a Master of Science Degree in Physics from the University of Utah, Salt Lake City, Utah (1990). Fritz also graduated from Squadron Officer School, Maxwell AFB, Montgomery, Alabama (1989). He currently lives in rural Virginia on a small farm with his wife and daughters.

- **Commercially Viable Long-Range Wireless Power Transmission Technology**
  - **Greg Kushnir,** EMROD

Abstract: Emrod has developed a world-first commercially viable long-range wireless transmission system using beam shaping, metamaterials, and rectenna technology. The initial pilot system has been developed in partnership with PowerCo, New Zealand's second-largest power distributor. Emrod's system is designed to replace power line infrastructure in applicable use cases. Greg Kushnir,

Founder and CEO of Emrod, will present Emrod's developments in the WPT field and the results of their pilot projects.

Bio: Greg Kushnir, Founder and CEO of Emrod, is an experienced founder and serial tech entrepreneur who has been inventing and commercializing tech for over 15 years. Greg specializes in Disruptive Innovation, Rapid Prototyping, and Technology Commercialization, with a proven track record of identifying disruptive technologies and business models and successfully taking them from inspiration to creation. He is passionate about developing technology and infrastructure that advances society and brings about positive change.

- **Analysis and Benefits of GaN in High Frequency Applications**
  - **Paul Wiener,** GaN Systems

Abstract: The last cord to cut is power. We did it with our phones moving from landline to IP or mobile phones and with Internet connectivity from dial-up to Wi-Fi. There is a lot of excitement and commitment to bring wireless power mainstream. But one thing remains clear the current low frequency wireless power transfer (WPT) technology is low power, slow charging and low efficiency – this will not advance the market. What is needed is high power, fast charging, high efficiency, drop-and-charge placement, multi-device charging flexibility with power levels suitable for all markets and gallium nitride (GaN) power transistors can deliver this.

Applications getting attention and penetrating the market include robots, drones, ebikes, power tools and medical devices. In this workshop, Paul Wiener of GaN Systems will give an overview of wireless power today and will go into detail on the limitations of WPT1.0, the wireless power user requirements, and the need to move to WPT2.0, and how GaN transistors are enabling these higher power level applications. Paul will lead an interactive workshop where attendees will come away with a better understanding of gallium nitride, its importance in wireless power and the reliability of the technology, the GaN market and where the primary growth will occur in the next several years.

Bio: Paul Wiener is GaN Systems' Vice President of Strategic Marketing. Prior to joining GaN Systems, Paul led the power magnetics business unit at Eaton. Paul brings more than 25 years' experience in operations, sales and marketing, and business development. His experience includes vice president of sales at Fultec Semiconductor Inc. and several management roles at Genoa, BroadLogic, and Raychem. Paul earned his MBA from Golden Gate University and his bachelor's degree in business from the University of California at Berkeley.

Workshop for Novel Compact Size Single and Multi-bands DGS Resonators for Wireless Power Transfer, and Energy Harvesting

- **Coupled Defected Ground Structures Resonators Principles and Applications**
  - **Adel Bedair,** Egypt-Japan University of Science and Technology, Alexandria, Egypt.

Abstract: This presentation introduces a novel technique for high efficiency and compact size wireless power transfer (WPT) systems. These systems are based on coupled defected ground structure (DGS) resonators with high quality factor, the DGS resonator is loaded by chip capacitors for miniaturization. Simulated electric field and magnetic field intensity within a DGS structures will be presented. Procedures for DGS equivalent circuit extraction using approximate quasi-static modelling will be developed. The theory for realizing the coupling matrix using coupled DGS resonators will be detailed. An analytical design procedure is then developed to calculate the optimum design parameters for a proposed WPT system. Performance improvement of different types of filters using DGS Structures, including 3D DGS coupled resonator filter will be reviewed. Different shapes of DGSs (H-shape and semi-H-shape) are proposed. The semi-H-shaped DGS realizes larger inductance value, and this results in higher WPT efficiency. Instead of using an inductive-fed resonant coupling, we propose capacitive-fed resonant coupling, which reduces the design complexity and enhances the efficiency further. The optimized structures are fabricated and measured. The simulation and measurement results are in good agreement. The proposed semi-H-shaped DGS WPT system has a peak efficiency of 73% at a transmission distance of 25 mm.

Bio: Adel B. Abdel-Rahman is currently a Professor at the Department of Electronics and Communications Engineering, Egypt-Japan University of Science and Technology, Alexandria, Egypt. He received his B.S. and M.S. in Electrical Engineering, Communication, and Electronics from Assiut University, Egypt, and his Dr.-Ing. degree in Communication Engineering from Otto von Guericke University, Germany in 2005. Since October 2006, he has been an Assistant Professor at the Electrical Engineering Department, South Valley University, Qena, Egypt. He has published more than 120 refereed journal and conference papers and has two patents. He was the Executive Director for Information and Communication Technology, South Valley University, from 2010-2012. Since October 2012, he joined the School of Electronics, Communications and Computer Engineering, Egypt-Japan University of Science and Technology (E-JUST), Alexandria, Egypt, and has been the Dean of the Faculty of Computers and Information, South Valley University from 2016-2018. His research interests include the design and analysis of antennas, filters, millimeter-wave devices, WPT, and metamaterials and their application in wireless communication, as well as optimization techniques with applications to microwave devices and antenna arrays.

- **Design of DGS WPT Systems Using Iterative Optimization Techniques**
  - **Sherif Hekal,** Shoubra - Benha University, Cairo, Egypt.

Abstract: This presentation introduces a new design for wireless power transfer (WPT) systems using asymmetric structures for the transmitter (TX) and the receiver (RX), where the TX/RX are constructed using spiral-strips defected ground structure (DGS) resonators. The spiral-strips DGS resonators overcome the problem of low self-inductance that encountered by conventional resonators, so that the presented WPT system has better efficiency and higher power transmission distance. These systems can be used in wireless charging applications for the biomedical implants and the portable electronic devices (mobile phones, laptop, etc.) that need compact RX structure irrespective of the area of the TX embedded in an external charging pad.

Bio: Sherif Hekal is currently an Assistant Professor at the Department of Electronics and Communications Engineering, Faculty of Engineering at Shoubra - Benha University, Cairo. He received his B.Sc. and M.Sc. degrees in Electrical Engineering from the same university in 2007 and 2012, respectively. He received his Ph.D. from the Egypt-Japan University of Science and Technology (E-JUST) in Electronics and Communications Engineering in 2016. As part of his PhD program, he spent time at the Faculty of Information Science and Electrical Engineering, Kyushu University, Fukuoka, Japan. Dr. Hekal also worked as a communications engineer at Motorola Co. Ltd. and Nokia Siemens Networks in the field of 2G/3G RF optimization. His research interests include RF/microwave applications, antennas, wireless power transfer, and energy harvesting systems.

- **Dual-band Rectenna Using Voltage Doubler Rectifier and Four-Section Matching Network**
  - **Ahmed Allam, Mohamed Ali,** Egypt–Japan University of Science and Technology, Alexandria, Egypt.

Abstract: This presentation introduces the design, fabrication and measurement results of a dual-band rectenna with maximum measured conversion efficiency of 63% and 69% at f1 = 1.95 GHz and f2 = 2.5 GHz, respectively over wide band of the input power, 14 and 15.5 dBm for conversion efficiency above 50% at f1 and f2, respectively with RL = 1KΩ. In addition, a dual-frequency band low input power rectenna will be presented. The rectenna comprises a cpw rectifier integrated with rectangular split ring antenna loaded by spiral strip line. Single diode series connection topology is used to miniaturize the losses at low input power. Spiral coil in addition to two short circuit stubs are used as a matching network for maximum power transfer between the antenna and the rectifying circuit. The rectifier is optimized and fabricated, then integrated with the antenna to introduce the proposed rectenna. The proposed rectenna operated at low input power with relatively high measured RF-DC conversion efficiency up to 74% at −6.5 dBm at the first resonant frequency f1 = 700MHz and 70% at −4.5dBm at the second band f2 = 1.4GHz at resistive load of 1.9KΩ. The measured rectenna sensitivity (the rectenna ability to receive low power with acceptable conversion efficiency) reaches up to −20dBm with conversion efficiency of 47% and 36% at f1 and f2, respectively and dc output voltage of 0.18V. The measured efficiency is over 50% from −18 to −3.5dBm and from −15 to −1.5dBm at f1 and f2, respectively. The antenna, as well as the rectifier circuit, are designed and tested separately. Finally, the matching circuit is designed, and the integration is done on the same PCB substrate.

Bio: Ahmed Allam (S'00–M'04) received the B.Sc. degree in electrical engineering from Alexandria University, Alexandria, Egypt, and the M.Eng. and Ph.D. degrees from the University of Alberta, Edmonton, AB, Canada. From 1994 to 1998, he was an Instrument Engineer with Schlumberger. From 2000 to 2001, he was with Murandi Communications Ltd., Calgary, AB, where he was involved in RF transceivers design. From 2007 to 2008, he was with Scanimetrics Inc., Edmonton, where he was involved in CMOS transceivers design. He is currently an Associate Professor with the Department of Electronics and Communications Engineering, Egypt–Japan University of Science and Technology, Alexandria. His current research interests include the design of RF circuits and systems.

Bio: Mohamed Aboualalaa received the B.S. degree in electronics and communications engineering from Menofia University, Egypt, in 2009, the M.S. degree in electronics and communications engineering from Cairo University, Egypt, in 2014, and the Ph.D. degrees in electronics and communications engineering from the Egypt-Japan University of Science and Technology (E-JUST), Alexandria, Egypt, in 2018. From 2010 to 2013, he was a Research Assistant with the Microstrip Circuits

Department, Electronics Research Institute, Egypt, where he was an Assistant Researcher, from 2014 to 2015. He was a special research student with Kyushu University, Japan, from 2017 to 2018. He has been dispatched to Kyushu University, Japan from 2019 to 2020 as a postdoctoral research fellow in Egypt-Japan Education Partnership (EJEP) program. He is currently an assistant professor at the Electronics Research Institute, Cairo, Egypt. His research interests include microwave planar antennas, reconfigurable antennas, energy harvesting, and wireless power transfer.