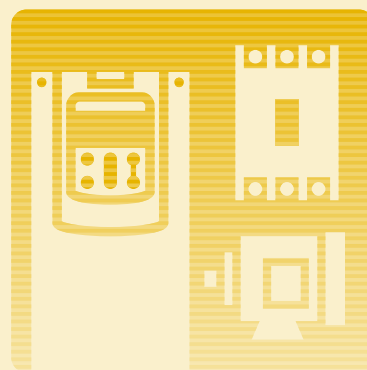


# Power Electronics Equipment

Drive Systems  
Power Supply Systems  
Transportation Systems  
Electric Distribution, Switching and Control Devices



## Outlook

Present day, power electronics products have permeated in all fields ranging from social infrastructure that supports lifelines to durable consumer goods. And it is raising great expectations from the perspective of energy conservation and high-efficiency utilization of electrical energy in particular. New power devices that use silicon carbide (SiC) are now in the practical application phase and are expected to become widespread.

In the field of drive systems, to meet various needs of customers relating to variable-speed driving of motors, Fuji Electric provides products based on platform technology. We have commercialized “FRENIC-Lift LM2A” as an inverter for machine-roomless elevators. It has achieved conformity to safety standards mandatory in the European market and realized slim dimensions that are among the industry’s smallest as an inverter with a built-in EMC filter. The “FRENIC-eHVAC Series” for air conditioning has a built-in EMC filter as standard model. It features the customization function, which has been received favorably in the “FRENIC-Ace Series,” further enhanced to offer a variety of control and communication options. In addition, we have commercialized the “FRENIC4600FM6e Series” of medium-voltage inverters capable of directly driving a large-capacity medium-voltage motor. It covers a wide range of ratings including the input voltage of 6 kV/10 kV and output apparent power of 460 kVA to 15.6 MVA and is equipped with various operation control functions such as inverter parallel operation and synchronous motor driving.

Regarding rotating machines, Fuji Electric has commercialized “Premium Efficiency Motors” of IE3 efficiency according to the Top Runner Program based on the “Act on the Rational Use of Energy” (Energy Conservation Act). The slot structure, windings and core materials have been optimized for loss reduction to achieve the premium efficiency IE3 level of IEC 60034-30/JIS C 4034-30, and they have been standardized in the IP55 degree of protection for outdoor types.

In the field of power supply systems, Fuji Electric has commercialized 2 series of uninterruptible power systems (UPSs). One is the “6000DX Series” of 3-phase

200 V large-capacity UPS to meet the replacement demand in the Japanese market, which features an output power density improved by 10% while maintaining compatibility with the current models. And the other is the “7000HX-T3U Series” of 3-phase 400 V large-capacity UPS for the North American market, offering the world’s highest level efficiency of 97.5%. In order to reduce power consumption of data centers, we have developed a rack-mounted DC UPS that integrates a UPS and switching power supply for a server. It is expected as a power supply system capable of reducing distribution losses and eliminating the need for UPS installation space. In relation to renewable energy, we have commercialized “PVI1000 AJ-3/1000,” a power conditioning sub-system (PCS) for mega solar power plants, employing an All-SiC module. It has achieved miniaturization with a footprint size 60% smaller than previous products by taking full advantage of the features of SiC power devices. It has awarded First Prize in the FY2015 (64th) Japan Electrical Manufacturers’ Association Technical Achievement Award.

In the transportation power electronics field, Fuji Electric has developed an auxiliary power unit with medium frequency link, combining a resonance inverter and medium frequency transformer. Compared to previous systems, the unit has achieved significant size and weight reductions. We have shipped a door system combining a rotating type permanent magnet flat motor with a rack-and-pinion mechanism to the North American market. In addition, we have started providing an auxiliary power unit and linear door system for subway cars of the Washington Metropolitan Area Transit Authority of the U.S. For both products, major parts procurement and final assembly are carried out according to the “Buy American Act,” the first of such cases of Fuji Electric’s products for electrical rolling stock. Furthermore, we have developed a passenger information system that uses a high-brightness, high-definition display and a train communication card with Ethernet applied.

In the field of electric distribution, switching and control devices, there is growing demand for space-

saving and highly reliable distribution equipment and control systems for production equipment, office buildings and commercial facilities in addition to the renewable energy sector. We have developed a non-polarity DC high-voltage breaker series of 400 to 800 AF, which is ideal for photovoltaic power generation equipment, and a 2-pole plug-in breaker of the industry's smallest size for data centers. As an energy monitoring system, we have developed a CT-based model of the "F-MPC PV Series." It adopts a current-detection system that uses a CT, supports an output voltage of 1,000 V DC as a standard feature and makes it possible to measure up to 12 strings of solar panels. Regarding magnetic

starters, we have developed AC- and DC-operated 18-A, 22-A and 32-A models of the "SK Series," which is suitable as the primary switch of a drive unit, and "SC-N12/DS" which is ideal for photovoltaic power generation equipment. As for control devices, we have developed  $\phi 30$  emergency stop pushbutton switches equipped with the Synchro Safe Contact for improved safety.

In the future, we intend to continue developing various technologies, products and solutions in power electronics equipment to ensure customer satisfaction and help realize a sustainable society.



## Drive Systems

### 1 Inverter for Air Conditioning “FRENIC-eHVAC Series”

In order to expand the offer of inverters for air conditioning, we have commercialized the “FRENIC-eHVAC Series,” which meets the specification and pricing requirements of the market. The main features are as follows:

- (1) The pricing requirements of the air conditioning market have been met by using the optimum design.
- (2) Reinforced customizable logic is provided as a standard feature to flexibly meet the end users' need for dedicated functions.
- (3) Functions required for air conditioning such as PID control, cascade operation and forced operation have been provided as standard features.
- (4) The BACnet communication protocol has been supported as a standard feature and various control and communication options have been commercialized to make it easy to build systems.
- (5) A multi-functional keypad panel supporting 19 languages is available as an optional feature so that the system can be used in more countries and regions.

Fig. 1 “FRENIC-eHVAC Series”



### 2 Medium-Voltage Inverter “FRENIC4600FM6e Series”

The price of medium-voltage inverters is falling at an accelerating pace in China, which is their biggest market, due to the emergence of local manufacturers. We have developed the “FRENIC4600FM6e Series” of medium-voltage inverters, which are competitive enough to cope with the business environment and equipped with differentiating and auxiliary functions suited for fields including electrical power and metallurgy.

- (1) Voltage/capacity class
  - 6.0 kV, 450 to 9,350 kVA
  - 10.0 kV, 500 to 15,600 kVA
- (2) Improvement of market competitiveness by simplifying the circuit configuration
- (3) Large-capacity motor and synchronous motor driving by inverter parallel operation control
- (4) Redundant operation by cell bypass function (auxiliary function)
- (5) Conformity to IEC, GB and DL (national electric power standards of China)

Fig. 2 “FRENIC4600FM6e Series” (10.0 kV, 1,280 kVA model)



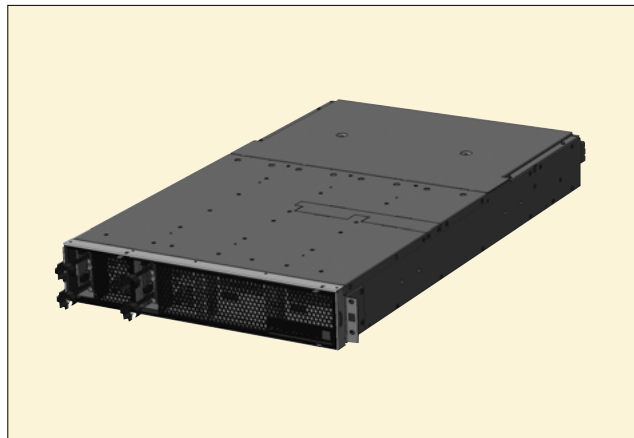
## Power Supply Systems

### 1 Rack-Mount DC UPS

Reducing the power consumption of data centers, which consume large amounts of electricity, is an important issue to deal with. Fuji Electric has developed a rack-mounted DC uninterruptible power system (UPS) that helps to save energy at data centers. This system integrates an uninterruptible power supply and switching power supply to reduce the power loss in the entire power distribution process. The main features are as follows:

- (1) It has achieved a 5 to 7% reduction in power distribution losses at data centers.
- (2) The need for space to install an uninterruptible power supply has been eliminated, achieving a footprint reduction of approximately 20%.
- (3) The single-unit output apparent power can be increased in increments of 2.5 kW.
- (4) The system has been given a power assist function, which allows server operation at a load exceeding the power limit for a certain period while imposing a power limitation on the server rack.

Fig. 3 Rack-mount DC UPS



## Transportation Systems

### 1 Door Drive System and Auxiliary Power Unit for Subway Cars of Washington Metropolitan Area Transit Authority

Fuji Electric has commercialized a door drive system (linear synchronous motor drive) and auxiliary power unit (input: 700 V DC / output: 230 V AC, 120 V AC, 37.5 V DC) for subway cars of the Washington Metropolitan Area Transit Authority and started delivering the equipment. The system links between incidental equipment such as the desktop automatic diagnostic system and on-board diagnostic PC software with the self-diagnosis function of the main unit to achieve improved maintainability.

In response to the “Buy American Act” that gives preference to U.S.-made products in purchases, we have transferred technology from our factory in Japan to a manufacturing base in the United States to procure major parts and carry out final assembly in the United States. The equipment conforms to the following standards required by the Transit Authority:

- (1) Standard for electrical equipment used on rolling stock: IEC 60571
- (2) EMC standard: IEC 61000-6-2, etc.
- (3) Shock and vibration standard: IEC 61373

Fig. 4 New subway car (7000 Series) of Washington Metropolitan Area Transit Authority

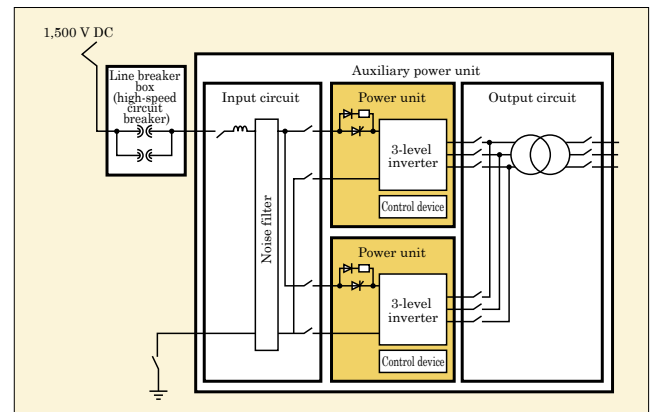


### 2 Auxiliary Power Unit for Newly Built Trains of Sanyo Electric Railway Co., Ltd.

Auxiliary power units for train cars require high reliability, quietness and reduction of size and weight due to the severe use environment of electrical rolling stock. And the requirements placed on them are becoming increasingly sophisticated on a daily basis.

The auxiliary power unit for newly built trains of Sanyo Electric Railway Co., Ltd. has a power unit of a redundant structure composed of the regular and standby systems. In addition, the reliability has been improved by adopting a standby redundancy system, in which the regular system is switched over to the standby system in the event of failure. The three-level inverter system that supports 1,500-V DC overhead line input has been adopted as the circuit system and a 1.7-kV rated insulated-gate bipolar transistor (IGBT) device with excellent switching characteristics has been used. In this way, we have managed to reduce the generated loss due to switching, reduce noise by increasing the carrier frequency and decreasing the output voltage distortion, and reduce size and weight by reducing the output AC filter reactors.

Fig. 5 Simplified connection diagram of auxiliary power unit for newly built trains



### 3 Power Unit for Echigo TOKImeki Railway Company

Echigo TOKImeki Railway started operations on March 14, 2015 as a conventional railway line that runs parallel to the Hokuriku Shinkansen Line. To the Nihonkai Hisui Line on the former Hokuriku Main Line section, new ET122 Series diesel multiple-units were introduced, and they are based on the KiHa 122 Series diesel multiple-units of West Japan Railway Company.

Fuji Electric has made use of its experience in auxiliary power units for diesel multiple-units, which it has offered up to now, to delivered power units for the ET122 Series diesel multiple-units. The main features are as follows:

- (1) The same generator control circuit as that of the KiHa 122 Series has been used and the rectifier control circuit changed from the conventional analog system to a digital system.
- (2) Redundancy is provided to allow backup with multiple cars connected in the event of failure of one power unit.

Fig. 6 ET122 Series diesel multiple-unit and power unit





## Transportation Systems

### 4 Rack and Pinion Door Drive System for Railways in North America

Fuji Electric delivered a door drive system for passengers and gangways for the diesel-powered rail cars to be introduced by Sonoma-Marín Area Rail Transit. This is the second example of a rack and pinion door system in the North American market following the service test car. The main features are as follows:

- (1) High reliability and safety have been realized by giving the new products the mechanism element of existing products, which is recognized for its high reliability.
- (2) Motor characteristics have been improved to reduce power consumption by 52%.
- (3) It is easier for the customer to make adjustments by factory adjustment.
- (4) The failure diagnosis function has been provided so that it is easier to identify the cause of any failure.
- (5) The detection performance for any passenger or belongings caught between doors has been improved to realize even higher safety.

Fig. 7 New car and rack and pinion door drive system



### 5 Passenger Information System for Rolling Stock

We developed a passenger information system jointly with Toyo Denki Seizo K.K., which was installed in cable cars (Cable Line) of Nankai Electric Railway Co., Ltd. and started operations on March 1, 2015. A passenger information display is installed at the top front part inside a cable car to show information about places along the cable line, station facilities and tourist spots in multiple languages (Japanese, English and French) together with images. The main features are as follows:

- (1) High-brightness, high-definition display (32-inch half-cut size)
- (2) Conforms to electronic equipment standard (IEC 60571) applied to electrical rolling stock
- (3) Integrated unit including control power supply and computer
- (4) Longer service life (60,000 hours) and lower power consumption achieved by applying long-life LED backlight

Fig. 8 Passenger information display in cable car

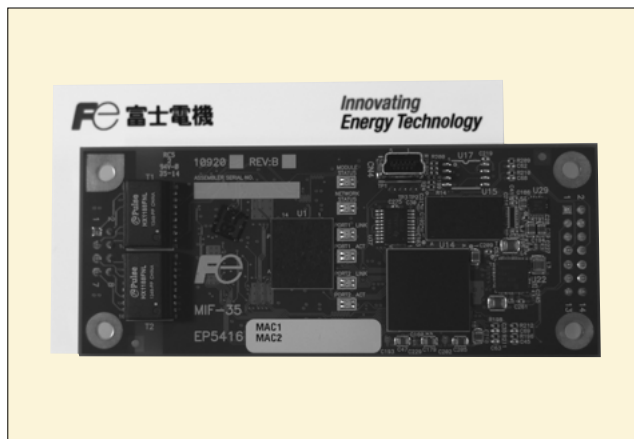


### 6 TRDP System Train Communication Card for Electrical Rolling Stock Conforming to IEC 61375-2-3

In the global railway industry, international standardization of communication networks for electrical rolling stock using Ethernet is in process. In line with this trend, we have developed a communication card that makes it possible to connect various types of on-board equipment of electrical rolling stock. The main features are as follows:

- (1) Equipped with the TRDP protocol conforming to IEC 61375-2-3.
- (2) Provided with two communication ports and the network switch function and can be integrated in devices such as propulsion equipment to configure various redundant communication topologies according to the functions of the application device.
- (3) Provided with the environmental endurance, high reliability and high-speed response required in the railway industry.
- (4) Allows incorporation of other communication protocols including PROFINET without a need to change the hardware.

Fig. 9 Communication card (comparison with business card)



## Electric Distribution, Switching and Control Devices

### 1 Expansion of Compact Magnetic Contactor “SK Series” (SK32 Type)

The compact magnetic contactor “SK Series,” types SK06 to 22 (5 ratings), have been received favorably since their release thanks to their smaller sizes and lower power consumption. We have developed a 32-A product (SK32 type), a larger frame size type of the series, to expand the lineup. The SK Series is specifically intended for contributing to size reduction and energy savings of machine control units and other devices. The main features are as follows:

- (1) It has a slim width of 53 mm (installation area reduced by 33% from “SC-N1,” our equivalent product).
- (2) A newly-designed electromagnet has been adopted to significantly reduce the electromagnet capacity (DC-operated electromagnet capacity 2.4 W, an electromagnet capacity reduction of 73% from “SC-N1/G,” our equivalent product).
- (3) The DC-operated type is equipped with a coil surge suppression device as a standard feature.
- (4) The terminal cover is provided as standard equipment (degree of protection: IP20).

Fig. 10 “SK32A”



### 2 Magnetic Contactor for Photovoltaic Power Generation Equipment “SC-N12/DS”

Magnetic contactors used in power conditioning sub-systems (PCSs) for photovoltaic power generation equipment need to meet various requirements including the specification and installation environment of the PCS.

Up to now, Fuji Electric has lined up the “SC-N14/DS” and “SC-N16/DS” Series of magnetic contactors with 660 and 800 A ratings for photovoltaic power generation equipment. We have expanded the lineup with the addition of 550-A rated “SC-N12/DS,” developed to meet diversifying needs. The main features are as follows:

- (1) The standard-type magnetic contactor (450-A rated) has been used as the basis to develop a 550-A model, the only product with this rating offered by a Japanese manufacturer, while maintaining the same dimensions.
- (2) The operating ambient temperature range has been expanded to deal with diverse use environments. (Standard type:  $-5$  to  $+55^{\circ}\text{C}$ , developed model:  $-10$  to  $+60^{\circ}\text{C}$ )

Fig. 11 “SC-N12/DS” 550-A rated model



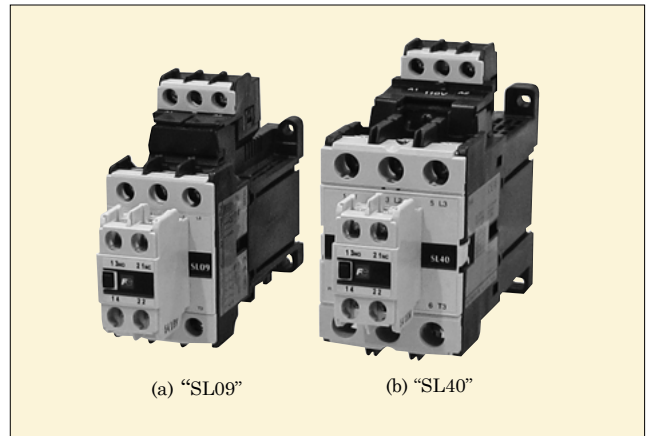
### 3 Mute Magnetic Contactor “SL Series”

In the Chinese elevator market, machine rooms have been increasingly eliminated mainly for exclusive hotels and condominiums and control panels have come to be installed near the elevator cages themselves. This has given rise to the requirement for reducing the operating noise of magnetic contactors.

With the mute magnetic contactor “SL Series,” the operating noise has been successfully reduced from that of the standard products to target the Chinese elevator market. The main features are as follows:

- (1) Reduced operating noise of the magnetic contactor (by approximately over 10 dBA from the standard AC products)
- (2) Operating circuit capable of both AC/DC operation
- (3) Acquisition of China Compulsory Certificate (CCC)
- (4) Integration of coil surge suppression function

Fig. 12 “SL Series”



Electric Distribution, Switching and Control Devices

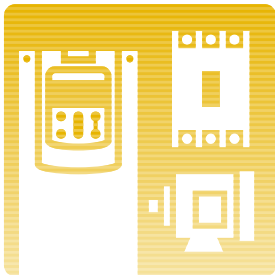
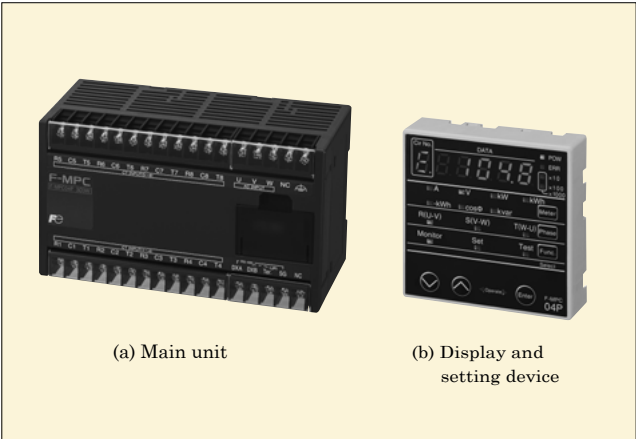
4 Line Expansion of Multi-Circuit Power Monitoring Unit “F-MPC04P Series”

As there are increasing needs to monitor energy, in order to contribute to miniaturization and power saving of distribution switchboards, we remodeled the 3-phase 3-wire type (8-circuit measurement) of the “F-MPC04P Series” in January 2014. We have now remodeled the single-phase 2-wire (12-circuit measurement) and 3-phase 4-wire (4-circuit measurement) types to expand the line.

The new “F-MPC04P” has been provided with a capability to measure a reverse power flow as distributed power sources have been becoming increasingly widespread in recent years. The main features are as follows:

- (1) Size and weight reduced (by 60% from previous products) and power consumption decreased (by 50%)
- (2) Usability improved by a larger display and setting device (□48 to □80)
- (3) Replaceable without changing higher-level system software
- (4) MODBUS/RTU added as an RS-485 communication protocol
- (5) 100 A and 800 A products added as split CTs exclusively for combination

Fig. 13 “F-MPC04P”





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