

Fundamental Technologies Supporting Power Electronics

Power Electronics Playing Leading Role in Japan's New Revitalization Strategy

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Evolution of Devices Supporting Power Electronics and Expansion of Technologies for Mounting, Circuits, and Application to Products

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With the ongoing introduction of renewable energy systems including photovoltaic power generation systems, whose output tends to vary according to the weather conditions, power generation systems with high efficiency over a wide output range are required. Power transmission systems must also offer high efficiency, in order to minimize energy losses while transmitting electricity from widely distributed power systems to distant power-consuming areas. Furthermore, there is a growing need for energy storage systems to balance supply and demand. On the other hand, to avoid wastage of precious energy, it is also important to make greater efforts to enhance energy conservation.

To fulfill these diverse requirements, Toshiba has been continuously engaged in the development of state-of-the-art power electronics technologies for optimal efficiency of electricity operation in each process from electricity generation through to transmission, storage, and consumption, aimed at the construction of smart communities.

High-Efficiency Power Conditioning Systems for PV Systems

IJIMA Yukihisa / IKAWA Eiichi / TAKAHASHI Nobuhiro

The introduction of renewable energy systems is rapidly expanding both in Japan and around the world, particularly in the photovoltaic (PV) market. In response to a broad range of market needs, the development and installation of various PV power plants, from those with a capacity of tens of kW for public facilities and industrial and commercial facilities to large-scale PV power plants with a capacity of tens of MW, are progressing in various countries. In the field of mega solar plants, both the reduction of current loss by using DC 1,000 V type power control systems (PCSs) and the reduction of the number of PCSs by increasing their unit capacity are spreading into the mainstream. In the field of rooftop PV plants, attention is being increasingly focused on compact PCSs for outdoor use to reduce installation and maintenance costs.

The Toshiba Group has now developed and released a lineup of new PCSs for PV power plants, including models with a capacity of 750 kW and 665 kW in addition to existing models with a capacity of 100 to 500 kW for mega solar plants in the Japanese market, and a 100 kW model for outdoor use to meet the requirements for rooftop PV power plants in the North American market in addition to an existing 500 kW model.

Power Electronics Technologies for Adjustable-Speed Pumped-Storage and Conventional Hydropower Systems

KUSUNOKI Kiyoshi / FUJITA Takashi / YAMAGUCHI Shinji

Toshiba put the world's first adjustable-speed pumped-storage hydropower system into practical use in 1990 applying a high-voltage, large-capacity cycloconverter realized through the progress of power electronics technologies. Since then, we have developed several types of self-commutated inverters for adjustable-speed pumped-storage hydropower systems, including the neutral point clumped (NPC) type and joint reactor type. We have also completed the development of a kW-class adjustable-speed system for conventional hydropower systems and are now developing a MW-class system.

The input power control function in pumping mode and quick response function of these systems contribute to the suppression of frequency and voltage fluctuations caused by renewable energy generation systems, as well as to the effective utilization of hydropower resources by improving efficiency and achieving wide-range operation. We have been promoting the development of adjustable-speed pumped-storage and conventional hydropower systems with higher performance in conjunction with the progress of power electronics technologies.

High-Voltage, Large-Capacity Modular Multilevel Converter for High-Voltage DC Transmission Systems

ARAI Takuro / NAKAZAWA Yosuke / TSUMENAGA Masahiro

High-voltage DC (HVDC) transmission systems are in practical use throughout the world for large-capacity and long-distance electricity transmission. However, the connection of HVDC and existing AC grid systems requires large-capacity AC-to-DC converters with a high voltage in the 100 kV class.

Based on its proprietary multilevel topology, Toshiba has developed a modular multilevel converter (MMC) equipped with three-winding transformers that has good performance for high voltage without the need for ancillary equipment such as filters. This high-efficiency converter makes it possible to reduce the number of passive elements and thus reduces the footprint of the system.

Compact, High-Performance EMI Filter Circuit Facilitating Smart Grid Connection of Power Electronics Devices

TSUDA Junichi / KOYAMA Yushi / HATANO Akira

Inverters offering greater compactness and higher efficiency have been developed in recent years due to the expansion of next-generation devices such as silicon carbide (SiC) and gallium nitride (GaN) power semiconductors, the practical application of Toshiba's proprietary technology called the advanced synchronous reverse blocking (A-SRB) method to drive superjunction metal-oxide-semiconductor field-effect transistors (SJ-MOSFETs) with low loss, and the realization of high-frequency switching. However, high-frequency switching has been accompanied by an increase in electromagnetic interference (EMI) noise. In particular, demand has arisen for EMI countermeasures in line with the widespread dissemination of power electronics equipment such as photovoltaic system converters for home use.

In response to this situation, we have developed a compact, high-performance EMI filter circuit suitable for high-frequency switching. By applying this noise suppression technology, we obtained third-party certification of the eneGoon home storage battery system from the Japan Electrical Safety & Environment Technology Laboratories (JET).

Battery System for Standard Elevators Realizing Energy-Saving Operation and Uninterrupted Operation in Event of Power Outage

OTSUBO Ryo / NOJIMA Shuichi / KOJIMA Daisuke

In order to meet the growing demand in recent years for elevators offering more effective operation even in the event of a power outage, Toshiba Elevator and Building Systems Corporation developed a battery system for the SPACEL-GR™ standard elevator. Applying this battery system, a function for uninterrupted operation in the event of a power outage, called TOSMOVE™, was released. We have now developed the TOSMOVE NEO™ function, which realizes energy-saving operation under normal conditions and improves usability in the event of a power outage while also enhancing user friendliness and comfort.

The battery system for the TOSMOVE NEO™ function, composed of SCiB™ rechargeable batteries with high input/output performance, long life durability, and high safety, makes it possible to reduce power consumption under normal conditions by storing regenerative power and discharging it during powered operation taking the principles of elevator operation into consideration. It also offers new functions in the event of a power outage, including a low-impact operation function that keeps the elevator running smoothly to the nearest floor without stopping and a new service function that allows it to continue running at close to the normal speed.

PMSM Drive System for Rolling Stock Contributing to Improvement of Energy-Saving and Environmental Performance

TASAKA Yosuke / KAWAI Hirotohi / TANIGUCHI Shun

Toshiba has been developing permanent magnet synchronous motor (PMSM) drive systems aimed at realizing rolling stock drive systems with higher energy-saving and environmental performance.

In the field of inverters, we have developed a 4-in-1 traction inverter for PMSMs with higher reliability, as well as smaller size and lighter weight comparable to those of conventional drive systems for induction motors. To enhance energy conservation, we have now developed an advanced inverter incorporating both a low-loss silicon carbide (SiC) device and a highly efficient control method. We have conducted verification tests and confirmed that the newly developed inverter achieves reductions in power consumption and losses compared with conventional inverters using Si devices.

Power Transfer and Receiver Circuit Technologies for 7 kW-Class Contactless EV Charging System

MATSUSHITA Akihisa / TAKEUCHI Fumiaki / ISHIHARA Hiroaki

To avoid troublesome cable handling and improve the ease of use of battery charging systems for electric vehicles (EVs), a contactless power transfer system that does not require any charging cables has been under investigation.

With the aim of realizing contactless EV charging, Toshiba has developed a prototype 7 kW-class contactless EV charging system using a magnetic resonance technology to realize high-efficiency power transfer while also taking the possibility of coil misalignment into consideration. Experiments on a prototype system, consisting of a high-efficiency inverter circuit and a compact, high-efficiency receiver circuit with a volume of only 5.3 L due to the use of high-density packaging, have confirmed that it achieves a power transmission of 7 kW with an efficiency of 89.0% at a transmission distance of 15 cm.

IGBT Module for HEV Inverters Achieving Low Loss and High Reliability by Improvement of Heat Dissipation

OHBU Toshiharu / TADA Nobumitsu / HAGIWARA Keizo

An inverter for hybrid electric vehicles (HEVs) converts the DC power generated by the batteries into AC power to drive the motor. Since such inverters are generally installed in the vehicle's engine compartment, they must be compact while offering both high efficiency and tolerance of high temperatures. The insulated gate bipolar transistor (IGBT) modules that serve as one of the main parts of the HEV inverter are also required to be compact with low loss, low thermal resistance, and high reliability.

To meet these requirements, Toshiba has developed an IGBT module for HEVs featuring a newly developed mounting structure that allows double-sided cooling of the chip inside the module. This IGBT module achieves a 60% reduction in thermal resistance and is about half the overall size of a conventional IGBT module. We have also confirmed through simulations and tests that the new module has improved electrical properties and sufficient reliability.

Feature Articles

Add-on Type Image Analysis Box for Realization of Intelligent Surveillance Camera Network Systems

KOZAKAYA Tatsuo / MARUYAMA Masayuki / OKADA Ryuzo

With the increase in the number of surveillance cameras in recent years, it has become necessary for cloud computing providers to set up large-capacity networks and computing resources for this purpose. However, analysis of a large number of video streams from distributed cameras using the cloud is not a realistic approach.

As a solution to this issue, Toshiba has developed an add-on type image analysis box equipped with an image recognition processor. When this image analysis box is connected to an existing camera network by a simple procedure, it offers the intelligent function of sending useful image recognition results for next-generation urban development, including in the areas of security, marketing, observation of public areas, and disaster prevention, to the cloud. We have conducted verification tests using actual video data and confirmed that the image analysis box can reduce network traffic volumes to between one-seventh and one two-thousandth in comparison with the case of directly sending H.264 video streams to the cloud, by sending only low-capacity processing results instead of the video data of all cameras.

Components for Large-Scale Battery Systems Applied to Social Infrastructure Systems

KOSUGI Shinichiro / OKABE Ryo / KURODA Kazuto

Large-scale battery energy storage systems equipped with lithium-ion battery (LIB) modules have become a focus of attention in recent years due to their small charge-discharge energy loss.

The SCiB™ battery, a rechargeable LIB developed by Toshiba, offers high safety by intrinsically eliminating the risk of smoke or fire even in the event of an internal short circuit, while providing high charge-discharge efficiency as a result of its low internal resistance through a wide state of charge (SOC) range, and a long life of 10,000 charge-discharge cycles. These features make the SCiB™ battery suitable for use in large-scale power storage systems. To facilitate the installation of large-scale power storage systems for social infrastructure systems, we have developed the main components for such battery systems including a 1.1 kWh battery module composed of 20 Ah SCiB™ battery cells, a battery management unit (BMU) to control the battery system based on collected information on the cell voltage and temperature data of the battery modules, a main contactor, a current sensor, and a service disconnecter with fuses. We have also developed a battery simulator for the planning of optimal battery systems.

Scene Detection and Scene Playback Technologies Using Closed Captions of TV Programs

YAMASHITA Michio

Toshiba has been supplying REGZA series liquid crystal display (LCD) TVs and REGZA Server recorders to the market incorporating the following functions: (1) the "Time-Shift Machine" function, which enables viewers to watch programs of interest at any time; and (2) the "Zanmai-Play" function, which introduces viewers' preferred programs from among recorded programs using the Time-Shift Machine function. As users have recently tended to spend less time viewing TV programs due to the growing diversity of entertainment resources, demand is also increasing for a function that will allow them to easily access scenes that they really wish to see.

In response to these sophisticated requirements, we have developed the DBR-T460/T450 REGZA Server recorders featuring scene detection and scene playback functions that can create a list of scenes related to a viewer's keywords such as the names of entertainers from the closed captions in all recorded programs and play these scenes, as well as a scene-related keyword detection function that can automatically extract topic keywords related to viewed program scenes using closed captions. These functions offer a new TV program viewing style that saves users' time and effort.

"Home Appliances Concierge" Service for Toshiba Smart Home Appliances

FURUTA Kazuhiro / MARUTANI Yuki / NAKAGAWA Tatsuya

Smart home appliances can connect to a cloud server via the Internet and provide a wide variety of services to support more convenient and comfortable lives.

Toshiba has developed the "home appliances concierge" service and installed it in newly launched smart home appliances such as refrigerators, drum-type washer dryers, and air conditioners. The home appliances concierge service offers various functions, including the "control from outside" function, which allows users to access images of the interior of their refrigerator while shopping at a store; the "fault predictive diagnosis" function, which informs users of failure signs so that they can contact the service center; the "energy saving advice" function, which visualizes the power consumption of home appliances and encourages energy saving according to the conditions of use; and the "watching support" function, which reports the room temperature if it becomes higher than a specified value, allowing the user to remotely control the air conditioner, and can also report the history of home appliance usage by a family member (such as an elderly relative) who is living at a different location. Furthermore, the home appliances concierge service makes it possible to improve the usage of smart home appliances in conjunction with the "TimeOn" REGZA cloud service for cloud-based TVs. Users can not only turn air conditioners on and off from the TV display, but also confirm the operating conditions and power usage of smart home appliances such as the completion of operation of a washer dryer through a display in a pop-up window on the TV.

Frontiers of Research & Development

Fast Spatial Indexing Technology for Querying Objects within Quadric Surface