Current Research and Development of Wireless Power Transfer via Radio Waves and the Applications at Kyoto University and in Japan

Naoki Shinohara
Kyoto University, Japan

Abstract:
A wireless power transfer (WPT) technology is considered as one of game changing technologies, which is the same as a wireless communication about hundred years ago. Both the WPT and the wireless communication are based on the same theory, Maxwell’s equations, and technologies. Only a difference is that radio wave carrier is used as energy itself for the WPT and is used as only carrier of information for the wireless communication. The WPT has a long history from an experiment by Nicola Tesla about 115 years ago. In 1960s, there were a lot of field WPT experiments in the world[1]. Recently, various WPT research and development are increased because of requirement of enhancement of convenience of a mobile with battery and an electric vehicle.

There are some kinds of the WPT, such as an inductive short-range WPT with magnetic field, a resonance coupling WPT with L and C resonance, and a long distance WPT via radio wave, especially via microwave. We, Kyoto University, focus on the WPT via microwave (WPT) and carry out a lot of WPT R&D from 1980s. We can classify the MPT to 1) a beam-type MPT with high beam efficiency, 2) a ubiquitous-type MPT to multi-users like the wireless communication, 3) an energy harvesting from broadcasting radio waves, and 4) MPT in closed space. In this paper, I show the current MPT R&D at Kyoto University and in Japan as follows;

1) Beam-type MPT with high beam efficiency
For the beam-type MPT, a high gain antenna is required to concentrate the microwave energy to one receiving antenna. In order to increase the beam efficiency, which is defined as ratio of a transmitted microwave power from a transmitting antenna and received microwave power at a receiving antenna. Additionally, a beam forming technology with a phased array and a target detecting technology are important for the beam-type MPT, especially for the MPT to a moving user like a drone and an electric vehicle. On February, 2015, two field experiments of beam-type MPT with a phased array were carried out as a governmental project whose aim is a Solar Power Satellite/Station (SPS). J-Space Systems conducted the projects which was supported by METI (Ministry of Economy, Trade and Industry) from 2009 with Japanese company of Mitsubishi Electric Corporation, Mitsubishi Heavy Industries,
Ltd., and IHI Aerospace. This project was corporative project with JAXA (Japan Aerospace eXploration Agency). One was a MPT field experiment with thin and high efficiency phased array with GaN transmitters. Frequency was 5.8GHzCW. Mitsubishi Electric Corporation developed a new phased array only with 2.5cm thickness with 70% efficiency of HPA with GaN. IHI Aerospace developed a large rectenna, rectifying antenna, array to receive the microwave from the phased array at 55m distance. The other was a MPT field experiment with magnetron phased array with 2.45GHz at 500m distance by Mitsubishi Heavy Industries, Ltd.

We, Kyoto University, has developed a wireless charger for a mobility scooter and for a nursing-care robot with 2.45GHz in 2015. A microwave beam can be chased to a moving user. Unexpected microwave power and interference is extremely suppressed in these MPT system.

2) Ubiquitous-type MPT to multi-users

On July, 2015, we, Kyoto University, carried out a demonstration experiment of a wireless power supported sensor by using a flying drone (multi-copter). The multi-copter carried a 5.8GHz microwave transmitter and the microwave power from the multi-copter drive the sensor on ground. An aiming of the MPT experiment is battery-less sensors near volcano, rescue and finding system of victims, and automatic measurement system of infrastructure. Some R&D of the ubiquitous-type MPT for sensors in Japan will be introduced in the presentation.

3) Energy harvesting from broadcasting radio waves

In 2015, Prof. Kawahara of University of Tokyo joins a new venture company ‘SenSprout’ of a battery-less moisture sensor with an energy harvesting from broadcasting waves. His aim is to promote IT agriculture with the WPT technology. The other Japanese group is developing low power IC and supporting energy harvester. At Kyoto University, broadband rectenna was developed.

4) MPT in closed space

NICT (National Institute of Information and Communications Technology) promotes ‘surface WPT and wireless communication’ in which a radio wave is transmitted within 2-simentional sheet-type waveguide. The surface WPT is discussed as the first Japanese MPT regulation. We, Kyoto University, carried out a wireless building with microwave power without any wire in the building with Japanese building company. The microwave is transmitted only inside pipes behind floor and wall instead of the
In the presentation, I also introduce activities of scientific society and of standardization of the WPT in the world.