

Power Electronics Equipment

Drives
Power Supply
Transportation Power Electronics
Electric Distribution and Control Devices



Outlook

The Great East Japan Earthquake raised people's awareness about the importance of electricity and focused attention on smart utilization of clean electrical energy. Fuji Electric set "creation," "connection" and "usage" of energy as keywords and has been developing power electronics technologies that become foundations to generate, supply and utilize (apply) electrical energy, and providing various products. We are expanding our range of products corresponding to globalization by developing technologies that are compliant with international standards in areas including functional safety. Moreover, we are focusing on the development of application technologies and products that use silicon carbide (SiC), a material that is expected to be used in next-generation power semiconductor devices.

In the field of power drive system, equipment that can directly drive high-voltage motors without using a transformer even though the voltage is different between input and output, was added to the lineup of the "FRENIC4600FM5" high-voltage inverters and put into production. The stack-type 690 V series was added to the lineup of the "FRENIC-VG Series" fast-response and high-accuracy inverters to provide large capacity up to 800 kW with a direct parallel connection. For plant facility and processing machinery, we have developed and launched "FRENIC-Ace Series" general-purpose inverters, which have the customizable logic function so that users can program the inverter control to suit their intended use. We have also expanded the voltage lineup of the "FRENIC-HVAC Series" inverters for HVAC with a DC reactor and an EMC filter built-in. IP55 protective structure employs the same size as IP21 and it does not require any cubicle board. "ALPHA5" servo amplifiers are compatible with an "E-SX bus," a synchronous bus distinctive to Fuji Electric. These can be combined with "MICREX-SX" to achieve high-speed, high-accuracy motion systems.

In the field of power supply system, we have been manufacturing and providing uninterruptible power supplies (UPS) which are required to be highly reliable and efficient as backup power supplies for data centers. In addition to these, we have developed "7000HX-T4"

high-efficiency, high-capacity UPS, which applies on-line double conversion system and is compatible with 3-phase, 4-wire type of 400 V power supply systems that are the mainstream overseas. They adopt the new three-level power conversion system with reverse-blocking insulated gate bipolar transistor (RB-IGBT) that is distinctive to Fuji Electric. As a front-end power supply for servers, we have developed a switching power supply that achieves both platinum-level conversion efficiency and the best-in-industry power density. We have also developed the "UX Series" as small-capacity, standby power system UPS for industrial equipment and PCs by expanding the OS shutdown system for PCs and enhancing the high-speed switching to battery operation.

In the field of power electronics equipment for transportation, we have manufactured and delivered power supply equipment for the coaches of the Cruise Train Seven Stars in Kyushu that has been in the spotlight since Kyushu Railway Company started its operation in October 2013. We have also manufactured and delivered linear motor driven doors series E233 trains, which are operated by East Japan Railway Company on the Saikyo Line and Yokohama Line. Furthermore, we have manufactured a door system that uses a combination of a flat-shape rotating type permanent magnet synchronous motor with a rack and pinion mechanism instead of a linear motor, and delivered it to Yurikamome Inc. for its new model trains. In the automotive field, we have continued to manufacture and delivered off-board battery chargers for electric vehicles and plug-in hybrid electric vehicles. At the same time, we have succeeded in creating the smallest on-board charger in the industry to directly charge batteries using an AC source with a power density of 1 W/cm³.

In the field of power receiving and distribution equipment and control device components, the expectations for technologies that can more safely and efficiently supply electrical energy and commercial products that are compatible with new energy are becoming higher. Along with this, it is becoming more important to construct power receiving and distribution facilities

and control systems that provide space-savings and high reliability for production equipment, office buildings and commercial facilities. In response, we combined the power receiving and distribution equipment with a current-limiting fuse and changed the high-voltage AC load switch model that is mainly used as a PF-type or an S-type main circuit breaker for 300 kVA or less, resulting in reduction of the volume by 10%. For photovoltaic power generation systems, we have developed the string monitoring unit "F-MPC PV" that measures the current and voltage in each photovoltaic panel string unit (consisting of multiple panels)

and works with the higher level system to help early detection of an abnormality in any photovoltaic panel and identification of a faulty section. We have also developed an emergency stop pushbutton switch that is equipped with a synchro-safe contact for use with control devices. We have enhanced the safety by providing the mechanism that opens the main circuit when the contact block is detached from the operation button.

Fuji Electric will continue to reinforce technologies and product lineups to provide various solutions and pursue customer satisfaction in the power electronics equipment business.



Drives

1 Expansion of “FRENIC-HVAC Series” Inverters for Air Conditioning (200 V and 575 V)

“FRENIC-HVAC Series,” which is suitable for Air Conditioning, now has the 200 V series [90 kW (125 HP) max] for a better voltage lineup. The main targets are Japan and North America. Moreover, Fuji Electric has a plan to put 575 V series (300 HP max) into production. The main features are as follows:

- (1) IP21 and IP55 have become to be provided in the same size. Thanks to the IP55 structure with a built-in EMC filter, it no longer has to be stored in a control panel and can help reduce equipment investment and cut down on the installation space required.
- (2) It has BACnet communication protocol installed as standard (BTL certified).
- (3) It has multiple functions such as a real-time clock and 4 PID (with an autotuning function).

Fig.1 “FRENIC-HVAC Series” (200 V and 575 V)



2 Capacity Expansion of Compact Inverter “FRENIC-Mini (C2S) Series”

For the “FRENIC-Mini (C2S) Series” of compact inverters, Fuji Electric has developed 5.5 to 15 kW products for 3-phase 200 V and 400 V input series and expanded the lineup. The main features are as follows:

- (1) Because these have the same functions as the already launched models rated 3.7 kW or less, the peripheral sequencers can be carried over and will be able to meet the needs for higher capacity of various applications.
- (2) These are certified by the UL standards and CE marking and can be distributed all over the world in places such as Asia, China, North America and Europe.

Fig.2 “FRENIC-Mini (C2S) Series”



3 “E-SX Bus” Compatible Servo Amplifier “ALPHA5”

A high-speed serial bus servo amplifier that is compatible with “E-SX bus,” a high-speed, high-accuracy synchronous bus distinctive to Fuji Electric, was added to the “ALPHA5 Series” servo systems. It can realize high-speed and high-accuracy control when combined with the “SPH3000MM” controller. The main features are as follows:

- (1) The minimum tact cycle is 0.25 ms. If the tact cycle is 1 ms, it can perform synchronous control of up to 32 axes.
- (2) ALPHA5 Series has a standard type (VE type) and a built-in positioning function type (LE type) for all capacities of the 200 V product lineup (0.05 to 5 kW).
- (3) Application software can be diverted by sharing the IQ area (memory map of the transmission data) with the existing “SX bus.”

Fig.3 “ALPHA5”



Drives

4 High-Speed Motor for Automotive Testers “GNQ1165A”

Fuji Electric has developed the “GNQ1165A” high-speed motor for automotive testers to test motors that are going to be mounted on hybrid electric vehicles or electric vehicles. The main features are as follows:

- (1) The maximum rotational speed is 20,000 r/min, the rated torque is 100 N·m and the rated output is 42 kW.
- (2) To reduce the moment of inertia, it uses a permanent magnet synchronous motor (PM motor) to realize a low cogging torque with its unique rotor shape. The tester can measure torque with high accuracy.
- (3) It applies a grease-sealed bearing for better maintenance. We will expand the capacities up to 400 N·m and 170 kW in the future.

Fig.4 “GNQ1165A”



5 Medium-Voltage Inverter that is Compatible with Different Input/Output Voltages

The medium-voltage inverter can directly drive medium-voltage motors at variable speeds and is increasingly used in more applications to fans and pumps for attaining energy saving operation. Fuji Electric has put into production a new medium-voltage inverter that is compatible with different input/output voltages where the output voltage differs from the input voltage. The main features are as follows:

- (1) Voltage series, capacity series
 - (a) Input 11 kV, output 3.3 kV, 390 to 3,500 kVA
 - (b) Input 11 kV, output 6.6 kV, 780 to 5,200 kVA
- (2) It can directly drive medium-voltage motors at variable speeds.
- (3) Input transformer is installed in the panel. It is unnecessary to implement wiring for the transformer and converter in the field.
- (4) Equipment efficiency: Approx. 97%
- (5) Power factor: 0.95 or higher

Fig.5 Medium-voltage inverter that is compatible with different input/output voltages



Power Supply

1 Small-Capacity Offline UPS “UX Series”

Highly efficient and inexpensive offline UPS is used as a backup power supply for industrial equipment and PCs.

Fuji Electric has developed the “UX Series” as a small-capacity UPS for continuous commercial power feeding UPS. Functions were added to maintain stable power feeding and reduce the output voltage fluctuations for connected equipment. It has an improved OS shutdown system for PCs and enables to select mode for high-speed switching to battery operation in case there is a problem with a commercial power source. The main features are as follows:

- (1) The OS shutdown system is established by using a USB (HID) to reduce customers’ verification load.
- (2) The commercial power failure detection sensitivity is enhanced for faster switching and it can continue to feed the power stably by reducing the output voltage fluctuations.
- (3) It sends out sine waves during backup operation.

Fig.6 “UX Series”



Power Supply

2 High-Efficiency Front-End Power Supply “FH02650UAD” for Servers

The data center market continues to grow and there is an urgent need to reduce the energy consumption of information and communication equipment. Thus, Fuji Electric has introduced “FH02650UAD” high-efficiency front-end power supply for servers to the market. It achieved high efficiency ranked as “Platinum” (e.g., at least 94% with a 50% load factor) according to the conversion efficiency standards, 80PLUS, and a top-class high-power density (1.7 W/cm³) in the industry. It contributes to downsizing and power consumption reduction of information and communication equipment. The main specifications are as follows:

- (1) Input voltage: 200 to 240 V, Output voltage: 12 V
- (2) Output power: 2,640 W
- (3) Dimensions: W100×D400×H41 (mm)

Fig.7 “FH02650UAD”



3 Low-Voltage, Large-Capacity Momentary Voltage-Drop Protector “UPS8000D-3/500S”

Momentary voltage drops can cause enormous damage to the production lines of high-value-added products at plants. The occurrences of momentary voltage drops are expected to increase in the future because distributed power sources are becoming popular.

Up to now, high-voltage products (6,600 V series) have been used for large-capacity, momentary voltage-drop protectors. This time, Fuji Electric has developed “UPS8000D-3/500S” as a 200 V series of low-voltage, large-capacity momentary line-drop protectors (output power 500 kVA/450 kW). The main features are as follows:

- (1) An electric double-layer capacitor (EDLC) is adopted to help reduce the running cost and environmental impact.
- (2) Larger-capacity systems can be established through a parallel run.
- (3) It helps to reduce size and weight (35% less than conventional ones).

Fig.8 “UPS8000D-3/500S”



Transportation Power Electronics

1 Rack and Pinion Door System for 7300 Series Trains Owned by Yurikamome Inc.

Fuji Electric has delivered a rack and pinion door system for the Yurikamome 7300 series trains, which were introduced as the new model starting the operation on January 18, 2014. The new trains form 18 train sets consisting of 108 cars with 432 door system equipment. The main features of the rack and pinion door system are as follows:

- (1) The mechanism of the linear door system is adopted to succeed in its high reliability and safety design.
- (2) The power consumption is reduced by 52% with the modification of the motor characteristics.
- (3) The weight of the equipment is reduced by 23% majorly by applying the rotary motor, of which the usage volume of the permanent magnet is decreased.
- (4) The door control for safety performance is enhanced to achieve higher accuracy in obstacle detection.

Fig.9 Yurikamome 7300 series vehicle and door system



Transportation Power Electronics

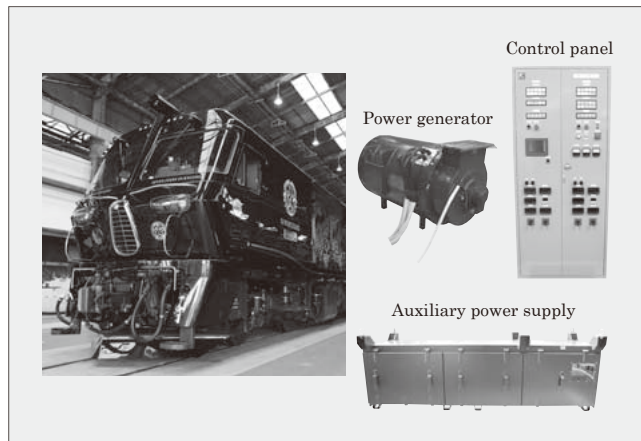
2 Power Supply Equipment for Cruise Train of Kyushu Railway Company

Kyushu Railway Company manufactured a cruise train with sleepers called “Seven Stars in Kyushu” that travels around famous sightseeing destinations in Kyushu, and started commercial operation in October 2013.

By utilizing the experience gained from delivering electric power supply for diesel-powered railcars, Fuji Electric manufactured a power supply unit consisting of power generator and auxiliary power supply. This is a key device that provides power to the coaches that are extremely luxurious and newsworthy. The main features are as follows:

- (1) It has two power generators and even if one of them fails, the other will back it up instantly. This power supply equipment has redundancy and is highly reliable.
- (2) The control panel installed on the floor can monitor and control the power supply system including the engine.

Fig.10 Cruise train and power supply unit



3 Linear Door System for E233 Series Vehicles for Saikyo Line and Yokohama Line of East Japan Railway Company

Fuji Electric delivered linear door systems to East Japan Railway Company for E233 series vehicles that run on the Saikyo Line (2,000 units, all the train sets started operation in October 2013) and Yokohama Line (1,792 units, operation started in February 2014). The main features are as follows:

- (1) It adopted a stand-by redundancy system by employing a complete duplication including the control power supply. More than 20,000 units have been delivered and the failure occurrence rate has become less than one-tenth of the customer requirement specifications.
- (2) With the direct drive method using linear motors and the latest power electronics control technologies, it attained high levels of control safety and intrinsic safety.
- (3) Based on data obtained from long-term operation, it was redesigned to reinforce the sliding area for improving reliability further.

Fig.11 E233 series vehicles for Saikyo Line and Yokohama Line and linear door system



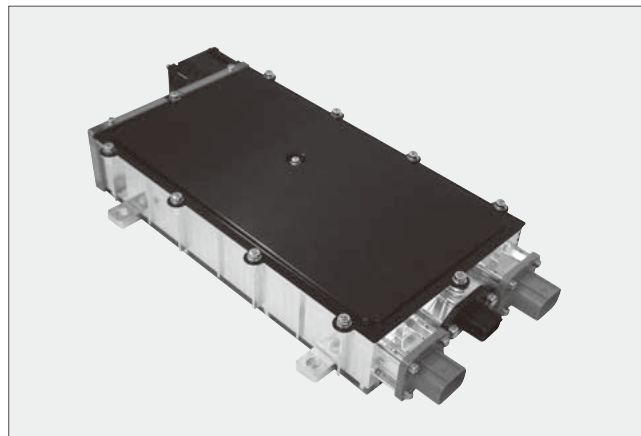
4 On-Board Charger (OBC) for Environmentally-Friendly Vehicles

Approach to environmentally-friendly vehicles has been accelerated around the world. In recent years, new plug-in hybrid electric vehicles that can be easily charged by using a household AC outlet have appeared.

These plug-in hybrid electric vehicles and electric vehicles need an AC to DC power converter on board. To satisfy this need, Fuji Electric has developed an OBC by applying our compact high-efficiency power supply technology and automotive semiconductor technology. The main features are as follows:

- (1) Isolated 3.3 kW-output with air-forced cooling
- (2) High power density of 1 W/cm³
- (3) Compatible with various domestic and international power sources situation (100 to 240 V AC)

Fig.12 On-board charger (developed product)



Electric Distribution and Control Devices

1 Expansion of Magnetic Contactor “FJ Series” (40 to 95 A)

Magnetic contactors used in developing countries such as China and other Asian countries have different requirements with regards to safety, quality, switching durability and compliance with international standards, depending on the users.

In addition to the standard type, Fuji Electric is providing the “FJ Series” in the lineup. They are small, economical and exclusive products for overseas applications. We have acquired a good reputation so far because we have added product choices to suit the market needs depending on the intended purposes. We developed a product rated 40 to 95 A this time to expand the lineup of economical specifications. The main features are as follows:

- (1) The main unit is equipped with a 1NO1NC (1a1b) auxiliary contact required for a simple control circuit as standard.
- (2) It is compliant with China Energy Efficiency Standard Class 2.

Fig.13 “FJ-B95” rated for 95 A



2 Expansion of Small Low-Voltage Circuit Breakers in “G-TWIN Λ Series”

As direct current equipment becomes popular, there is a greater need for small high-voltage circuit breakers. To meet such market needs, Fuji Electric has developed a neutral circuit breaker for high-voltage direct current (500 V DC, 3 poles) to expand the lineup of the “GTWIN Λ Series.” The main features are as follows:

- (1) It adopted arc commutation breaking method and acquired a high breaking performance (500 V DC, 10 kA).
- (2) The neutral specification allows it to be applied to circuits that change in polarity such as EV charging circuits or battery systems.
- (3) The outline dimensions were reduced (54 mm in width) and the mounting space became 30% less than conventional ones.
- (4) Rated current: 10 to 63 A

Fig.14 Circuit breaker for high-voltage direct current (500 V DC, 3 poles)



3 Molded Case Neutral Circuit Breaker for High-Voltage Direct Current (400 to 800 AF)

Demand for direct current equipment used in the new energy market, such as photovoltaic power generation, is expected to expand both in Japan and overseas, and there is a need for safety improvement. Fuji Electric has developed this molded case neutral circuit breaker for a high-voltage direct current for industrial photovoltaic power generation equipment. This product will help improve the safety of photovoltaic power generation systems. The main features are as follows:

- (1) It maintains compatibility with the conventional products because the rated operational voltage, breaking capacity and outline dimensions are kept in the same, and it actualizes neutral performance. It can be connected in reverse and thus can break a reverse flow current.
- (2) Compared with conventional products, the rated insulation voltage was increased from 750 V DC to 800 V DC for the 3-pole product, and from 1,000 V DC to 1,150 V DC for the 4-pole product and also provided better safety.

Fig.15 “BW400RAG-3P400 CP”



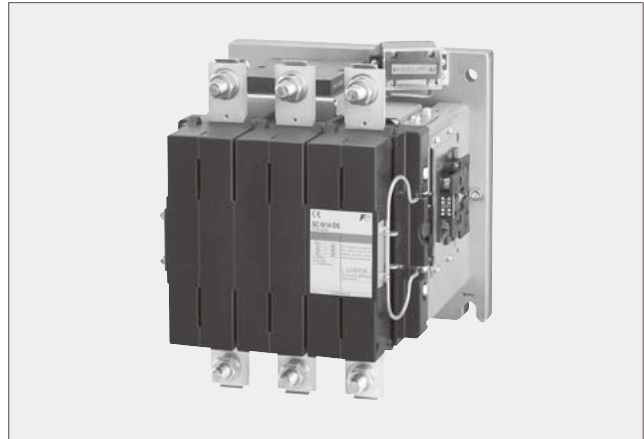
Electric Distribution and Control Devices

4 Magnetic Contactors for Photovoltaic Power Generation Equipment “SC-N14/DS” and “SC-N16/DS”

A magnetic contactor is placed on the alternate current side of the power conditioner (PCS) for photovoltaic power generation equipment and is used to isolate the equipment from the power system during maintenance or in case of equipment failure. Therefore, it needs to be compatible with various installation environments of photovoltaic power generation equipment. Fuji Electric has developed “SC-N14/DS” and “SC-N16/DS” magnetic contactors rated at 660 A and 800 A for photovoltaic power generation equipment to meet the particular growing demand for PCS in mega solar stations. The main features are as follows:

- (1) The contact structure with improved performance during current carrying time reduced the calorific loss by approximately 7%.
- (2) To be compatible with various use environments, the operational ambient temperature range was expanded. (Conventional product: -5°C to +55°C, developed product: -10°C to +60°C)
- (3) By improving the control circuit, the standing loss was decreased by approximately 10%.

Fig.16 “SC-N14/DS” rated for 660 A



5 Lineup Expansion of Small Contactor “SK Series” (Types SK18 and SK22)

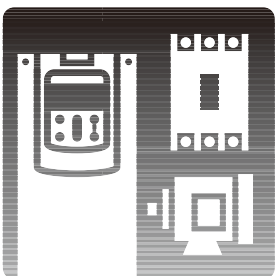
Since the launch of the “SK Series” types SK06 to SK12, the world's smallest contactors (magnetic contactors), they have been well-received because they are best suited for downsizing and globalizing of mechanical equipment and control panels. This time, Fuji Electric has developed types SK18 and SK22 of small contactors as upper frames to expand the lineup of the series. In recent years, servo systems have become more widely utilized for motor control and the magnetic contactors are often placed on the primary side of the servo amplifiers. Thus, types SK18 and SK22 models were particularly developed for these applications. The main features are as follows:

- (1) The width was unified to 45 mm (15% less than conventional products).
- (2) It achieved 2.4 W as a DC-operated type (66% less than conventional products).
- (3) It can accept the inrush current caused by the servo amplifier.

Fig.17 “SK22A”



Power Electronics Equipment





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