EDITORIAL
WIRELESS POWER TRANSFER TECHNOLOGY AND EV APPLICATION

Transmitting electricity from one source to another passive electric element without having a wire or cord is an innovative concept, though practical demonstrations have been recent achievements in science and technology. The experiment at Wardenclyffe Tower, located Long Island during 1900-1906, was an astonishing challenge, as we recall it was Nikola Tesla's million-dollar folly. Started from the mathematical model on magnetic field by Jean-Baptiste Biot (1774-1862), we remember many scientists in magnetic field studies, like Andre Marie Ampere (1775-1836), Carl Friedrich Gauss (1777-1855), Michael Faraday (1791-1867), Joseph henry (1799-1878), William Weber (1804-1891), James Clerk Maxwell (1831-1879), and Nikola Tesla (1856-1943).

Over the last century until early 2000, we have observed sporadic developments in wireless energy transfer in two main streams: microwave beam radiation and electromagnetic induction coupling. Recently Marin Soljacic, a professor at MIT, successfully formulated the power transmission between resonant circuits as an extension of microwave beam radiation, called as a resonant magnetic coupling in 2006. He demonstrated lightening up a 60W bulb from the distance of 1.8 m with the transmission efficiency of 40% applying 10 MHz AC electricity. It should be noted that the patent filed by John Boys, a professor in Auckland University, New Zealand, in 1988, also provided the inductive power transfer technology development.

In 2009, KAIST, a university specialized in science and technology, Korea, announced about OLEV (on-line electric vehicle) or wireless charged electric vehicle while in motion with the transmission efficiency of more than 80% with the air gap distance of 15 cm applying 20 kHz AC electricity. The fundamental principle of this approach has been named as the "Shaped Magnetic Field in Resonance" (SMFIR) by the project group in 2010. One of the important elements in the fundamental principle is to design or optimize the magnetic field between two resonance circuits in order to achieve better performance of wireless power transmission, which proved the feasibility of applying wireless power transfer technology to EV charging either in motion or at stationary. Continuing research effort in 2010 showed with the transmission efficiency of more than 80% at an air gap of 20 cm, while meeting general guideline of maximum permissible EMF (Electric Magnetic Field) exposure level to human body. KAIST announced the first successful commercial launch of OLEV in 2011, as highlighted in CNN Eco Solutions in August.

In industry, the Wireless Power Consortium (WPC) was created in 2008 as a leading role of industrial standards effort focused on inductive wireless power transfer technologies, which is having more than 50 members. Initially their focus was about the interoperability standards for low power consumer electronics devices, while their roadmap indicates expanding the standards for larger and high power mobile electronics and other applications. The following Table 1 shows a summary of current application status of wireless power transfer technologies by several companies.

In electric vehicle (EV) application of wireless power transfer technology, it is worthwhile to note the standards activity by the SAE International as a working group of on-going effort of developing SAE J2954 (tentative). Its roadmap claims that the standard of interoperability and charging EV will be

developed considering the intended applications to personal home garage, public roadside and on-road dynamic charging until 2015.

OLEV system referred above opened up the opportunity to introduce the EVs into the market massively and promptly by emphasizing the safety and convenience in customers' perspective, practically applicable efficiency level, lesser cost to the EV owners and business-competitive to other available technologies.

Table 1 A summary of applications of the wireless power transfer technology

	Railway	Roadway	Mobile Devices	TV	Mid-Range Power Transfer
List of companies	Bombardier Alstom Ansaldo STS	KAIST Conductix-Wampfler Hino Nissan	Palm Pre Touch stone Powermat iPhone with charge Qualcomm eZone	Haier-WiTricity Sony Samsung	WiTricity Intel WREL
Power capacity	~100 kW	~100 kW	~1 W	~10 W	-
Distance	~1 cm	~10 cm	~1-10 cm	~10 cm	~1 m

Yet, however, the challenges to the new technology are not a few, in addition to relatively slow pace of customers' acceptance and market penetration since it is related with the infrastructure of power supply system. The convergence movements of integrating vehicle, infrastructure and IT technologies, including smart grid strategy, are in positive direction toward the earlier adoption of the new technology.

While introducing wireless power transfer technology based upon SMFIR principle to the public, numerous questions were asked about any adverse effect on human body by electric magnetic field (EMF). The reference levels for general public exposure to time-varying magnetic field in unperturbed rms values are specified as 270 mG in the frequency range between 3 kHz and 10 MHz, as recommended by ICNIRP (International Commission on Non-Ionization Prevention) in 2010. KAIST OLEV technology demonstrated meeting the reference levels of EMF exposure limit with only passive shielding techniques, while KAIST developed active cancellation techniques as well.

While those technological challenges include EMI/EMC and EMF exposure, codes and regulations, and global collaboration in standards and interoperability discussions, the basic performance studies such as transmission efficiency, positioning allowance, supporting multiple devices, and identification and authentication issues are yet in strong research and development phase.

In this special edition of Journal of Integrated Design and Process Science, a couple of papers are introduced which covered application examples of KAIST OLEV technology, which is considered as an innovative invention in wireless power technology on the EV application. Earlier massive launch of EVs into the market with customers' acceptance will contribute to lower CO_2 generation and lesser burning of fossil fuels on global basis, I do believe.

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