

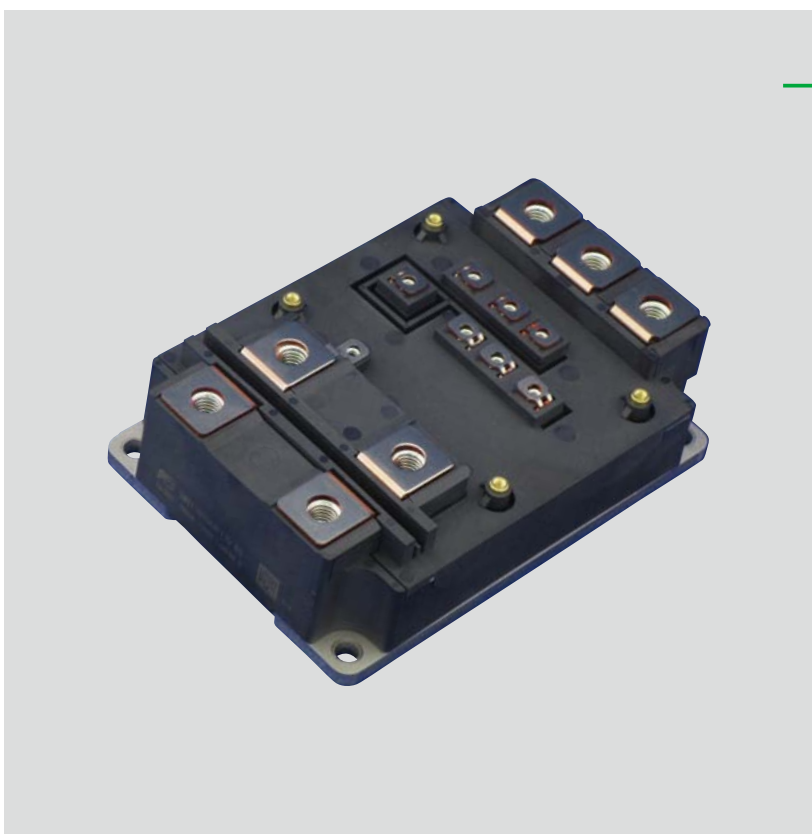


Exhaust Gas Cleaning System for Marine Vessels (SO_x Removal Cyclone Scrubber)

In order to prevent air pollution from vessels, exhaust gas regulations are being gradually tightened on the basis of the MARPOL Annex VI. In October 2018, Fuji Electric released an exhaust gas cleaning system for marine vessels (SO_x removal cyclone scrubber) to deal with regulations on sulfur oxide (SO_x) and particulate matter (PM). This device sprays alkali water into the exhaust gas to reduce SO_x by dissolving it in the droplets.

The main features are as follows:

- (1) The industry's smallest equipment having about 50% smaller volume compared with competitors' products
- (2) Small size and low pressure loss by using a cyclone type equipment that is different from the conventional packed bed type
- (3) Lower pressure loss and droplet dispersal rate compared with competitors based on fluid simulations and model experiments on SO_x dissolution

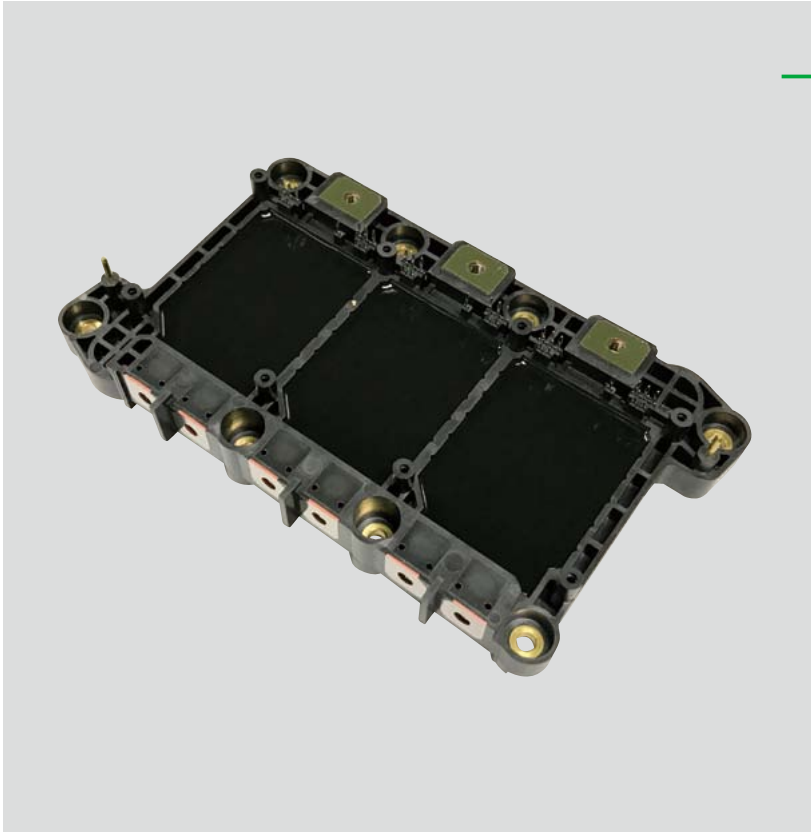


"HPnC" High-Capacity Power Module for Electric Railways

In recent years, power conversion systems using power semiconductors have been spreading in various fields while becoming smaller in size and higher in capacity. To meet the demand for higher capacity and smaller size, we developed "HPnC" (High Power next Core), a high-capacity power module for electric railways that is equipped with the 7th-generation "X Series" chip.

In order to realize smaller inductance, the HPnC uses internal terminals having a laminate structure and main terminals positioned optimally. As the result of terminals positioned optimally, HPnC achieved 10 nH and 76% smaller than that of the conventional product "HPM" (42 nH). This made it possible to suppress surge voltage and downsize a snubber circuit.

Further, the reliability of the main terminal joint with DCB surface are improved by adopting ultrasonic bond. Solder fatigue is reduced by using a new base plate having low thermal expansion. This increased the ΔT_c power cycle capability.



High-Power, Direct Liquid Cooling Module for Automotive Applications

Fuji Electric is offering its power modules for the EV and HEV markets, which are rapidly growing universally. IGBT modules for these markets need to be small and high in power density. We have therefore developed an IGBT module with a rating of 750 V / 1,200 A, which is the industry's top-class capacity.

In order to achieve lightweight and high heat radiation, the IGBT module adopts a direct liquid cooling structure having an integrated aluminum water jacket for the cooling unit. The module uses a lead frame for the internal wiring and reverse-conducting IGBTs (RC-IGBTs), having an IGBTs and FWDs formed on the same chip, as the power elements, allowing it to improve the area efficiency and increase the power density. In addition, the chip temperature can be directly monitored with a temperature sensor built in the RC-IGBT. This structure make it possible to reduce the design margin compared with the NTC thermistor and increase the allowable current.



RC-IGBT Module for High Power Industrial Applications

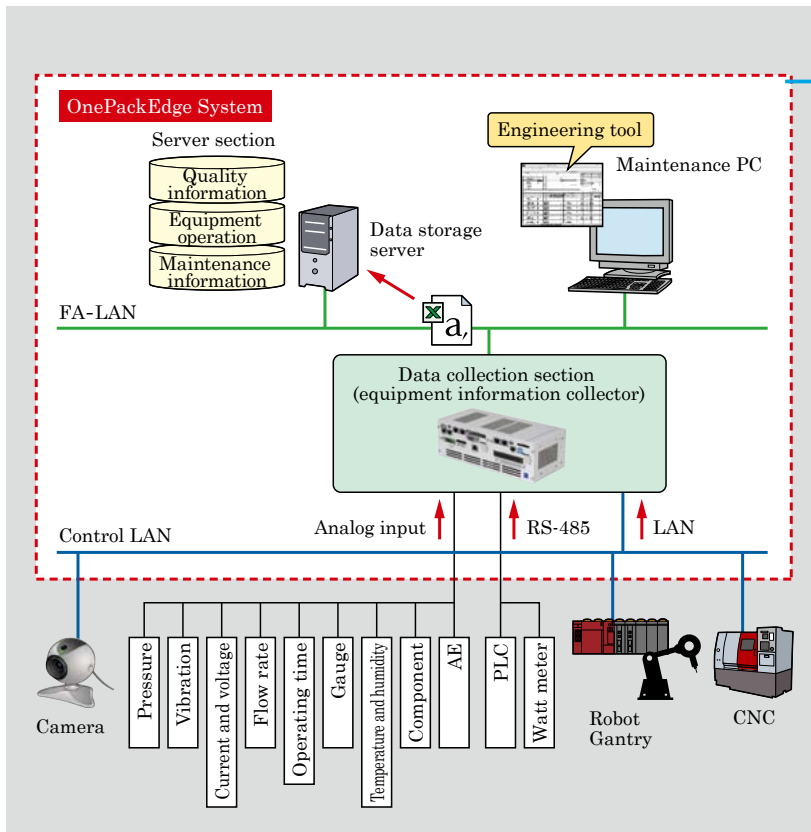
Fuji Electric has commercialized a reverse-conducting IGBT (RC-IGBT), which integrates IGBT and FWD functions into one chip, to meet market demands for the expansion of output power and higher reliability for IGBT modules.

Fuji Electric has developed the 7th-generation "X Series - PrimePACK™" RC-IGBT module for high power industrial applications. Maximum rated current of the new product has been extend to 2,400 A from conventional 6th-generation "V Series" 1,400 A by utilizing the new developed RC-IGBT technology. In addition, the performance for output power has been greatly improved under various operating conditions of power conversion systems such as overload, DC lock and low-frequency operations.

As a result of Fuji Electric's efforts, this product achieves a further output power and a longer reliability of power conversion systems.

Note: PrimePACK™ is a registered trademark of Infineon Technologies AG, Germany.

“OnePackEdge System” that Realizes Non-Stop Equipment



Fuji Electric developed and released “OnePackEdge System,” a system solution including a data collection devices and analysis software by utilizing the performance of the measurement control system. The system collects environment data and processing data from CNCs, PLCs and sensors and accumulates them in one package for each product or production cycle.

The main features are as follows:

- (1) Information necessary for each department can be acquired from the integrated database.
- (2) Equipment abnormality and failure occurrence can be suppressed by conducting polygonal analysis of field information.
- (3) The system can easily be installed in the existing equipment afterwards, and thus, the introduction costs can be reduced.

Smart Community Demonstration Project in Industrial Parks in Java, Indonesia

(a) System overview

(b) Operation start ceremony (NEDO, PLN, etc.)

From FY2012 to FY2018, Fuji Electric was entrusted with the “Smart community demonstration project in industrial parks in Java, Republic of Indonesia” from NEDO and introduced the distribution automation system to an overseas power company for the first time. We demonstrated the following power stabilization technologies:

- (1) We demonstrated the effect of reduced outage time due to the introduction of a distribution automation system.
- (2) We installed a high-quality power supply system (a instantaneous voltage drop protector and a medium-voltage UPS) in the distribution system of the power company, and provided high-quality power supply service to consumers. As a result, there were significant effects such as a reduction in the damage caused by a instantaneous voltage drop. In addition, we verified the feasibility of the shared-service model.



EMS Model Factory in China

Fuji Electric has established Dalian Fuji Bingshan Smart Control Systems Co., Ltd. (DFBCS) with the Bingshan Group in October 2018 to expand system business outside Japan. We developed an energy management system (EMS) package for the Chinese market, and DFBCS delivered it to the new factory of Dalian Refrigeration Co., Ltd., an affiliated company of the Bingshan Group. The EMS provides visualization and comprehension.

The factory serves as a model factory to expand Fuji Electric's business in China. We are going to add functions such as optimum operation of energy center equipment and energy consumption rate management by cooperating with a manufacturing execution system (MES) in the future.



“MICREX-SX SPH5000H” Highly Reliable Duplex System

In April 2019, Fuji Electric offered the “MICREX-SX SPH5000H” programmable controller for markets that require highly reliable lifeline equipment.

The main features are as follows:

- (1) Redundant CPU having high performance operation with 1-Gbits/s equalization bus
- (2) High-speed duplexed control network using 1-Gbits/s FL-net
- (3) Duplexed I/O network and loop function with an E-SX bus capable of high-speed I/O refresh
- (4) CPU RAS information stored in non-volatile memory for high maintainability

These functions contribute to stable and continuous 24-hour operation.



“XCS-3000 Type E” High-Speed Controllers for Electrical Machinery Control

Fuji Electric developed the “XCS-3000 Type E” electrical machinery programmable controller (PLC) for drive control systems, which is designed to be used in the “MICREX-VieW” monitoring and control system. The controller platform is unified with the “XCS-3000,” a conventional distributed control system (DCS) controller for measurement control systems. Unifying electrical machinery and measurement control systems in the same plant enables uniform management of data and seamless connection of both systems. Expanding and mounting the functions of the conventional electrical machinery PLCs can achieve a drive control system having high speed and high reliability.

The main features are as follows:

- (1) A loop configuration of SX-Net is supported, a high-speed, high-capacity control LAN
- (2) A loop configuration of an E-SX bus is supported, a high-speed, high-capacity I/O bus
- (3) A control cycle of 0.5 ms is achieved, necessary for drive control in steel plants



Start of Commercial Operation of Sakata Biomass Power Plant of Summit Sakata Power Corporation

Fuji Electric delivered a 50-MW steam turbine and generator to Sakata Biomass Power Plant of Summit Sakata Power Corporation via Sumitomo Heavy Industries, Ltd. It is one of the largest biomass power plants in eastern Japan and started commercial operation in August 2018. The fuel used in the power plant is wood biomass such as domestic chips, imported pellets and palm kernel shell (PKS).

The steam turbine meets the required conditions for the plant. It employs an one-casing reheat steam turbine, which has been used in power plants with a rating of 75 MW or above, and expands its application range to low-capacity while maintaining the high reliability and efficiency.

By taking advantage of this experience, Fuji Electric will continue receiving orders for steam turbine and generator for biomass power plants having a similar capacity range.



Transformer for Global Market

Fuji Electric developed 115-kV and 50-MVA transformers for global markets, such as Southeast Asia, whose power demand is expected to grow in the future. The following approaches allow for the world's smallest size, mass and oil amount.

- (1) The lead insulation structure is optimized, and the insulation dimension for tanks is greatly reduced.
- (2) The transformer mass is reduced by 28% by optimizing the structure of windings, iron core tightening, and cooling unit.
- (3) The oil amount is reduced by 47% by optimizing the tank structure in accordance with the size reduction of (1) and (2).
- (4) The stray load loss is reduced by optimizing the tank shield structure.



66-kV Substation in Harmony with the Environment for Canon Group

We delivered extra-high-voltage substation equipment with high performance and good harmony with environment to deal with the aging of the 66-kV substation of Canon Components, Inc.

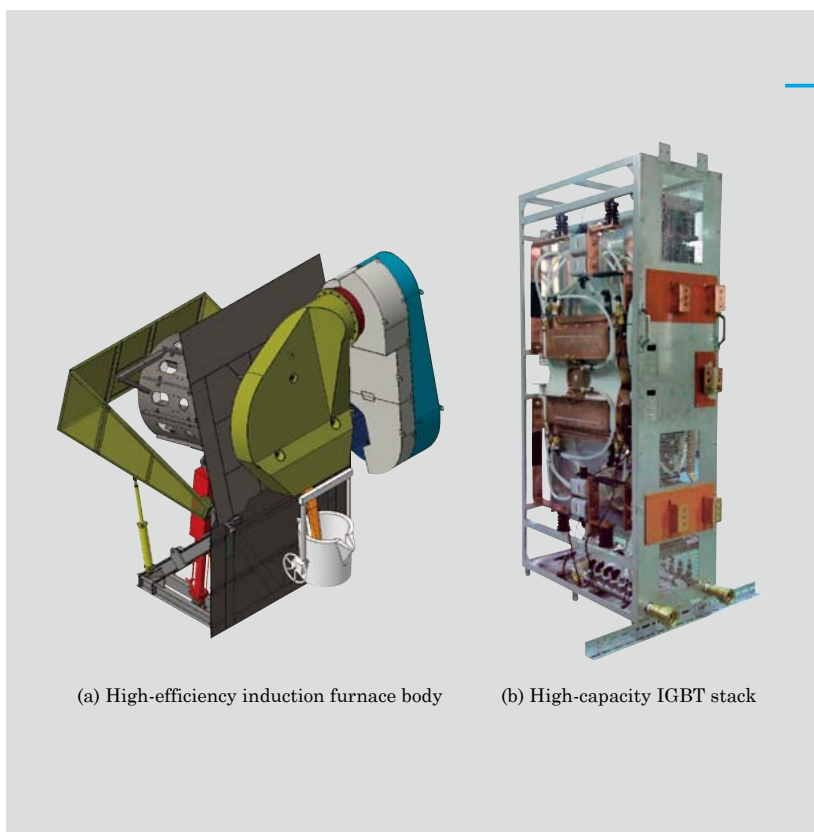
The main features are as follows:

- (1) The insulation oil of the transformer (Ecore Trans) uses plant-derived palm fatty acid ester (PFAE) instead of conventional mineral oil. With this low viscosity oil, the transformer improves in cooling performance, allowing downsizing. Even if the oil leaks, environmental load can be suppressed because it is biodegradable.
- (2) The cubicle-type gas insulated switchgear (C-GIS) uses dry air for insulation. Since it is not a greenhouse gas (SF_6), recovery is not needed at the internal inspection. Even if the air pressure drops to atmospheric pressure, the insulation for the system voltage is maintained, ensuring Safety



“PIS-50/500” Power Conditioning System for Solar Power Generation

Fuji Electric has only offered central-type power conditioning systems (PCSs) for solar power generation with 500 kW or more in Japan. On the other hand, the mainstream in the Chinese market is a string type of a 50-kW class; therefore, we have newly developed a string type PCS utilizing the technology of low-voltage inverters. The 500-kW central type unit performs maximum power point tracking control collectively for about 2,000 solar panels; however, the string type unit of Fuji Electric performs control for every about 40 panels. This can minimize the influence of a drop in the output of solar panels due to the weather; therefore, the power generation amount is expected to increase by several percent. In the future, we are going to provide it also in Japan, South Korea and Southeast Asia, in addition to China. We will meet various customer needs by providing the central type and the string type.



(a) High-efficiency induction furnace body

(b) High-capacity IGBT stack

High-Efficiency and High-Frequency Induction Furnace for Overseas Markets

Energy saving regulations are spreading as environmental measures in many countries. Fuji Electric developed a high-efficiency and high-frequency induction furnace for overseas markets such as China and Southeast Asia in addition to Japan by utilizing its unique induction heating and power electronics technologies.

The main features are as follows:

- (1) The electric power consumption is reduced by 5% compared with the conventional type because of the optimum yoke structure and coil structure.
- (2) The coil voltage is approximately doubled by using unique insulation technology, thus greatly reducing the joule loss of coils.
- (3) The newly developed IGBT stacks feature compactness and high-capacity by using low-loss IGBT modules.

We will continually provide additional functions, such as for optimum furnace operation and self-diagnosis management, to enhance productivity, safety and maintainability for customers.

Coffee Machine for Seven-Eleven Japan Co., Ltd.

Fuji Electric developed a new coffee machine for SEVEN CAFÉ with Seven-Eleven Japan Co., Ltd.

The main features are as follows:

- (1) We developed a function that the sensor identifies the cup type, which differs depending on the drink. This function allows purchasers not to get confused or make mistakes when selecting the button.
- (2) We developed an extraction mechanism that sprinkles hot water. This enables continuous extraction of a large amount of coffee, shortening the preparation time. The sprinkle hot water can efficiently wash out attached material on the extraction part.
- (3) A wireless communication function is mounted, making it possible to change the beverage setting and contents displayed on the large LCD panel by distribution. Operating states such as sold out beverages and failure can remotely be monitored.

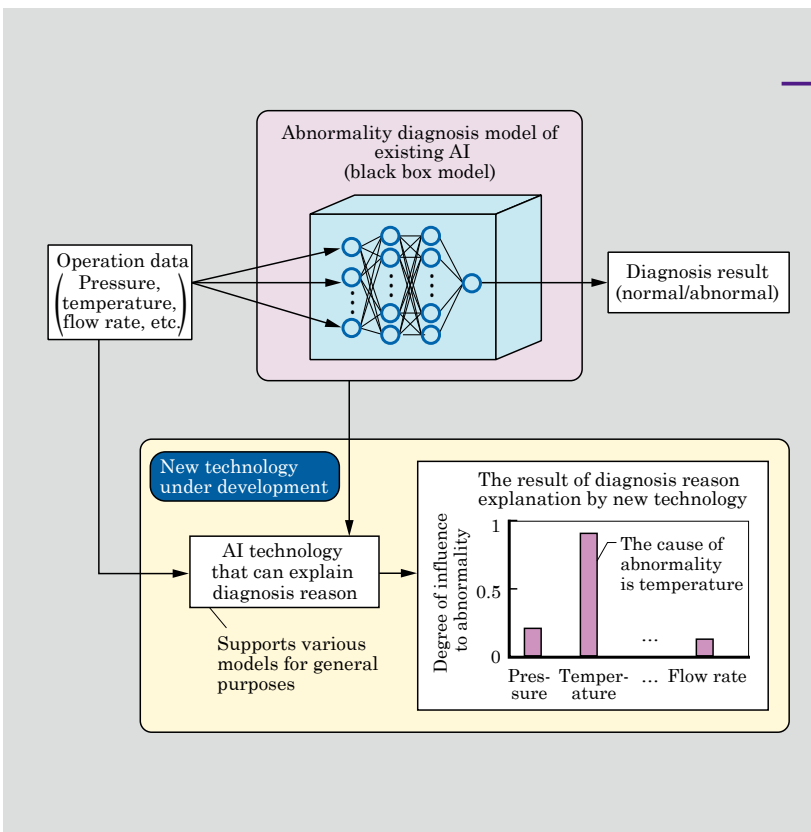


Explainable AI for Diagnosis

The progress of artificial intelligence (AI) technology has made it possible to diagnose abnormality in complicated phenomena.

However, existing AI has black box structure, and reason why it judged as abnormality is unknown. Because of this, the cause of abnormality cannot be quickly removed. Thus, AI that can explain the reason of abnormality diagnosis is necessary for industries, that require reliability, including manufacturing plants and production lines.

Under these circumstances, Fuji Electric is developing AI that can explain the diagnosis reason early among others. By adding this technology to the existing AI, contribution of each feature to the abnormality can be quantified to explain causes. This technology will help customers improve yield rate and product quality.





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