

FUJI ELECTRIC REVIEW

2022
Vol.68 No.

2

Technical Achievement and Outlook in FY2021



**Contributing to the Creation
of Sustainable Societies through
Our Energy and Environment Businesses**



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Cover Photo:

- (1) Automotive power module
- (2) "SPH5000EC" CPU Module of "MICREX-SX Series"
- (3) Power conditioning system (PCS)
- (4) Power generation
- (5) "Frozen Station" frozen food vending machine



Technical Achievement and Outlook in FY2021

In 2022, Fuji Electric revised its "Fiscal 2030 Goals" to achieve its "Environmental Vision 2050" established in 2019. Establishing a reduction goal for greenhouse gas (GHG) emissions throughout the supply chain, we are committed to CO₂ emissions reduction in society through our products to achieve the carbon neutrality. Our Management Policies include "through our innovation in energy and environment technology, we contribute to the creation of a responsible and sustainable society." In accordance with the policy, we have been promoting our research and development to create new customer value and solve social issues.

This issue summarizes technical achievement for FY2021 and our future outlook. We hope you find the content informative.

The archives from the first issue, including articles in this issue, are available from the URLs below.

FUJI ELECTRIC REVIEW (English)

<https://www.fujielectric.com/company/tech/contents3.html>

FUJI ELECTRIC JOURNAL (Japanese)

https://www.fujielectric.co.jp/about/company/contents_02_03.html

FUJI ELECTRIC JOURNAL (Chinese)

<http://www.fujielectric.com.cn/jtkw.html>



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Preface

Contributing to the Creation of New Social Value Through Our Energy and Environment Businesses



My name is Shiro Kondo, and I have served as President and COO since April, 2022. I am pleased to extend my greetings on the occasion of the publication of Fuji Electric Review, Vol. 68 No. 2.

Since our company was established in 1923, Fuji Electric has pursued innovation in energy and environment technology, and has contributed widely to the world in the fields of industry and social infrastructure.

The international community is currently undergoing a major shift toward the development of the Sustainable Development Goals (SDGs) and the realization of a decarbonized society. Our corporate philosophy is for us to “contribute to prosperity,” “encourage creativity,” and “seek harmony with the environment,” and our management policies are centered on the notion of contributing to society through our energy and environment businesses. This aligns precisely with the concept behind the SDGs, which is to integrate economic, social, and environmental improvement. Moreover, as the issue of energy security to maintain a stable energy supply has entered the spotlight as of late, we believe that it will become even more important to address and contribute to solutions for environmental and social issues throughout the supply chain.

In particular, the realization of a decarbonized society is an area where our strengths in the energy and environment businesses can be used. This era is seeing the mainstreaming of clean energy at the supply side, the spread of distributed power sources, and the utility customer side taking responsibility for energy saving, electrification, and even supply, and it will be necessary to optimize the supply-demand balance for a variety of energy sources. As we thoroughly refine power electronics and power

semiconductors as our core technologies, we will provide total solutions to our customers in various industrial fields by integrating digital technology into these core technologies, making the most of all technology—both real and cyber, analog and digital.

Under the five-year Medium-Term Management Plan “Reiwa Prosperity 2023,” which ends in FY2023, the 100th anniversary of the establishment of our company, we are making a concerted effort to achieve sales of 1 trillion yen and an operating margin of 8% or more, with the power electronics and power semiconductor businesses as growth drivers, based on the basic policy of establishing a foundation as a company with sustainable growth.

We believe that the most important thing is to enhance our adaptability to change, based on the understanding that various changes and unpredictable events will occur as new social trends emerge. We will not only focus more on R&D to meet market needs, but also improve productivity by promoting DX (digital transformation) in R&D and manufacturing within the company, and take on the challenge of creating new social value in the energy and environment businesses.

We will put into practice our slogan “to be enthusiastic, ambitious and sensitive” in all aspects of our business activities, and contribute to the creation of a responsible and sustainable society through our energy and environment businesses, with a corporate culture that respects diverse personalities and teamwork.

As Fuji Electric takes on these challenges, I would like to thank all of our stakeholders for their continued support and understanding.

KONDO, Shiro
President and COO

A stylized, handwritten signature in black ink that reads “Shiro Kondo”.

Creating New Customer Value and Resolving Social Issues Through Our Innovation in Energy and Environment Technology

NAKAYAMA, Kazuya

Corporate General Manager, Corporate R&D Headquarters, Fuji Electric Co., Ltd.



Fuji Electric has been implementing research and development to create new customer value and resolve social issues based on our Management Policies to contribute to the creation of a responsible and sustainable society through our innovation in energy and environment technology. In addition to developing new products in line with our business strategy and creating products that will expand our global business, we are also strengthening our search for research themes and product planning to respond to major changes in the market environment, such as the advent of carbon neutrality and DX (digital transformation).

In order to achieve the 2023 Medium-Term Management Plan and growth strategies beyond, we have been concentrating resources on the development of products and technologies to achieve electrification in the mobility field, including automobiles, railroads, and ships, as well as to resolve environmental issues and other global challenges. Below, I will introduce our key efforts in FY2021 for each segment of business.

In the power electronics energy segment, for the expanding electricity balancing market, we have developed the “PVI1400CJ-3/2600” PCS (2,600 kVA) for large-capacity storage batteries, which has the world’s smallest size. Using Fuji Electric’s proprietary power semiconductors, it achieves a high conversion efficiency of 98.2%. Using a high voltage DC input has reduced the cable losses between the battery and the PCS.

In the power electronics industry segment, we have been developing systems that combine IoT with our distinctive components, such as inverters, servos, control equipment, and measuring equipment, on the basis of power electronics as core technology. These systems serve to create value, for instance, providing automation systems, improving productivity, and saving energy in all of the industries. In control equipment, we have developed the “SPH5000EC,” a new CPU module for the MICREX-SX Series of programmable controllers, for use in packaging machines, printing machines, semiconductor manufacturing equipment, and other machinery and equipment. Using EtherCAT open network facilitates the building of high-speed, high-precision motion systems in combination with servo and other devices. In measuring instruments, we have developed the FCX-AIV Series of pressure transmitters

for the process automation market, including petrochemical plants. It has acquired the functional safety standard IEC 61508 (SIL2) and can be used for emergency stop functions of control systems that require high reliability.

In the semiconductor segment, we have been developing products that contribute to low power dissipation (higher efficiency), compactness, and high reliability of power electronics equipment. As for industrial modules, we have developed a 3.3-kV All-SiC module for power conversion equipment used in railcars. It integrates 2nd-generation SiC trench gate MOSFET chips and has reduced power dissipation. Combined with a newly developed low inductance package, it contributes to improved efficiency and size reduction of equipment. In addition, we have developed automotive power modules for electric vehicles and hybrid electric vehicles. They use RC-IGBT chips that have been reduced in power dissipation, a cooler with high heat dissipation efficiency, and a lead frame package that reduces internal wiring inductance. The modules accomplish twice the power density of previous products and contributes to the size and weight reduction of electrified vehicles.

In the power generation segment, we are developing geothermal, solar, biomass, and other power generation systems to help achieve a decarbonized society and create resilient power infrastructure. With regard to geothermal power generation, a market that is expected to expand further toward achieving carbon neutrality, the Rantau Dedap geothermal power plant (49.2 MW × 2 units) in Indonesia has started commercial operation. We developed and put to practical use the world’s first “double-flush multi-pressure combined system” to maximize power output.

In the food distribution segment, we have been developing vending machines to promote improved convenience and to save labor and energy. We have developed “Frozen Station,” a frozen food vending machine, for restaurants and retail stores, which use a wide range of methods to serve their products. The product storage structure has been devised to achieve the industry’s top class product capacity.

Next, I will introduce efforts in common fundamental and advanced technologies. We have developed an analytics and AI technology that automatically ana-

lyzes factors in reducing the efficiency of energy plants using a combination of cause-and-effect analysis and machine learning. As for power electronics technology, we have been developing technology to substitute SF6 gas, which has a high global warming potential, for use in gas insulated switchgear (GIS). With regard to heating and cooling technology, we have developed the industry's first compressor-less high-efficiency ejector cooling technology to effectively use factory waste heat. Unused low-temperature waste heat generated in pro-

duction process can be utilized to efficiently generate cool water.

In this way, Fuji Electric refines its real-world technology and enhances its digital technology to create new value for customers and solve social and environmental issues. We will innovate energy and environment technology through the sophisticated synergy and integration of these technologies to contribute to the creation of a responsible and sustainable society.



(a) Customer site
(Chlor-alkali
electrolysis plant)



Rectifier

(b) "S-FORMER Mini" (Rectifier and related equipment)

Delivery of Rectifier Equipment for Train-6 Chlor-Alkali Electrolysis Plant of AGC Inc.

Fuji Electric has provided thyristor-type DC power conversion equipment (S-FORMER Mini), and related equipment such as the voltage regulating transformers and the harmonic filters for the Kashima Plant operated by AGC Inc. The plant started operation in November 2021.

The main features of this system are as follows:

- (1) The system can satisfy harmonic regulation at 66-kV receiving power point since harmonic current flowing into the grid system is mitigated by applying multi-pulse rectification (36-pulse rectification) and employing both voltage regulating transformer and harmonic filters.
- (2) High power factor operation has been achieved among wide DC output range (221 to 670 V DC, 5 to 24 kA) thanks to thyristor firing angle control and load tap changer installed in the voltage regulating transformer.

"PVI1400CJ-3/2600" PCS for Large Capacity Storage Batteries for the Real Time Market

Demand for large-scale storage battery systems for stabilizing the grid is increasing to allow renewable energy, such as solar and wind power, to be the main source of power. Fuji Electric developed the "PVI1400CJ-3/2600," a 2,600-kVA outdoor PCS for large-capacity storage batteries. This system is the first central PCS from Fuji Electric that conforms to the certification standard of high-voltage grid Interconnection protection devices by the Japan Electrical Safety & Environment Technology Laboratories.

The main features are as follows:

- (1) Thermal loss reduction in the cable between the battery and PCS (36% lower in current at the same capacity) with high voltage DC input.
- (2) High conversion efficiency (98.2%) through the use of highly efficient power semiconductors
- (3) The world's smallest class footprint [dimensions: W2,516 × D1,545 × H2,653 (mm)]
- (4) Standby loss reduction with an idling function (390W or less)



Industry's Smallest Class Switchgear That Complies with IEC Standard

Recent switchgear used as substation equipment is required to have both large capacity and small size due to the increase in load capacity. Fuji Electric has developed switchgear with an expanded rated current range despite the reduced depth dimension of the busbar compartment and acquired its third-party certification in accordance with IEC standards (IEC 62271-200). The main features are as follows:

- (1) The installation area has been reduced (20% smaller than the previous model, the smallest class in the industry^{*1}) through the use of a round shape conductive busbar structure to reduce the depth dimension.
- (2) Its loss of service continuity category is LSC-2B-PM^{*2}, and therefore the circuit breakers can be removed for inspection even while the bus bar is energized during equipment operation.
- (3) It achieves AFLR^{*2} of the internal arc classification, which indicates that the entire surrounding area of the product is safe. Its internal cooling system can rapidly cool the hot gases generated in the event of an accident to safely discharge upward, eliminating the need for exhaust ducts.

^{*1} Comparison based on specifications of a rated voltage of 24 kV, breaking capacity of 25 kA and rated current of 1,250 A

^{*2} LSC-2B-PM, AFLR; Terms for specifications used in IEC standards specifications



“SPH5000EC” (Controller configuration example)

“SPH5000EC” CPU Module of “MICREX-SX Series”

Packaging machines, printing machines, semiconductor manufacturing equipment and other machine equipment require high-speed and high-precision motion control. At the same time, easy connectivity with devices in the machines also required to improve design flexibility and to reduce system start-up person-hours. In response to these requirements, Fuji Electric has developed the “SPH5000EC.”

The main features are as follows:

- (1) Equipped with the open network EtherCAT master function, the module can be easily connected to slave devices such as servo systems and remote I/Os.
- (2) Up to 32 axes of servo motors can be synchronously controlled in a control cycle of 1 ms.
- (3) A multi-CPU module system with up to three units of the SPH5000EC can be configured, allowing easy system expansion to accommodate additional customer equipment functions.



(a) Pressure transmitter (L-type)



(d) Differential pressure transmitter



(c) Absolute pressure transmitter (T-type)



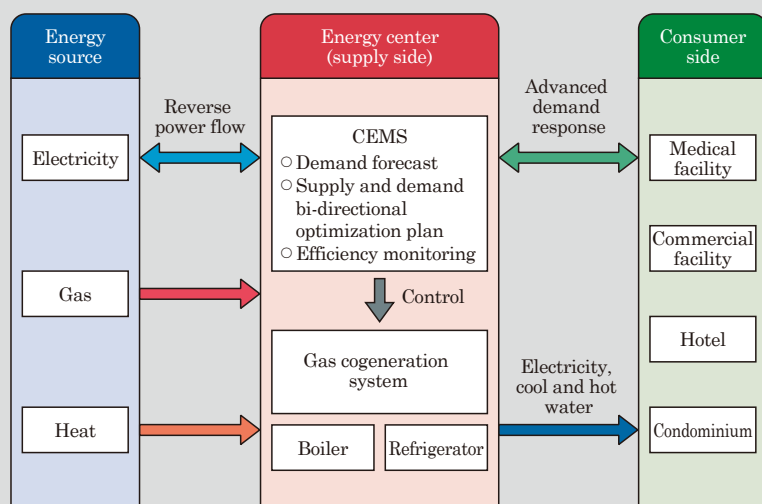
(d) Level transmitter

“FCX-AIV Series” Pressure Transmitters

Since the pressure transmitter “FCX Series” was launched in 1989, they have accumulated over 1 million sales results worldwide. Fuji Electric has developed the “FCX-AIV Series” as the latest model to respond to requests for higher performance and new functions such as functional safety compliance.

The main features are as follows:

- (1) Improved measurement accuracy, responsiveness and long-term stability
 - High accuracy: $\pm 0.065\%$ (standard)
 - Response time (dead time): 40 ms
 - Zero shift for maximum span: $\pm 0.1\%/5$ years
- (2) Certified to IEC 61508 (SIL2), the functional safety standard, the transmitters can be used for an emergency stop system for plants, which requires high reliability.
- (3) Field configurator allows non-contact setting of transmitter parameters even in explosion-proof areas.
- (4) Revision7, the latest version of HART communication, is supported.



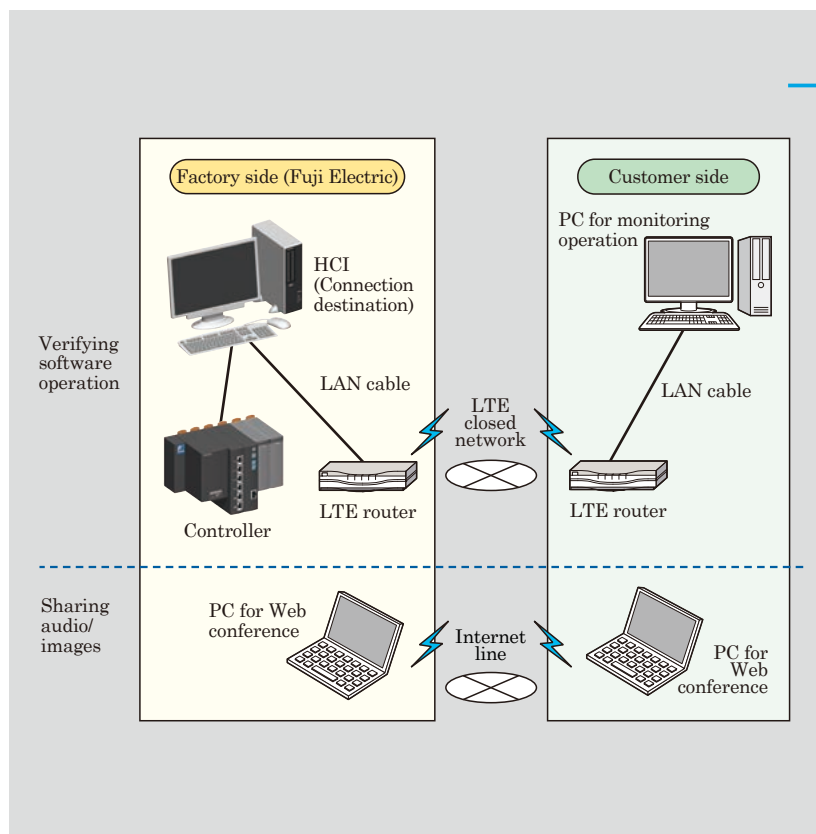
CEMS for a Shin-Sapporo Station Area Development Project by Hokkaido Gas Co., Ltd.

Hokkaido Gas Co., Ltd. is participating in the Shin-Sapporo Station Area Development Project and is constructing a new energy center that aims to save energy and labor through the automation of operations. For this project, Fuji Electric has developed a community energy management system (CEMS*) that makes use of AI.

The main features of this system are as follows:

- (1) Statistical machine learning methods are used to predict demand with high accuracy and automatically detect changes in energy efficiency. Further, automatic extraction of efficiency change factors contributes to labor-saving analysis work.
- (2) The system creates an optimal supply plan based on the amount of energy demand and automatically curbs demand while maintaining the comfort of consumers, thereby maximizing the efficiency of the entire urban areas.

* CEMS: Community energy management system

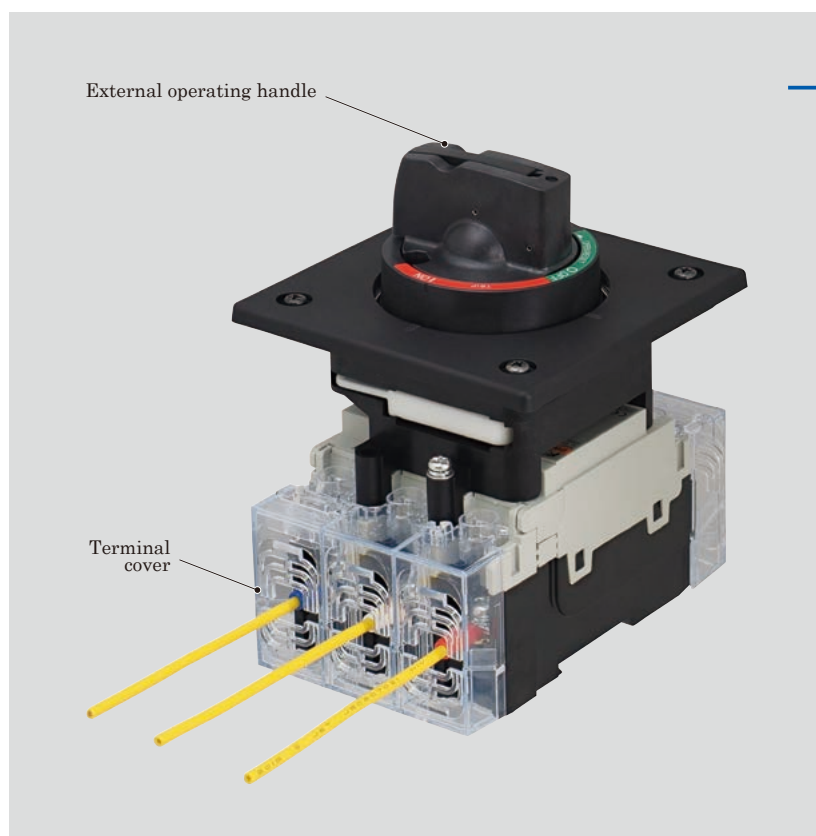


Remote Witness Inspections via LTE Wireless Communications

There has been an increasing number of cases that conventional on-site witness inspections, in which customers visit a Fuji Electric factory to check software functionality, could not be conducted due to the COVID-19 pandemic. Fuji Electric has created and put into operation a remote inspection system that can be operated remotely from a human communication interface (HCI) screen, taking security into consideration.

The main features are as follows:

- (1) PC remote operation software allows both our factory staff and customers to operate software screens bidirectionally, making it possible to remotely conduct the same type of inspections as conventional on-site inspections.
- (2) Since dedicated software such as a monitoring and control system includes confidential information, such as customer facilities and equipment, LTE closed networks, which are separated from the Internet, are used to prevent information leaks.
- (3) Customers are not required to prepare specific special infrastructure.

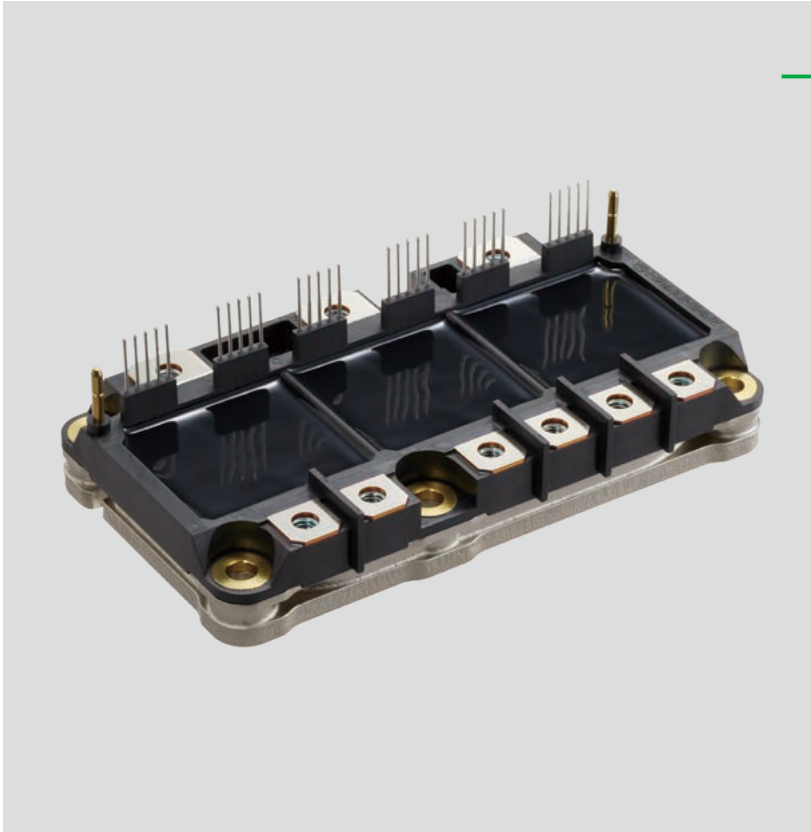


External Operating Handles and Terminal Covers with Improved Electrical Safety

Molded-case circuit breakers and earth leakage circuit breakers are required to comply with the electrical safety standard for machinery (IEC 60204-1) and to improve worker safety and product reliability in transportation and maintenance work as equipment and panel manufacturers, who are our customers, are expanding their business globally. Fuji Electric has developed external operating handles and terminal covers with enhanced electrical safety for molded-case circuit breakers and earth leakage circuit breakers. The main features are as follows:

- (1) Protection with the external operating handles (IP54)*
 - Inhibiting the ingress of splashing water at the rotating part or panel contact surface
 - Suppressing insulation degradation of internal equipment to improve electrical safety
 - Preventing transport damage and misoperation with the handle lying flush with the panel surface
- (2) Protection with the terminal covers (IP20)*
 - Preventing finger and hand entry from all directions
 - Allowing the insertion hole diameter to be adjustable according to the electric wire size used
 - Improving maintainability with insertion holes for electric and temperature inspection

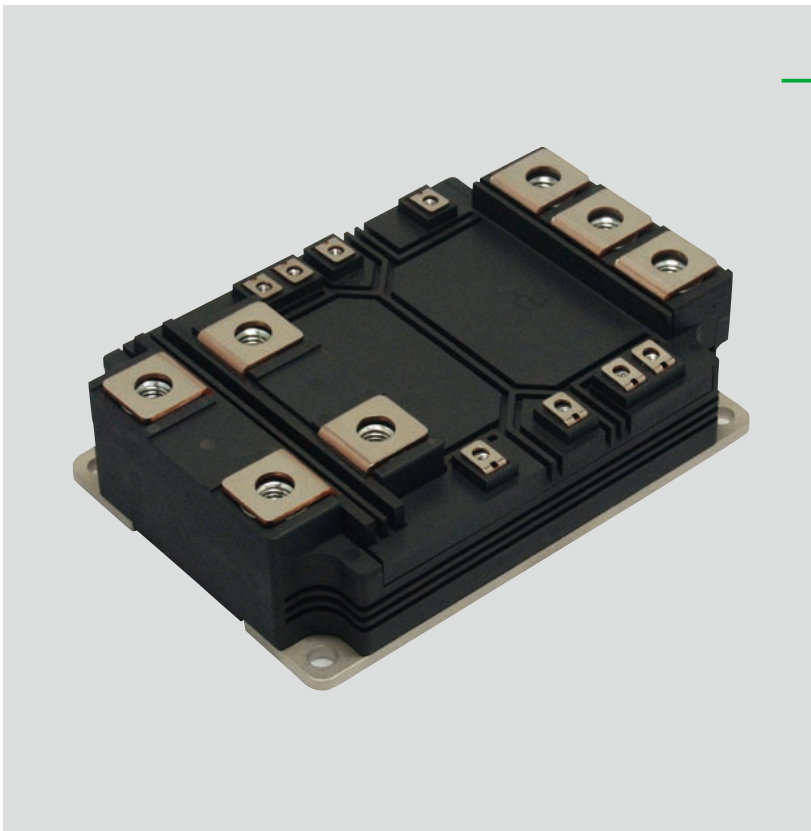
*Certified by a third party



“M677” 100-kW Class Ultra-Compact RC-IGBT Module for xEVs

Fuji Electric has been proactively offering IGBT modules for the market of EVs, PHEVs, and HEVs, which is growing both in Japan and overseas. Since inverters for vehicles are mounted in a limited space in vehicles, power modules for vehicles, which are key components, are needed to have small size and high power density. To meet the requirements, we have developed an automotive power module that has doubled the power density of conventional products by using advanced 7th-generation RC-IGBTs (reverse conduction IGBTs) with low dissipation loss, aluminum water jacket integrated coolers with high heat dissipation efficiency, and a lead frame package that reduces internal wiring area.

6-in-1 power modules rated at 750 V/600 A are of the smallest class in the industry and are targeted at motors with an output of 100 kW-class.



3.3-kV All-SiC Modules integrated with the 2nd-Generation Trench Gate SiC MOSFETs

In the traction market, improving transport efficiency is an important issue. Thus, power conversion systems installed in railcars are required to be more compact and light-weight. To achieve this demand, reduction of power dissipation is essential for power modules. In order to realize lower dissipation, SiC devices are attracting attention alternative to conventional Si devices because of their lower dissipation. For this reason, Fuji Electric has developed 3.3-kV All-SiC Modules integrated with the 2nd-Generation Trench Gate SiC MOSFETs. Optimizing the SiC-MOSFETs cell pitch has reduced on-state resistance and eliminating SiC-SBDs has increased the chip mounting area, thereby increasing output current. Furthermore, a newly developed low inductance package was adopted to take advantage of the high-speed switching characteristics of SiC-MOSFETs. These ones contribute to allowing power conversion systems to be more compact and light-weight.



Commencement of Commercial Operation of Rantau Dedap Geothermal Power Plant in Indonesia

Fuji Electric has completed construction and commissioning of a geothermal power plant (rated output at generator terminal: 49.2 MW \times 2 units) of PT Supreme Energy Rantau Dedap. We received the order of this project in partnership with PT Rekayasa Industri in Indonesia as a turnkey contract, including design, procurement, manufacturing, installation, and commissioning. The commercial operation started in December 2021. This plant uses the world's first "double-flush multipressure combined system." This system was designed to maximize power output by optimizing the use of low-pressure secondary steam generated from high-pressure hot water in addition to the two types of steam, high pressure and low pressure, from the production wells. Furthermore, to minimize the fluctuation in geothermal fluid caused by topography, we applied a new method that the steam separator system absorbs sudden changes in water pressure and volume. This power plant supplies power to approximately 500,000 households, contributing to an offset of approximately 470,000 tons of CO₂ emissions yearly.

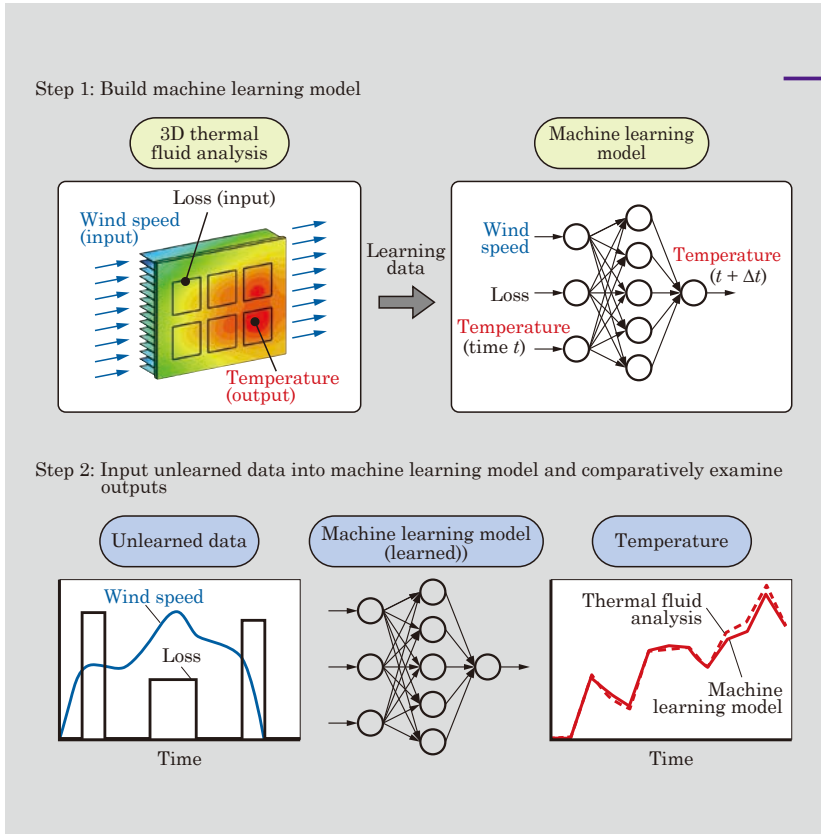


"Frozen Station" Frozen Food Vending Machine

Restaurants and retailers are increasingly diversifying their product distribution channels. Processed foods traditionally served in stores have now started being sold as frozen products. Fuji Electric has developed the "Frozen Station," a frozen vending machine that can sell frozen foods 24 hours a day at a variety of locations, including storefronts, train stations, and parking lots.

The main features are as follows:

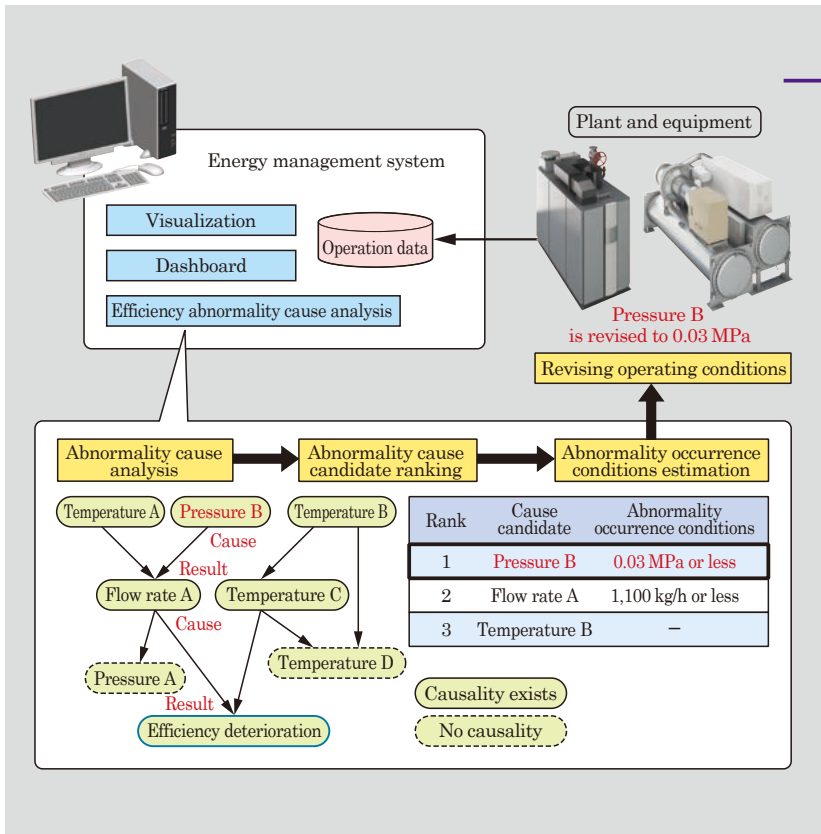
- (1) Internal space-saving design delivers a large capacity (standard: 7 types, 70 items; optional: 7 types, 84 items).
- (2) Enhanced airtightness of the internal structure improves thermal insulation and reduces power consumption (20% lower than our previous models).
- (3) Vending machine operation services that Fuji Electric offers allow customers to collect sales and inventory information online, reducing lost sales opportunities due to out-of-stock products while reducing operational labor (optional).



Model Reduction Technique Using Machine Learning Models with Thermo-Fluid Analysis Results

Advances in computing power have allowed 3D analysis to use larger models and shorten computation time. On the other hand, it remains impractical to estimate unsteady fluctuations over several hours or to perform structural studies involving hundreds of cases using only 3D analysis. Fuji Electric has thus been developing a model reduction technique that uses machine learning models with thermo fluid analysis results to reduce calculation time.

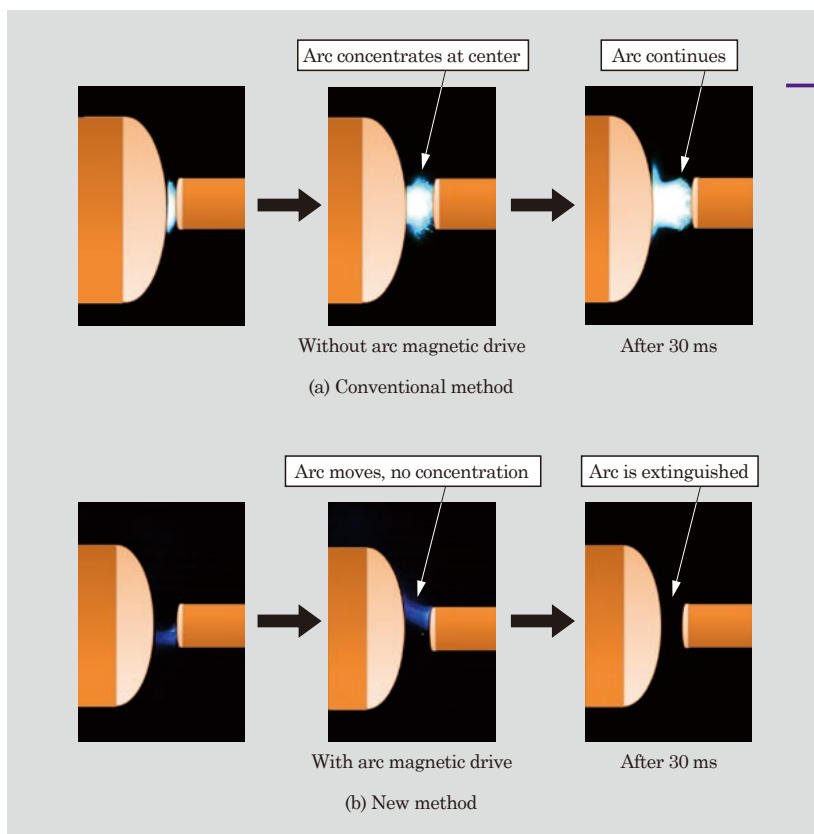
We comparatively examined peak temperatures observed in railcar inverter heat sinks, which fluctuate over several hours during operation. As a result, we confirmed that analysis with machine learning models obtained results with the same accuracy in a few seconds as 3D thermal fluid analysis. We aim to further develop this technique to increase the reliability of the method and apply it in product development.



Analysis of Abnormality Causes with Cause and Effect Analysis and Machine Learning

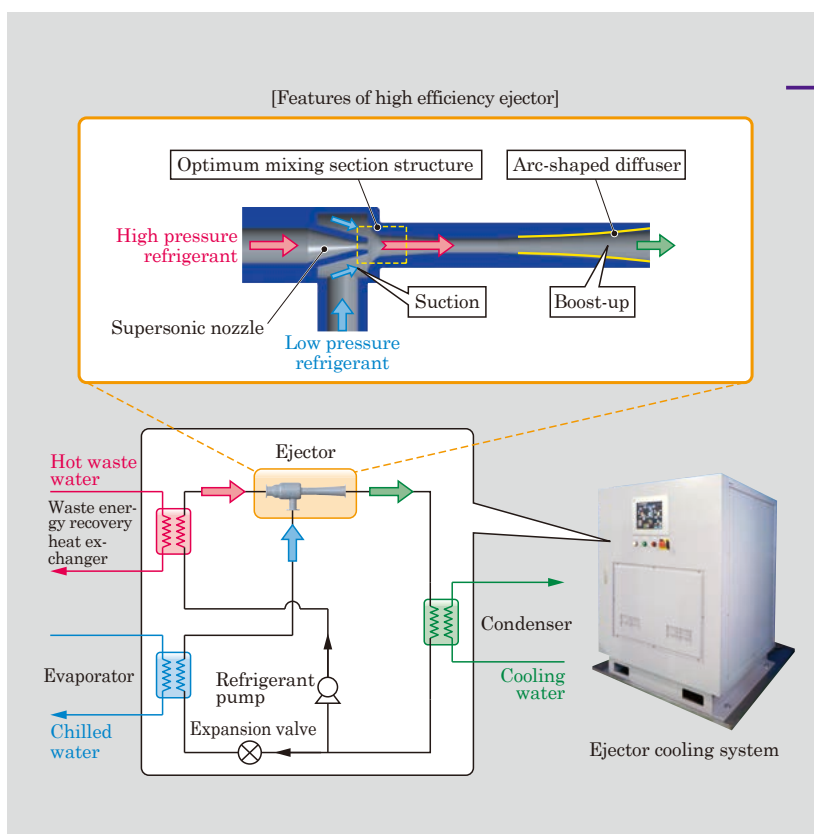
Plant operations require quick recovery in case an abnormality occurs. Cause analysis of abnormalities, which is required to implement countermeasures, had been conducted manually, relying on the knowledge of expert engineers, which was time-consuming. To address this issue, Fuji Electric has developed a technology to automatically analyze the cause of abnormalities from operation data.

This technology uses statistical causal inference to automatically extract candidate causes of abnormalities and display them in order of likelihood. It also uses machine learning to automatically extract abnormal conditions, which are the boundaries between normal and abnormal conditions. Combining these management functions can identify abnormality causes early, reducing time for recovery. Energy Management system software that Fuji Electric provides use this technology to streamline the abnormality cause analysis in energy efficiency of utility facilities.



Electrical Contact Technology for GIS with a SF₆ Alternative Gas

In line with international greenhouse gas reduction policies, SF₆ gas used in gas insulated switchgear (GIS) is required to be replaced with an alternative due to its high global warming potential. Air, a candidate alternative gas, has approximately one-half the breakdown voltage and approximately one-hundredth the arc extinction velocity of SF₆ gas. We have been developing the technology to compensate for the differences because obtaining the same performance would otherwise require GIS to have a larger size. For the breakdown voltage, we mitigated the electric field by reviewing the layout of the charging section around the electrical contacts. For the arc extinguishing speed, we magnetically drove the arc on the electrical contact and diffuse the arc heat. Our basic test demonstrated that these technologies above are promising to achieve a breakdown voltage and arc extinction speed equivalent to that of a GIS of approximately the same size and using SF₆ gas. We will apply these technologies to future designs.



Compressor-Less Highly Efficiency Cooling Technology

To achieve the carbon neutral plants, the effective use of low-temperature waste heat (hot waste water) and power reduction in chilled water supply are required. To address this, we have developed the industry's first cooling technology "ejector refrigeration systems." This system produces chilled water with lower power consumption than the conventional compressor-used refrigeration system by utilizing the waste heat energy.

The main features are as follows:

- (1) The high efficiency heat driven ejector is utilized in the system and achieves approximately one-third power consumption of conventional compressor-used refrigeration system. It leads reducing chilled water supply costs and the amount of CO₂ discharge.
- (2) The optimization of the mixing section structure and adopting the unique diffuser (arc-shaped diffuser) lead the utilization of low temperature waste heat (50°C to 60°C).

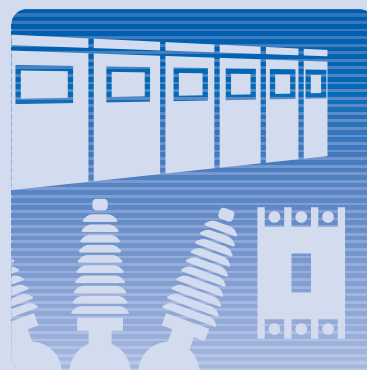
Power Electronics Energy

Energy Management

Transmission and Distribution Systems

Power Supply and Facility Systems

Electric Distribution, Switching and Control Devices



In the power electronics energy segment, Fuji Electric is committed to the technologies for power electronics, substations, and energy monitoring and control. Focusing on these technologies, Fuji Electric offers components such as switchgear, transformers, protection relays, uninterruptible power systems (UPSs), power conditioning systems (PCSs), and switchgear and control gear, as well as energy solutions that combine these. We provide one-stop solutions from system construction to maintenance services for power companies, material plants, and data centers, contributing to the construction of infrastructure that provides a stable supply of energy.

Energy Management

We offer solutions for increasing the use of renewable energy to customers pursuing carbon neutrality. In the field of power transmission and distribution, we have developed an operation support system for power distribution system planning to address the increasing complexity of power flow due to the expansion of renewable energy. In addition, we have delivered test equipment for verification of electric facilities consisting of reduced models of independent power systems on islands.

Geared toward operators targeting the growing real time market, we have developed the “PVI1400CJ-3/2600” PCS for large-capacity batteries, for which demand is expected to increase.

Transmission and Distribution Systems

We have been offering a solutions business that improves reliability, efficiency, and environmental friendliness through the use of substation equipment and power electronics equipment for the electric power, industrial, and transportation sectors.

We supplied a complete set of high voltage substation equipment, along with turbines and generators made by Fuji Electric, for one of the largest biomass power plants that use only wood pellets in Japan. Together with auxiliary equipment, we have delivered rectifiers for saline water electrolysis plants that have complied with harmonic regulations and achieved highly efficient operation. These facilities contribute to the car-

bon neutrality, a global challenge. We have delivered power transformers in response to transportation conditions that have become more severe due to the aging of bridges by significantly reducing transportation weight. In the replacement of the transformer rectifiers for direct current electric furnaces (DC furnaces), we completed the site works with the shortest power outage period. In the field of transportation, we have delivered operational notice transmission systems that use smart devices to support safe operation for local railways.

Power Supply and Facility Systems

Data centers (DC) and semiconductor manufacturing plants in Japan and overseas require power supply systems to deliver not only reliable and stable power supply, but also space saving and short construction periods. Fuji Electric’s “proposal of comprehensive electrical equipment,” including high voltage substation equipment, emergency power generation equipment, and UPS systems, optimizes systems, reduces installation areas, and shortens construction periods. We have delivered highly reliable UPS systems that can be maintained while supplying power for large-scale DC and computer centers. Furthermore, we have developed the “VC-V20 A-1,” the industry’s smallest 24-kV switchgear in compliance with IEC standards (IEC 62271-200) for the expanding infrastructure development in Southeast Asia.

Electric Distribution, Switching and Control Devices

In the field of electric distribution, switching and control devices, we offer electric distribution and switching devices for the efficient and safe use of electricity in renewable-energy-related equipment, electrical equipment in buildings and facilities, and control systems of plant production lines. We also provide control devices to automate and optimize manufacturing equipment and machinery.

Regarding low-voltage electric distribution equipment, we have developed and launched external operating handles and terminal covers with enhanced waterproofing, dust resistance and safety for molded case circuit breakers and earth leakage circuit breakers of

32 AF to 100 AF (ampere frame). These products meet the need for enhanced electrical safety protection degrees and the conformity with international electrical safety standards for industrial machinery and have acquired third-party certification, thereby promoting the safety of equipment and workers.

Demand is increasing for high-voltage electric distribution equipment that has improved reliability and reduce costs and work load of planned maintenance (preventive maintenance) as manufacturing equipment and

information network are highly developing. We have thus developed a high-voltage vacuum circuit-breaker that enables the equipment inspection cycle to be extended from the previous three years to six years by extending the life of the lubricating oil and optimizing the mechanisms.

We will continue to contribute to society by developing electric distribution, switching and control devices that meet social needs.

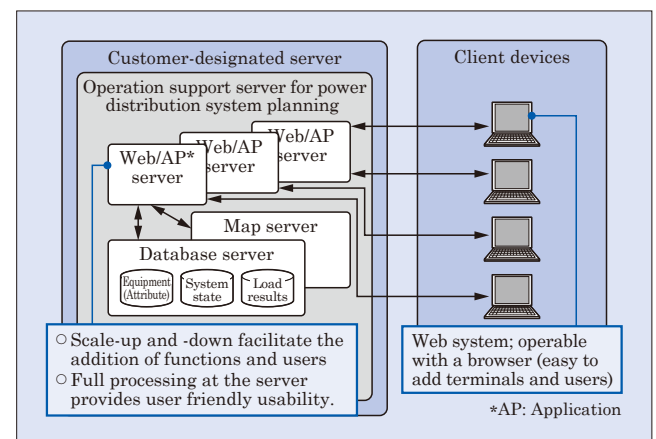
Energy Management

1 Operation Support System for Power Distribution System Planning

In order to maintain a stable supply of electric power against future demand changes, electric power companies are engaged in distribution system planning for the expansion and removal of distribution lines and the installation of voltage regulators. With the increasing complexity of electric power flow due to the expansion of renewable energy in recent years, distribution system planning work has become more difficult. To address this issue, Fuji Electric has developed an Operation support system for distribution system planning. The main features are as follows:

- (1) High-speed and high-precision power flow calculation and optimization technique enable analytical calculations, such as those for identification of voltage violations, optimum setting of voltage control equipment, short-circuit capacity calculation, thereby improving efficiency in system planning operations.
- (2) Adoption of the Web method eliminates the need for dedicated software for client devices, making it easy to add devices and users and reduce costs.

Fig.1 System configuration and features



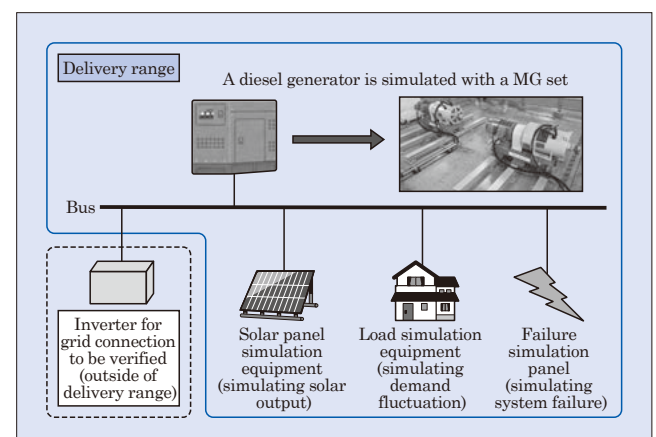
2 Delivery of Test Equipment for Power System Reduced Models

Fuji Electric has delivered test equipment for the verification of electrical equipment to a business facility operated by TEPCO Power Grid, Incorporated. The test equipment uses scaled-down models of independent electric power systems on islands. This system was made to check the performance of the control equipment developed for the project to demonstrate a 100% renewable energy power supply* on Hahajima Island before installation. The following features enable the reproduction of phenomena such as supply and demand of power and failures that occur in the system.

- (1) The same governor control and excitation control as the existing diesel generator employs can be simulated using a motor-driven synchronous generator (MG set).
- (2) It is possible to simulate solar power output, demand fluctuations based on local data, and system failure. The type and time settings of failure are variable.

* The Tokyo Metropolitan Government, Ogasawara Village, and TEPCO Power Grid participated in this project.

Fig.2 Configuration of test equipment



Transmission and Distribution Systems

1 Commercial Operation Started at Fukushima Iwaki Biomass Power Plant

As one of the measures to realize carbon neutrality, the practical application of power plants is advancing that are based on comprehensive CO₂ circulation biomass, which uses biological resources. Fuji Electric, through Sumitomo Heavy Industries, Ltd., has supplied high voltage substation equipment, turbine, generator, and other equipment to the Fukushima Iwaki Biomass Power Plant of Able Energy Limited Liability Company. The plant started commercial operation in April 2022. The order for a full set of Fuji Electric products allowed the design, prototyping, and evaluation to be carried out efficiently, enabling an optimal design that minimizes the power plant area and shortens the time from installation to start of operation. This power plant is one of the largest power plants in Japan that uses only wood pellets instead of co-firing with fossil fuels. It generates 770 million kWh of electricity annually, and is expected to significantly reduce annual CO₂ emissions (approximately 333 kilotons*) compared to fossil fuel power generation.

* Calculated using the national average CO₂ emission coefficient for FY2020 (0.433 kg-CO₂/kWh)

Fig.3 High voltage substation equipment

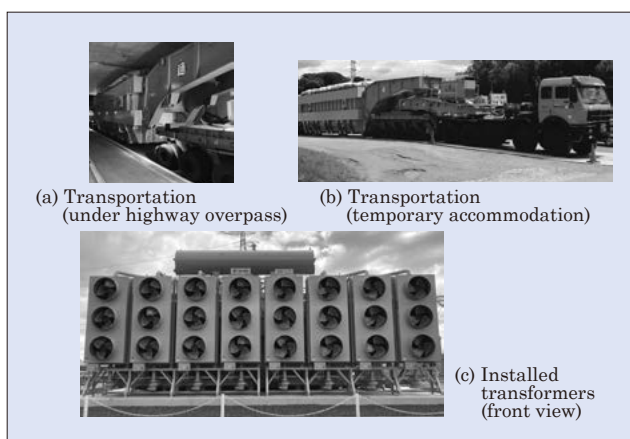


2 275-kV, 450-MVA Transformers for Shin-Kisarazu Substation, TEPCO Power Grid, Incorporated

Fuji Electric has delivered two transformers (275 kV, 450 MVA) for 5B and 8B in the Shin-Kisarazu Substation, which is operated by TEPCO Power Grid, Incorporated. We delivered transformers with the same specifications to the substation in 2000. This time, however, we took the following measures to meet the new mass restriction for passing vehicles on the bridge on the transport route to the substation:

- (1) The weight was reduced by redesigning the tank structure, eliminating the tertiary current-limiting reactor by devising windings, and using on-load tap change with a vacuum valve, thereby reducing the transport mass by 20 tons compared with the past product (below the mass limit of 220 tons).
- (2) We transported transformers by land for about 25 km from Kisarazu New Port to the substation using a 240 type Schnabel trailer running only at night, taking two nights per unit.

Fig.4 Transportation and installed transformers



3 Replacing a Transformer Rectifier for DC Furnace for Tokyo Steel Manufacturing Co., Ltd.

Fuji Electric has been manufacturing and selling transformer rectifiers, which integrate transformers and rectifiers, for direct current electric furnaces (DC furnaces) for more than 30 years. To reduce the risk of operation shut-down due to aging, we replace equipment that has been in operation for a long time. In August 2021, we replaced the transformer rectifier for a DC furnace at the Kyushu Plant of Tokyo Steel Manufacturing Co., Ltd. In order to prevent local overheat, this equipment uses Fuji Electric's unique technique of in-phase contra-polarity connection, which ensures high reliability. In addition, by conducting sufficient performance verification tests on the combination of transformers and rectifiers in a Fuji Electric's manufacturing plant, we reduced risks during operation and achieved vertical start-up.

Fig.5 Transformer rectifier for DC furnaces



Transmission and Distribution Systems

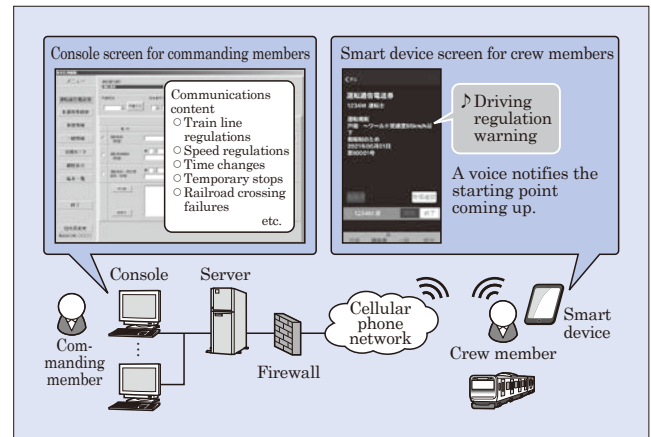
4 Operational Notice Transmission System for Local Railways of Kyushu Railway Company

The safe operation of trains is a top priority for railway companies, and, therefore, the prompt sharing of operational instructions is indispensable. Fuji Electric has supplied Kyushu Railway Company with an operational notice* transmission system for local railways that serves as a means of communication between directors at dispatching centers and train crews. The main features are as follows:

- (1) The function of transmitting operational notice data prepared by directors to smart devices carried by crew members has streamlined the equipment and at the same time improves convenience and maintainability.
- (2) By changing from a system in which character information is superimposed on the train radio to a communication system using a cellular phone communication network, the communication capacity has been increased and stabilized.
- (3) Safety is ensured through security measures such as unauthorized communications cutoff and spoofing prevention.

* Operational notice: A communication form to be used when operating conditions are changed, such as train line regulations, speed regulations.

Fig.6 Operational notice transmission system for local railways



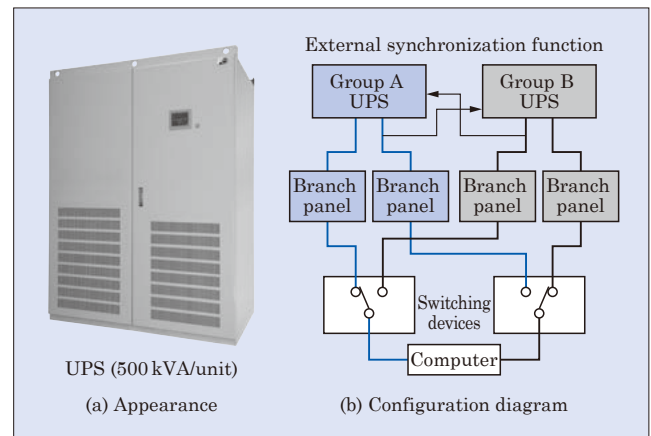
Power Supply and Facility Systems

1 Delivery of a UPS System to a Computer Center

With the globalization of the economy and the increase in electronic commerce, computer processing systems are being developed to deal with transactions 24 hours a day, 365 days a year. In addition to stable power supply, such systems require electric equipment to continue to supply power even during maintenance work. Fuji Electric has delivered a redundant system constructed with a four power system configuration at a computer service bureau. Stabilization of power supply to computers, including during maintenance, has been achieved by the following features:

- (1) The UPS system consists of two groups of parallel redundant UPSs, each of which has two output power branches (four systems in total).
- (2) A switching device is provided on the secondary side (computer side) of each UPS to continuously supply power through the two switching devices.
- (3) By synchronizing the UPS outputs of different groups (external synchronization function), voltage fluctuation at the time of power supply switching is suppressed.

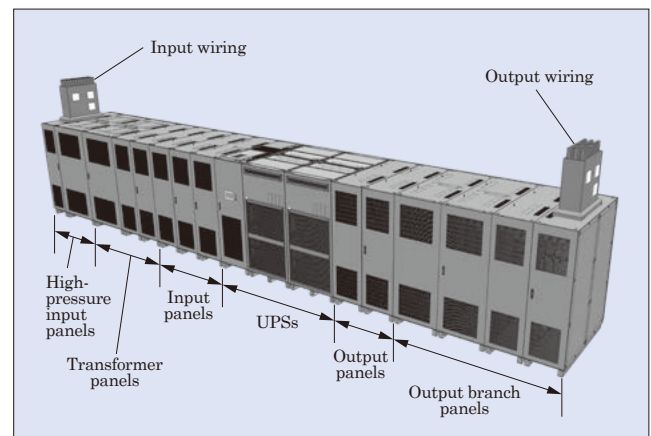
Fig.7 UPS and switch configuration



2 Delivery of a Large Capacity UPS System (1,200 kVA)

In recent years, the number of large-scale data centers (DCs) being constructed has increased, and the need for UPS systems necessary for stable operation of DCs has grown. Space-saving and reduced installation periods are required for UPS systems. Fuji Electric has developed a UPS system that uses a UPS whose single unit capacity has been increased from 500 kVA to 1,200 kVA and delivered it to a DC. By increasing the capacity of the single unit, the number of UPSs has been reduced from three to one, and the number of battery panels, from nine to seven. In addition, in response to the increase in heat generation due to the increase in capacity, the cooling efficiency has been improved by separating and arranging the internal equipment of the UPS according to the degree of heat generation, and space-saving has been achieved by reducing the size of the heat sink. In addition, the high-voltage input panels, transformer panels, UPSs, input and output panels, and output branch panels are directly connected to each other, reducing wiring work and significantly shortening the construction period.

Fig.8 Configuration of UPS systems (1,200 kVA)



Power Supply and Facility Systems

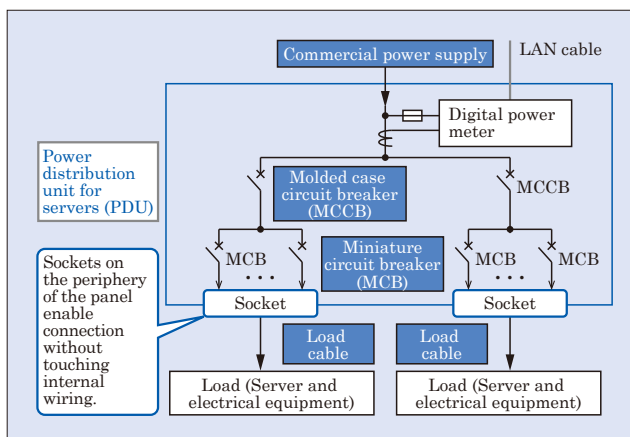
3 IEC-Compliant Power Distribution Unit (PDU) for IDC Servers, Marketed in Japan

Fuji Electric offers its Proposal of Comprehensive Electrical Equipment, which provides a full package for substation equipment, from optimal system design to installation, operation monitoring, and maintenance services. To help stabilize IDC* operation, we have offered a power distribution unit (PDU) for servers, made by Fuji SMBE, as an additional product for the Japanese IDC market. The PDU complies with IEC 61439-1: 2020. The main features are as follows:

- (1) Installation is easy because fault and measurement signals are transferred together through a LAN cable, instead of previously used separately-installed control cables.
- (2) Installation is safe because load cables can be connected to loads via the sockets mounted on the periphery of the panel top without contacting the internal wiring.

*IDC: Internet data center

Fig.9 Circuit configuration diagram



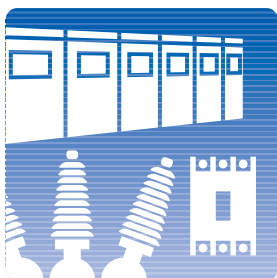
Electric Distribution, Switching and Control Devices

1 “HS2006X Series” Vacuum Circuit Breakers with Reduced Life Cycle Cost

High-voltage equipment is used for a long period of time, from 15 to 30 years. During this period, periodic maintenance such as cleaning and lubrication is recommended to prevent unexpected failure. On the other hand, there is a need to reduce the frequency of on-site maintenance work. To address this, Fuji Electric has developed the “HS2006 X Series” vacuum circuit breakers with reduced life cycle costs.

The recommended inspection period of this product has been extended from 3 years to 6 years by reducing friction in the operation mechanism parts and changing the lubricant for the internal mechanism to a type that takes longer to solidify.

Fig.10 “HS2006X Series”



Power Electronics Industry

Factory Automation
Process Automation
Information Solutions
Social Solutions
Field Services



The Power Electronics Industry combines driving equipment, measuring instruments and control equipment with artificial intelligence (AI) and Internet of Things (IoT) to create systems and contribute to automation, energy saving and stable operation of equipment across all industrial fields. Furthermore, we also expand our products to the railway and marine sectors, contributing to the safety and security of social infrastructure and energy saving.

Factory Automation

In factory automation, Fuji Electric contributes to automation, energy saving, and optimal operation of equipment by using driving equipment, such as inverters and rotating machines, measuring instruments, such as pressure transmitters, and control equipment, such as programmable controllers and programmable operator interfaces.

In the field of driving equipment, we have worked to expand the functions of the “FRENIC-MEGA (G2) Series” of high-performance, multi-functional inverters and developed a line-up of zero-phase reactor built-in types and communication cards for major industrial networks.

In the field of measuring instruments, we have developed the “FCX-AIV Series” of pressure transmitters. It is certified to IEC 61508 (SIL2), the functional safety standard so that the transmitter can be used for systems that require high reliability.

In the field of control equipment, we have developed an “abnormality diagnosis solution” that uses AI to detect and analyze abnormalities in product processing in the production process. We have also developed the “SPH5000EC” CPU module for the “MICREX-SX Series” of programmable controllers that support EtherCAT, an open network. A high-speed, high-precision motion system can be constructed by combining this module with the “ALPHA 7” servo system.

In the field of FA systems, we have developed testing equipment for electric vehicles (EVs) in response to the needs of testing equipment for electrification of automobiles.

Process Automation

In process automation, highly reliable control of equipment, remote monitoring, and detection of abnormal signs are achieved based on know-how accumulated through a wide range of product line-ups and abundant delivery records.

In the field of driving control systems, we contribute to the stable operation of customer facilities by improving the reliability of medium-voltage inverters and expanding existing replacement tools, in addition to control systems based on the “XCS-3000 Type E” controller, which is capable of achieving high-speed control with a large capacity, and the “f(s)NISDAS7” high-speed data acquisition and analysis support device.

In the field of measurement systems, we reduce environmental impact by delivering an extra-high voltage substation equipment, monitoring and control system, analyzer, field equipment collectively to our customer plants such as waste treatment plant. We also provide predictive maintenance with abnormal sign monitoring, as well as control functions that utilize model prediction and AI functions. In addition, we have established an environment for remote monitoring and control system witness inspection and have begun to use this environment in the face of restrictions on human interaction due to the COVID-19 pandemic.

In the field of industrial electric heating, we have developed a refractory abrasion trend monitoring function and a maintenance parts management function to improve the maintainability of induction furnaces. This makes it easy to manage refractory replacement, and we contribute to labor saving in maintenance work by recording and visualizing the operating time and number of operations of consumable parts.

Information Solutions

In information solutions, we have been developing digital solutions and creating new products. We have been developing information business with DX (digital transformation) and carbon neutrality as the starting point, including factory DX and digitalization of offices in the new normal and administrative work.

Also in the field of information control systems, we

have developed a cluster energy management system using AI that contributes to energy saving and decarbonization.

Social Solutions

In the social solutions field, we contribute to the safety, security and energy saving in social infrastructure by developing electric systems for railcars, marine systems, transportation equipment systems, and radiation control systems.

In the railways field, we have developed a platform for door drive systems for railcars to enhance safety, reliability and maintainability by modularizing components to facilitate installation and replacement of equipment.

In the marine vessel field, we have developed a hybrid exhaust gas cleaning system (EGCS) for navigation in waters where wastewater discharge is prohibited. This enables switching between the conventional system and a circulation system in which wastewater is repeatedly used for exhaust gas purification without discharg-

ing it overboard. This makes it possible to operate the EGCS in accordance with the regulations of the sea area.

In the field of radiation monitoring equipment and systems, we have developed a new monitoring post that measures radiation in the environment continuously for 24 hours. The post is designed to work under extreme heat and cold as well as to improve the efficiency of maintenance operations.

Field Services

In the field services, in addition to conventional maintenance services such as periodic inspections and repairs, we have been developing equipment maintenance optimization solutions using IoT, analytics and AI.

For the “Comprehensive Service for Smart Industrial Safety,” which we have offered for customer facilities, a camera-based meter reading function and a predictive fire detection function have been added in conjunction with other companies’ systems.

Factory Automation

1 Zero-Phase Reactor Built-In Type of “FRENIC-MEGA (G2) Series”

One of the main applications of general-purpose inverters is energy saving of fans and pumps. Fuji Electric has been providing the “FRENIC-Eco Series” for this application. However, in order to comply with the standard specifications for public construction work supervised by the Ministry of Land, Infrastructure, Transport and Tourism, it was necessary to add reactors, which required cost reduction. To meet this requirement, we have added a line-up of zero-phase reactor built-in models to the “FRENIC-MEGA (G2) Series.” The products have the same basic functions and performance as the standard type of the FRENIC-MEGA (G2) Series, and they support a capacity range of 1.5 to 75 kW at 200 V and 1.5 to 75 kW at 400 V. Incorporating the zero-phase reactor helps reduce installation space and facilitate wiring work. We intend to expand use of the new line-up in fan and pump applications by making use of FRENIC-Eco Series compatible functions.

Fig.1 “FRENIC-MEGA (G2) Series”



Factory Automation

2 Ethernet Communication Card for the “FRENIC-MEGA (G2) Series” Low-Voltage Inverters

In recent years, Ethernet-based industrial open networks have rapidly come into wide use to achieve smart factories. Fuji Electric has developed an Ethernet communication card for the “FRENIC-MEGA (G2) Series” of low-voltage inverters, the card of which supports major industrial protocols in the global market. The main features are as follows:

- (1) Supports EtherNet/IP and PROFINET-I/O, which can be switched by a setting on the inverter (certified to each communication protocol standard).
- (2) Supports ring and daisy-chain topologies in addition to star, tree and bus topologies with two communication ports.
- (3) Supports switching of communication paths at the time of wire break in a ring configuration, enabling the building of highly reliable network.

Fig.2 Ethernet communication card for “FRENIC-MEGA (G2) Series”



3 “FRENIC-RHC (RHC-E) Series” PWM Converters

In motor control using general-purpose inverters, PWM converters are used to suppress input current harmonics and recover braking energy from the motor. They are increasingly used for large-scale systems recently and are required to have larger capacity and enhanced monitoring functions. Fuji Electric has accordingly developed new 400-V and 690-V stack types as the “FRENIC-RHC (RHC-E) Series” PWM converters.

- (1) Up to four stacks being parallelly connected without an isolation transformer, 400-V series stands at 3 MW and 690-V series, 1.7 MW.
- (2) High-speed, large capacity “E-SX bus” communications enable detailed monitoring by notifying high level systems of an operating state at a minimum cycle of 250 μ s.

Fig.3 “FRENIC-RHC (RHC-E) Series” (Stack type)



4 JFII Series Breaker-Shaped Watt-Hour Meter with Communication Function

Fuji Electric has developed the “JF II Series” breaker-shaped watt-hour meters with a communication function as a successor to the “JF Series” of watt-hour meters. The JF II Series can reduce wiring, installation man-hours, and outer dimensions. The main features of the JF II Series are as follows.

- (1) Bi-directional currents, forward and reverse, can be measured by a single unit, reducing installation costs of facilities such as solar power plants.
- (2) Visualizing power consumption help consumers save energy by collecting data every 30-minutes through Modbus/RTU communications and data can be stored for 45 days.
- (3) The incorrect wiring verification assistance function prevents incorrect measuring and wiring during installation work.
- (4) Users can confirm the validity period of certification and prevent expiration by setting expiration date (4 digits) on meter.

Fig.4 “F6JF-TN1” (Single-phase, 3-wire, 120-A type)



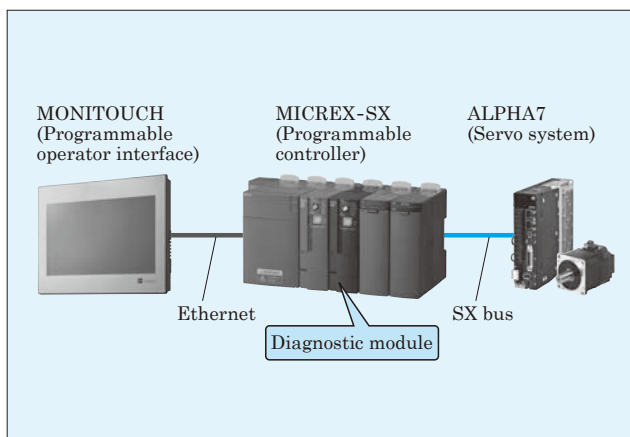
Factory Automation

5 “Abnormality Diagnosis Solution” Powered by Analytics and AI (MSPC)

At processing sites such as those for food packaging and metal processing, methods are being devised to detect the occurrence of defective products in real time on the basis of the behavior of machinery to improve productivity and prevent defective products from being passed on to the next process. Fuji Electric has developed a diagnostic module as a new module for programmable controllers to detect abnormalities during product processing and helps analyze the causes. This module is provided as an “abnormality diagnosis solution” in combination with a servo system and a programmable operator interface. By means of analytics and AI (MSPC*) technology, this solution detects abnormalities in real time by comparing operation data with a model generated based on data during normal processing of equipment. The history of diagnosis results is stored on a programmable operator interface, and the results (waveforms) to be checked can be selected and displayed to assist in determining the cause of the abnormality.

*MSPC: Multivariate statistical process control

Fig.5 System configuration example

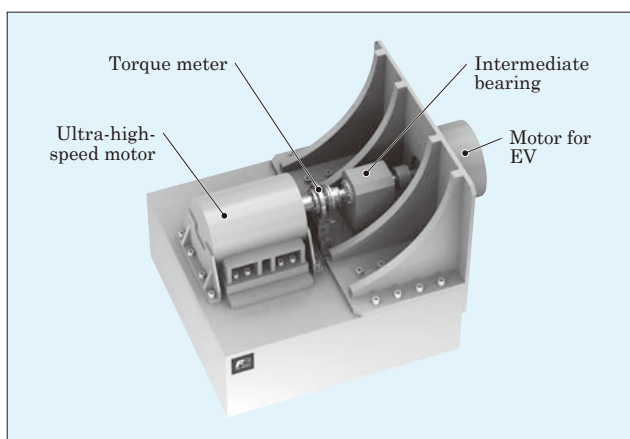


6 Test Equipment for EVs

With the global trend of emissions regulations and decarbonization, electrification of automobiles is progressing. In Japan, approximately 40% of automobiles sold in FY2030 are expected to be EVs, and demand for test devices for EVs is increasing. In response to this, Fuji Electric has developed a test device for EV motors that integrates the high-speed rotation design technologies used for our own ultra-high-speed motors, drive equipment, and intermediate bearings. The main features are as follows:

- (1) Tests can be performed with high-speed drive at a maximum speed of 20,000 r/min.
- (2) Grease lubrication of the intermediate bearing eliminates the need for pumps and other auxiliary equipment, thereby simplifying maintenance.
- (3) Installation of a thermostatic chamber enables reliability evaluations to be performed under simulated weather conditions.

Fig.6 Test equipment for EVs



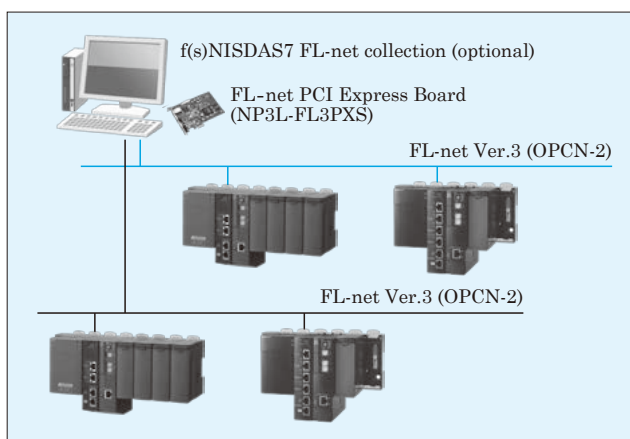
Process Automation

1 Enhancement of Functionality of “f(s)NISDAS7” Supporting Package Software for Data Acquisition and Analysis

Fuji Electric has enhanced the functionality of “f(s)NISDAS7” supporting package software for data acquisition and analysis, which supports operation monitoring and equipment maintenance operations. By increasing the amount of data collected and speeding up the collection cycle, the software contributes to reductions in the start-up time of production facilities and improvements in the accuracy of detecting signs of abnormalities in facilities. The enhanced functions are as follows:

- (1) Simultaneous data acquisition through two FL-net lines has been enabled.
- (2) NISDAS protocol specifications have been expanded to increase the amount of data acquired (Example: from 96 points to 16,256 points for the “MICREX-SX” and “MICREX-View XX”).
- (3) Continuous mode has been added to the data acquisition method to support high-speed acquisition of large-capacity data (up to 3,200 points with 150 ms cycle).
- (4) Remote usability has been enhanced, including sharing analyzer settings.

Fig.7 Simultaneous data acquisition via two FL-net lines

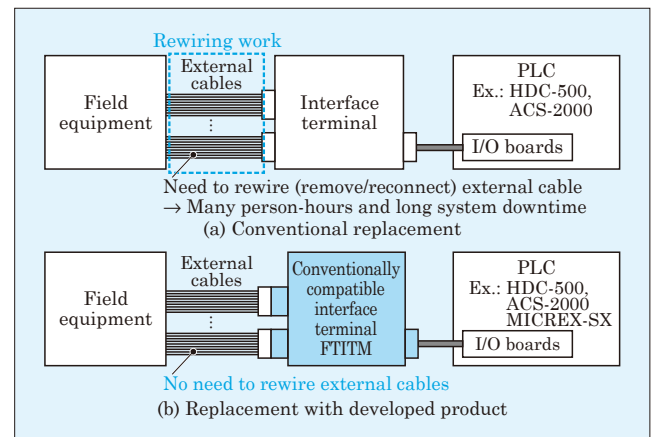


Process Automation

② Replacement of Existing I/O Using the “FTITM” Conventionally Compatible Interface Terminal

When replacing PLCs for the purpose of maintenance and repair of monitoring and control systems, on-site wiring work so far need reattaching all external cables connecting field devices and interface terminals, which required many person-hours and entailed risks such as mis-attachment and mis-wiring. To address this, Fuji Electric has developed the “FTITM” conventionally compatible interface terminal, which supports systems that use the “HDC-500” and the “ACS-2000” PLCs released in 1980’s. The current model “MICREX-SX” can be connected by simply replacing the existing interface terminal with the FTITM without relaying the external cables. Thus, PLCs, which are long-term operation devices, can be easily and quickly replaced while effectively utilizing the hardware assets of customers.

Fig.8 Connection image of “FTITM”

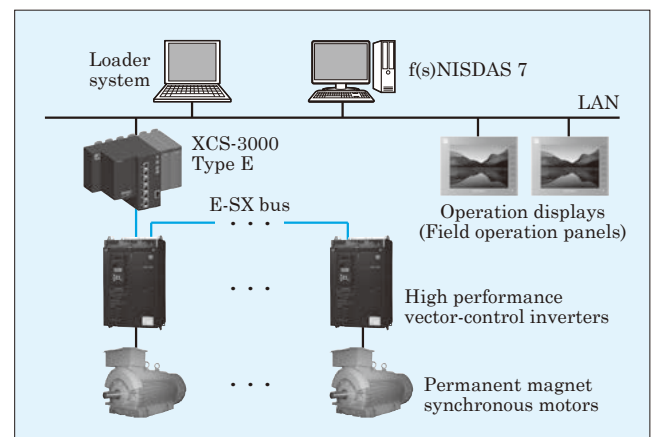


③ Delivery of Drive Control System for Film Manufacturing Facility

Fuji Electric has delivered a drive control system for a Japanese film manufacturer's latest film manufacturing equipment, which began operation in March 2022. The features of the system are as follows:

- (1) Delivers larger data capacity and high-speed control (up to 0.5 ms) using the “XCS-3000 Type E” as the main controller.
- (2) Achieves high-speed synchronous operation (60 units/5 ms) of multiple film conveyance mechanisms via the “E-SX bus” of the XCS-3000 Type E.
- (3) Highly improves the operating efficiency (IE3 level) with the use of permanent magnet synchronous motors (PM motors).
- (4) Supports failure cause analysis and optimal operation pattern creation based on long-term operation data speedily collected by “f(s) NISDAS7” supporting software for data acquisition and analysis.

Fig.9 System configuration diagram



④ “FRENIC4600FM6e” Medium-Voltage Inverter Increased in Reliability

In social infrastructure, such as electric power and water treatment facilities, and in materials industries, such as cement and petrochemistry, medium-voltage inverters have increasingly used for critical facilities in plants to save energy. These facilities are required to have high reliability not to stop operation. In order to improve the reliability of the medium-voltage inverter, Fuji Electric has taken measures for limited-life components with a high failure stop risk.

(1) Redundant cooling fans

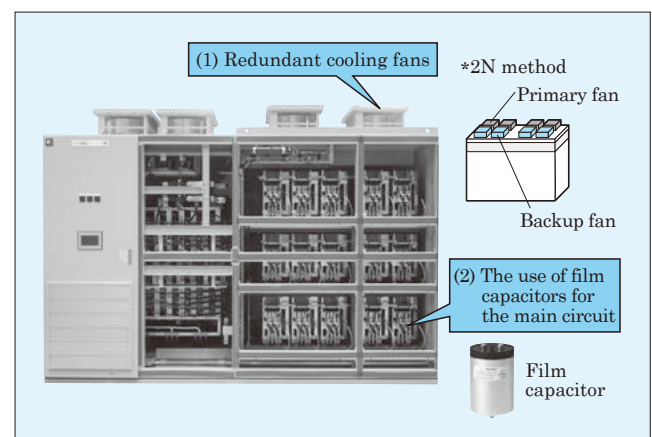
Two redundancy methods, complete duplex (2N*) and N + 1, are available to reduce the failure stop risk.

(2) The use of film capacitors for the main circuit

Aluminum electrolytic capacitors in the main circuit, which are limited-life components, have been changed to film capacitors, eliminating the need for future replacement.

*N: Number of cooling fans

Fig.10 “FRENIC4600FM6e” improvements



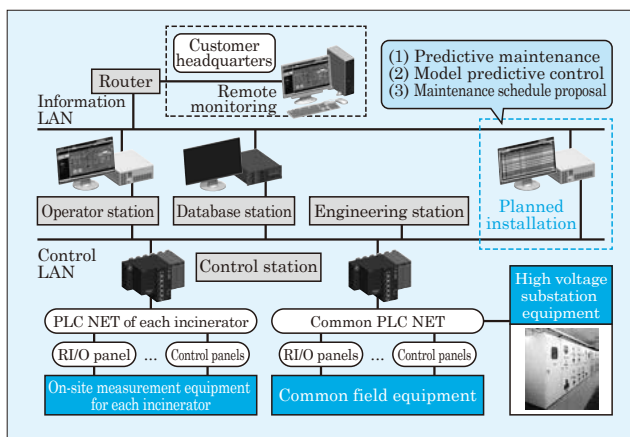
Process Automation

5 Delivery of Electrical and Instrumentation Equipment for Eco Cleanpeer Harima

Fuji Electric, through Kobelco Eco-Solutions Co.,Ltd., has delivered electrical and instrumentation equipment together to Eco Cleanpeer Harima (Toban Seaside Wide-Area Clean Center), including high voltage substation equipment, a monitoring and control system (DCS), field control panels, analyzers, and field measuring instruments. Receiving the bulk order resulted in a streamlined, integrated electrical and instrumentation system, and furthermore, the coordinated operation of the component equipment could be confirmed in advance, significantly shortening the time required to commission the equipment on site. In the future, we will contribute to the maintenance and management of the products and implement the following:

- (1) Predictive maintenance through the monitoring of abnormal signs
- (2) Advanced control with model predictive control and AI
- (3) Proposal of optimal maintenance schedules based on remote monitoring of equipment conditions

Fig.11 Delivery system configuration

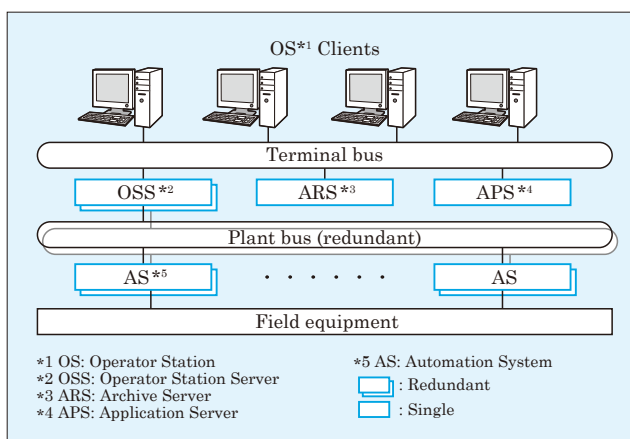


6 Monitoring and Control System for Off-Site Facilities of an Oil Refinery

Fuji Electric has delivered many monitoring and control systems to off-site facilities of oil refineries. However, we face challenges in dealing with unstable operation of hardware caused by long-term operation after delivery and security risks, such as malicious viruses and malware. In order to solve these issues, we took following measures when replacing a "MICREX-NX" monitoring and control system at the off-site facilities of an oil refinery:

- (1) Increasing processing speed by updating the CPUs of operator station clients from V6.1 to V9.0 and expanding memory capacity to speed up plant control.
- (2) Improving reliability with dual CPU configuration for Automation Stations.
- (3) Strengthening security to prevent unauthorized applications from being activated with white lists installed in the servers.

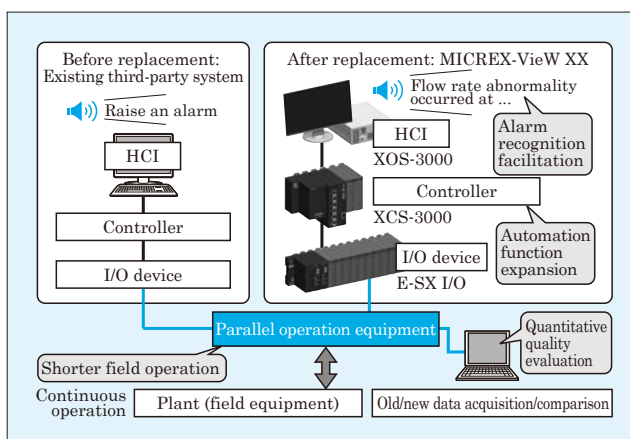
Fig.12 Monitoring and control system configuration



7 Replacement of Monitoring and Control System for Water Facilities at a Steelworks

Fuji Electric has replaced the monitoring and control system for the water facilities of a steelworks in Japan with a system using the "MICREX-VieW XX." Water facilities are continuously operating facilities, and they must continue to operate even when switching between old and new systems. However, in the past, the facilities had been temporarily stopped for the trial operations to evaluate a new system. To address this, we introduced a parallel operation equipment internally having a circuit switching function. The equipment can automatically compare and verify data during an old and new systems operate in parallel. This function allowed us to verify that the old and new controllers had equivalent control functions in a short period of time and replace the monitoring and control system without shutting down the water supply facilities. In addition, the new system has a voice annunciator that provides an audible indication of the type of plant abnormality, enabling rapid restoration after an alarm is issued.

Fig.13 Monitoring and control system configuration



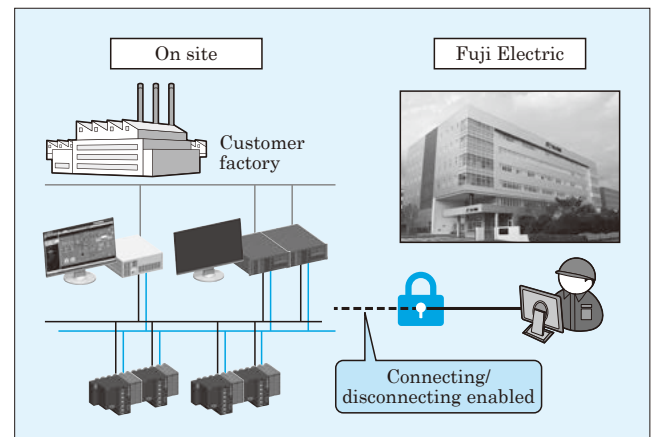
Process Automation

8 Remote Maintenance System for Industrial Monitoring and Control Systems

There is a growing need for remote equipment repair, maintenance and troubleshooting. Fuji Electric has constructed a remote maintenance system that guarantees cybersecurity and started providing a service to support on-site systems remotely. The main features are as follows:

- (1) Security is enhanced through the use of OpenVPN (encrypted communication) and the installation of firewalls.
- (2) An external access restriction function that turns VPN connections on and off locally enables flexible operation while ensuring security.
- (3) The system can be easily introduced at low cost by eliminating the need for dedicated software and dedicated lines for remote maintenance.

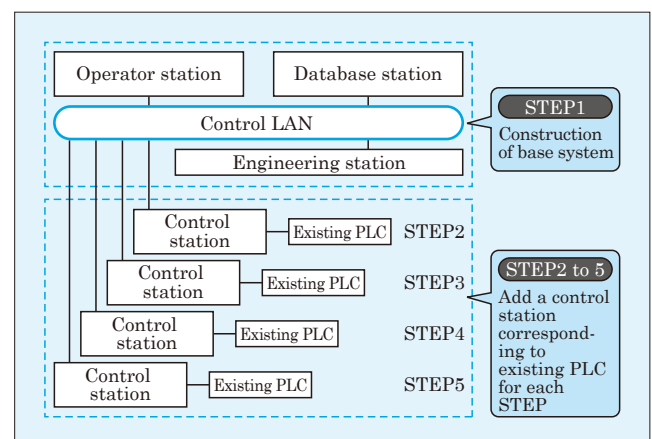
Fig.14 Remote maintenance system overview



9 Replacement of the Monitoring and Control System at a Chemical Plant

Fuji Electric has replaced the monitoring and control system at a chemical plant. In order to reduce the burden on the customer and minimize the impact on production, the project, the time period of which is divided in five steps until 2025, proceeds in stages. In Step 1, which was carried out in FY2021, we introduced a “MICREX-View XX” operator database control engineering station to build a base system. The customers remotely confirmed functionality during the witness inspection of the system using remote PC software provided by Fuji Electric. Since the software allows the customers to operate the system on their PC screen, they participated in the on-site witness inspection to verify and inspect the system functions from their own workplace.

Fig.15 Example of “MICREX-View XX” replacement in stages

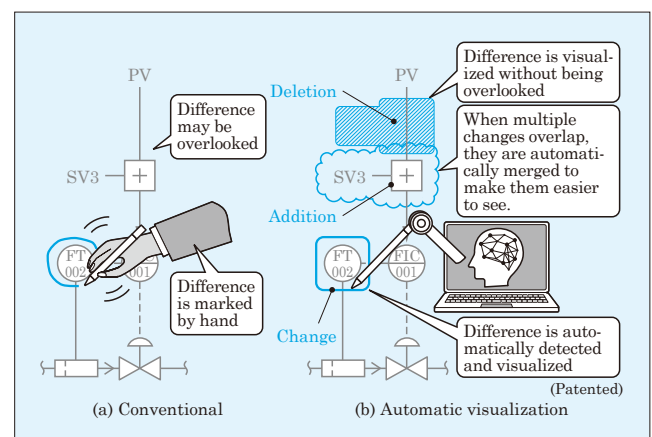


10 “HEART” Highly Efficiency Engineering Support Tool Automatically Visualizing Changes in Specifications and Diagrams

Specifications and diagrams, which are engineering documents, are changed according to changes in specifications and on-site modifications. Changes (differences) are usually indicated (marked) by circling them by hand, however, which leads oversights and mis-recognition caused by the individual notation. To address this, we have developed an automatic visualization function for differences and incorporated it into the “HEART” engineering support tool. The main features are as follows:

- (1) A database of text that makes up specifications and diagrams as well as software elements is created, and 17 types of changes, including additions, changes, and deletions, are automatically extracted using a proprietary algorithm. Extracted differences are automatically displayed and visualized so that oversights are prevented.
- (2) If multiple changes overlap and they are in the same classification, they are automatically combined and displayed in an easy-to-read manner.

Fig.16 Overview of automatic visualization



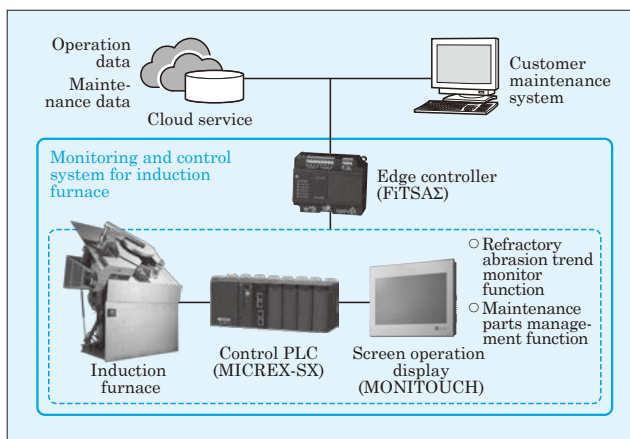
Process Automation

1 Maintenance System for Induction Furnace Operation

Fuji Electric has improved the data acquisition and recording function of the current system and developed a maintenance system for induction furnace operation equipped with a refractory abrasion trend monitoring function and a maintenance parts management function to improve the maintainability of induction furnaces and promote IoT.

- (1) The number of data acquisition items for the power supply and auxiliary equipment of induction furnace has been expanded to approximately three times that of the conventional system, and the collected data are stored in the "FiTSAΣ" and transmitted to the customer's maintenance system or Fuji Electric's cloud service to share information.
- (2) Abrasion trends of refractories are monitored on the basis of voltage, current, and other data to support proper management of equipment.
- (3) Preventive maintenance functions have been expanded, such as recording and visualizing the operating time and the number of operations of the consumable parts of equipment.

Fig.17 Entire system configuration

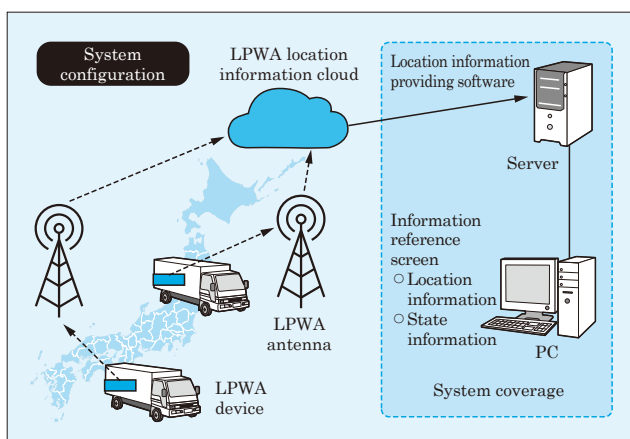


Information Solutions

1 Location Information Provision Software Using LPWA Devices

As part of its PORT 2030 medium- to long-term port policy, the Ministry of Land, Infrastructure, Transport and Tourism is promoting smart port areas. Currently, shipping work in the vicinity of ports is complex and requires efficiency improvement because the location information of containers and trailers is managed on paper by people. To address this challenge, Fuji Electric has developed software that supports work efficiency by managing location information using low power wide area (LPWA) devices. Positioning by LPWA uses electric field strength in communications with multiple base stations. The battery life of LPWA devices is more than 5 years, and operating costs start at approximately 100 yen per unit per year, which is very low compared with GPS. In the future, we will help achieve the PORT 2030 by deploying this software throughout the shipping industry in Japan.

Fig.18 Example of system configuration using location information provision software



Social Solutions

1 Door Drive System for Series 315 Conventional Line Commuter Train (Central Japan Railway Company)

Fuji Electric has delivered door drive systems for Series 315 conventional line commuter trains to Central Japan Railway Company through Nippon Sharyo, Ltd. This is the first delivery case of the door drive system for side sliding doors in the Tokai region. Revenue service of trains equipped with this system started in March 2022. This system, which is based on our domestic standard products with a proven track record in the Tokyo metropolitan area, realizes high safety, reliability, and maintainability with the following features:

- (1) Enhances passenger safety by improving the obstruction detection function to make it easier to pull out obstacles.
- (2) Increases reliability by using controllers with redundant control functions.
- (3) Improves maintainability by modularizing components to facilitate installation and replacement of equipment.

Fig.19 Series 315 conventional line commuter train



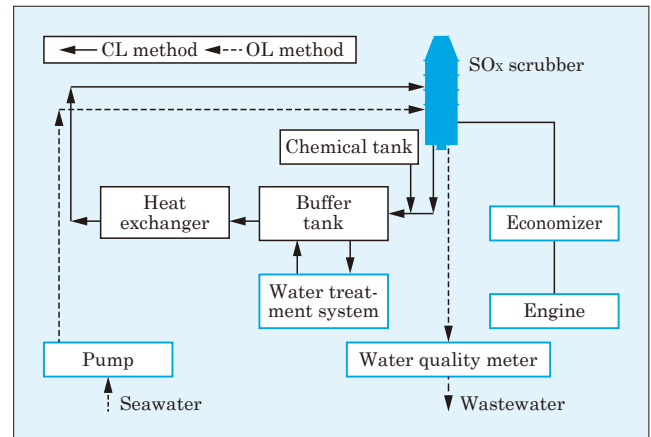
(Photo courtesy of Central Japan Railway Company)

Social Solutions

2 Exhaust Gas Cleaning System for Navigation in No-Discharge Zones

In addition to the International Maritime Organization's regulations on sulfur oxide (SO_x) concentrations in exhaust gas, a growing number of countries and regions are banning wastewater discharge from exhaust gas cleaning systems (EGCSs). To use EGCSs in countries and regions with these regulations, Fuji Electric has developed an exhaust gas cleaning system for navigation in no-discharge zones (hybrid EGCS). The hybrid EGCS allows the user to select between the conventional open loop (OL) method and the new closed loop (CL) method. The CL method features a system configuration in which the functions for supplying alkali components, preventing water temperature rise, removing soot, and defoaming of wash water have been added to the EGCS, and waste water is circulated through a SO_x scrubber and repeatedly used for cleaning exhaust gas. With this system, the operation method can be switched according to the regulations of the sea area, and the marine route can be selected flexibly.

Fig.20 Exhaust gas cleaning system for navigation in no-discharge zones

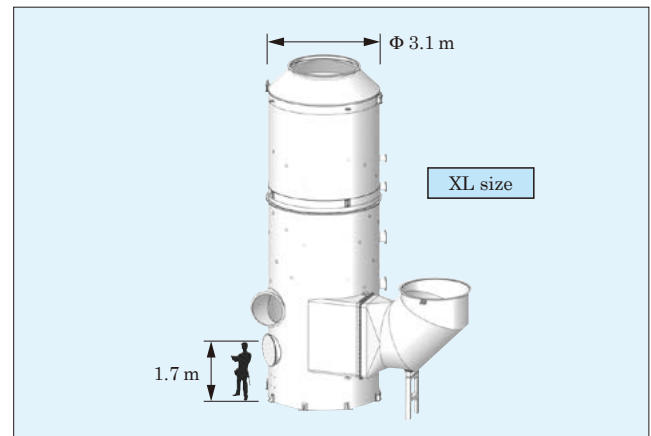


3 Capacity Expansion of the SO_x Scrubber for Marine Vessels

Fuji Electric provides SO_x scrubbers that comply with the sulfur oxide (SO_x) discharge regulations for marine vessels, as well as an exhaust gas cleaning system (EGCS) for marine vessels equipped with the scrubber. For large-scale marine vessels such as a very large crude carriers (VLCC), we have developed and added to our line-up an XL size SO_x scrubber for engine outputs of up to 24 MW. The main features are as follows:

- (1) By redesigning the internal structure of the scrubber, the pressure loss has been reduced and the exhaust gas has been brought into contact with seawater efficiently, resulting in high desulfurization treatment efficiency even in the XL size.
- (2) The diameter of the tower has been reduced to 3.1 m (27% smaller than other company's products).
- (3) To facilitate installation work in shipyards, a hanging structure has been provided.

Fig.21 SO_x scrubber



4 New Monitoring Post

Fuji Electric has developed a new monitoring post that measures radiation in the environment continuously for 24 hours in the vicinity of nuclear power facilities. Since continuity of measurement is required in the field of environmental measurement, the internal components of the detector, which affect measurement performance, are the same as those of conventional products to ensure measurement reliability and accuracy. Conventional products were divided into a NaI scintillation detectors for detecting radiation and measuring sections for recording measurement data. However, the new product has the structure in which the measuring section is removed and integrated into the detector, reducing cost and saving space. In addition, the enclosure for the detector has a new structure to endure severe heat and cold (snowfall). We will continue to contribute to the safety and security of local communities with this product and other products for environmental radiation management.

Fig.22 New monitoring post



Field Services

1 “Comprehensive Service for Smart Industrial Safety” Additional Functions

Fuji Electric started providing on May 2021 its “Comprehensive service for smart industrial safety” that enables centralized management and analysis of operation and maintenance information for power distribution equipment, which is an IoT-based system solution called “Promizer.” The following two items has been added to the Remote Monitoring Service Menu:

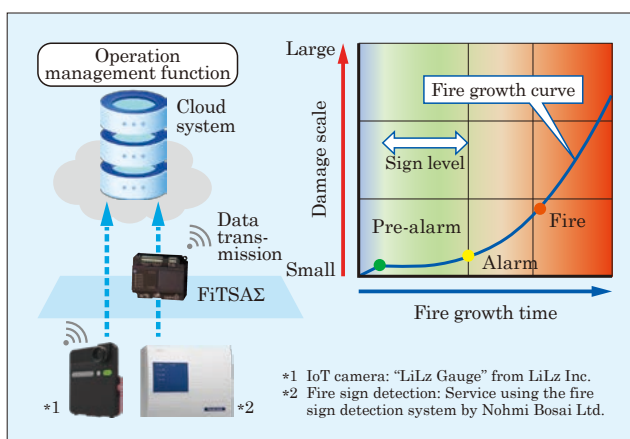
(1) IoT camera for meter reading

The meter images captured by the camera are converted into numerical values by AI and saved to reduce person-hours for patrol and inspection work, as well as to facilitate trend display and report creation.

(2) Fire sign detection

Fire prevention is supported by notifying security guards of abnormalities that could lead to electrical fires at an early stage through synchronization with a fire sign detection system that uses high-sensitivity smoke sensors.

Fig.23 Additional service options



2 “Fuji Wearable Remote Operation Support Package (FWOSP-Glass)” Additional Functions

The number of skilled maintenance personnel is on the decline, and passing on skills and improving efficiency in inspection and maintenance work has become a challenge. In response to this, Fuji Electric offers a “wearable remote operation support package” cloud service. Latest additional features are as follows:

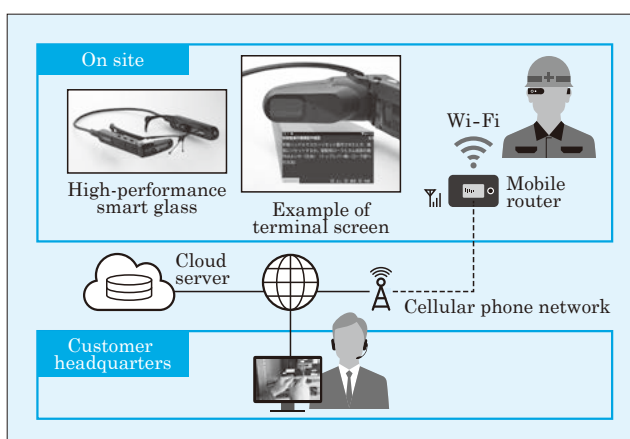
(1) High-performance smart glass

A lightweight smart glass with environmental endurance (IP67 compliant) can be used, which has been upgraded from the previous model. Hands-free operation with voice recognition reduces the workload.

(2) Linkage to a web conferencing system

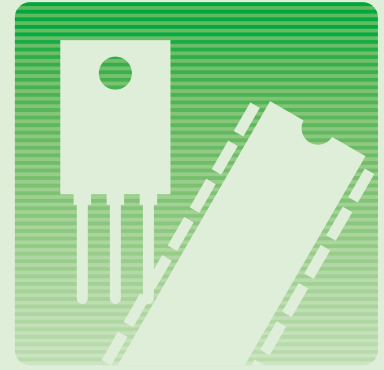
Sharing high-quality audio and video between smart glass in the field and PCs in the customer headquarters improves the quality of remote support operations. In addition, the recorded data can be stored on a cloud server, allowing the parties concerned to share them, supporting passing on skills.

Fig.24 Function overview



Semiconductors

Industrial
Automotive



Global efforts to realize a decarbonized society are progressing rapidly in order to solve the climate change problem, which is one of the aims of the Sustainable Development Goals (SDGs). Increasing the efficiency of power electronics equipment for the electrification of automobiles and the stable and efficient use of energy is an effective approach toward decarbonization, and Fuji Electric's power semiconductors are key devices that contribute to the realization of these efforts. Specifically, we have developed products that meet the needs for higher efficiency, size reduction, and higher reliability, mainly with the insulated gate bipolar transistor (IGBT), a typical device of power semiconductors, together with many technical innovations.

Industrial

Fuji Electric is expanding its product line-up of industrial modules that use the latest 7th-generation IGBT technology, which guarantees low-loss, high-temperature operation. The standard product line-up of 7th-generation IGBT modules is complete, and a line-up of intelligent power modules (IPMs) with drive and protection functions is in progress. In the line-up of 7th-generation IGBT-IPMs are medium capacity products with withstand voltages of 650 V and 1,200 V for application in FA, machine tools, and air conditioners, as well as a line-up of large capacity products of 650 V/200 to 450 A and 1,200 V/100 to 300 A. For room air conditioners and motor drives, we have developed 3rd-generation small capacity IPMs of 650 V / 15 to 30 A. We have also been working to expand the scope of application of SiC devices and develop a line-up of products equipped with 2nd-generation SiC trench gate MOSFETs. For this line-up, we developed a new 3.3-kV/750-A All-SiC module for railway applications.

With the new module, we can contribute to higher efficiency, reduced size and weight, and increased reliability of power conversion equipment.

For IC products, we have developed the "FA8C00 Series" of 7th-generation PWM power supply control ICs in order to meet the market demand for higher efficiency of power supplies, reduction of standby power, and improved safety in response to various power supply conditions due to globalization. By selecting external components to connect to the terminals of the IC, it is possible to optimize efficiency under light load and reduce standby power according to the power source in use, and the safety of the IC has also been improved by the high voltage input terminals.

Automotive

For the automotive field, we have developed and commercialized compact, high-power-density power modules for inverters used to control driving motors of electrified vehicles (xEVs). As part of these efforts, we have developed a 6-in-1 directly water-cooled automotive power module for 100-kW class motors. By improving the performance of reverse conducting-IGBTs (RC-IGBTs) and using a newly designed aluminum cooler, we now lead the industry in compactness and high power density. In response to the high integration of power conversion devices such as DC/DC converters for xEVs, we have commercialized the 2nd-generation SJ-MOSFETs with a high-efficiency, compact, low-noise super junction structure. In order to accommodate the increase in battery voltage and the size reduction of equipment, we have added products that use T-packs (D2-packs), which are small surface-mount packages with a rated voltage of 650 V.

Industrial

1 Line-Up of the “P633C Series” 3rd-Generation Small IPMs

In response to the growing need for global energy efficiency improvements to realize a decarbonized society, the use of inverters in industrial motor drive equipment has accelerated, and the application of IPMs with built-in IGBTs and drive circuits has been expanding, particularly in low-capacity equipment. Fuji Electric has developed a line-up of products that can be used with large current loads in industrial inverters and servo amplifiers, based on the “P633C Series” of 3rd-generation small IPMs previously commercialized for use in room air conditioners overseas. The main features are as follows:

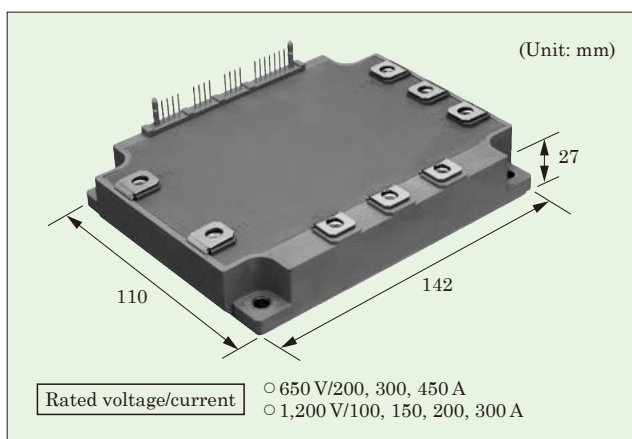
- (1) The low-power-dissipation design for operation under high current loads has reduced the IGBT on-voltage $V_{CE(sat)}$ by approximately 13% compared with previous products, contributing to higher equipment efficiency.
- (2) Two types of the overheat protection functions: One type is temperature sensor output only. Another type is temperature sensor output with self-shutdown function.

Fig.1 “P633C Series”

**2 Line-Up of the “P631” 7th-Generation High-Power IGBT-IPM**

In order to save power and space for power conversion devices, the intelligent power modules (IPMs) must have even lower power dissipation and higher output current. In response to this, Fuji Electric offers the 7th-generation IGBT-IPM, which achieves a 10% reduction of the power dissipation compared to the 6th-generation IGBT-IPM by applying the 7th-generation technology. The maximum output current has also been increased by expanding the allowable chip temperature during continuous operation from 125°C to 150°C. Fuji Electric now provides a line-up of the “P631” 7th-generation high-power IGBT-IPM. Using the same package as the previous P631 6th-generation high-power IGBT-IPM, The P631 7th-generation high-power IGBT-IPM has expanded the maximum rating from 600 V/400 A and 1,200 V/200 A to 650 V/450 A and 1,200 V/300 A. This allows the device to handle more power with the same external dimensions as the previous IPM, contributing to power and space savings for customer equipment.

Fig.2 “P631”

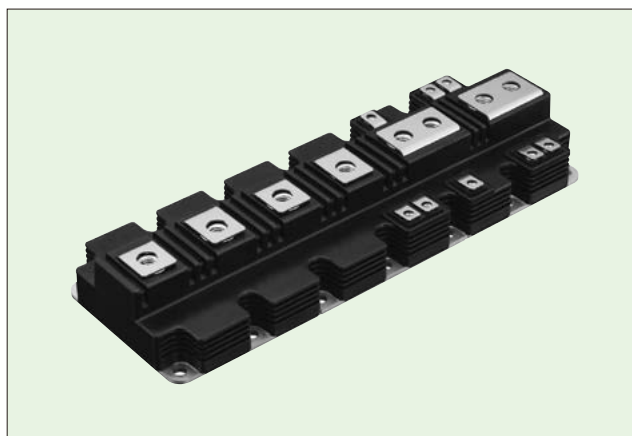
**3 Line-Up of the “X Series” 7th-Generation High-Power IGBT Modules**

Fuji Electric has commercialized the “X Series” of 7th-generation 1,200-V, 1,800-A, 2-in-1 IGBT modules to meet the market demand for less power dissipation and high reliability in IGBT modules. To support further increases in capacity of power conversion equipment for solar and wind power generation, we developed the “PrimePACK™3+,” which features additional output terminals, and added it to our line-up. The main features are as follows:

- (1) Less power dissipation by applying 7th-generation X Series chip technology
- (2) High reliability in high-temperature operation (up to 175°C) through the application of 7th-generation package technology

* PrimePACK™: A trademark or registered trademark of Infineon Technologies AG

Fig.3 “PrimePACK™3+” high-power IGBT module



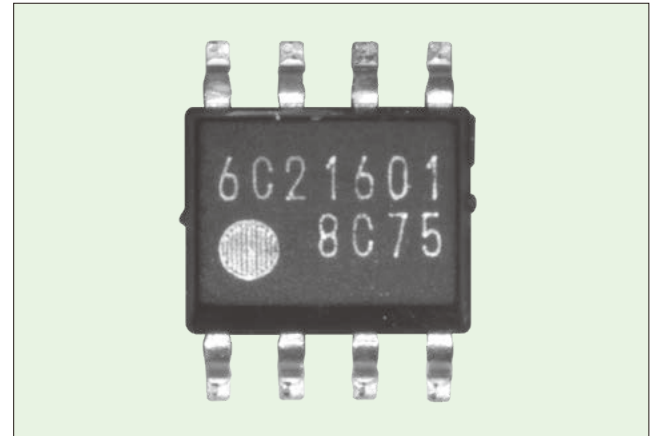
Industrial

4 “FA8C00 Series” 7th-Generation PWM Power Supply Control ICs

In recent years, efforts to reduce greenhouse gas emissions as a countermeasure against global warming have attracted attention, and there has been a demand for more efficient electronic equipment. There is also a need to respond to power supply conditions in various countries and regions. In response to this demand, Fuji Electric has developed the “FA8C00 Series” 7th-generation PWM power supply control ICs.

- (1) High-voltage input terminals with higher withstand voltages (from 650 V to 710 V) enable use in markets outside Japan where the power supply is unstable.
- (2) It is equipped with an X-cap discharge function to prevent electric shock while reducing the number of required parts.
- (3) The minimum pulse width of the MOSFET gate signal is selected from three types based on the constants of the external components to achieve high efficiency under light load.
- (4) External regulators can be removed with the built-in output voltage clamp function.

Fig.4 “FA8C00 Series”

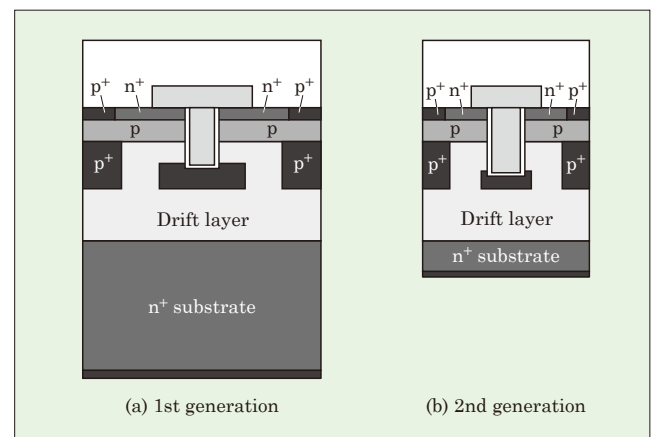


5 3.3-kV 2nd-Generation SiC Trench Gate MOSFETs

Fuji Electric has developed a 2nd-generation SiC trench gate MOSFETs rated at 3.3 kV with lower on-state resistance than conventional MOSFETs for railcars. The main features are as follows:

- (1) The cell pitch has been reduced to approximately two-thirds, and the thickness of the SiC substrate to approximately one-fourth of 1st-generation MOSFETs. As a result, the on-state resistance per unit area has been reduced by approximately 7%.
- (2) Fuji Electric's unique technology suppresses the increase of on-state resistance caused by defects when the current flows through the body diode of SiC-MOSFETs.
- (3) The recommended gate drive voltage could be +15 V by the optimization of device structure for ease of replace of Si-IGBTs.

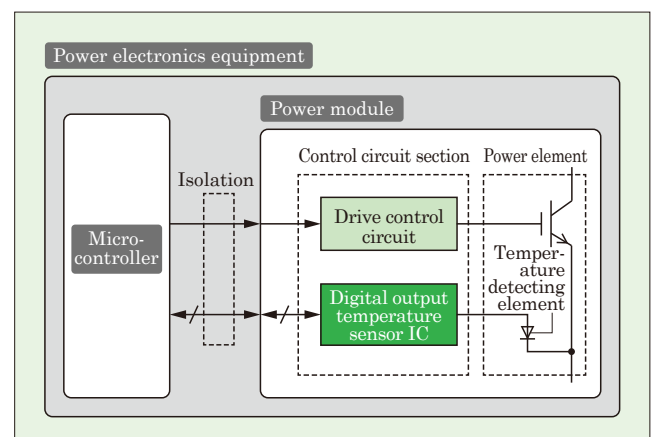
Fig.5 Cross section of SiC trench gate MOSFETs



6 Digital Output Temperature Sensor IC Technology

To support predictive maintenance of power electronics equipment, there is a demand for technology to enable high-precision temperature measurement of power elements mounted on a power module. In addition, as IoT utilization is progressing in the industrial fields where power electronics devices are used, it is desirable to have the ability to output measured values as digital data. To address the demand, Fuji Electric has developed a technology for high-precision digital output temperature sensor ICs incorporated in power modules. The output range of the newly developed IC is from -50°C to $+200^{\circ}\text{C}$, the resolution is 0.25°C , and the precision is $\pm 3^{\circ}\text{C}$. By detecting the temperature of the power element, converting the data into digital values using an AD converter built into the IC, and outputting them, the data can be processed in a digital device such as a microcontroller. This IC has a broad scope of industrial application, and it contributes to the high-precision predictive maintenance of power electronics.

Fig.6 Digital output temperature sensor IC application example



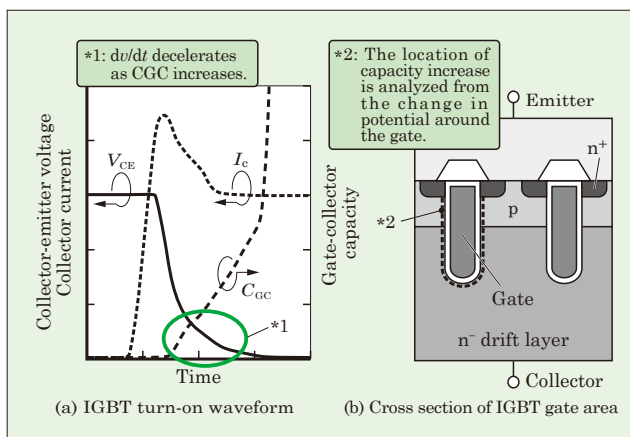
Industrial

7 Capacitance Analysis Technology to Reduce IGBT Turn-On Loss

To improve the efficiency of IGBTs, it is important that turn-on loss is reduced. The rate of change (dv/dt) of collector-emitter voltage during turn-on is not constant and slows down partway, causing loss increases.

Through TCAD simulation, Fuji Electric has discovered that dv/dt is slow due to the increase in capacitance between the gate and the collector (C_{GC}) during turn-on. We also have established a method to analyze where the capacitance increases from changes in potential around the gate. In the future, we will use this analysis method to reduce turn-on loss and further improve the characteristics of IGBTs.

Fig.7 IGBT Capacitance analysis example



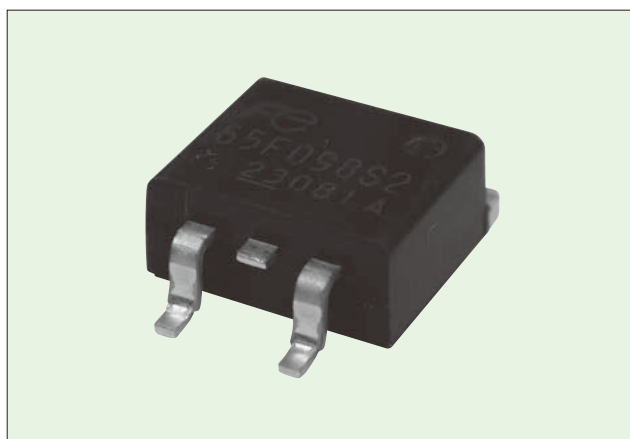
Automotive

1 Line-Up of the “Super J MOS S2FDA Series” 2nd-Generation Automotive SJ-MOSFET

Fuji Electric offers a line-up of the “Super J MOS S2FDA Series” 2nd-generation automotive SJ-MOSFET with rated voltages of 400 V to 600 V for use as a power MOSFET suitable for power conversion devices such as an automotive DC/DC converter and on-board charger. To meet the demand for higher battery voltage and smaller DC/DC converters, we added products with a rated voltage of 650 V in the small surface-mount T-pack (D2-pack) to the line-up. The T-pack (D2-pack) line-up will contribute to higher power density (reduced size) of power conversion equipment. The main features are as follows:

- (1) Low on-state resistance (98 mΩ) achieves less power dissipation
- (2) AEC-Q101 compliance ensures the reliability of automotive products

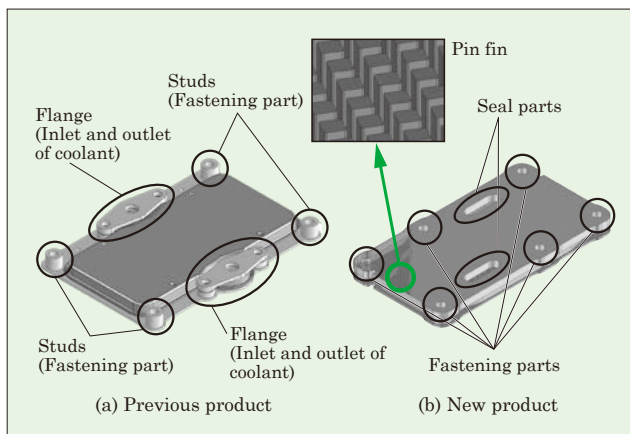
Fig.8 “Super J MOS S2FDA Series”



2 Ultra-Compact RC-IGBT Module Coolers for xEVs

For electrified vehicles (xEVs), the development of integrated electric and mechanical systems with integrated drive systems is accelerating, and there is a demand for power modules with high power density (small, thin, and high output) suitable for these systems. Fuji Electric has developed a new aluminum cooler using pin fins to achieve higher power density in power modules. The cooling performance was improved by optimizing the shape of the pin fins and the flow of the coolant using particle image velocimetry (PIV) in addition to thermal fluid analysis. In addition, the cooler has been miniaturized by integrating the seal part and the fastening part with the plate. In addition to this compact and high-heat dissipation cooler, the 4th-generation power module, which applies RC-IGBT elements and leadframe wiring technology, achieves approximately twice the power density of the 3rd-generation power module.

Fig.9 Aluminum cooler



Power Generation

Renewable Energy and New Energy Solution Services



Working towards the realization of a decarbonized society has become a global trend. In Japan, the Sixth Basic Energy Plan was approved by the Cabinet in October 2021. Efforts to expand the use of renewable energy are accelerating, with the goal of reducing greenhouse gases emissions by 46% by 2030 and achieving carbon neutrality in 2050. In the field of solar power generation, projects with corporate power purchase agreements (PPA) is drawing attention. The Ministry of Economy, Trade and Industry's efforts to promote geothermal power generation aim to "reduce lead times by up to 2 years and double the number of geothermal power plants nationwide by 2030." Attention has been placed on expanding the introduction of renewable energy in harmony with local communities. Fuji Electric continues to accelerate its efforts to make a social contribution in the fields of renewable energy and distributed power sources.

Renewable Energy and New Energy

In the field of geothermal power generation, for which we have the largest market share in the industry, we are continuously promoting our power generation equipment and system backed by our extensive track record as we target Japan and promising regions in Asia, Africa, Iceland, New Zealand, and the United States. In FY2021, a geothermal power plant delivered to PT Supreme Energy Rantau Dedap started commercial operation in December 2021, which we constructed on an engineering procurement and construction (EPC) project (turn-key project) basis, jointly with PT Rekayasa Industri in Indonesia. We have also received an order for the Tauhara Geothermal Power Station in New Zealand, the world's largest single unit capacity geothermal power plant, and we are on track to complete the project in FY2023. In Japan, we will expand sales of power generation equipment for small-scale heat sources as distributed power sources, and in other countries, we will strengthen relationships with local companies and supply chains to improve our presence in the market.

In the fields of solar and wind power generation, we are promoting the expansion of solar and wind power generation equipment, supported by our track record of

successful deliveries, as well as our technological superiority in contributing to the stabilization and peak shift of electric power using high-efficiency power conditioning systems equipped with power semiconductors and storage batteries. In FY2021, we received an order from a local government for a solar power plant for a microgrid including power purchase agreement (PPA), creating a foothold for the change from large EPC projects to small and medium EPC projects. We also have steadily received orders for substation equipment for wind power plants, as well as an order for a storage battery system for the effective use of renewable energy power. In FY2022, we will further promote the transformation of the business form for solar power generation from a large-scale EPC projects to a small- and medium-scale EPC projects for microgrid and private consumption PPAs. In the field of wind power generation, by taking advantage of its strength in power system analysis technology, Fuji Electric will work to further promote our substation equipment while also assuming onshore small and medium EPC projects.

Solutions Service

In the field of maintenance and replacement, in the current trend toward carbon neutrality, there is a demand for solutions that enable changing the fuel type of existing power generation facilities and changing the operation in accordance with changes in the power source configuration. We have been developing various diagnostic and repair technologies in addition to replacement technologies to improve efficiency and operational flexibility. In generator stator diagnosis, we have developed one of the industry's thinnest inspection robots to enable diagnosis without having to pull out the rotor, thereby contributing to a shorter outage period. In turbine repair, we are promoting onshore and on-site implementation by applying ASTM standard* alternative materials and to complete repair services on site overseas.

In the field of nuclear power, we are continuously contributing to safe resumption of operation, decommissioning, and radioactive waste treatment for nuclear power plants by utilizing our proprietary technology, which focuses on remote handling, radiation measure-

based on continuous economic and environmental recycling by supplying highly efficient and environmentally friendly clean energy and providing services to monitor, maintain and manage a safe and secure energy supply.

Fuji Electric is promoting efforts to realize a society

Its steam turbine, which requires high reliability and high efficiency, is a single casing reheat turbine. It uses an air-cooled brushless exciter generator with an extensive operational track record. We optimized the facility layout to reduce the building area.

The diagram illustrates a power distribution system architecture. At the top left, a 'Power system' is connected to a 'Power distribution switchgear and monitoring operation panel'. This panel is connected to two parallel paths. The top path includes a 'Booster transformer', a 'Solar PCS' (Power Conversion System), and a 'Solar cell array'. The bottom path includes a 'Booster transformer', a 'Storage battery PCS', and 'Storage battery' units. A 'Charge' arrow points from the solar path to the storage path, and a 'Discharge' arrow points from the storage path back to the solar path. Both paths are connected to 'Public facilities, etc.' at the bottom left. A 'Electric power storage system controller' at the bottom center manages the system, connected to the 'Storage battery PCS' and the 'Control and communications' system at the bottom right.

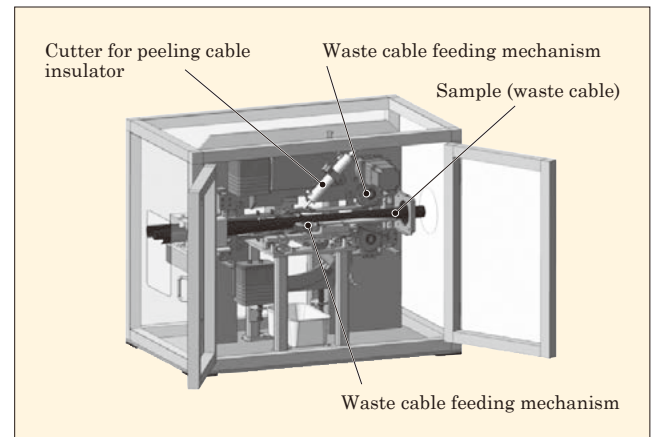
Solution Services

1 Efforts to Recycle Waste Cables Generated in the Decommissioning of Nuclear Power Plants

The decommissioning of nuclear power plants generates approximately 2,000 km of waste cable per plant, and the disposal is said to be costly. Fuji Electric, in cooperation with Fuji Furukawa Engineering & Construction Co., Ltd., is developing an automatic system to separate waste cables into insulator and conductor. Most of the radioactive contamination on waste cables is on the insulator surface. This system aims to automate the identification of contaminants, separation of contaminated insulator, extraction of conductor, measurement of radiation amount, and determination of contamination level. Since non-contaminated wires can be recovered as clearance material*, waste costs can be saved by reducing the amount of radioactive waste, and resources can be recovered and reused. This contributes to safe and efficient decommissioning.

* Clearance material: Material that has very low levels of radioactivity and do not need to be treated as radioactive waste.

Fig.3 Automatic cable insulator separating system (under development)

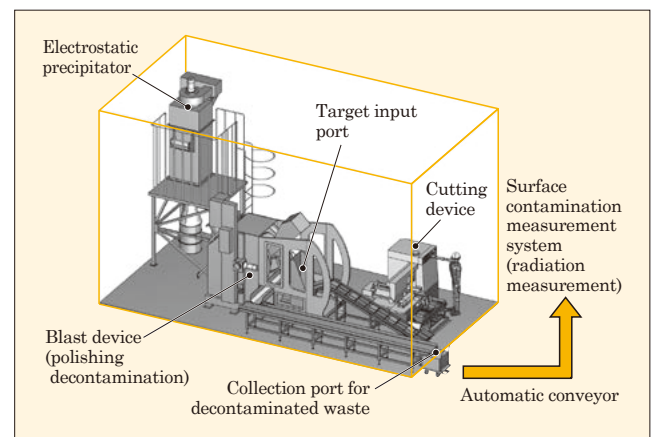


2 Decontamination System for Small Diameter Tubes

Safe and efficient decommissioning of nuclear power plants is important not only for operators but also for local communities and citizens. The dismantling of heat exchangers, which are the core equipment of nuclear power plants, is said to produce approximately 100 tons of waste heat exchanger tubes per nuclear power plant. However, due to the current high cost of processing, all of these tubes are assumed to be radioactive waste rather than clearance material*. Fuji Electric, in cooperation with Fuji Furukawa Engineering & Construction Co., Ltd., has developed a process to automatically cut heat exchanger tubes in round slices, decontaminate them, and measure their radiation. We then built an automatic processing system and are evaluating it in cooperation with the Tokyo Institute of Technology. Using this method, we aim to allow the heat exchanger tubes to be treated as clearance material while reducing the costs for decontamination and measurement.

* Clearance material: Material that has very low levels of radioactivity and do not need to be treated as radioactive waste.

Fig.4 System overview



Food Distribution

Vending Machines
Store Distribution



Vending Machines

The use of phrases such as “with Corona” and “the new normal” to describe a post-COVID-19 world has decreased, and it has begun to be accepted that we must coexist with COVID-19. The frozen food market, which has been on the rise due to the increase in people staying at home, is expanding due to the need to save time and labor as well as the advancement of quality and diversification. In addition, the vending machine market, which used to be dominated by major beverage manufacturers, has begun to expand to include individual restaurants and other businesses, as the vending machine’s inherent function of contact-free, non-face-to-face sales has gained recognition and has stimulated business models that involve the sales of not only conventional beverages but also refrigerated and frozen foods. While the market for beverage vending machines continues to decline slightly, the market for food vending machines is expanding. Food retailers and the food and beverage industry, which are suffering from the COVID-19 pandemic, have come to realize vending machines as unattended stores that are open every day and have started to use them as new distribution tools. In particular, frozen foods are attracting attention, and since they have a long shelf life, they can be replenished with flexible frequency regardless of sales volumes, and since there is almost no need to worry about sales loss, they are suitable for sale through vending machines. To meet this demand, Fuji Electric has developed “Frozen Station,” a frozen food vending machine. Our unique and advanced heat insulation technology maximizes interior space in spite of the machine’s small size, allowing room for 84 products, which is the largest capacity in the industry, and with the ability to change the attachments, the machine is flexible in its ability to hold products of various sizes. The new machine has high thermal insulation, which reduces power consumption by 20% compared with our other products, as well as a safety function that stops sales if the internal temperature rises above a specified temperature. In addition, we have prepared an operation system as a support tool for those who are not familiar with the quick and efficient operation of vending machines. We

expect the product to play an important role in energizing the food market and vending machine market.

Store Distribution

Following the United Nations Framework Convention on Climate Change in 1992, the Paris Agreement (COP 21) in 2015 established the target for efforts to suppress the global average temperature increase to 2.0°C or less and 1.5°C or less. In addition, with the adoption of the Sustainable Development Goals (SDGs) at the 2015 UN Summit and the Japanese government’s declaration to become carbon neutral by 2050, efforts to combat global warming are rapidly increasing. In response to these changes in the environment, retailers have set medium- and long-term goals and are working to reduce CO₂ emissions as their top priority, with the three pillars of energy creation through solar power generation, increasing the use of renewable energy, and energy conservation (energy saving). Since power consumption of showcases and other freezing and refrigeration equipment in convenience stores accounts for about 50% of the total power consumption of the entire store, energy conservation for this equipment is an urgent requirement. Fuji Electric has developed a control technology which enables energy saving for showcases through the optimized operation of outdoor cooling units. By more precisely measuring the cooling conditions inside the case and controlling the pressure of the outdoor cooling unit based on this data, we have established a control technology that optimizes the evaporation temperature and flexibly responds to environmental changes, reducing power consumption by approximately 20% compared with conventional systems.

In many countries around the world, the use of coinage made from a combination of multiple materials is expanding to prevent forgery more effectively. Fuji Electric has developed an automatic change dispenser and a coin mechanism for the new 500-yen coins issued in November 2021. We implemented a new identification algorithm to improve identification performance.

In the future, we will continue to respond to our

customers' needs for labor and labor saving as well as social needs such as energy saving and carbon neutrality, and will strive to develop products to remain as a

pioneering company in the retail and distribution industry.

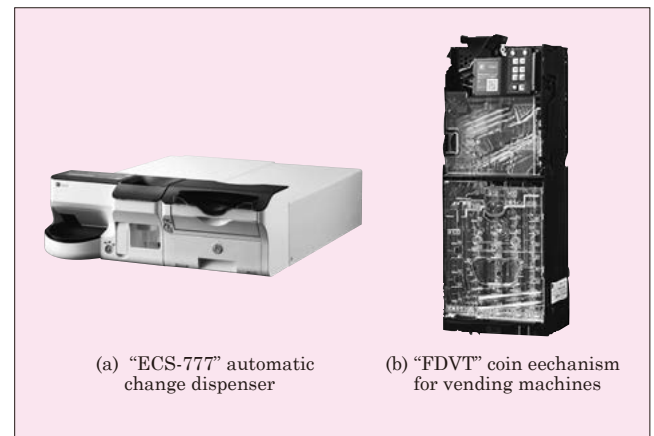
Vending Machines

1 Recoinage Support for Automatic Change Dispensers

On November 1, 2021, the new 500-yen coins began to circulate in the market. Fuji Electric offers automatic change dispensers for POS cash registers that process deposits and withdrawals and coin mechanisms for vending machines. We have remodeled the conventional products to handle the new 500-yen coins. The main features are as follows:

- (1) The new products deliver higher identification accuracy than ever by identifying the typical material feature of the new coin, which is a bicolor clad (two-color, three-layer) coin.
- (2) A new algorithm allows those products in the market to handle the new coin by modifying their software alone, which provides more economical solution to customers.
- (3) The setting on whether to accept or prohibit the use of the old 500-yen coins is optional, enhancing operational flexibility.

Fig.1 Product appearance

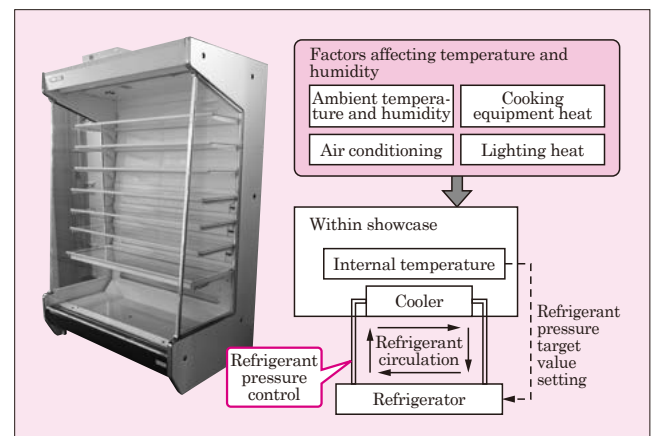


Store Distribution

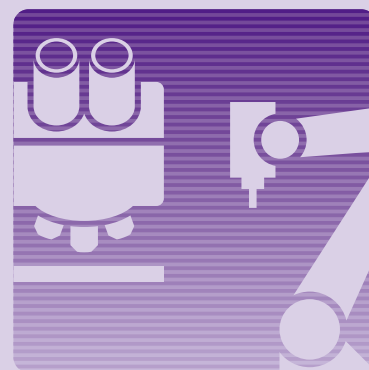
1 Showcase Control Technology for Energy Saving

Fuji Electric has developed the new showcase control technology for better energy saving by detecting internal temperature to operate outdoor cooling units optimally. Conventional showcases control refrigerant pressure in the refrigeration unit within a certain range, which stabilizes refrigerant evaporation temperature in the refrigerant circuit, thereby maintaining constant temperature. This control system cannot respond to changes in temperature or humidity inside the store, resulting in unnecessary energy consumption due to overcooling. The new technology determines the target refrigerant pressure according to the temperature inside the showcase and command the target value to the cooling unit for efficient performance. In this way, excess or deficient refrigeration capacity due to changes in temperature and humidity in the store can be finely compensated, consuming 20% less energy than the conventional model. We will continue to pursue energy conservation performance and promote the development of environmentally friendly products in the future.

Fig.2 Product appearance and control overview



Fundamental and Advanced Technologies



Fundamental Technology
Advanced Technology

Fuji Electric has been tackling research and development on fundamental and advanced technologies to achieve differentiation, for early launch of new products and expansion of carbon-neutral-related businesses as “growth strategy promotion.”

In order to achieve carbon neutrality in factories, we have developed the industry’s first cooling technology which can cool hot waste water and simultaneously generate cold water with high efficiency using a refrigerating cycle driven by thermal energy of the hot waste water. This technology will help use low-temperature exhaust heat effectively and reduce power consumption accompanying generation of cooling water.

To support stricter environmental regulations, we have developed a gas measurement technology that can measure gases including SO_x of low concentration by using ultraviolet C rays that has no absorption spectrum of inhibitory components such as water. We also have developed a technology to reduce the burden of cleaning drainage pipes by dissolving slime components (such as polysaccharides) in the drainage pipes and removing them with bacteria with synthesizing alkaline water and supplying it to the pipes.

As a technology to promote substitution of low-environmental-load materials, we have developed a technology to magnetically drive arcs on electrical contacts to diffuse arc heat. SF₆ substitution enables improving insulation ability and cutoff performance which are issues and suppresses enlargement of equipment. We have also developed a high-thrust density linear motor for railcar door systems by magnets not using rare earth elements, of a new structure that utilizes magnetic design technology.

As an advanced technology for new products, we have developed a dust collection technology for marine engines in which both SO_x and fine particle removal are achieved in combination with scrubbers with directly repairing particles or removing them from exhaust gas of high temperature and high wind by the power of electricity. In addition, we are developing a spatial virus inactivation technology that can be used for countermeasures against infectious diseases by using a hybrid method of electrostatic collection and ultraviolet C rays

irradiation.

By applying the meta-heuristics method to the control constant optimization operation of a voltage regulator for a distribution system voltage adjustment, we have developed a technology where an optimum control constant can be obtained in a short time from the combination of enormous control constants. This technology can properly maintain the voltage of the distribution system, which has been complicated with the large introduction of the renewable energy.

As artificial intelligence (AI) related technology, we have developed a technology which automatically analyzes the cause of the plant abnormality occurrence from the operation data by the application of causal inference in statistics. It has been already installed in the energy management system and is applied to the efficiency anomaly analysis. In addition, we have developed a technology where a user teaches a correct area to an image recognition AI for relearning to utilize an image recognition AI technology. It facilitates user engineering to maintain recognition rate after introduction.

To expand cloud usage, we have developed a log management platform that automatically collects and centrally manages the operation logs of a plurality of software with different log formats. It contributes to labor saving of operation management work of a cloud system.

As a technology to support design and manufacturing, we have been developing a method to perform large-scale simulation in a short time and constructed a machine learning model using 3D thermo-fluid analysis result data. Results were obtained within a few hundredth the time for 3D thermo-fluid analysis with the same accuracy. In the future, we will further improve the reliability of the method and aim to apply it in product development.

In order to reduce the number of person-hours required for software development, a means to sufficiently verify open source software (OSS), which is used for some functions, on an actual machine is required. We have developed a test environment where there are enough test cases, and a test can be automatically implemented for OSS on an actual machine. We will effi-

ciently develop high quality software utilizing OSS under this environment.

We have developed a noise canceler technology to cancel leakage current, which is an occurrence source of disturbance voltage, in a power-factor control circuit used for a small capacity power supply of several hundred watts. It will be applied to miniaturization of electromagnetic interference (EMI) filter.

We have constructed a freezing circuit model and internal air flow model as simulators instead of an actual machine test of a vending machine. An operation control test can be conducted with a short time simulation.

We have conducted outdoor exposure tests and accelerated degradation tests with the latest coating film configuration of our products, such as distribution equipment and vending machines, to establish the coating film configuration as a company standard. We contribute to quality assurance and enhancement of manufacturing fundamental technology.

In this way, Fuji Electric will continue to strengthen our advanced and fundamental technologies that support product development, aiming to create social values in the fields of energy and environment.

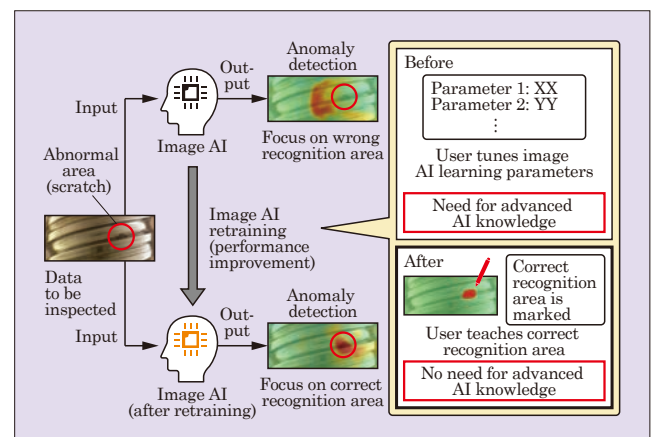
Fundamental Technology

1 Performance Improvement of Image Recognition AI with Recognition Area Correction Technology

In recent years, the image recognition technology using AI has rapidly developed and its application has been advancing to industrial fields such as visual inspection. However, when an abnormal area was erroneously recognized in the detection by image recognition AI (image AI), it was necessary to tune learning parameters by an expert with advanced AI knowledge to correct it. To facilitate the tuning, Fuji Electric has developed a recognition area correction technology that enables users without AI knowledge to improve performance. The technology improves performance by teaching a correct area and retraining image AI so as to reduce an error with an anomaly detection result. Thus, image AI can be easily improved in quality without the knowledge of an expert.

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Fig.1 Procedure for improving recognition*



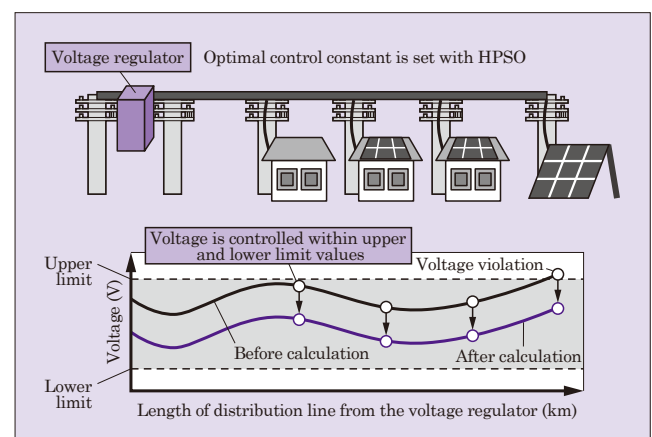
2 Control Constant Optimization Technology for Voltage Regulator

To achieve carbon neutrality in 2050, the introduction of renewable energy is expected to expand. Since effect on voltage of distribution systems becomes large with the introduction of a large amount of renewable energy whose output fluctuates depending on the weather, an advanced monitoring and control technology is required to maintain the energy within the upper and lower management limits specified by the Electricity Business Act.

Fuji Electric has developed a technology to optimize the control constants of voltage regulators that regulate the voltage in distribution systems. With this technology, by applying HPSO*, one of the meta-heuristics methods in the optimal setting calculation, an optimal control constant can be obtained in a short time from a combination of enormous control constants. By applying this technology to distribution system planning systems, we contribute to retention of stable operation of complicated distribution systems.

* HPSO: Hybrid Particle Swarm Optimization

Fig.2 Overview of control constant optimization technique



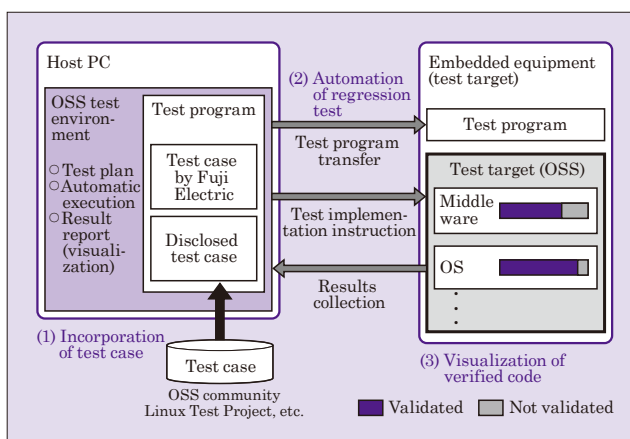
Fundamental Technology

3 OSS Firmware Quality Assurance Technology

The scale of software for embedded equipment has been expanding with advanced functionality and the use of open source software (OSS) has been advancing to reduce development person-hours. Verification of software using OSS, on the other hand, has challenges such as labor saving for test case preparation, efficiency improvement of regression test for OSS, which is frequently updated, and clarification of verified code range. To solve the challenges, Fuji Electric has built an OSS test environment with the following features:

- (1) Test preparation person-hours has been reduced by allowing incorporation of published test cases (2,000 or more).
- (2) Person-hours for regression tests on OSS updates has been reduced by automating test case execution.
- (3) Completeness of testing can be confirmed with visualization of verified codes.

Fig.3 Embedded system test environment example

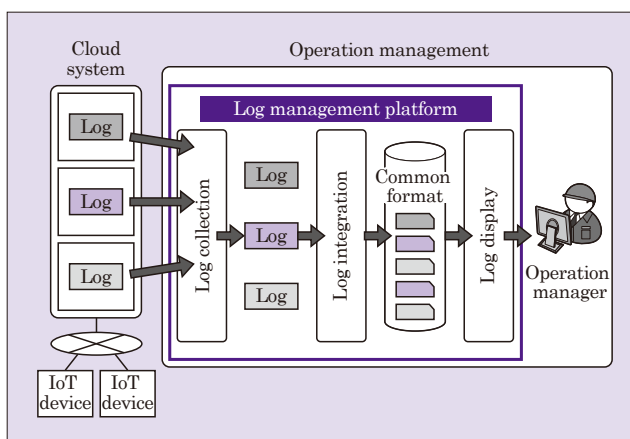


4 Log Management Technology for Cloud Systems

The use of cloud systems is expanding through the use of data collected from IoT devices. Since multiple software applications typically work together on a cloud system, monitoring operation logs of each software is essential for stable operation of services. However, since operation logs are stored for each software and the log format varies, management of operation logs has been complicated.

To make the job straightforward, Fuji Electric has developed a log management platform that facilitates log collection, integration, and display. The platform automatically collects operation logs from the cloud system, converts them into a common format, manages them in an integrated manner, and graphically displays the correlation of occurrence times to support improving efficiency of monitoring and quickly analyzing an error occurrence cause. We will promote application of this technology and contribute to the stable operation of cloud systems.

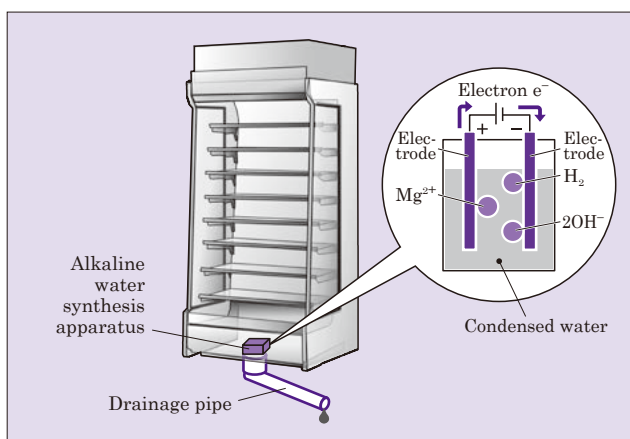
Fig.4 Log management platform



5 Alkaline Cleaning Technology with Water Electrolysis by Magnesium

Fuji Electric has developed a technology to synthesize alkaline water by electrolyzing water with alloy electrodes containing magnesium. One of possible applications is a cleaning of the drainage pipe of a showcase used in convenience stores. Condensed water generated in a cooler of a showcase does not contain chlorine component unlike tap water and therefore does not have sterilization or cleaning effect, and bacteria easily propagate. Stores regularly clean drainpipes because they become slimy and dirty due to the growth of bacteria, causing clogged pipes and odors. Condensed water is stored in an electrolytic treatment tank equipped with this technology, alkaline water above a certain pH is synthesized and supplied to a drainage pipe to dissolve slime compounds (polysaccharides, etc.), and remove them together with bacteria. Thus, the generation of slimy dirt is suppressed and the burden of cleaning drainpipes can be reduced.

Fig.5 Equipment implementation example (Slime removal in showcase drainage pipe)



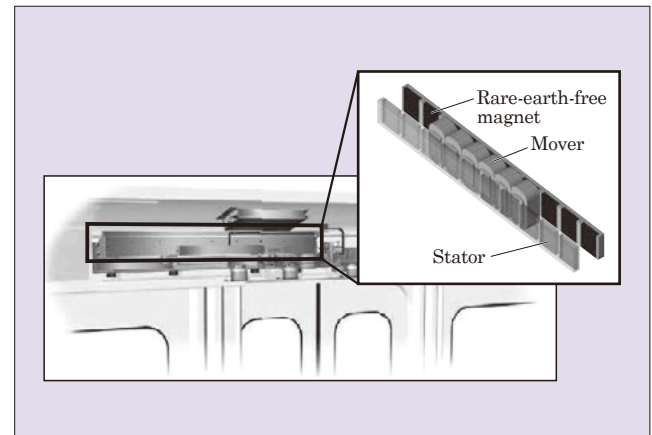
Fundamental Technology

6 High Thrust Density Linear Motor Not Using Rare Earth

Linear motors for railcar door systems require both high thrust density and reduced door opening resistance to allow passengers to open and close doors in emergency. This can be achieved by using a coreless structure and strong magnets; however, rare earths commonly used in such magnets have a uncertainty in long-term stable procurement. Fuji Electric has therefore developed a linear motor for railcar door systems using magnets that do not use rare earths by utilizing the magnetic design technology. By adopting a motor structure with a core and optimizing the structure, even a low magnetic force magnet achieves thrust density equivalent to that of a conventional magnet, while suppressing an increase in door opening resistance caused by the interaction between the magnet and the core.

This development has enabled the stable supply of linear motors for railcar door systems that require safety and security.

Fig.6 High thrust density linear motor

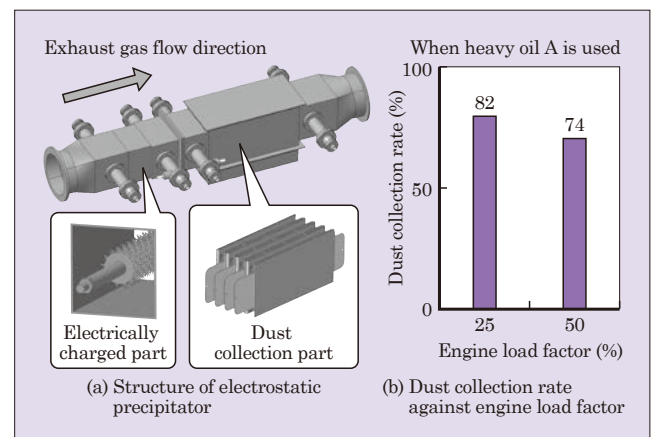


7 High Temperature, High Wind Electrostatic Precipitator Technology for Marine Engines

As a countermeasure for environmental problems related to marine transportation, a technology to remove fine particles contained in exhaust gas of marine vessels is required. Fuji Electric has been developing a technology to apply an electrostatic precipitator system for roads to marine engines. We have demonstrated that a high dust collection rate (more than 70 %) can be obtained for heavy oil A and heavy oil C and have been promoting safety evaluation to obtain certification by a third party. The main features are as follows:

- (1) Directly collecting and removing particles using electric force from high-temperature (over 250°C), high-speed (over 20 m/s) exhaust gas flow in ducts
- (2) Adopting a two-stage method of a charging section that charges fine particles by discharging a needle electrode and a dust collection section that attracts and collects charged particles with a high electric field. The function is retained by preventing deposition of particles in the charging section.
- (3) Removing both SO_x and fine particles is enabled with combination with a scrubber.

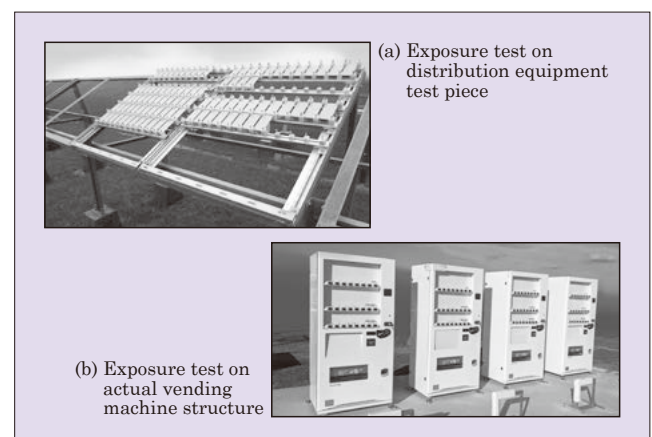
Fig.7 Electrostatic precipitator structure and dust collection rate



8 Establishing Coating Film Evaluation Technology

Fuji Electric applies coating to provide additional values such as corrosion resistance and design property to sheet-metal enclosures such as power distribution equipment and vending machines. In recent years, with the diversification of the environment in which products are installed and the evolution of paints, a new testing method have become necessary. Therefore, we have conducted outdoor exposure tests and accelerated degradation tests on the durability of the latest coating film and developed the type, thickness, and construction method of the coating film in accordance with the present product installation environment. In addition, by correlating the degradation of the coating film and the corrosion rate with the exposure test product and the accelerated degradation test product, we have simulated the actual use environment of the products and established the accelerated degradation test where degradation can be accelerated in a shorter period of time than before. These efforts enable selecting coating films suitable for the installation environment of products and confirming quality using the accelerated degradation tests and contribute to the provision of highly reliable products.

Fig.8 Exposure test appearance



Advanced Technology

1 Low Concentration Gas Measurement Technology by Ultraviolet Absorption Spectroscopy

As environmental regulations become stricter, gas analyzers are required to improve the measurement accuracy in the low concentration range. With conventional infrared gas analyzers, stable measurement of low concentration gas has been difficult due to the influence of disturbance caused by absorption of inhibitory components such as water contained in the gas. Fuji Electric has developed a low concentration gas measurement technology that uses the ultraviolet spectroscopy technology, which does not have absorption spectrum of inhibitory components. The main features are as follows:

- (1) Measurement of low concentration range (0 to 25 ppm) is enabled by extending the measured optical path length by application of a multi-reflection gas cell.
- (2) Three types of gas components (sulfur dioxide, nitrogen monoxide, and nitrogen dioxide) can be measured simultaneously.
- (3) Low running cost is achieved because the consumable nitrogen oxide conversion catalyst is not required.

Fig.9 Ultraviolet gas analyzer

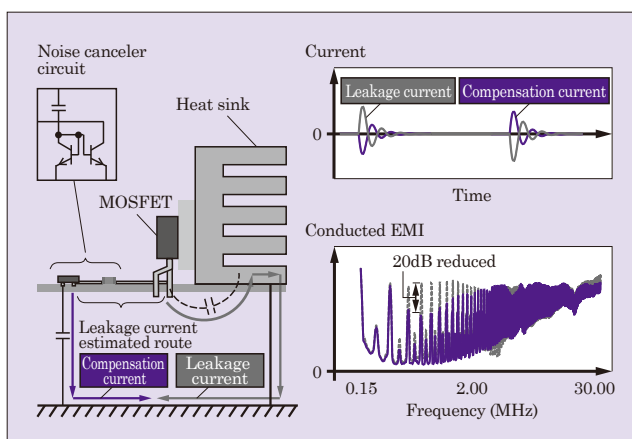


2 Noise Canceler Technology for Power Factor Correction Circuit

For a power factor correction circuit used in a small-capacity power supply of several hundred watts, an EMI filter provided for reducing a conducted EMI hinders miniaturization. Therefore, Fuji Electric has developed a noise canceler technology that cancels a leakage current, which is the occurrence source of the conducted EMI, by injecting a compensation current of opposite polarity. The main features are as follows:

- (1) Sufficient effect is obtained even with a compact and simple circuit configuration using a general-purpose transistor.
- (2) The conducted EMI is reduced by up to 20 dB (about 90%) in the 150 kHz to 2 MHz band.
- (3) EMI filters can be miniaturized to approximately 50% of conventional ones by also using the spread spectrum technology.

Fig.10 Active noise canceler technology principle and effect



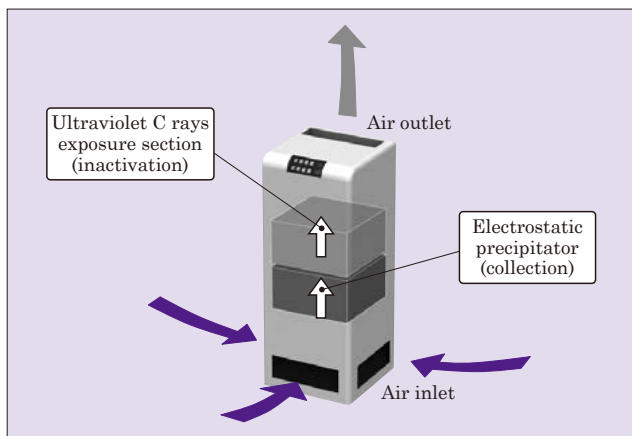
3 Airborne Virus Inactivation Technology

Fuji Electric has been developing a hybrid airborne virus inactivation apparatus combining electrostatic precipitation and ultraviolet C rays irradiation in the demonstration project* of the Ministry of the Environment for infection control measures. This apparatus eliminates the need for ventilation of large air volume and can reduce the electricity cost for air conditioning by up to 40%. The main features are as follows:

- (1) Using our proprietary disk-shaped electrodes can highly efficiently collect viruses while suppressing the discharge of ozone, which is harmful to the human body (99% of collect rate, ozone emissions under 0.05 ppm).
- (2) Viruses passing through the apparatus are highly efficiently inactivated (99% of airborne virus inactivation rate) by a LED module with uniform irradiation of ultraviolet C rays developed based on the interaction analysis of spatial illumination intensity and airflow.

* "The Demonstration Project for Implementation of Innovative Infection-Control and Digital Technologies with Low CO₂ Emissions" from the Ministry of the Environment, Government of Japan.

Fig.11 Hybrid airborne virus inactivation apparatus

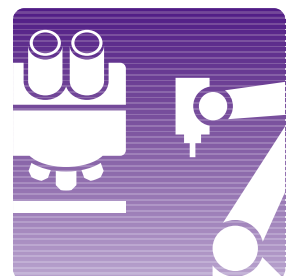
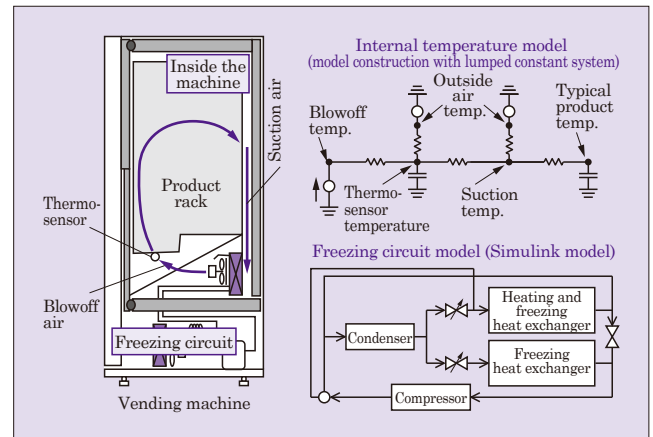


Advanced Technology

4 1D Simulation for Freezing and Heating Technology Development of Vending Machines

In the COVID-19 pandemic, contact-free, non-face-to-face sales channels have attracted attention, increasing product diversity sold through vending machines. Conventionally, development of vending machines has taken time because operation control tests have been conducted on actual machines for each model. Therefore, we have constructed an internal temperature model using the simulator MATLAB/Simulink. This model is simplified by representing the three-dimensional air flow with a 1D circuit model connecting the minimum necessary temperature points to shorten the analysis time. As a result, the operation control test, which had taken 48 hours for the prototype test, was shortened to 15 minutes. The error between the actual machine and the simulation has reached the average prediction accuracy of $\pm 1.5\text{ K}$ at the commodity temperature. Ultimately, we aim to shorten the total development period for a vending machine to approximately half.

Fig.12 Vending machine 1D simulation model





“FRENIC-MEGA Series” Low-Voltage Inverters Win Good Design Award 2021.

This line-up smoothly control motors that are used in high-performance, multi-function equipment, such as conveyance machinery, machine tools, and fluid machinery. It provides industry-leading responsiveness and enhanced predictive maintenance functions while having functional compatibility with and the same size as its predecessor. Its models for motors of 30 kW or more have a main cooling section that is waterproof and dustproof (IP55) and enough space for communication modules that enhance network functions, allowing it to be used for a wide range of applications. The operation panel comes standard with a 7-segment LED 5-digit display and offers improved usability in terms of key-button operation and cursor-based digit movement. In addition, the operation panel, caution label, and product name are arranged in a unified manner in consideration of the many external shapes in the series.

Although the line-up includes a wide range of variation, it has a simple design with a sense of unity as a brand and series, based on specifications usable for a long time without being affected by trends, which has been evaluated.



**GOOD DESIGN
AWARD 2021**

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② Noise Canceler Technology for Power Factor Correction Circuit	
③ Airborne Virus Inactivation Technology	
④ 1D Simulation for Freezing and Heating Technology Development of Vending Machines	

Overseas Subsidiaries

• Non-consolidated subsidiaries



Fuji Electric website
<https://www.fujielectric.com/>

America

Fuji Electric Corp. of America

Sales of electrical machinery and equipment, semiconductor devices, drive control equipment, and devices

URL <https://americas.fujielectric.com/>

Reliable Turbine Services LLC

Repair and maintenance of steam turbines, generators, and peripheral equipment
Tel +1-573-468-4045

Fuji SEMEC Inc.

Manufacture and sales of door opening and closing systems
Tel +1-450-641-4811

Asia

Fuji Electric Asia Pacific Pte. Ltd.

Sales of electrical distribution and control equipment, drive control equipment, and semiconductor devices

URL <http://www.sg.fujielectric.com/>

Fuji SMBE Pte. Ltd.

Manufacture, sales, and services relating to low-voltage power distribution board (switchgear, control equipment)

URL <http://smbe.fujielectric.com/>

Fuji Electric (Thailand) Co., Ltd.

Sales and engineering of electric substation equipment, control panels, and other electric equipment

URL <http://www.th.fujielectric.com/en/>

Fuji Electric Manufacturing (Thailand) Co., Ltd.

Manufacture, sales, engineering and service of low-voltage inverters, instrumentation and sensors, switchgear, gas insulated switchgear, PCS, UPS

Tel +66-2-5292178

Fuji Tusco Co., Ltd.

Manufacture and sales of Power Transformers, Distribution Transformers and Cast Resin Transformers

URL <http://www.ftu.fujielectric.com/>

Fuji Electric Vietnam Co., Ltd. *

Sales of electrical distribution and control equipment and drive control equipment

URL <http://www.vn.fujielectric.com/en/>

Fuji Furukawa E&C (Vietnam) Co., Ltd. *

Engineering and construction of mechanics and electrical works

Tel +84-4-3755-5067

Fuji CAC Joint Stock Company

Provide the Solution for Electrical and Process Control System

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PT. Fuji Electric Indonesia

Sales of inverters, servos, UPS, tools, and other component products

URL <http://www.id.fujielectric.com/>

P.T. Fuji Metec Semarang

Manufacture and sales of vending machines and their parts

URL <http://www.fms.fujielectric.com/>

Fuji Electric India Pvt. Ltd.

Sales of drive control equipment and semiconductor devices

URL <http://www.ph.fujielectric.co.in>

Fuji Electric Consul Neowatt Private Limited

Development, manufacture, engineering, sales and servicing of UPS, Stabilizers, Active Harmonic Filters and other component products

URL <https://www.india.fujielectric.com/>

Fuji Gemco Private Limited

Design, manufacture, sales, and engineering for drive control systems

Tel +91-129-2274831

Fuji Electric Philippines, Inc.

Manufacture of semiconductor devices

Tel +63-2-844-6183

Fuji Electric Sales Philippines Inc.

Sales of energy management systems, process automation systems, factory automation systems, power supply and facility systems, and power generation

URL <https://www.ph.fujielectric.com/>

Fuji Electric (Malaysia) Sdn. Bhd.

Manufacture of semiconductor devices

URL <http://www.fujielectric.com.my/>

Fuji Electric Sales Malaysia Sdn. Bhd.

Sales of energy management systems, process automation systems, factory automation systems, power supply and facility systems, and vending machines

URL <https://www.my.fujielectric.com/>

Fuji Furukawa E&C (Malaysia) Sdn. Bhd. *

Engineering and construction of mechanics and electrical works

Tel +60-3-4297-5322

Fuji Electric Taiwan Co., Ltd.

Sales of semiconductor devices, electrical distribution and control equipment, and drive control equipment

URL <http://www.fujielectric.com.tw/>

Fuji Electric Korea Co., Ltd.

Sales of power distribution and control equipment, drive control equipment, rotators, high-voltage inverters, electronic control panels, medium- and large-sized UPS, and measurement equipment

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Fuji Electric Co., Ltd. (Middle East Branch Office)

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Representative office of Fuji Electric Co., Ltd. (Cambodia)

Providing research, feasibility studies, Liaison services
Tel +855-(0)23-964-070

■Equity-method Affiliates

Fuji Furukawa E&C (Thailand) Co., Ltd. *

Design and installation contracting for electric facilities construction
Tel +66-2-308-2703

Europe

Fuji Electric Europe GmbH

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URL <https://www.fujielectric-europe.com/>

Fuji Electric France S.A.S

Manufacture and sales of measurement and control devices

URL <https://www.fujielectric.fr/en>

Fuji N2telligence GmbH *

Sales and engineering of fuel cells and peripheral equipment
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China

Fuji Electric (China) Co., Ltd.

Sales of locally manufactured or imported products in China, and export of locally manufactured products

URL <http://www.fujielectric.com.cn/>

Shanghai Electric Fuji Electric Power Technology (Wuxi) Co., Ltd.

Research and development for, design and manufacture of, and provision of consulting and services for electric drive products, equipment for industrial automation control systems, control facilities for wind power generation and photovoltaic power generation, uninterruptible power systems, and power electronics products

Tel +86-510-8815-9229

Wuxi Fuji Electric FA Co., Ltd.

Manufacture and sales of low/high-voltage inverters, temperature controllers, gas analyzers, and UPS

Tel +86-510-8815-2088

Fuji Electric (Changshu) Co., Ltd.

Manufacture and sales of electromagnetic contactors and thermal relays

URL <http://www.csfe.com.cn/>

Fuji Electric (Zhuhai) Co., Ltd.

Manufacture and sales of industrial electric heating devices

URL <http://www.fujielectric.com.cn/fez/>

Fuji Electric (Shenzhen) Co., Ltd.

Manufacture and sales of photoconductors, semiconductor devices and currency handling equipment

URL <http://www.sz.fujielectric.com.cn/>

Fuji Electric Dalian Co., Ltd.

Manufacture of low-voltage circuit breakers

Tel +86-411-8762-2000

Fuji Electric Motor (Dalian) Co., Ltd.

Manufacture of industrial motors

Tel +86-411-8763-6555

Dalian Fuji Bingshan Vending Machine Co., Ltd.

Development, manufacture, sales, servicing, overhauling, and installation of vending machines, and related consulting

Tel +86-411-8754-5798

Dalian Fuji Bingshan Control Systems Co., Ltd.

Energy management systems, distribution systems, and related system engineering

Tel +86-411-8653-6010

Fuji Electric (Hangzhou) Software Co., Ltd.

Development of vending machine-related control software and development of management software

URL <http://www.fujielectric.com.cn/fhs/>

Fuji Electric FA (Asia) Co., Ltd.

Sales of electrical distribution and control equipment

Tel +852-2311-8282

Fuji Electric Hong Kong Co., Ltd.

Sales of semiconductor devices and photoconductors

URL <http://www.hk.fujielectric.com/en/>

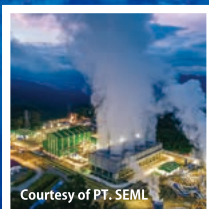
Hoei Hong Kong Co., Ltd.

Sales of electrical/electronic components

URL <http://www.hoei.com.hk/>

Innovating Energy Technology

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Inverters



Power Electronics Technology
Uninterruptible Power Supply
Systems (UPS)



Heat exchange and refrigerant control technology
Hybrid heat pump Vending
Machines

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