

TOSHIBA REVIEW

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Special Reports

Power Electronics

Special Reports Power Electronics	Feature Articles	Epoch-Making Toshiba Technologies
<ul style="list-style-type: none">*Power Electronics Creating Comfortable Environments*Trends in Power Electronics Technologies*High-Power Device IEGTs for Power Electronics*Technology of IEGT Application*Large-Scale IEGT Converter Technology for Power System Application*Power Electronics Equipment for Rolling Stock Using IEGTs and IGBTs*High-Voltage Inverters Employing IEGTs for Industrial Motor Drives*AC Variable-Speed Drives Becoming More Intelligent in Industrial Plant Applications*Recent Motor Drive Technologies for Elevators*Power Electronics for Energy Saving, New Energy, and Electric Power Quality Improvement*Highly Dependable UPS Supporting IT Revolution*Permanent Magnet Motor and Drive Equipment for Industrial and Vehicular Applications*Inverter and IPDU_{TM} (Intelligent Power Drive Unit) for Air Conditioners*Latest Power Electronics Technologies in Household Electrical Appliances	<ul style="list-style-type: none">*Three-Dimensional CAD/CAM System for Sheet-Metal Parts*Novel Characterization Technique of pn Junctions for Advanced LSI*Junction Leakage Mechanism Induced by Single Oxide Precipitate in Silicon Diode*Improvement of Recognizability of Home Appliance Function Sounds*DynaBook SS3440/3410 Slim Notebook PCs	<p>6. Inverter Air Conditioner</p>

Special Reports

Power Electronics

*Power Electronics Creating Comfortable Environments

IKEDA Hiroshi

*Trends in Power Electronics Technologies

SAITO Suzuo WATANABE Yozo

Power electronics (PE) technologies have already been applied in many fields, and will become increasingly important against the background of the severe energy balance in the future. Toshiba is manufacturing various types of PE equipment having distinguishing features such as high operating efficiency, high controlling performance, highly functional performance, and so on, according to the needs of customers.

PE core technologies—namely, power devices, PE specialized microprocessors, and PE equipment structure and motor technologies—are of prime importance in determining the fundamental performance and cost of such PE products. We are therefore carrying out R&D activities in this area, especially in the field of power unit technologies which condense these core technologies in order to extract the maximum performance of power devices.

*High-Power Device IEGTs for Power Electronics

IESAKA Susumu OGURA Tsuneo NISHITANI Kazunobu

With the spread of insulated gate bipolar transistor (IGBT) applications in high-power electronics systems, the need for higher voltage IGBTs is growing. However, the IGBT has the major problem of increased saturation voltage ($V_{ce(sat)}$) at higher voltage ratings.

We identified an electron injection effect, and using this effect we have developed a 4.5 kV Injection Enhanced Gate Transistor (IEGT) having a low saturation voltage like a gate turn-off thyristor (GTO) and excellent switching performance like an IGBT. In addition to an original, highly reliable, press-pack type IEGT, we have also developed a high-voltage module type.

This paper describes the basic structure and electrical characteristics of these IEGTs.

*Technology of IEGT Application

MATSUMOTO Toshiaki TAI Hiromichi KODANI Kazuya

The power device is the key component of a high-power converter main circuit. The Injection Enhanced Gate Transistor (IEGT) not only can withstand high voltage, but also has fast switching capability like an insulated-gate bipolar transistor (IGBT). Therefore, it is difficult to make a compromise between the isolation design required for high-voltage equipment and the compactness required to reduce stray inductance in order to suppress voltage surge. To enlarge the power unit rating, it is important to realize a low-inductance main circuit so as to utilize series or parallel connection of IEGTs.

The press pack type IEGT has large thermal capacitance and is used for large power converters, and the need exists for improvement of the IEGT utilization rate. The module type IEGT has smaller thermal capacitance than the press pack type, so the mounting technology to enhance the power unit capacity becomes more important.

*Large-Scale IEGT Converter Technology for Power System Application

IROKAWA Shoichi TAKEDA Hideo KANAI Takeo

The development of a highly efficient self-commutated converter is essential to enlarge the application of power electronics equipment to electric power systems. This paper explains a new technology to freely connect Injection Enhanced Gate Transistors (IEGTs) in series or in parallel. This technology will be commonly applied to voltage-sourced converters ranging from small (1 MVA class) to large-scale (100 MVA class) systems.

*Power Electronics Equipment for Rolling Stock Using IEGTs and IGBTs

OYAMA Takio YASUOKA Ikuo AOYAMA Ikuya

Efforts are being made to improve riding comfort and energy saving by adopting the latest power electronics technologies in equipment applied to rolling stock for the Shinkansen ("Bullet Train"), which represents rapid-transit railways, as well as existing railway lines and subways that support urban transportation. In recent years, greater comfort and lighter weight have been realized compared with previous equipment by developing a series of products; namely, three-level conversion equipment utilizing insulated-gate bipolar transistors (IGBTs), and two-level conversion equipment utilizing high-withstand-voltage IGBTs.

In the midst of this trend, Toshiba has developed conversion equipment for the Shinkansen applying the Injection Enhanced Gate Transistor (IEGT), which is a power semiconductor with higher withstand voltage than the IGBT and lower loss than the gate turn-off thyristor (GTO). Moreover, for direct-current electric railway substations, Toshiba has developed a rectifier with an eco-friendly heat-pipe cooling system using water as a coolant.

*High-Voltage Inverters Employing IEGTs for Industrial Motor Drives

CHIKAWA Kohsaku NAITO Yoshio NAKAJIMA Ryo

A high-voltage Injection Enhanced Gate Transistor (IEGT) has been developed in recent years and begun to be used in practical applications. This paper describes two newly developed types of equipment for which a 4.5 kV–4kA turn-off press-packaged type IEGT and a 4.5 kV–1.6kA module-packaged type IEGT are employed. One is an 8 MVA rated capacity, water-cooled type, three-level inverter which can be used for gate turn-off thyristor (GTO) applications such as rolling mill motor drives. The other is a 3 MVA rated capacity, air-cooled type, multilevel inverter for energy-saving type motor drives in which the conventional insulated gate bipolar transistor (IGBT) is replaced by an IEGT.

Both types of equipment have advantages for next-generation systems compared to conventional inverters with identical power using GTOs and IGBTs, thanks to their higher efficiency, smaller size, and greater reliability.

*AC Variable-Speed Drives Becoming More Intelligent in Industrial Plant Applications

NAKAMURA Ritaka ABE Kikuo MIYAZAKI Satoshi

AC variable-speed drives for industrial plant applications have become more functional and compact with higher performance. As a consequence, they are not only supporting energy saving in plants and the improvement of product quality, but also greatly contributing to improved productivity in small-lot, large-variety manufacturing.

Toshiba has a product lineup of AC variable-speed drives covering the range from several kW to several tens of MW. We are making efforts to further improve the functions of these drives such as automatic tuning, speed sensorless vector control, and remote maintenance, in order to respond to users' future needs.

*Recent Motor Drive Technologies for Elevators

IJIMA Atsushi SONODA Michiyoshi SHIMANE Kazuo

The appearance of machine-roomless elevators, which eliminate the necessity to locate a machine room at the top of a hoistway, has brought great advantages to the field of building construction and had a major impact on the market.

This paper describes recent technologies for elevators, focusing on the control technology for permanent magnet synchronous motor (PMSM) adopted for the SPACE_{LM} machine-roomless elevator, and also on the motor drive technology for the "ultra-high-speed and large-capacity elevator."

*Power Electronics for Energy Saving, New Energy, and Electric Power Quality Improvement

YOSHINO Teruo KAWAGUCHI Akira ASHIZAKI Yusuke

Two issues of increasing importance in the field of industrial electric power supply facilities are contribution to environmental preservation through energy saving and renewable power generation, and electric power quality improvement to ensure the stable operation of electronic and information devices in production facilities.

Toshiba has developed various power electronics products in response to these needs. Furthermore, Toshiba provides support in system design and system analysis in order to identify appropriate solutions with advanced power electronics. In other words, Toshiba proposes power electronics solutions from the aspects of both products and support for their application.

*Highly Dependable UPS Supporting IT Revolution

MATSUZAKI Kaoru YASUDA Nobuyuki NAKAJIMA Kazuhiro

As the information technology (IT) revolution progresses, economic activities are now beginning to affect each other in a very short time on a global scale. In order to support such a society, it is necessary to continuously supply power 24 hours a day, 365 days a year, without the occurrence of power failures. Highly reliable uninterruptible power systems (UPS) have therefore become indispensable. UPS have been considered to be the power supply supporting the advanced information society up to now, and such demand has been further increasing in recent years.

In response to this need, Toshiba has developed the large-capacity TOSNIC_{TM}-7000 series and the medium-capacity TOSNIC_{TM}-6100 series UPS based on high-reliability technology cultivated over many years. Moreover, we have been applying this equipment to supply standby redundant UPS that can supply stable power from the UPS at any time as a system.

*Permanent Magnet Motor and Drive Equipment for Industrial and Vehicular Applications

YOSHIDA Koki HAGIWARA Keizo OOISHI Koji

In order to realize environmental protection, there is strong demand for higher efficiency, natural resource saving, and space saving in motor drive applications. We have developed technologies for permanent magnet (PM) motors and their control equipment that provide an effective solution meeting these requirements.

This paper describes the optimization of PM motors and their control equipment using specialized drive control in the field of industrial and vehicular applications.

*Inverter and IPDU_{TM} (Intelligent Power Drive Unit) for Air Conditioners

HIRUMA Atsuyuki

Although inverter type air conditioners have been on the market for some 20 years now, the issues of energy saving and electromagnetic compatibility (EMC) restrictions are currently attracting attention. Toshiba has been developing air conditioners utilizing the latest power electronics know-how, and the energy-saving characteristics of these products are highly evaluated. For example, the "Daiseikai" series has been awarded the Minister of International Trade and Industry Prize for the past two years.

These products are developed with original Toshiba technologies. They are highly efficient while at the same time gentle to the environment, due to the new type of refrigerant gas used as well as our development of IPDU_{TM}.

*Latest Power Electronics Technologies in Household Electrical Appliances

MATSUO Katsuharu TANAKA Toshimasa MAEDA Masahiko

Inverter technologies are of great importance in recent household electrical appliances because of the significant progress made in enhancing the merits of such technologies.

Toshiba has taken the initiative in the industry in applying inverter technologies, and has become the industry leader in commercializing various household electrical appliances incorporating these technologies. Among the latest examples are the direct-drive (DD) inverter fully automatic washing machine that achieves super silence, twin-cooling refrigerators that achieve improved food freshness preservation along with energy saving, and a microwave oven with a half-bridge inverter system that achieves the best efficiency and highest output in the industry. These products have been well received in the market.

Feature Articles

*Three-Dimensional CAD/CAM System for Sheet-Metal Parts

UCHIDA Yasuo SANO Katsumi KURIBAYASHI Koji

Three-dimensional computer-aided design (CAD) systems have become widely used in product design in recent years. It has also become necessary to build up a 3D-based manufacturing system for sheet-metal components.

Responding to these needs, we have developed a 3D CAD/CAM (computer-aided manufacturing) system for sheet-metal parts. In this system, necessary numerical control (NC) data and instruction manuals for processing can be generated automatically. The main feature of the system lies in such functions as automatic extraction of necessary processing information and construction of a database of preparation know-how for sheet metal. These functions realize a significant reduction in human operations.

This system is now in actual operation at two factories, and is producing excellent results as expected.

*Novel Characterization Technique of pn Junctions for Advanced LSI

—JUNCTION LEAKAGE MECHANISM INDUCED BY SINGLE OXIDE PRECIPITATE IN SILICON DIODE

TSUCHIAKI Masakatsu FUJIMORI Hiroyuki IINUMA Toshihiko

The impact of a single oxide precipitate, an extended defect in silicon, on junction leakage was directly observed and thoroughly investigated with new characterization techniques. It was found that the electric field in the depletion layer facilitates the hopping of electrons from the silicon/precipitate interface states into the associated thermal donor formed nearby. The leakage current was generated by field enhanced thermal emission from the donor.

Insights on the specific leakage mechanism obtained through pn junctions allow electrical detection of the corresponding defects at a sensitivity far exceeding that of physical analysis.

*Improvement of Recognizability of Home Appliance Function Sounds

NAMBA Seiji

Home appliances used in everyday life generate various sounds during operation, including many types of function sounds (signal sounds). However, the messages communicated by these function sounds are often unclear and tend to confuse users at the time of usage.

Focusing on the fact that one cause of users' confusion is their inability to discern each appliance according to its function sounds, we conducted research with the aim of producing sounds that allow users to recognize an appliance by adding a specific image of the appliance to each sound. We first developed a method based on the conceptual system then tested it on typical home appliances, namely, a microwave oven, a washing machine, and a rice cooker, with the application of this technology in the actual market in view.

*DynaBook SS3440/3410 Slim Notebook PCs

TAKENAKA Tsutomu NANNO Nobuyuki TANAKA Hideaki

The current market demand for B5-size notebook PCs is not only for slim size but also high performance. Toshiba's DynaBook SS3000 series has achieved a good reputation in the market. The new DynaBook SS3440 and SS3410 models support mobile Pentium® III-500 MHz and mobile CeleronTM-400 MHz, respectively. Both models have an 11.3-inch XGA TFT-LCD (extended graphic array, thin-film transistor liquid crystal display), a high-capacity hard disk, and an IEEE1394 interface. They are designed for mobile PC users.

In order to realize the excellent radiation performance and silent operation of the DynaBook SS3440/3410, they are structured with vents for air intake and exhaust in three directions using a turbo fan. These products have been developed taking environmental protection into consideration, and conform with Toshiba's voluntary environmental regulations for PCs.

Epoch-Making Toshiba Technologies

*6. Inverter Air Conditioner