FUNDAMENTALS OF INDUCTIVE POWER TRANSFER

Wireless power today is being applied to many developing applications, each of which has different interesting and challenging targets for development that include; gap and misalignment, weight and size, efficiency, thermal management, uni- and bi-directional power flow control and interoperability across various supplier platforms. In high power applications industrial, and electrified transportation have been key focuses for the past two decades, using frequencies from 20-100kHz. For lower power systems such as drones, smart devices and lightweight instrumentation or appliances much higher frequencies are often of interest.

Wireless technologies help overcome barriers that other wired solutions simply cannot. For example, 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) particularly for medium and heavy duty fleets. 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.

The school will start with a brief discussion on the history of wireless power transfer (WPT) technology. Subsequently, the fundamental operating principles of an inductive power transfer (IPT) system will be presented. Commonly used compensation networks, power electronics converters and magnetic designs will be then reviewed. This will be followed by a discussion on a few applications of IPT technology, with a special focus on wireless electric vehicle (EV) charging. A summary of developments to-date on both stationary and dynamic EV charging will be presented. WPT can also be used as a power delivery method in other applications, particularly in dirty or dangerous environments, e.g. industrial, medical and supply chain, space, light transport etc. As such other applications will be discussed where light weight is extremely important, along with Multi MHz approaches that can be useful in achieving low weight, and basic magnetics and circuit design for MHz IPT.

Some design examples will be provided that can be validated using LTspice and Ansys Maxwell simulation models. Participants post school, should continue to supplement their understanding using free software such as - LTspice and Ansys Electronics Desktop Student .to evaluate circuits and magnetics.

Speaker's Bio:

Duleepa J. Thrimawithana (M'06-SM'18), is an Associate Professor at the University of Auckland. He 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, Computer, and Software Engineering at The University of Auckland in 2009. He has co-authored over 100 international journal and conference publications and holds 24 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.

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 in the 2000's began focusing 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 leading the interoperability sub-team within the SAE J2954, J2954/2 and J2954/3 wireless charging standards for light, medium, heavy and dynamic power transfer to EVs.

Paul D. Mitcheson (Senior Member, IEEE) received the M.Eng. degree in Electrical and Electronic Engineering and the Ph.D. degree in Micropower Motion Based Energy Harvesting for Wireless Sensor Networks from Imperial College London, London, U.K., in 2001 and 2005, respectively. He is currently a Professor in Electrical Energy Conversion with the Control and Power Research Group, Electrical and Electronic Engineering Department, Imperial College London. His research interests include energy harvesting, power electronics, and wireless power transfer to provide power to applications in circumstances where batteries and cables are not suitable. His research has been supported by the European Commission, Engineering and Physical Sciences Research Council, and several companies. Prof. Mitcheson is a fellow of the Higher Education Academy and is on the Executive Committee of the U.K. Power Electronics Centre. He was the General Co-Chair of IEEE

Wireless Power Week in 2019 in London, U.K. and is chair of IEEE PELS TC-9, Wireless Power.