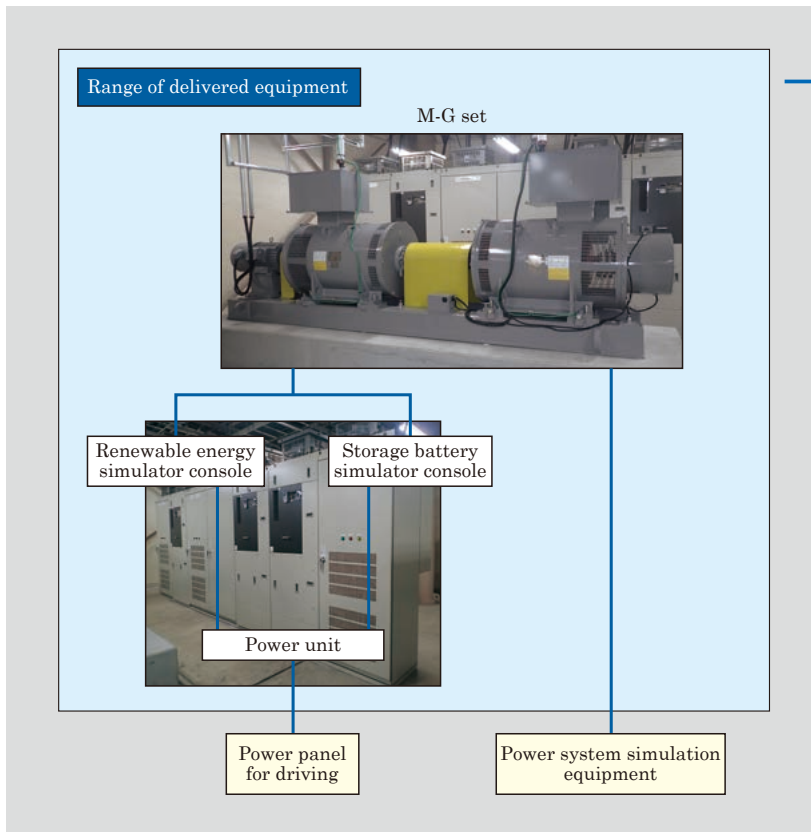
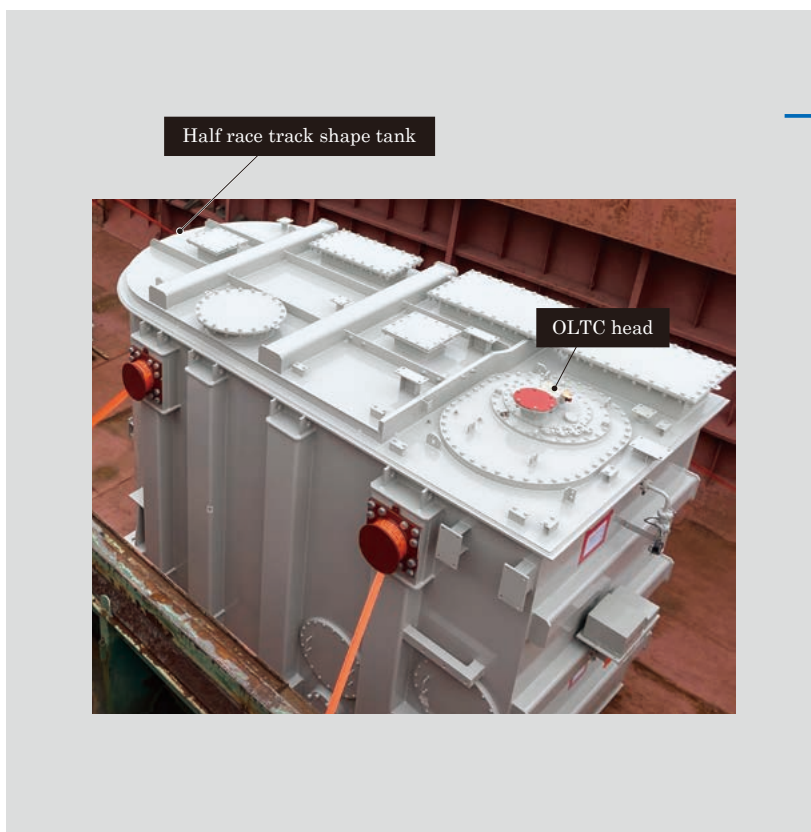




M-G Set Demonstration System Combined with Renewable Energy and Storage Battery

As the adoption of renewable energy expands, maintaining the inertia power, which depends on synchronous generators, has become a challenge in the operation of power systems. The M-G set consists of a motor (M) and a synchronous generator (G) that are arranged on the same axis and generates electricity through the rotational force of the motor. It runs on renewable energy and storage batteries to accommodate increased renewable energy while maintaining inertia power, thus creating expectations of contributing the power system stability. Fuji Electric has delivered an M-G set demonstration system to the Central Research Institute of Electric Power Industry that combines renewable energy and storage batteries. This system consists of an M-G set, a renewable energy simulator console, and a storage battery simulator console. It enables the frequency and voltage maintenance capability and the behavior of the M-G set itself to be verified under the assumption that a storage battery and an M-G set equivalent to 100MVA are installed in the power system to which a large amount of renewable energy is introduced.

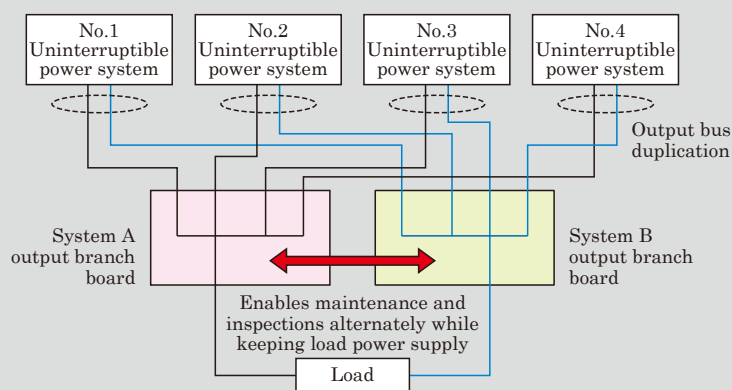


Special Three-Phase Transformer for Minamiota Substation, TEPCO Power Grid, Incorporated

Fuji Electric delivered a special three-phase transformer of 154kV and 200MVA to the Minamiota substation of TEPCO Power Grid, Incorporated. The special three-phase transformer has a structure of iron cores and the windings, both of each phase housed in separate tanks and their leads of the windings are connected in the common duct. Therefore, the three-phase transformer is divided into three single-phase transformers that can be transported and reassembled on site. As bridges on transportation routes deteriorate over time, there are an increasing number of projects where ordinary three-phase transformers cannot be transported due to size and weight restrictions, and inquiries for special three-phase transformers have increased in recent years. In this project, we designed the tanks of each phase to have a half race track shape and stored the on-load tap changer (OLTC) in the U-phase tank to reduce the weight, and as a result, the installation area has been reduced by 20% compared to typical special three-phase transformers of the same specifications.



(a) "UPS7500WX-T4"



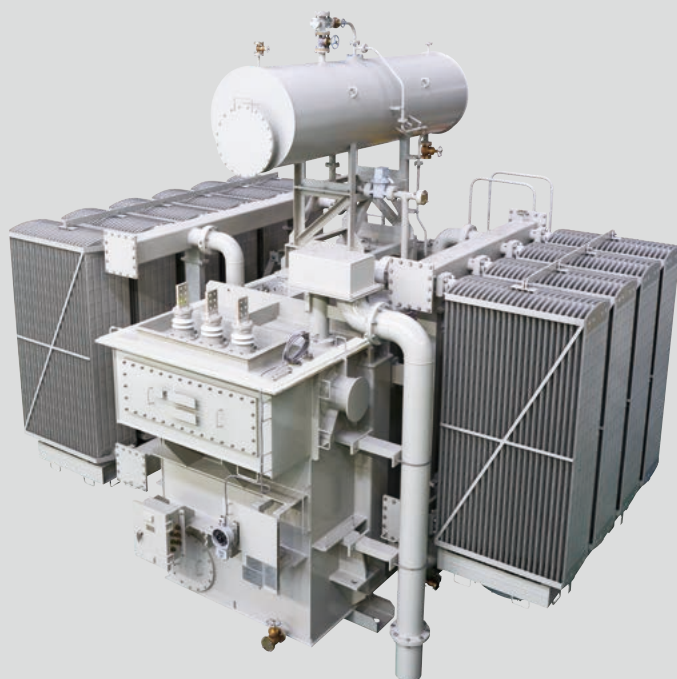
(b) System configuration

Delivery of a High-Capacity UPS System to a Data Center

In recent years, the hyper-scaling of cloud operators and the improvement of business continuity of enterprises have attracted attention. In data centers, demand is thus increasing for larger capacity power supply systems and uninterruptible power systems that can supply power even during maintenance and inspection. Fuji Electric has delivered a high-capacity UPS system with a parallel redundant configuration to a data center.

The main features are as follows:

- (1) The system has a 3+1 configuration, each unit having a capacity of 1,200 kVA, to supply up to 3,600 kVA even when one unit is under maintenance or inspection.
- (2) Each UPS unit has two outputs and dual output bus, allowing the system to continue load feeding even during maintenance or inspection of an output branch panel by feeding power through the other output branch panel.



Deployment of FR3[®] Transformers in the Data Center Market in Japan

In recent years, demand has been growing, especially among foreign customers, for transformers that use natural ester insulating oil for data centers in Japan, where capital investment is substantial. Natural ester oil is highly biodegradable and non-toxic, and its impact on the environment can be reduced in the unlikely event of an oil spill. In addition, it has a flash point of 326°C, which is higher than that of mineral oil (188°C) and does not burn easily, allowing ancillary equipment such as fire equipment to be simplified to save installation costs. Fuji Electric has launched In December 2022 the "FR3[®] Fluid-Applied Transformer," a transformer with a rated capacity of 2 to 100 MVA that uses natural ester oil, and received an order for a 25 to 30 MVA transformer for a data center in Japan. Natural ester oil has a high viscosity, but we redesigned the structure inside the transformer to achieve the required cooling performance with dimensions equivalent to that of transformers that use mineral oil.

We will continue to offer proposals for data centers, where demand is expected to increase, thereby contributing to the conservation of the global environment.



(a) Standard model for $\phi 16$ holes



(b) Thin model for $\phi 22$ holes
(Silver bezel specifications)



(c) Thin model for $\phi 30$ holes

Redesigned “Command Switch”

In recent years, the panel designs of mechanical devices have been subject to continuous refinement. In response, Fuji Electric has stylishly redesigned its “command switches” to be attached to panels.

The main features are as follows:

- (1) A design applicable to a wide range of machinery and equipment, from machine tools to medical applications
- (2) An additional thin model that protrudes less than the panel surface to make the entire device look slimmer and prevent unintended contact or erroneous operation by operators
- (3) Illuminated pushbutton switches with the illuminated surface enlarged by 20% from the previous design, improving visibility with bright, uniform surface illumination in all corners
- (4) Button press surface with a finger-fitting design to reduce operator fatigue during prolonged operations



(a) Standard model



(b) Model with Ethernet communications

“FRENIC-Ace (E3) Series” High-Performance, Standard Inverters

In line with the advancement of factory automation, efforts to improve productivity by collecting and analyzing large amounts of equipment data are gaining momentum in production facilities. To meet these needs, Fuji Electric has developed the “FRENIC-Ace E3 Series” low-voltage inverter, which extends the functions of the “FRENIC-Ace” with a capacity of 0.1 to 22 kW.

The main features are as follows:

- (1) A built-in Ethernet interface, which was optional in conventional models, has reduced the size by approximately 27% compared to the conventional model, thereby saving space.
- (2) Equipped with a diagnosis function that evaluates the life expectancy of IGBTs to detecting inverter failure before it occurs, preventing long-term shutdown of equipment.
- (3) A traceback function that collects and stores the previous waveform data when alarms stop contribute to investigations on the causes of stops through data analysis and quick equipment recovery.



“S-Flow” Compact Ultrasonic Flowmeter for Small-Diameter Pipes

In the semiconductor manufacturing equipment and air conditioning equipment market, for which capital investment is robust, there is a growing need for small clamp-on type flowmeters that can measure fluid in small-diameter pipes without contact. In response to this need, Fuji Electric has developed the “S-Flow,” a small, palm-sized ultrasonic flowmeter.

The main features are as follows:

- (1) Capable of measuring with a high accuracy of $\pm 2.0\%$ R.D. (R.D.: Reading) in small-diameter pipes with an inner diameter of 8 to 32 mm
- (2) Small external dimensions of W120 × D42 × H65 mm (for pipe diameter $\phi 8$ mm), integrating the converter and detector to reduce installation space and installation cost
- (3) Easy installation without the need to apply grease during installation



“MONITOUCH V10 Series” Programmable Operator Interface

Programmable operator interfaces are widely used in the monitoring and operation of equipment and machinery at manufacturing sites. Fuji Electric has developed the “MONITOUCH V10 Series,” which achieves industry-leading* performance in all basic HMI functions (rendering, operation, communication, start-up, transferring, and custom code) and provides stress-free operation.

The main features are as follows:

- (1) Use of a quad-core CPU and thorough optimization of applications deliver stable operation and communication performance even on high-load screens.
- (2) Full compatibility with existing “MONITOUCH” allows customers to reduce development costs.
- (3) Adoption of the latest eMMC technology reduces start-up and transfer latency.

* Comparisons conducted with current models of major domestic and overseas HMI manufacturers using sample screens from our company (according to our research).



R211 subway car for New York City Transit
(Photo courtesy of Kawasaki Rail Car, Inc.)

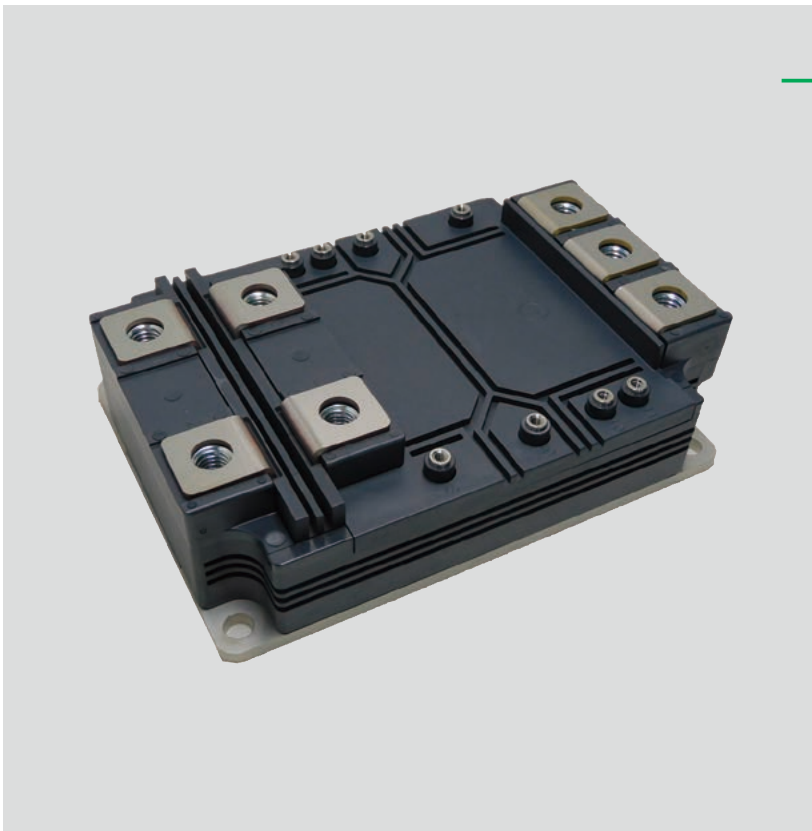
An Approach for Increasing Safety and Reliability in Fuji Electric's Door System

Door System for the railcars is critical safety and reliability because it is in direct contact with passengers. Fuji Electric designs some components of it for the overseas market locally, and it is necessary to guarantee the same level of safety and reliability.

As an approach for software, Fuji Electric expanded the scope of Capacity Maturity Model Integration (CMMI) activity, the standard to evaluate maturity of organization and management, to overseas subsidiaries. As a result of these activities, Fuji Electric, including overseas subsidiaries, received the certification of CMMI level 2.

Regarding hardware, Fuji Electric improved the reliability of Door System further by replacing the contact parts with highly reliable semiconductor switches, with the exception when usage of contact parts is a specified requirement.

Door Systems with the above measures were installed on New York City Transit's R211 cars, which started operations in March 2023.



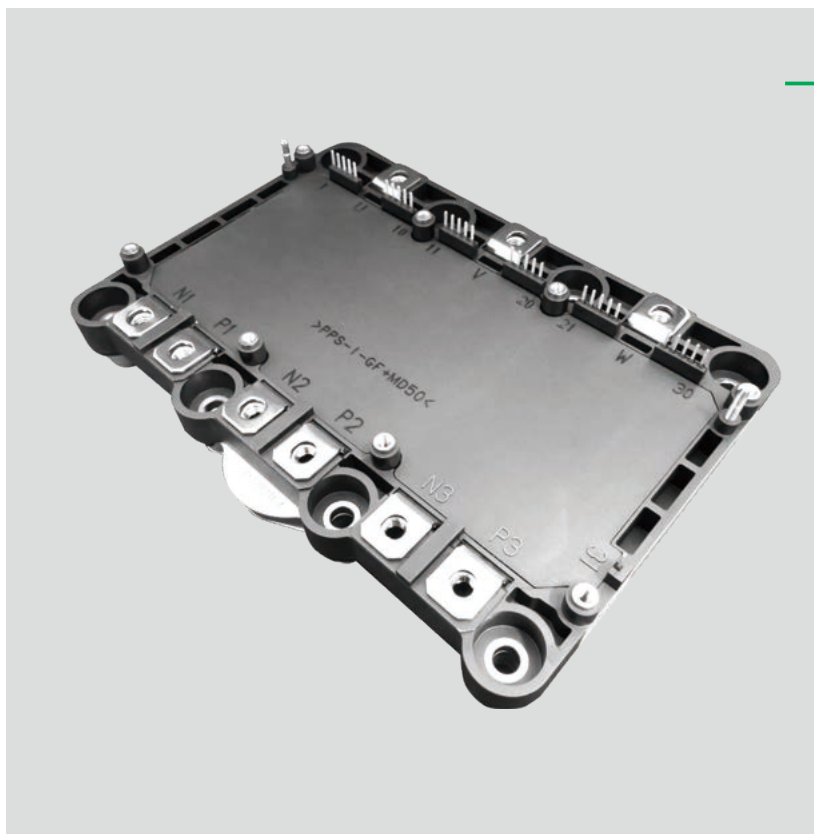
"HPnC" Industrial High-Capacity Module

As the market for solar, wind, and other renewable energies expands with the aim of achieving a decarbonized society, demand is increasing for higher efficiency, larger capacity, and reduced size in power conversion equipment. To meet this demand, Fuji Electric has developed the "HPnC" high-capacity industrial module

The main features are as follows:

- (1) A lineup of 2,300-V/1,200-A rated modules suitable for boosting the input voltage from 1,000 V DC to 1,500 V DC to increase power converter efficiency
- (2) Package terminal arrangement designed for easy multiple parallel connections, facilitating-capacity expansion of power converters
- (3) Use of the 7th-generation "X Series" IGBT chips to increase current density, helping downsize power converters

To further improve the efficiency of power conversion equipment, we are also developing a family product (rated at 2,300 V) using low-loss SiC-MOSFET chips.



“M675” Automotive Module for the Chinese Market

As society progresses toward decarbonization, the electrification of cars is advancing worldwide, and particularly in China, the need for electrified vehicles is increasing as a result of new energy vehicle (NEV) regulations. For the Chinese market, Fuji Electric has offered the “M653” direct water-cooled power module. We have recently developed the “M675,” a 750-V/820-A rated module for the Chinese market, with 30% improved output characteristics and 20% improved heat dissipation compared to the M653.

The main features are as follows:

- (1) Use of the “X Series” 7th-generation RC-IGBTs has reduced watt loss by 13%.
- (2) Enhanced internal fin structure of the cooling part has improved the heat dissipation by 20%. Combined with water jacket, usability is improved.
- (3) Main body size and fastening hole and water channel hole positions are the same as those of the M653, making it easy to perform replacements.



Turbine generator delivered by Fuji Electric

Start of Commercial Operations of Olkaria Geothermal Power Station (Unit 6)

The sixth power generation unit (86.9 MW) of the Olkaria I Geothermal Power Station began commercial operations in June 2022. Kenya Electricity Generating Company PLC ordered the unit from Fuji Electric through Marubeni Corporation. The Olkaria Geothermal Power Station is where Fuji Electric first delivered geothermal power equipment in Africa. Fuji Electric applied its corrosion-resistance technology developed over the years to the unit and optimized the plant layout and equipment to achieve the largest single-unit output in Kenya, where geothermal power generation is thriving. We worked with Kenyan civil engineering and architectural design firms and local construction companies to manage the project. We designed and procured a complete set of power generation equipment, including our own geothermal steam turbine, generator and condenser, as well as dispatched engineers to the site to work on the project.

The operation of this power station will contribute to the stable supply of electricity in Kenya.



120-kW hydrogen fuel cell system

Hydrogen Fuel Cell Systems for Factories and Facilities

The world is expected to see the arrival of a hydrogen society, which will contribute to the stable supply of energy and the realization of carbon neutrality. In preparation, Fuji Electric has started the development of a hydrogen fuel cell system as hydrogen power generation equipment for factories and facilities. This fuel cell system uses polymer electrolyte fuel cell modules that are mass-produced for automobiles. Since the amount of available hydrogen varies depending on the factory or facility, the system configuration allows the number of groups of built-in fuel cell modules to be changed easily so that the rated power generation capacity can be selected accordingly from 50 to 480 kW. Fuji Electric has produced a prototype fuel cell system that can operate for more than 10 years without replacing the fuel cell modules using our newly developed proprietary operating technology in addition to the fuel cell design technology cultivated so far. We are currently conducting demonstration tests for this system.



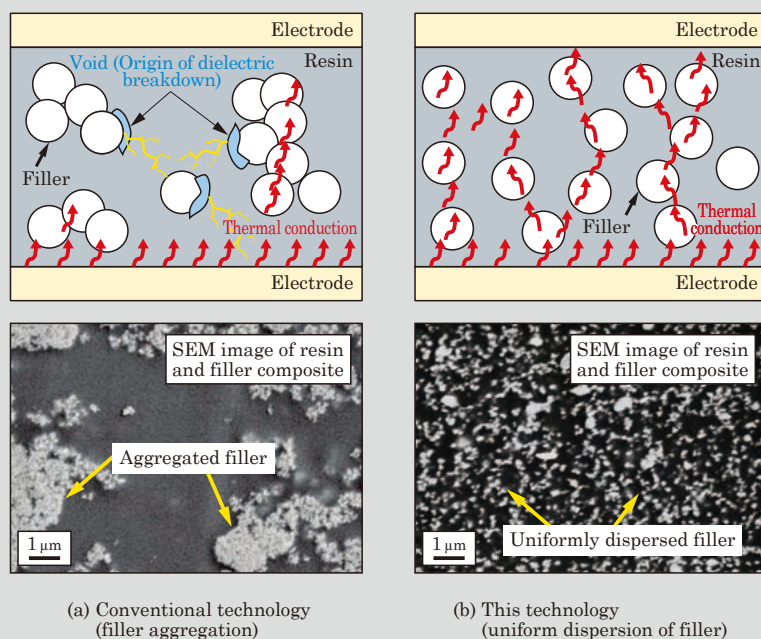
“Sustainable Vending Machine Series”

Against the backdrop of the SDGs and other factors, environmental measures are becoming increasingly important for beverage vending machines. Fuji Electric has thus developed the “Sustainable Vending Machine Series,” a series of environmentally friendly machines designed for energy saving and natural resources saving.

The main features are as follows:

- (1) Expanding rotational speed range in the cooling inverter compressor has improved cooling efficiency and optimal arrangement of additional vacuum insulation has reduced power consumption by up to 20%.
- (2) Improved sheet metal bending structure has reduced plate thickness while maintaining base strength, thereby saving natural resources (10% thinner than conventional models).
- (3) New packaging system that can be configured with minimal materials results in a 70% reduction in packaging materials
- (4) Cloud collaboration via multi-communication modules has optimized delivery plans and reduced lost sales opportunities.

Enhancing Performance of Electrical Insulation Composite with Filler

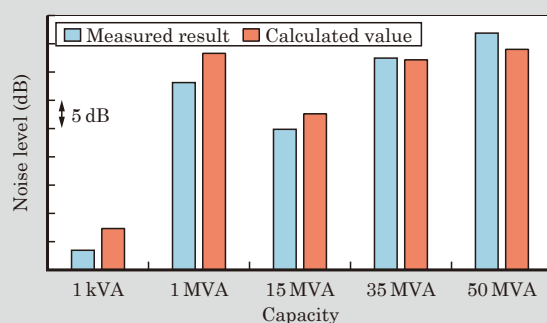
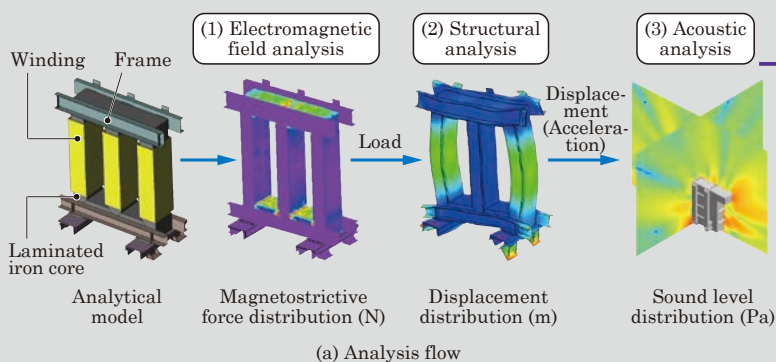


In recent years, as the size reduction of electrical equipment has accelerated, demand is increasing for insulating materials with high thermal conductivity and insulation property. As a way to achieve high thermal conductivity, it is effective to mix highly thermally conductive filler into base resin. However, to ensure high thermal conductivity while retaining insulation property, it was necessary to prevent the form of aggregated filler and voids, which can be the starting point of dielectric breakdowns.

To overcome this issue, Fuji Electric has developed a technology to control filler dispersion behavior and reduce voids in resin by improving compatibility between resin and filler by modifying the filler surface.

As a result of applying this technology to a varnish resin (unsaturated polyester) for the impregnation of stator coils of rotating machines, the thermal conductivity has improved from 0.3 to 1.0 W/(m·K) without losing insulation performance.

Laminated Iron Core Magnetostrictive Vibration and Noise Simulation Technology



(b) Noise level around the transformer

In recent years, urbanization around substations has progressed, and low noise is required for transformers and other substation equipment. The main cause of noise generated by the transformer is the vibrations caused by the magnetostriction, that is, the expansion and contraction of the electromagnetic steel sheet that makes up the laminated iron core during energization. We have developed a simulation technology to accurately estimate this magnetostrictive vibration and the associated noise. First, this simulation technology obtains the magnetostrictive force through electromagnetic field analysis, then uses structural analysis to calculate the displacement along with the vibrations caused by the magnetostrictive force, and acoustic analysis to calculate the sound level produced by the displacement.

The main features are as follows:

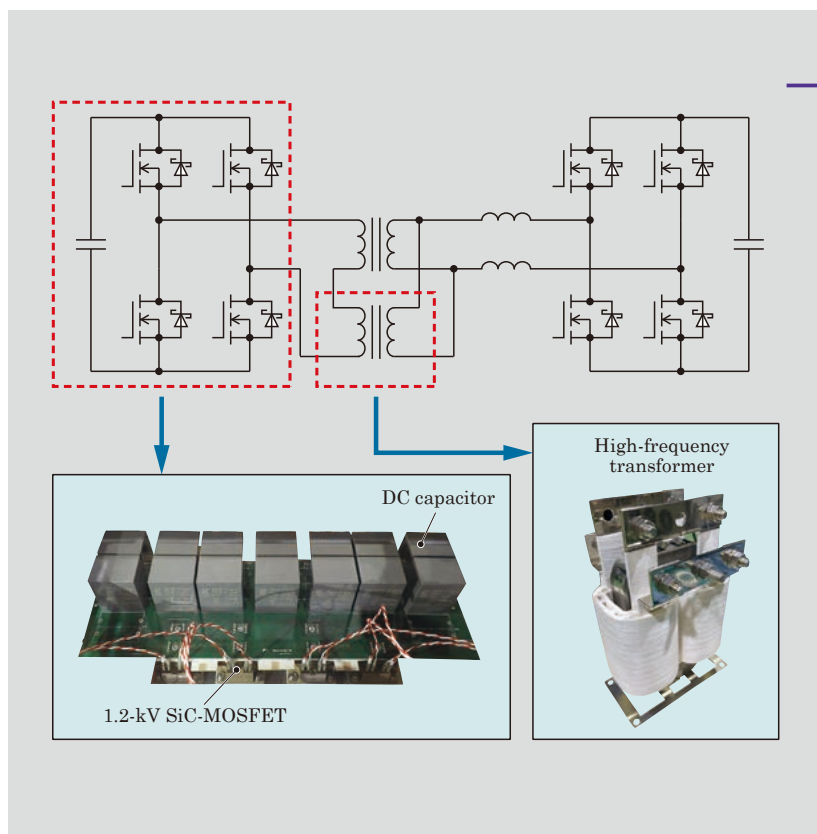
- (1) Capable of estimating the noise level with a high accuracy of ± 5 dB from the measured value.
- (2) Enables noise level estimation and structure examination to achieve low noise during the design phase, thereby reducing the time required for noise-related design work to a quarter of that required with conventional products.

Bi-Directional Isolated DC/DC Converter

In recent years, the application of a DC bus system using electrolysis equipment, fuel cells, and storage batteries for hydrogen utilization has been studied as part of efforts toward realizing carbon neutrality. In order to achieve the practical application of DC bus systems, power converters providing galvanic isolation as well as high conversion efficiency are required. To fulfill these requirements, Fuji Electric has developed a bi-directional isolated DC/DC converter for DC bus systems.

The main features are as follows:

- (1) High conversion efficiency over a wide range of loads achieved by using SiC power devices with a withstand voltage of 1.2 kV and dual active bridge (DAB) circuit configuration (rated efficiency 98.0% for 200-kW prototype)
- (2) Adaptable to a wide range of voltage fluctuations with Fuji Electric's proprietary modulation technology (Voltage range 400 to 800 V)

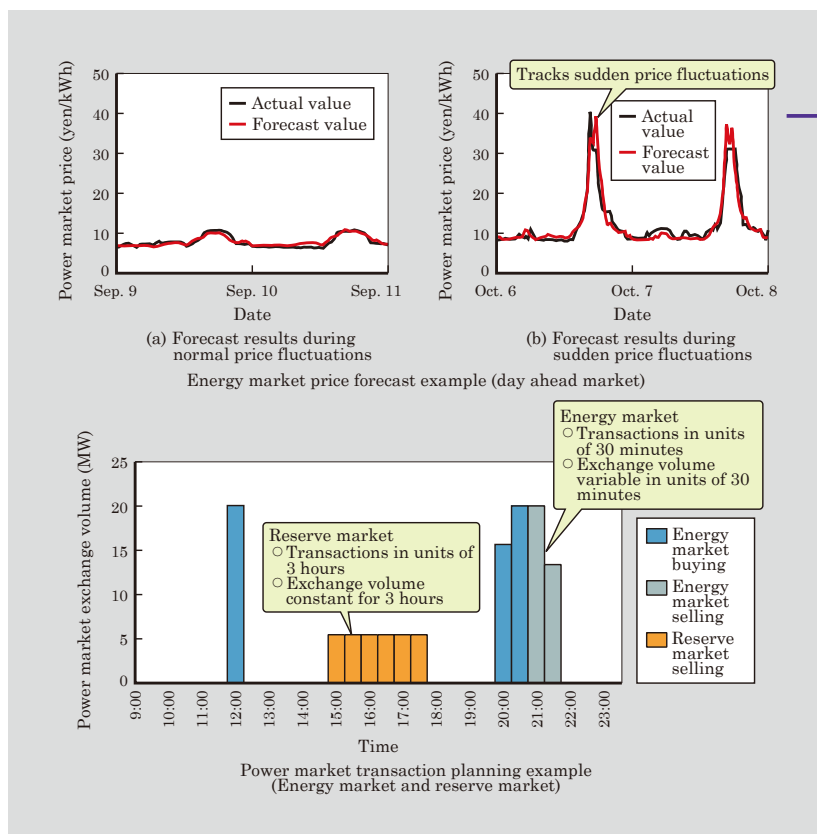


Energy Market Price Forecasting and Planning of Transactions Using Storage Batteries for the Power Grid

The establishment of the energy market has led to an increase in the need for storage batteries to be utilized in electricity utilities. In response to this need, Fuji Electric has developed a technology to forecast the power market price and create an exchange plan based on the forecast to maximize profits by effectively utilizing storage batteries.

The main features are as follows:

- (1) Power market price forecasting
 - Capable of forecasting with high accuracy by using a wide range of information, such as nationwide supply and demand information and inter-connection line information.
 - Capable of tracking sudden price changes by using short-term historical data.
- (2) Power market transaction planning
 - Enables simultaneous planning of transactions in existing energy markets with different transaction units and new reserve markets.





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