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Special Reports

Wireless Power Transfer/Transmission Technologies

Wireless Power Transfer/Transmission Creating Novel Social Infrastructures
KIKUMA Nobuyoshi

Efforts toward Practical Use of Wireless Power Transfer/Transmission Technologies
SHOKI Hiroki
Wireless power transfer/transmission (WPT) technologies have been attracting considerable attention in recent years for application to charging and power supply functions for home appliances, electric vehicles (EVs), and other electric systems and devices. With this trend as a background, the Broadband Wireless Forum (BWF), which was established in 2009 in Japan, has formulated a scenario for the commercialization of WPT technologies. In particular, a wireless EV charging system is scheduled to be commercialized in 2015. In order to realize the practical use of WPT technologies, however, various institutional and regulatory issues remain to be resolved including frequency allocations for WPT, WPT-related regulations, guidelines for protecting the human body from radio frequency (RF) exposure, and standardization, as well as the development of WPT technologies themselves.
To overcome these issues, Toshiba is actively promoting the practical application of WPT in cooperation with related organizations as well as the research and development of its technologies.

Kilowatt-Class Wireless Power Transfer/Transmission System for Contactless Charging
OTAKA Shoji / MOCHIKAWA Hiroshi
In order to apply wireless power transfer/transmission systems to battery chargers for electric vehicles (EVs), it is necessary to increase the power transfer distance of the system and to reduce the weight of the power receiver installed in the EVs so as to respectively ease the requirement for a precise parking position when charging the vehicle and enhance the driving distance per charge.
Toshiba has been developing a kilowatt-class wireless power transfer/transmission system for contactless EV charging using a magnetic resonance technology to realize long-distance power transfer and a solenoid coil to realize light weight and high power-transfer efficiency. Experiments on a prototype wireless power transfer/transmission system, which operates in constant-current mode, have confirmed that it achieves a power transfer of 1 kW with an efficiency of 83.2% at a transfer frequency of 120 kHz and a transfer distance of more than 200 mm.

Wireless Communication Technology for Control of Wireless Power Transfer/Transmission System
OBAYASHI Shuichi / KUDO Hiroki
Users of electric vehicles (EVs) and plug-in hybrid EVs (PHEVs) find it troublesome to charge the battery using connecting cables. As a solution to this issue, kilowatt-class wireless power transfer without any charging cables is under consideration to accelerate the dissemination of EVs and PHEVs.
Toshiba has developed a wireless communication technology for EVs and PHEVs to achieve stable control of wireless power transfer even when load impedance fluctuations occur. With this technology as a basis, we are actively participating in standardization activities for wireless communication between EVs and PHEVs and wireless chargers, as a member of related domestic and overseas organizations including the Society of Automotive Engineers (SAE International) and the International Electrotechnical Commission (IEC).

Magnetic Resonance Type Wireless Power Transfer/Transmission Technology for Small Devices
USAMI Yutaka / KATO Masakazu / ODACHI Noriaki
Wireless power transfer is attracting attention as a technology that offers a convenient style of charging electric devices by simply placing them on a charger, eliminating the need to plug them in to a power supply. Wireless power transfer using the magnetic resonance method has the advantage that power can be transferred to relatively distant locations. In the case of small devices, however, although relatively short transfer distances are usually sufficient, there is demand for larger tolerance of charger setting positions.
Toshiba TEC Corporation has developed a wireless power transfer/transmission technology for small devices by customizing the magnetic resonance method to provide a short-distance power transfer range of within a few centimeters. As the inductive coupling coefficient remains at around 0.1 to 0.3 due to the distances involved, it is possible to design a multi-resonant circuit satisfying the power transfer requirement by taking the tendency of this inductive coupling coefficient into consideration. By applying simulation, we have developed a solution to derive the applicable range from the coil distance, load, and circuit resonance conditions.

Wireless Power Transfer Circuit with High-Frequency Magnetic Resonance
ISHIDA Masaaki / KANEKIYO Yasuhiro / ABE Bunichiro
To realize a long-distance wireless power transfer/transmission system, circuit miniaturization, enhancement of efficiency, measures against interference with other wireless systems, and reduction of spurious emissions in accordance with legal restraints are required.
Toshiba has developed a wireless power transfer circuit with a 13.56 MHz magnetic resonance, by applying a high-frequency inverter system to the power transfer circuit and fast-switching devices to the power receiving circuit. The new wireless power transfer circuit achieves a total efficiency of electric power transfer of 67% and a 60 dBc reduction in spurious emissions.

Feature Articles

DR Optimization Technology with Flexibility to Respond to Demands of Multiple Buildings under Electricity Demand Uncertainty
OTSUKI Tomoshi / AISU Hideyuki / IINO Yutaka
Toshiba has been engaged in the development of technologies for the realization of smart communities to achieve a balance between the electricity demand of individual buildings and optimized energy usage in the community as a whole. As part of this effort, we are developing a clustered building and energy management system (BEMS) technology for comprehensive energy management among multiple buildings, and are now conducting demand response (DR) demonstration experiments in the Yokohama Smart City Project (YSCP), one of the largest smart city demonstration projects in Japan. The clustered BEMS is targeted at reducing the aggregate power consumption of a group of buildings through the development of a power reduction plan (DR plan) consistent with each building and the implementation of that plan.
As one of the basic technologies for the clustered BEMS, we have now developed a DR optimization technology that takes into consideration both the power demand characteristics of individual buildings and electricity demand uncertainty in the region. We have conducted computer simulations and confirmed that the average costs and average number of failures in power reduction at the implementation of DR using this method are lower compared with those using other methods.

Integrated Simulation Technology Maximizing Performance of All-SiC Modules
KIKUCHI Takuo / TAKAO Kazuto / SHINOHE Takashi
Silicon carbide (SiC) power devices with superior performance compared with currently available Si power devices are a focus of high expectations for application to power conversion equipment such as inverters. However, their intrinsic fast switching speed causes serious problems including increases in surge voltages and electromagnetic noise as well as non-uniform operation among parallelized chips, due to undesirable parasitic inductances in the power module.
Toshiba has developed a novel integrated simulation technology for all-SiC modules, allowing these issues related to electrical circuits and electromagnetic and thermal effects to be comprehensively handled. This technology makes it possible to implement more detailed verification and design early in the development phase, thereby contributing to the development of all-SiC modules with optimized performance and shortening of the overall development period.

Miniaturization Technologies for Large-Caliber DD Motor for CT Scanners
YOKOYAMA Akiyuki / SHINDO Yasutaka
There has been an ongoing need in the field of computed tomography (CT) scanners in recent years for both expansion of the inside aperture of the gantry to ease the physical restriction on patients, and downsizing of the equipment to save installation space.
In the Aquilion$_{TM}$ PRIME, a high-end multislice CT scanner released in April 2013 by Toshiba Medical Systems Corporation, miniaturization of the units in the gantry and downsizing of the equipment have been realized by changing the unit layout. Miniaturization technologies for the hollow type large-caliber direct drive (DD) motor, which rotates the X-ray tubes and detectors, played a critical role in the development of the Aquilion$_{TM}$ PRIME. The specifications of the DD motor, including the winding arrangement, and form of the permanent magnets, were optimized to reduce the size to a minimum while maintaining the conventional output level. As a result, the new Aquilion$_{TM}$ PRIME achieves reductions in volume and weight of 34% and 28%, respectively, compared with our conventional models.

Hydrogen Electric Power Storage System Using Renewable Electricity
WATANABE Hisao / KAMEDA Tsuneji / YAMADA Masahiko
With the widespread introduction of renewable energy sources including photovoltaic and wind power facilities in Japan since the Great East Japan Earthquake of March 11, 2011, electricity storage systems have become necessary for load leveling and demand regulation.
Toshiba has been developing a hydrogen electric power storage system, which produces hydrogen using surplus electricity and generates electricity by fuel cells using the produced hydrogen. Through conceptual design of such a system using solid oxide electrolysis cells (SOECs) with high charge and discharge efficiency, we have confirmed that a system using SOECs achieves a system charge and discharge efficiency of 80% and has a cost advantage in the case of large-capacity and long-term electricity storage.

Electrical Equipment for N700A Shinkansen Trains
TERAKADO Yasuhiro / KOIZUMI Satoshi
Toshiba has been actively engaged in technology development as a core manufacturer since the beginning of the Shinkansen project, and has now supplied electrical equipment for the mass-produced N700-1000 series (N700A) Shinkansen trains running on the Tokaido Shinkansen Line of Central Japan Railway Company.
In addition to equipment supplied for the N700 series Shinkansen trains, we have developed new equipment for the N700A Shinkansen including constant speed control equipment that automatically controls the train at a constant speed in response to the speed signal with sufficient accuracy, and main converter/inverter equipment that achieves a reduction in weight of 15% compared with that for the N700 series, in order to realize advanced safety, reliability, riding comfort, and environmental friendliness.

Phased-Array Weather Radar for 3D Observation of Life Cycle of Local Torrential Downpours
MIZUTANI Fumihiko / MASUDA Yasuharu / HANDA Hironori
Sudden and unexpected weather events such as torrential rain and tornadoes are mainly caused by cumulonimbus clouds that rapidly grow in a short time of about 10 to 30 minutes. Weather radars are therefore required to conduct precise three-dimensional (3D) observations of the life cycle of cumulonimbus clouds extending to a high altitude, within a time frame of one minute.
Toshiba has developed a phased-array weather radar for 3D weather observations that is equipped with a phased-array antenna consisting of 128 slotted waveguides, offering high-speed observation with high spatial resolution. By applying a digital beam forming (DBF) technology combined with electronic scanning in the vertical direction, the radar can simultaneously observe an elevation range of 0 to 90 degrees. As a result, it is capable of weather observation within a radius of 60 km and at altitudes up to 14 km with only one horizontal rotation of the antenna, while reducing the time required for observation to only 10 to 30 seconds.

Small Intelligent Gateway Devices for Smart Communities and Industrial Systems
NAKAZATO Junichi / IZUMI Yasuichiro / MATSUZAWA Katsuya
A recent trend in supervisory and control systems in the social infrastructure and industrial fields has been an acceleration in the transition from conventional on-premises systems, whose main functions are processed at the site, to cloud systems, whose main functions are processed at a data center featuring software as a service (SaaS) and scaleout architecture. A cloud system contributes to the reduction of system introduction and operating costs due to centralized administration in the data center, and offers high-value-added services due to cooperation with other systems and big-data mining in the data center.
Toshiba Solutions Corporation has developed the following equipment optimized for cloud systems: (1) a gateway device for linking a data center with sites, and (2) an input and output (IO) device for gathering data on sites. These devices are equipped with scaleout architecture, a remote software update function, and an intelligent function to resist disconnection from the data center. We have also developed a middleware for the development of applications for a distributed system at sites consisting of this gateway and IO equipment. This advanced equipment developed using the comprehensive technologies of the Toshiba Group for the social infrastructure and industrial fields including smart communities offers environmental robustness and long-term supply and support.

CAONS$_{TM}$ 140 Air-Source Circular-Heating Heat Pump with Maximum Output Water Temperature of 90°C
IMATO Naoki / TAKAYAMA Tsukasa / ISHIDA Keiichi
Various types of heating equipment including boilers and electric heaters are used for various heating processes in manufacturing plants. As boilers are often installed at a particular location in a plant, it is necessary to reduce radiative heat losses from the long pipes required to transport heat to the destination, while in the case of electric heaters, it is also necessary to reduce energy consumption.
As a solution to these issues, Toshiba Carrier Corporation has developed the CAONS$_{TM}$ 140 air-source circular-heating heat pump for high-temperature water. The CAONS$_{TM}$ 140 features higher energy efficiency, higher temperature circular-heating water, and compact design, permitting decentralized arrangement near locations where heat is required. Its cascade refrigerating system realizes a maximum output water temperature of 90°C and energy-efficient operation that achieves a 60% reduction in primary energy consumption compared with that of a gas boiler. The footprint of each CAONS$_{TM}$ 140 unit is only 0.29 m^2, allowing to be installed in locations with limited space.

Frontiers of Research & Development

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