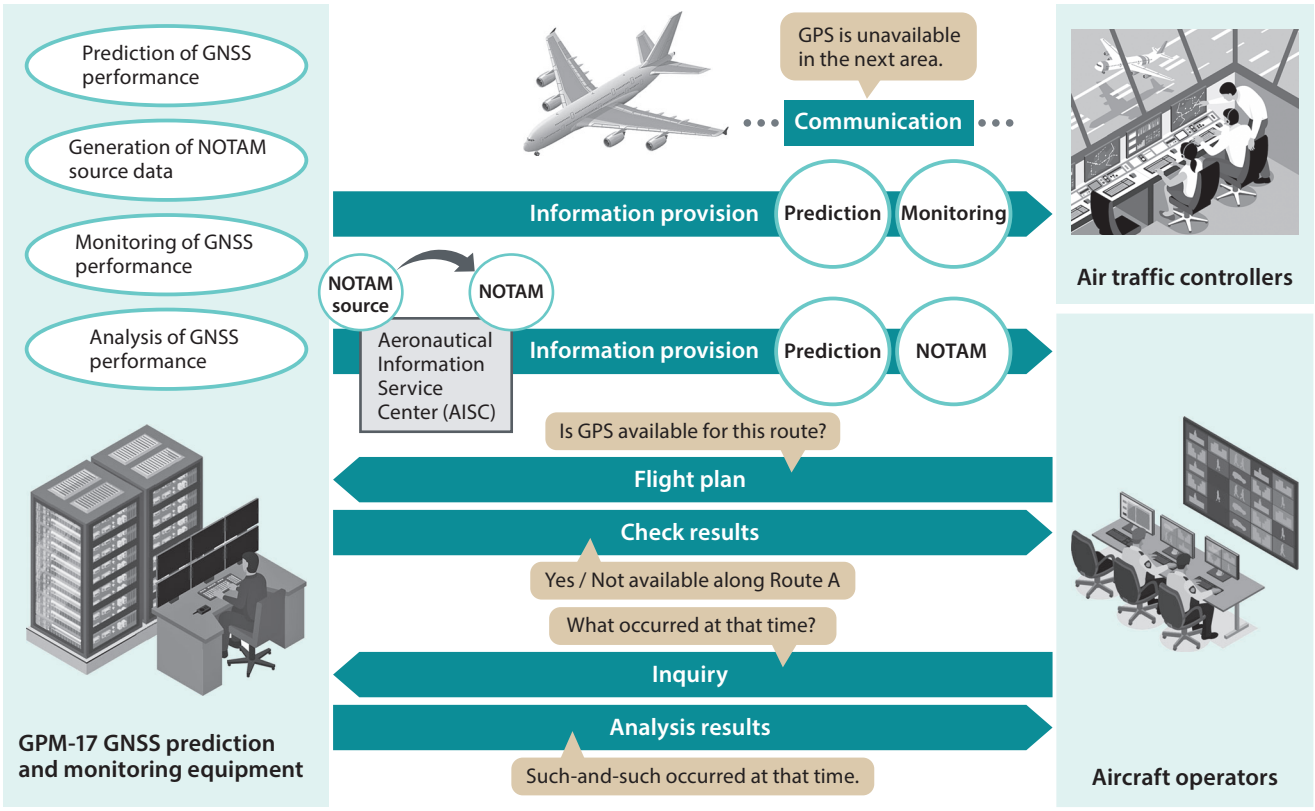
4. Infrastructure Systems

4.1 GPM-17 GNSS Prediction and Monitoring Equipment for Japan Civil Aviation Bureau



Overview of operation of GPM-17 GNSS prediction and monitoring equipment

The ever-increasing volume of civil aviation traffic is accentuating the importance of global navigation satellite systems (GNSS) to track the positions of aircraft more efficiently for air traffic management.

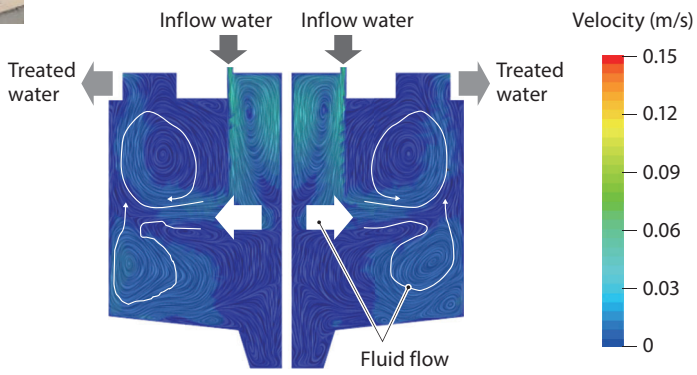
Toshiba Infrastructure Systems & Solutions Corporation has delivered GPM-17 GNSS prediction and monitoring equipment to the Japan Civil Aviation Bureau. The newly developed equipment predicts the integrity and availability performance of GNSS and transmits notice-to-airmen (NOTAM)(*) source data to notify the Aeronautical Information Service Center (AISC) of flight routes where satellite information is unavailable. AISC, in turn, issues NOTAMs to alert the air traffic community. The new GNSS prediction and monitoring equipment also collects and analyzes GNSS signals to provide airline operators and civil air traffic controllers with information for air traffic management.

To ensure air traffic safety, we have been endeavoring to improve GNSS prediction performance by enhancing time and distance resolution while providing an on-demand GNSS integrity and availability verification service that collates an aircraft flight plan with the predicted GNSS performance and provides enhanced information about the GNSS performance via the web.

(*) A notice filed with an aviation authority to alert aircraft pilots of potential hazards along a flight route

4.2 New Upsized High-Rate Clarifier Models with Reduced Footprint

Pilot plant with upsized high-rate clarifier



Example of visualization of water flow inside high-rate clarifier

Small-footprint equipment is required by industrial wastewater treatment plants because of area constraints. In 2015, Toshiba Infrastructure Systems & Solutions Corporation launched the first model of a high-rate clarifier. A clarifier is a settling tank for the removal of suspended solids from wastewater. With a quarter of the footprint of conventional clarifiers, this high-rate clarifier has been receiving positive evaluations from clients in various industrial sectors.

In recent years, demand has been increasing for upsized models, particularly in emerging countries. In response, we have now released upsized high-rate clarifiers with up to eight times the capacity of the 2015 model. The new high-rate clarifiers have a unique structure to achieve uniform water flow distribution and thereby reduce the dispersion of suspended solids, promoting rapid settling. This helps to increase throughput per unit area of water surface, making it possible to reduce the clarifier footprint.

We developed a method for modeling the behavior of suspended solids with various specific gravities and sizes in wastewater and incorporated it into a computational fluid dynamics (CFD) simulation model. In addition, we verified by means of a pilot plant that this simulation model reproduces the fluid flow and performance of the clarifier, and demonstrated that it is applicable to the upsized clarifiers. We employed the new CFD simulation model to optimize the structure and estimate the throughput performance of the upsized clarifiers.

We will promote these high-rate clarifiers to industrial clients to meet their needs and contribute to the industrial development of emerging countries.

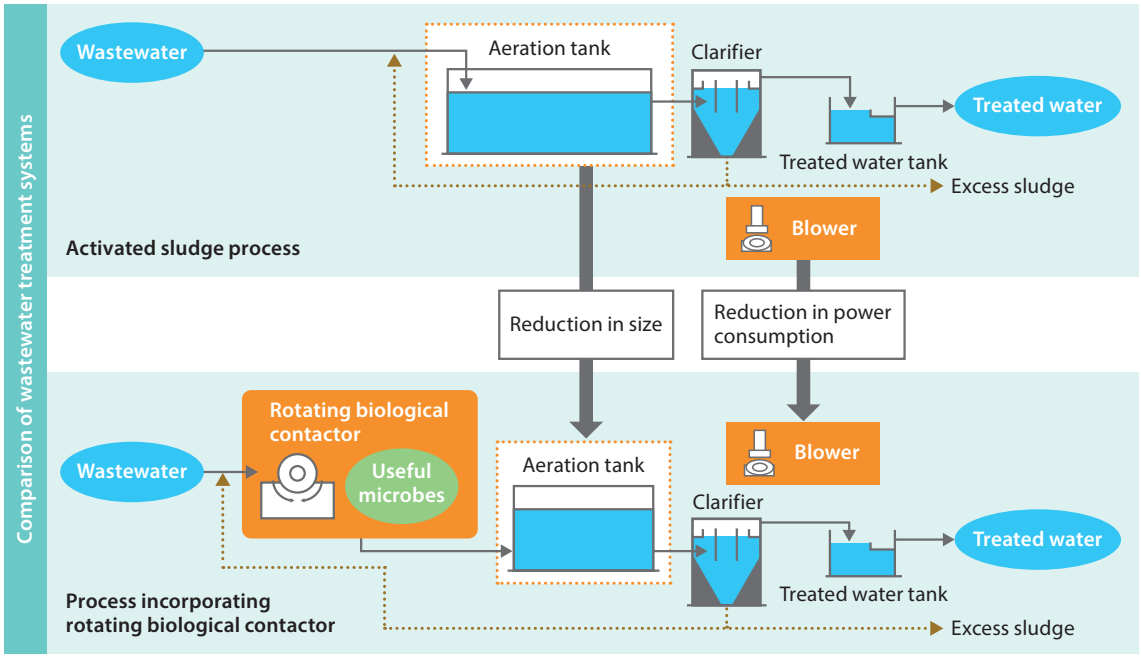
4.3 Water Treatment Device Employing Microbes to Reduce Running Cost of Wastewater Treatment Plants

In the biological treatment of wastewater with aerobic microbes, which utilize oxygen to decompose organic matter, the cost of the electricity required for aeration accounts for 30 to 50% of the total running cost of a wastewater treatment plant.

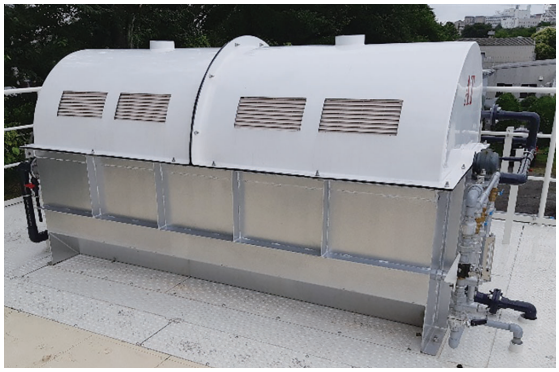
To reduce the power consumption of the aeration process, the Fuchu Complex of Toshiba Infrastructure Systems & Solutions Corporation has introduced a rotating biological contactor that employs useful microbes to decompose organic matter in wastewater from the cafeteria kitchen. The rotating biological contactor has a water tank in which disks made of a special fiber are vertically submerged in wastewater to half of their diameter. Useful microbes form a biofilm on the surface as the disks slowly rotate. The rotating biological contactor provides high microbial activity because the aerobic condition on the biofilm surface and the anaerobic condition inside the biofilm are well balanced.

The rotating biological contactor is installed immediately upstream of the aeration tank to decompose about 40% of the organic matter in the wastewater, contributing to a reduction in the load of organic matter flowing into the aeration tank. As a result, the new aeration tank is physically smaller and consumes 40% less power than that used in the conventional activated sludge process.

We will utilize this rotating biological contactor to construct sustainable social infrastructure facilities.

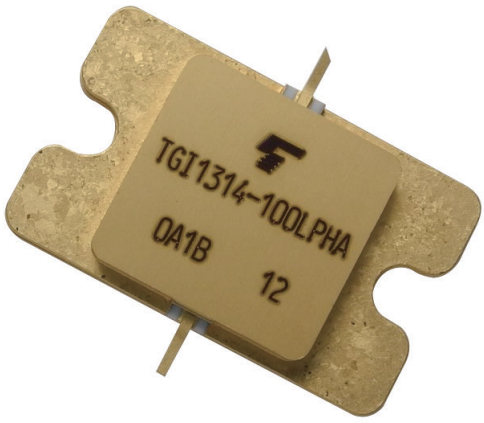


Comparison of wastewater treatment system based on activated sludge process and system incorporating rotating biological contactor employing useful microbes



Rotating biological contactor

4.4 Ku-Band 100 W-Class GaN HEMT with Reduced Distortion for Wideband Modulation



Ku-band 100 W-class gallium nitride high-electron-mobility transistor (GaN HEMT)

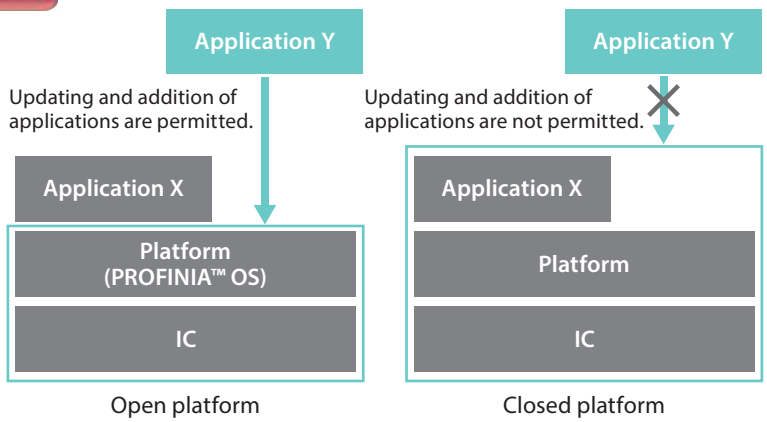
Accompanying the recent increase in the volume of information transmitted, satellite communication systems are being equipped with more sophisticated modulation schemes and multicarrier transceivers. An amplifier is therefore required in such systems to reduce distortion during wideband modulation while increasing output power.

Against this background, Toshiba Infrastructure Systems & Solutions Corporation has commercialized a Ku-band (12–18 GHz-band) 100 W-class gallium nitride (GaN) high-electron-mobility transistor (HEMT) with low distortion for microwave solid-state power amplifier applications. When GaN HEMTs are used as amplifiers, it is necessary to suppress the memory effect, which is one of the causes of distortion. A newly developed amplifier, which incorporates a memory effect compensation circuit in the same package, provides reduced intermodulation distortion with a wide offset frequency of up to 150 MHz, 30 times that of a conventional amplifier.

The new high-power, low-distortion GaN HEMT achieves an output power of 125 W under pulsed operation and 80 W under continuous operation at a frequency of 14.1 GHz. Measuring only 25 × 15 × 5 mm, this GaN HEMT will contribute to the realization of small, light, and large-capacity satellite communication systems.

4.5 PROFINIA™ Operating System Certified as Compliant Open Platform by EMVCo

PROFINIA™ F404 smart payment card compliant with EMVCo security standard



Differences between open and closed platforms when updating and adding applications

Integrated circuit (IC) chips for mobile and Internet of Things (IoT) devices must have the capability to receive security updates and add new services after being launched on the market whereas payment IC chips require strict security and interoperability with multiple payment applications.

To satisfy these market requirements, Toshiba Infrastructure Systems & Solutions Corporation has developed the PROFINIA™ operating system (OS) and incorporated it into smart payment cards as its first application. The PROFINIA™ OS is the first product of the Toshiba Group to be certified by EMVCo(*) as an open platform that meets its security requirements. An EMVCo-compliant firewall protects the confidentiality and integrity of application data. As an EMVCo-certified open platform, the PROFINIA™ OS provides a security-level guarantee for customers when updating and adding applications after market launch.

We will utilize the PROFINIA™ OS not only for smart payment cards but also for mobile and IoT devices.

(*) A technical institution collectively owned by six international payment brands: American Express, Discover, JCB, Mastercard, UnionPay, and Visa

4.6 BISCADE™ Card Smart Card with Fingerprint Authentication for Security Systems

BISCADE™ Card smart card with on-card fingerprint authentication

Accompanying the prevalent use of the Internet in recent years, security measures have become increasingly important. Under these circumstances, Toshiba Infrastructure Systems & Solutions Corporation has developed the BISCADE™ Card, a smart card with fingerprint authentication, and supplied it to Laurel Intelligent Systems Co., Ltd. for use in its FSS SmartLogon TFPA security system.

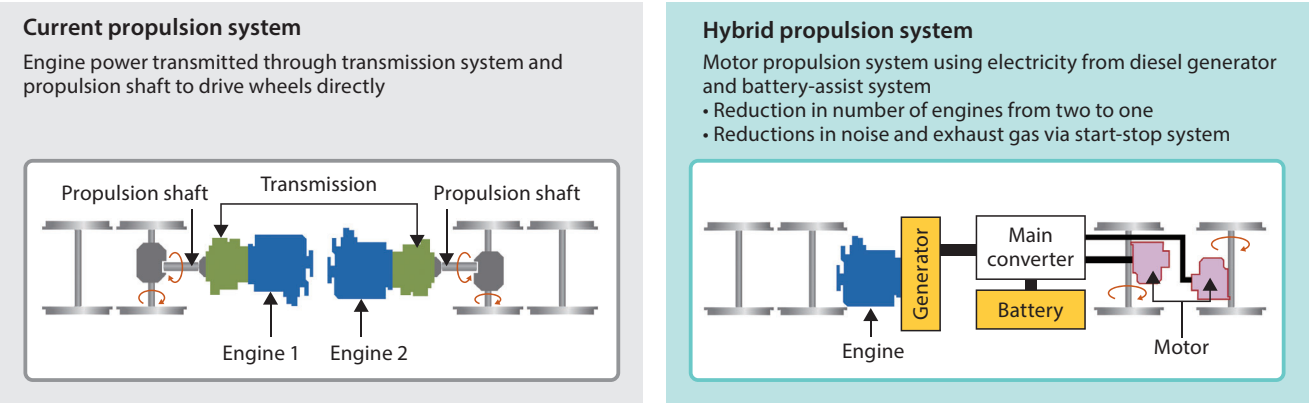
Once a cardholder's fingerprint is registered, the BISCADE™ Card recognizes the registered fingerprint when the cardholder places the relevant finger onto the sensor of the card. It allows the use of existing smart card readers, eliminating the need for a fingerprint authentication server. The BISCADE™ Card thus provides convenient yet strict identity authentication through its combination of ownership and biometric authentication.

We will contribute to the dissemination of smart cards through the development of contactless smart cards, credit cards, and other types of cards that support fingerprint authentication.

4.7 Delivery of Hybrid Propulsion System for HC85 Series Test Vehicles of Central Japan Railway Company

Courtesy Central Japan Railway Company

HC85 series test vehicles of Central Japan Railway Company



Mechanism of existing propulsion system for KiHa 85 series and hybrid propulsion system for HC85 series

Toshiba Infrastructure Systems & Solutions Corporation has delivered a compact and high-efficiency hybrid propulsion system for the test vehicles of the HC85 series, a next-generation diesel-electric multiple unit train for limited express services operated by Central Japan Railway Company ("JR Central").

The existing KiHa 85 series is propelled by transmitting power from a diesel engine directly to the wheels through a traction transmission system. In contrast, the HC85 series employs a hybrid propulsion system that drives a motor using energy generated by a diesel engine and energy stored in a battery during braking. This eliminates the need for a transmission and a propulsion shaft, improving reliability, safety, and riding comfort.

4. Infrastructure Systems

The HC85 series is the first rolling stock in Japan to incorporate a fully enclosed permanent magnet synchronous machine(*1) for both motors and generators(*2). Since this machine improves the efficiency of transmission of the engine output to the wheels, it provides a 10% higher tread output than our conventional hybrid system(*3). With its high conversion efficiency and battery-assist system, the HC85 series has achieved a maximum speed of 120 km/h, the first time in Japan that a hybrid train has reached this speed(*1).

In addition, the engine of the HC85 series stops while it is waiting at stations in order to reduce exhaust gas and noise created by idling. The HC85 has an onboard battery system to store energy generated during braking and uses the stored energy to power air conditioning and lighting in the cars, making it more environmentally friendly for station platforms and their neighboring areas.

The test vehicles were delivered to JR Central in December 2019. A four-car train started test runs shortly thereafter for the verification of basic performance and functionality. In addition, it was confirmed that the test vehicles run smoothly in snowy conditions and provide a roughly 35% higher fuel efficiency than the existing KiHa 85 series. At present, a one-year test is being conducted to verify long-term durability and other performance factors. The HC85 series is scheduled for full production in 2022.

(*1) As of March 2020 (as researched by Toshiba Infrastructure Systems & Solutions Corporation)

(*2) Rated efficiency of motors and generators: 97%

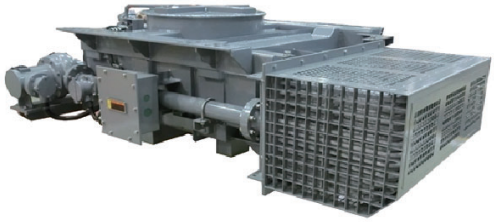
(*3) An open-frame structure model with a rated induction motor efficiency of 91% and a rated induction generator efficiency of 93%

4.8 Electrical Equipment of Traction System of EMU900 Series Commuter Trains for Taiwan Railways Administration

Main converter/inverter

Traction motor

Forced-air-cooling type main transformer



Self-cooling type compact main transformer

Toshiba Infrastructure Systems & Solutions Corporation has designed the electrical equipment of the traction system for 520 cars of the EMU900 series commuter trains (52 trains composed of 10 cars each) ordered by the Taiwan Railways Administration (TRA) and verified its main functions. We have reduced the size and weight of the equipment compared with that of the current EMU800 series while further enhancing its reliability and ease of maintenance.

In order to achieve high reliability, the main converter/inverter is composed of (1) a three-level pulse-width-modulation (PWM) converter incorporating the insulated-gate bipolar transistors (IGBTs) currently used for the EMU800 series and (2) a three-phase voltage type two-level variable-voltage, variable-frequency (VVVF) inverter.

We have adopted two types of main transformers: a forced-air-cooling type transformer that has been well proven in the EMU800 series and a self-cooling type compact transformer that is to be used for the first time in overseas trains. The self-cooling type main transformer eliminates the need for a cooling blower, making it smaller, lighter, and easier to maintain than the existing main transformer.

The new traction motor, which is designed to have the same dimensions as that of the EMU800 series, incorporates an air filter for separating and discharging sand and dust, reducing the frequency of maintenance required.

We will remain committed to the Taiwanese railway market and leverage our technological capabilities and experience to contribute to Taiwanese customers and expand our record of achievements there.

4.9 Delivery of Electrical Components for N700S Shinkansen Trains to Central Japan Railway Company

Courtesy Central Japan Railway Company

N700S Shinkansen train

Battery unit for battery-based self-traction system

Main converter/inverter

Static inverter

Toshiba Infrastructure Systems & Solutions Corporation has delivered main electrical components for the N700S Shinkansen trains to Central Japan Railway Company ("JR Central"), including a battery unit for a self-traction system, main converter/inverter, static inverter, train information system, and automatic train control (ATC) system.

The main converter/inverter is 8% smaller and more power-efficient than the conventional model. This was achieved by using silicon carbide (SiC) devices capable of high-speed switching as main semiconductor circuit elements, contributing to the reduction of power loss and optimization of cooling efficiency.

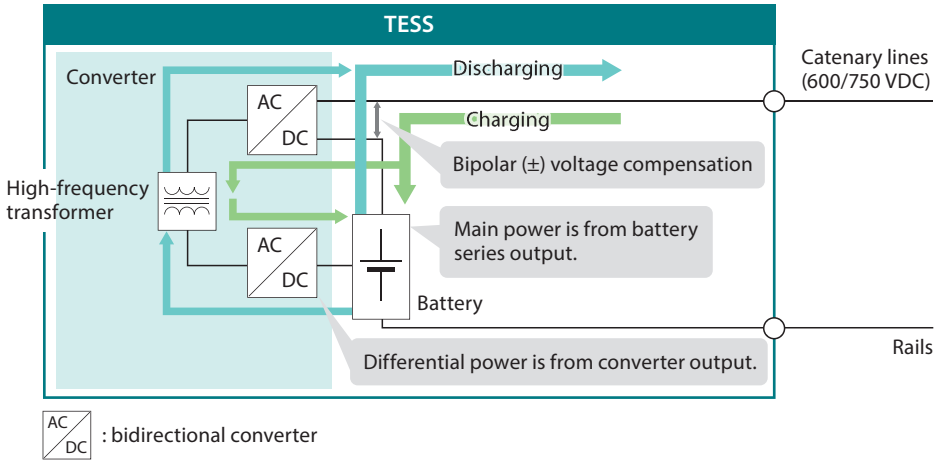
The static inverter incorporates a high-frequency DC/DC converter using SiC devices and soft switching technology in order to scale it to the same size as the main converter/inverter. This breakthrough has contributed to the realization of standard Shinkansen vehicles with flexible equipment layout.

The N700S is equipped with a battery-based self-traction system that was jointly developed with JR Central utilizing our SCiB™ lithium-ion rechargeable battery. Even in the event of a prolonged power failure due to a natural disaster, etc., this system makes it possible for the Shinkansen train to continue running to a location where the passengers can be safely evacuated.

The N700S commenced commercial service in July 2020.

4.10 Commencement of Operation of First Traction Energy Storage System for 600 VDC Feeding System

600/750 VDC TESS for railway electrification system of Hiroshima Electric Railway Co., Ltd.



Configuration of series compensation type circuit

Toshiba Infrastructure Systems & Solutions Corporation has installed its first traction energy storage system (TESS) for a 600 VDC feeding system (400 kW output) at the Miyajima Substation operated by Hiroshima Electric Railway Co., Ltd. The TESS commenced operation in February 2020 to utilize regenerated energy effectively.

This TESS contains a series compensation type circuit incorporating bidirectional converters connected to battery panels in series to achieve line voltage compensation. With this configuration, only conversion of the difference in voltage between the battery and the feeding line is necessary. Incorporating high-frequency insulation technology, the new converter panel is equipped with two bidirectional converters and one high-frequency transformer. Because of this configuration, the converter panel has a 76% smaller footprint and weighs 80% less than the conventional converter panel for TESS applications.

In addition, the new TESS supports 750 VDC feeding systems (with 500 kW output), making it possible to apply our lineup of TESS to all DC-powered railway systems operating in Japan.

We will continue to develop more compact TESS models with higher output and enhanced service functions in order to contribute to energy saving and stable operation of railway systems.

4.11 Upgrading of IT Subsystems for Taiwan High Speed Rail

Courtesy Taiwan High Speed Rail Corporation

Taiwan High Speed Rail train

The Operation Management Center of Taiwan High Speed Rail is equipped with information technology (IT) subsystems including a supervisory control and data acquisition (SCADA) system supplied by Toshiba Infrastructure Systems & Solutions Corporation. With more than 10 years having passed since their installation, the end of their hardware product life was approaching. We therefore commenced the upgrading of the IT subsystems in May 2017, completing the work in February 2020.

Since it was technically difficult to perform large-scale upgrading without affecting the daytime train services, we performed installation and interface tests on each of the subsystems at night after the last train.

This part of the project was successfully completed in July 2019 after interface tests with other subsystems, followed by decommissioning and removal of the obsolete subsystems.

We organized technical training programs for local engineers at an early stage of the project, considering the need for subsequent upgrading projects. Utilizing the experience acquired through this project, we will continue to contribute to the safe and stable operation of Taiwan High Speed Rail.

4.12 ER383D RAID Controller for Industrial Computers

ER383D RAID controller for industrial computers

Main specifications of ER383D

Feature	Specification
Processor	Broadcom LSISAS3108 I/O processor (1.2 GHz)
Onboard cache memory	512 MB (with 32+8-bit ECC)
Host bus	Four PCI Express slots (compliant with PCI Express 3.0 standard)
Storage drive	SAS: HDD (512n/512e) SATA: HDD (512n/512e), SSD
Data transfer rate	Up to 6.0 Gbit/s per port
RAID levels	0, 1, 5, 6, 10, 50
Maximum number of HDD/SSD devices	Up to 8
Physical dimensions	167.65 mm (width) × 68.9 mm (height)

ECC: error check and correct
PCI: Peripheral Component Interconnect
SAS: Serial Attached SCSI (Small Computer System Interface)
SATA: Serial Advanced Technology Attachment
HDD: hard disk drive
SSD: solid-state drive

Toshiba Infrastructure Systems & Solutions Corporation has developed a new redundant array of independent disks (RAID) controller, the ER383D.

The ER383D is equipped with a high-performance input/output (I/O) processor and a high-capacity cache memory. Because of its optimized control software, this new model provides a more than 30% higher transfer rate than its predecessors, the ER382C and ER382D. Being backward compatible, the ER383D can replace its predecessors without any software changes.

In order to further enhance the reliability of the ER383D, we have adopted long-life components, optimized its design (e.g., the selection and mounting of components), and verified its board robustness through stress simulation. To achieve the same high level of availability as its predecessors, the ER383D has the same failure threshold settings such as the prioritization of startup in the event of failure (e.g., loss of cache data or degraded mode).

In cooperation with the Corporate Manufacturing Engineering Center and overseas electronics manufacturing services, we have made efforts to suppress any increase in the cost incurred to achieve performance enhancement and thereby maintained the product cost at the same level as the predecessors.

We will utilize the ER383D to realize high-performance, high-reliability industrial computers and ensure their long-term supply.

4.13 Analysis Technology for High-Frequency Insulation Circuits to Reduce Size and Weight of Power Supply Units

A power supply unit must electrically isolate a low-voltage load from a high-voltage supply using a transformer. Increasing the operating frequency helps to reduce the size of the transformer. Therefore, the size and weight of a power supply unit can be reduced by creating a high-frequency insulation circuit using a semiconductor inverter. However, high-frequency operation might increase the switching loss of semiconductor devices as well as conductor loss due to the skin and proximity effects(∗1)(∗2), causing a rise in circuit temperature.

In order to reduce the power loss and increase in temperature of power circuits, Toshiba Infrastructure Systems & Solutions Corporation performed a coupled analysis combining circuit, electromagnetic field, and heat transfer analyses on a newly developed high-frequency insulation circuit. The new circuit incorporates an LC circuit that acts as an electrical resonator according to the inductance (L) of the transformer and conductors and the capacitance (C) of the capacitors. The coupled analysis, which took variations in LC constants into consideration, enabled us to determine the resonance frequency at which power loss is reduced.

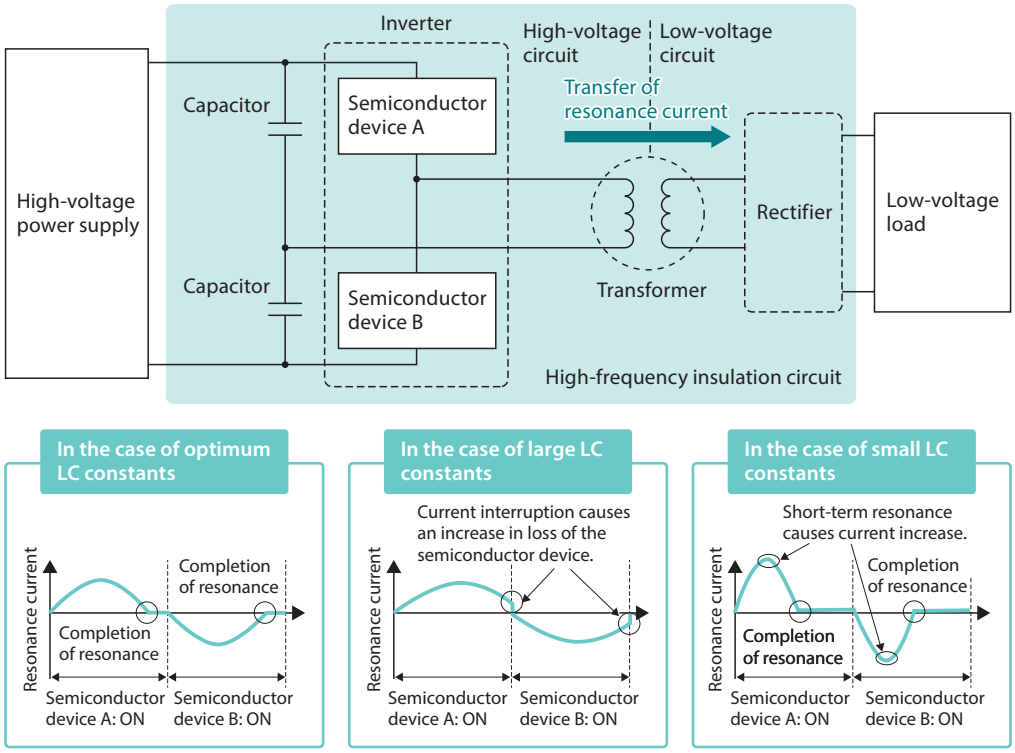
In the low-voltage domain, conductors are connected in parallel because of the high resonance current. However, these parallel conductors might cause nonhomogeneous power losses if they have nonhomogeneous current distribution at high frequency. We therefore performed the coupled analysis to reduce the circuit's power loss taking both current imbalance and the skin and proximity effects into consideration.

As a result of these efforts, the newly developed circuit has achieved a roughly 38.5% reduction in temperature rise as against a target of 30%. Furthermore, the result of the coupled analysis had only a 1.7% error relative to the measured value.

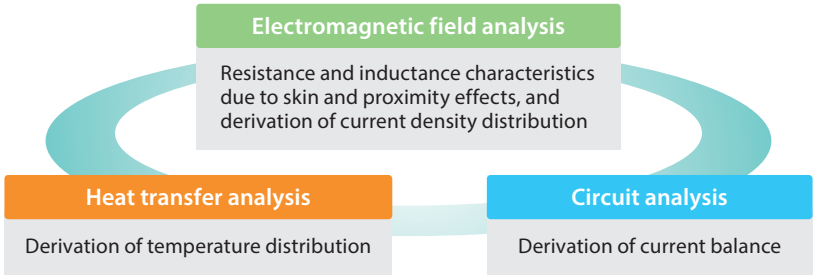
It was confirmed that coupled analysis is effective in reducing a circuit's power loss and temperature rise. We will expand its application to optimize circuit parameters and configurations.

(∗1) Skin effect: A tendency for AC current to concentrate near the surface of a conductor because of eddy currents induced by a changing magnetic field

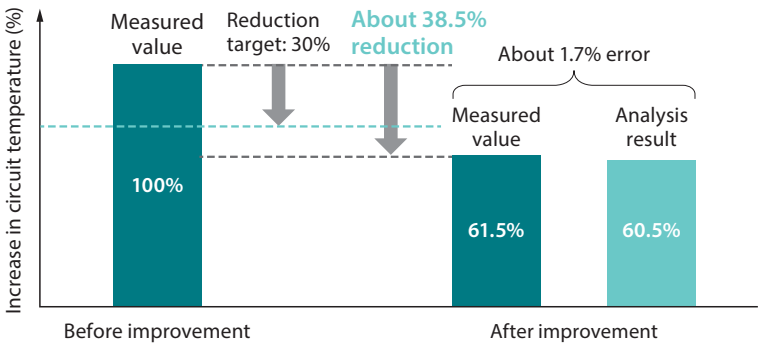
(∗2) Proximity effect: Nonhomogeneous distribution of current density through a conductor due to eddy currents induced in adjacent conductors by magnetic flux interlinkage



Configuration of high-frequency insulation circuit and relationship between LC constants and resonance current

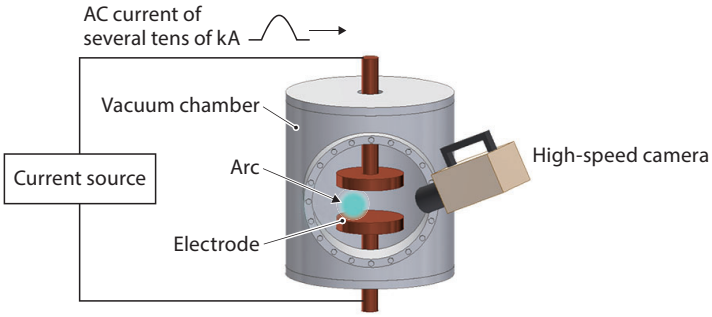


Application of coupled analysis combining circuit, electromagnetic field, and heat transfer analyses

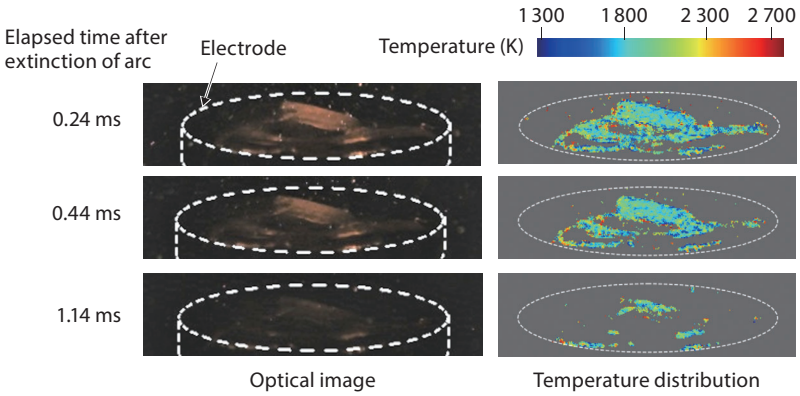


Reduction of increase in circuit temperature achieved by newly developed high-frequency insulation circuit

4.14 Measurement of Transient Temperature Distribution on Electrode Surfaces in Vacuum Circuit Breakers



Method for measuring electrode surface temperatures

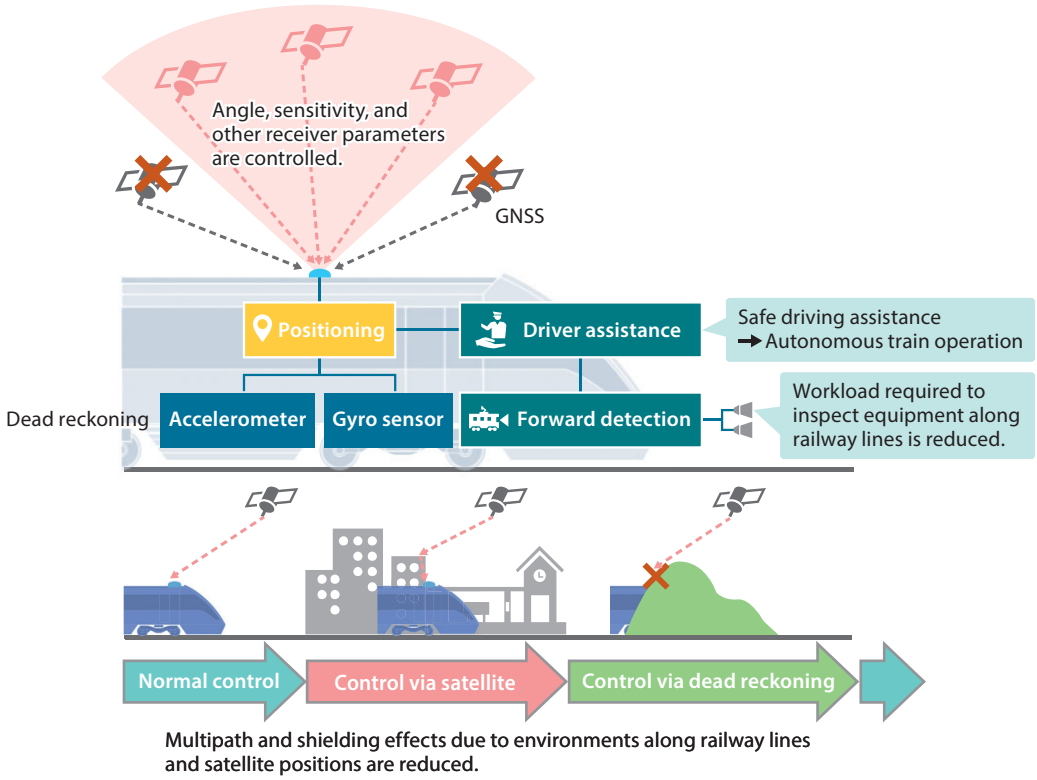


Optical images and temperature distributions of electrode surface after current interruption

Circuit breakers are widely used to protect electric power systems from damage caused by ground faults, short-circuit faults, and other types of faults. Vacuum interrupters are commonly utilized as switching devices for circuit breakers because of their advantages of being compact and maintenance-free. Vacuum interrupters can break currents of several tens of kiloamperes by opening a pair of electrodes in a vacuum vessel. However, the vacuum arcs generated upon current interruption heat and melt the electrode surfaces. Consequently, the insulation performance of vacuum interrupters is degraded by metal vapors and electrons generated from the electrodes. It is therefore important to control vacuum arcs so as to minimize the rise in electrode temperature in order to further reduce the size and improve the interruption performance of vacuum interrupters.

Toshiba Infrastructure Systems & Solutions Corporation has investigated a method for measuring the distribution of electrode temperatures, which reach several thousand degrees Kelvin, and their changes over time in order to elucidate the phenomenon of vacuum arcs. Since a voltage of several tens of kilovolts is applied to the electrodes, it is necessary to measure the temperatures without contact. We have developed a temperature measurement technique for this purpose based on a two-color method using a high-speed camera. As a result, we have succeeded in clarifying the electrode temperature distribution and its changes every few microseconds after fault current interruption.

4.15 High-Precision Positioning Technology Utilizing Global Navigation Satellite Systems



Overview of advanced autonomous train operation technologies

Railway operators need to further improve the efficiency of train operations because of a shortage of train drivers and railway maintenance personnel coupled with a decrease in the number of passengers. In response to this need, Toshiba Infrastructure Systems & Solutions Corporation is developing high-precision positioning technology to realize autonomous railway operations in the future.

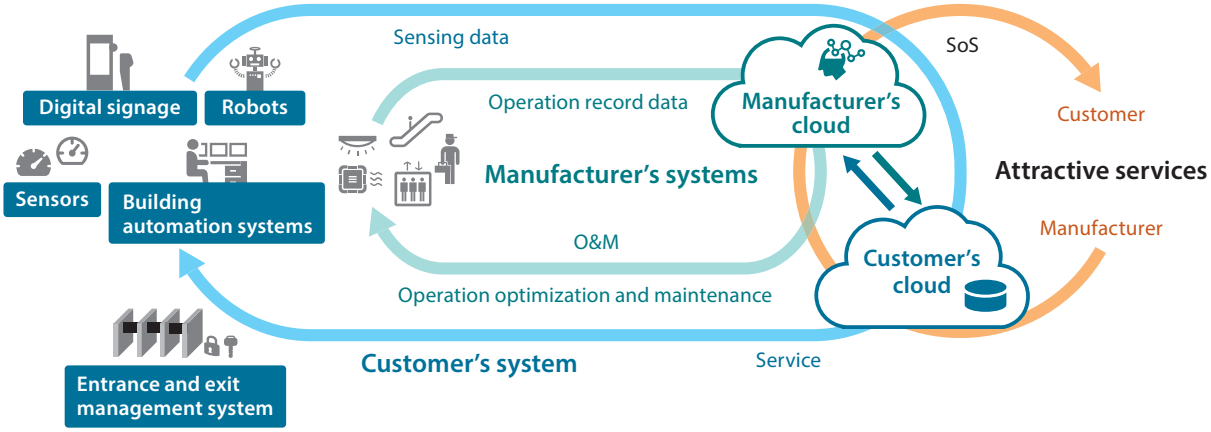
The technology under development includes a positioning device that uses global navigation satellite systems (GNSS) and inertial sensors to measure train positions in real time. It also provides accurate time information, which is indispensable for railway traffic management.

We have developed two positioning techniques so that a train's position can be determined regardless of the environment along the railway line: (1) a technique to control the angle and sensitivity of a receiver in areas where a GNSS signal is available so as to reduce positioning error and (2) a dead reckoning technique to estimate the train position using inertial sensors when a GNSS signal is unavailable. We have developed and verified a prototype system equipped with an algorithm to dynamically switch between these two techniques.

The prototype system is also equipped with a function to achieve positioning accuracy on the order of several centimeters and a function to measure train speed with high precision.

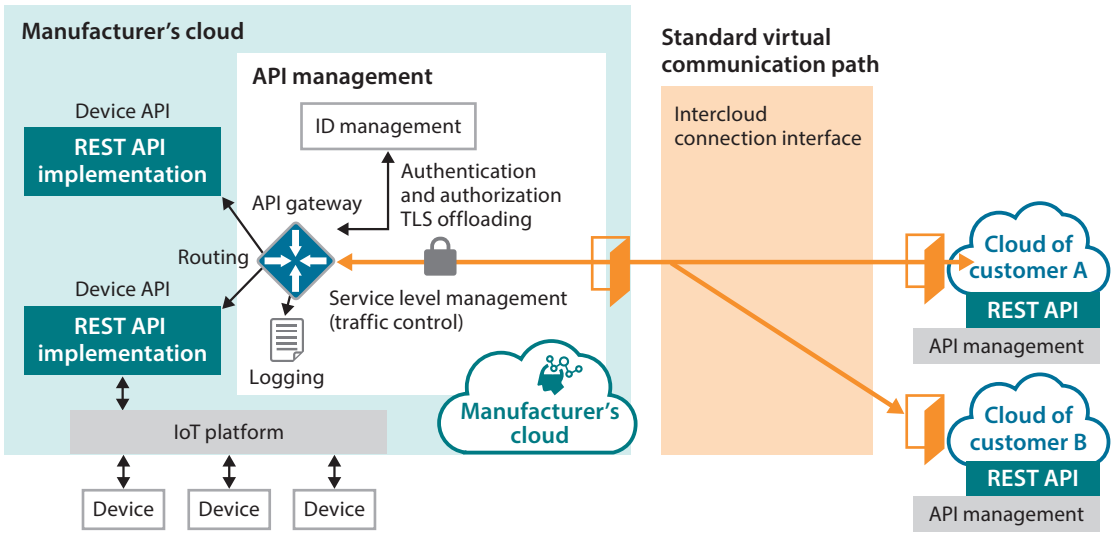
We are planning to further improve the performance of this system from now on.

4.16 Interconnection Method for Cloud-Based System of Systems



O&M: operation and maintenance

Outline of cloud service to achieve collaboration between individual cloud systems through construction of system of systems (SoS)



TLS: Transport Layer Security

Intercloud connection interface

The control and remote maintenance systems for various facilities in a building and the building management system are generally operated independently. In the future, these systems are expected to be equipped with the capability to communicate and cooperate with one another using IoT technology.

Toshiba Infrastructure Systems & Solutions Corporation is developing a technology for orchestrating multiple independently operated cloud services to create new, more complex services. The key to success lies in establishing a framework for the integration of very different and independently operated systems into a system of systems (SoS).

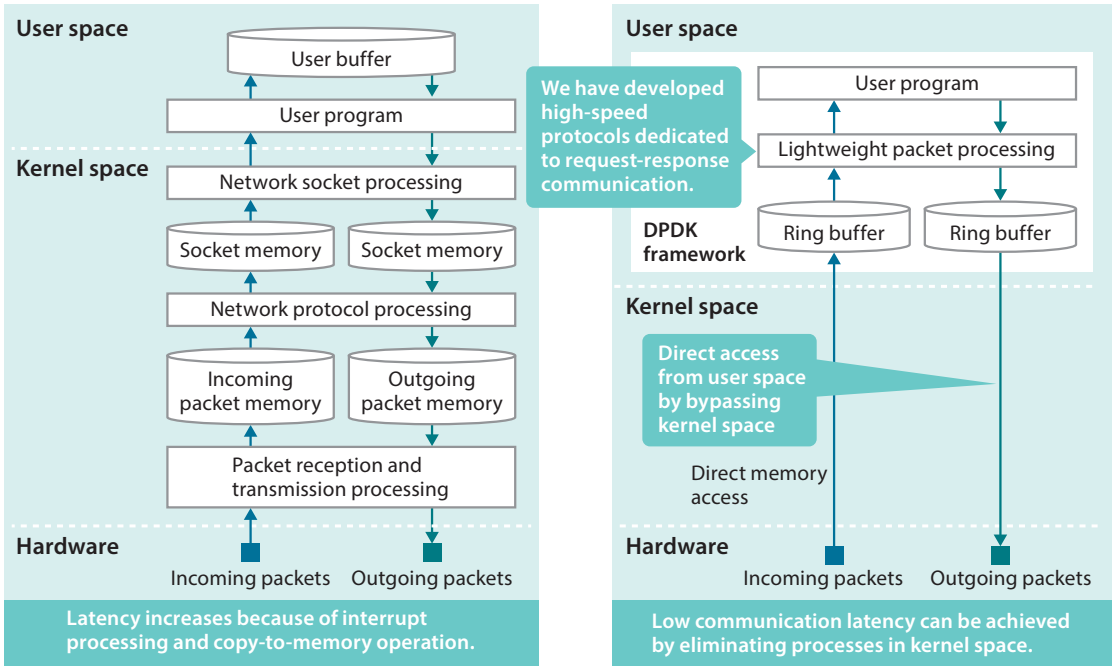
Our new technology incorporates a virtual common communication path to enhance inter-cloud interoperability based on a combination of representational state transfer application programming interface (REST API)(*) and API management functions.

We have created a prototype SoS service that links air conditioners, elevators, and a building management system to optimize their operations by acquiring information that cannot be collected by each facility alone, such as flows of people and spatial conditions.

In the future, we will utilize the new technology to realize services that create new value.

(*) An interface that allows the operations of web resources to be specified using Hypertext Transfer Protocol (HTTP) methods

4.17 Low-Latency Packet Processing Technology for Network Interfaces in Social Infrastructure Systems



(a) Conventional packet processing

(b) Network interface processing to achieve low latency

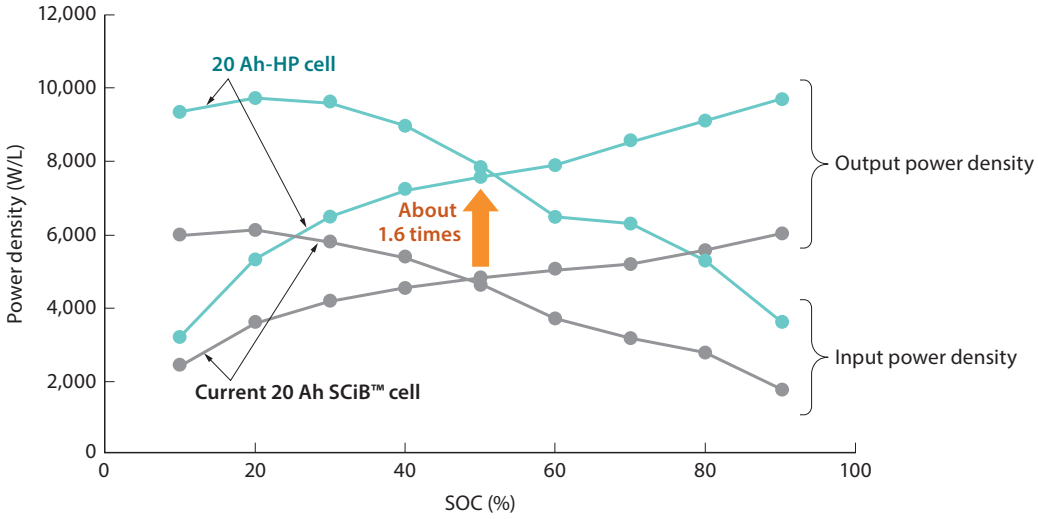
Network interface processing bypassing kernel space to achieve low latency

For social infrastructure systems, it is becoming increasingly important to control client devices from a remote server from the viewpoints of both costs and scalability. Social infrastructure systems require high-speed processing with a response time on the order of milliseconds. In this respect, minimizing the server's packet processing time is a key challenge. Packet processing is usually performed in the kernel space of an operating system (OS). However, if the number of interrupts in the kernel space increases under high-load conditions, an unexpected delay might occur in packet processing.

To solve this issue, Toshiba Infrastructure Systems & Solutions Corporation has developed a low-latency packet processing technology using lightweight packet processing for request-response communication. We have implemented lightweight packet processing in the user space and utilized a kernel bypassing framework called the Data Plane Development Kit (DPDK). In this way, our new method removes the causes of delays in the kernel space to achieve high-speed communication.

To evaluate our method, we generated 50 000 incoming and outgoing packets per second and simulated high-load communication in 2 000 clients. Our new method achieved average and maximum round-trip delays of 0.069 ms and 0.187 ms, respectively, whereas the conventional method required average and maximum round-trip delays of 2.636 ms and 23.640 ms, respectively. These results indicate that our method can reduce the packet round-trip delay and the packet processing time.

4.18 Development of High-Energy, High-Power 20 Ah SCiB™ Cell



Output and input power density of current and newly developed 20 Ah SCiB™ cells at 25°C (10-second energization)

Many countries have adopted stringent environmental regulations to meet the Paris Agreement targets for the reduction of greenhouse gas emissions. In particular, regulations on automobile carbon dioxide (CO_2) emissions are becoming increasingly strict. Against this background, all major automakers have announced plans to shift toward plug-in hybrid electric vehicles (PHEVs) or electric vehicles (EVs) in order to comply with these regulations.

SCiB™ lithium-ion batteries are widely used for various applications because of their outstanding features, including long life, a high level of safety, and rapid charging. In particular, they are considered to be ideal for constant-voltage hybrid vehicles requiring a reduction in fuel consumption. Toshiba Corporation will commercialize a high-energy, high-power 20 Ah SCiB™ cell (referred to as the 20 Ah-HP cell) in 2021.

We have optimized the design parameters for the anode, cathode, and electrolyte of the new 20 Ah-HP cell while achieving a 25% reduction in the volume of the separator using a new material. As a result, the 20 Ah-HP cell achieves a power density of 7 590 W/L, roughly 1.6 times that of the current 20 Ah SCiB™ cell(*).

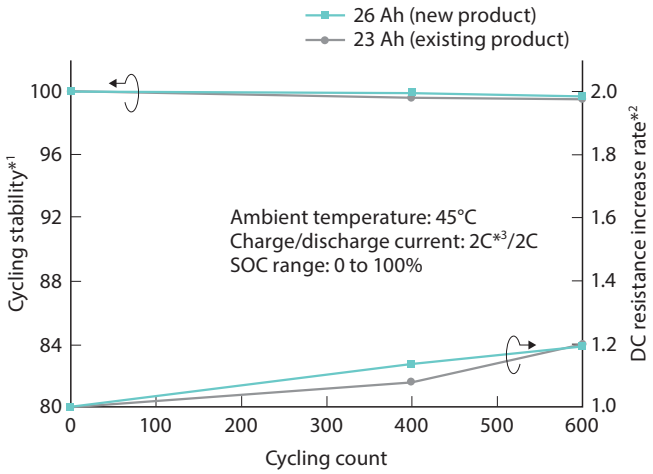
In addition to the 20 Ah-HP cell, we are developing a computational model required for the simulation of storage systems. The combination of a highly precise computational model and the SCiB™ cell will facilitate customers' model-based development efforts.

(*) At a state of charge (SOC) of 50% at 25ºC, 10-second energization

4.19 Development of High-Energy 26 Ah SCiB™ Cell

Specifications of high-energy type SCiB™ cells

Model	23 Ah cell	26 Ah cell
Rated capacity (Ah)	23	26
Nominal voltage (V)	2.3	2.3
Volumetric energy density (Wh/L)	202	229
Weight energy density (Wh/kg)	96	107
Dimensions (mm)	116 (width) × 22 (depth) × 106 (height)	116 (width) × 22 (depth) × 106 (height)
Weight (g)	Approx. 550	Approx. 560



SOC: state of charge

*1: Normalized with the initial value (at cycle 0) set to 100
*2: Normalized with the initial value (at cycle 0) set to 1.0
*3: A unit that expresses the charge/discharge rate of a battery calculated as the charge/discharge current (A) divided by the battery capacity (Ah)

Cycle characteristics of 23 Ah and 26 Ah SCiB™ cells at temperature of 45°C

The SCiB™ series of rechargeable lithium-ion batteries provide outstanding safety and environmental ruggedness. They have a wide range of applications, including automobiles, railways, portable devices, and large-scale stationary battery energy storage systems that support frequency regulation for renewable energy systems. At present, the high-energy 23 Ah SCiB™ cell is widely used in various industrial applications. However, in order to reduce the number of parallel cell strings in a module, it is necessary to further increase the cell capacity.

Under these circumstances, Toshiba Infrastructure Systems & Solutions Corporation is developing a 26 Ah SCiB™ cell that provides about 13% higher volumetric energy density per cell than the existing 23 Ah SCiB™ cell without compromising the cell performance by using a new material and optimizing the cell design.

In order to combine high performance and safety, lithium-ion cells generally have a positive electrode made of a material with low energy and high thermal stability as well as a thick separator that is unlikely to break or cause a short circuit. In contrast, the 26 Ah SCiB™ cell is equipped with a positive electrode made of a material with higher energy density and thermal stability because of an improved particle shape, as well as a thin, difficult-to-break separator.

In general, when the amount of energy in a given positive electrode increases, its crystal structure becomes unstable, causing the cycle performance to deteriorate. In order for the 26 Ah SCiB™ cell to achieve as high a cycle performance as the 23 Ah SCiB™ cell, we have optimized the balance between the positive and negative electrode capacities, increased the electrode density, and suppressed the increase in battery resistance by means of a new electrolyte additive.