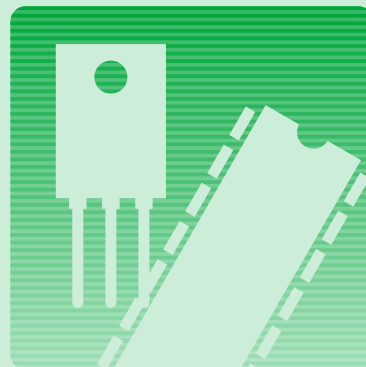


# Electronic Devices

Semiconductors  
Disk Media



## Outlook

### Semiconductors

Power semiconductor industry is being faced with the situation that there are high expectations for power electronics technology, which utilizes electric energy efficiently to save energy and create energy. The technology, utilizing power semiconductors, can contribute to the prevention of world energy demand increase and global warming to create a responsible and sustainable society. Demand has been recently expanding for power semiconductors, which are a key devices of power conversion elements in various fields, such as automobiles, photovoltaic power generation, and wind power generation in addition to industrial equipment and home appliances. The power semiconductor of Fuji Electric has high energy conversion efficiency and has contributed to miniaturization and high performance of products over a long time. In 1988, we offered an insulated gate bipolar transistor (IGBT), which is used as a representative element of a power semiconductor. Furthermore, we have achieved low power loss, high heat dissipation and longer life time through many technical innovations over generations to meet the market needs, such as higher efficiency, miniaturization, and higher reliability.

The 7th-generation IGBT modules have been launched as the latest IGBT. They have a wide variety of product line-ups having a breakdown voltage of 650 to 3,300 V for various applications. The products have lower loss, smaller size, and higher guaranteed maximum junction temperature than the conventional ones while maintaining high reliability. Further, we have a line-up of small-capacity intelligent power modules (IPM) having a dual in-line structure installing a drive IC and a protection function mainly for room air conditioners. We are now developing products of 50 to 75 A to expand the product line-ups, targeting their application in industrial air conditioners.

A reverse conducting IGBT (RC-IGBT), recently developed, integrates IGBT and free wheeling diode (FWD) functions into a single chip and is expected to be higher density. We are extending product line-ups with the expanded maximum rated current in the same

package by using the 7th-generation chip and its package and applying the RC-IGBT technology.

On the other hand, we are also developing products that use silicon carbide (SiC), which has been attracting attention recently as the next semiconductor material in place of silicon. We developed an All-SiC module installing SiC trench metal-oxide-semiconductor field-effect transistor (MOSFET) chips with a breakdown voltage of 1,700 V, subsequent to one with a breakdown voltage of 1,200 V.

In the automotive field, we have developed the 6.5th-generation automotive pressure sensor that contributes to high engine efficiency and clean exhaust gas to reduce the environmental load of automobiles. The sensor has a structure that can resist electro static charge due to oil mist, as well as corrosive exhaust gas contained in measuring medium. It has also been given an output voltage clamp function related to failure diagnosis. The sensor is reduced in volume (about 48% of the 6th generation) and is guaranteed to operate at 150°C. Furthermore, regarding automotive IGBTs for driving motors used in hybrid electric vehicles and electric vehicles, we are making a product line-up that uses the above RC-IGBT and our original direct water-cooled structure.

For discrete products, we created a line-up of DFN 8×8 packages, which have small and thin surface-mount structure, to meet the requirements of industrial and communications equipment. The DFN package can be mounted on a printed circuit board at high density and delivers high-speed switching with a sub source terminal. It incorporates “Super J MOS S2 Series” or “Super J MOS S2FD Series,” which are the latest series, as switching element. LEDs are becoming increasingly used for facility lighting to save energy and reduce maintenance work. We have launched the “FA7A00Y Series” light control ICs for the power supply of facility LED lightings. The series supports input signals for various dimming and controls LED lighting with high accuracy and quick response. Furthermore, power supplies can be designed with fewer components in accordance with the revised safety standard IEC

61347-1.

We will continue developing earth-friendly power semiconductor products to create a responsible and sustainable society.

### Disk Media

With the acceleration of the Internet of Things (IoT), the demand for storage capacity is increasing at a 40% annual rate. Hard disk drive (HDD) accounts for a large amount of storage capacity of hyper data centers

that are operated by Amazon, Google and so on. The driving force in the HDD market is shifting to nearline HDDs. We started mass producing magnetic recording media for nearline HDDs on a full scale in FY2017. We will develop high magnetic layer design technology and reliability technology for higher recording capacity to help expand the industry of data centers, which serve as social infrastructure, contributing to the development of advanced information society.

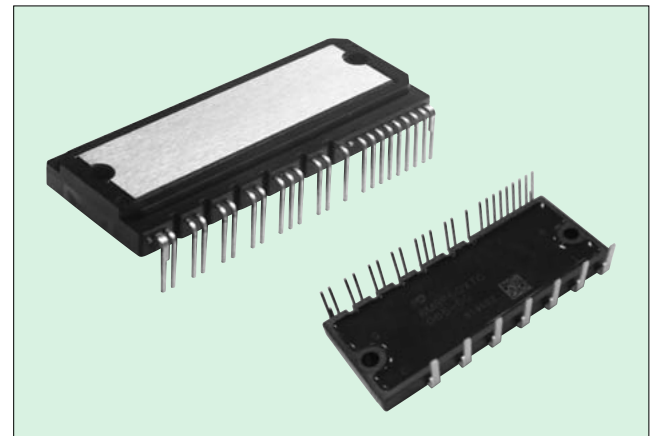
## Semiconductors

### 1 650-V/50-A, 75-A Small-IPM

The inverter market including air conditioners, general-purpose drives, and servo drives is increasing on the basis of a highly energy-saving demand.

Fuji Electric has developed new product line-up of 650-V/50-A and 650-V/75-A Small-IPM to facilitate the construction of inverter systems that drive motors of these equipment. Small-IPM incorporates 7th-generation IGBTs to lower power loss, as well as protection circuits and drive circuits into one package. In addition, the operating junction temperature of IGBTs and FWDs is increased to 150°C with high heat resistant packaging technology. These contribute to improvement in energy-saving performance and increase in power density of inverter systems. The product employs the dual in-line package of 79 × 31 (mm).

Fig.1 650-V/50-A Small-IPM



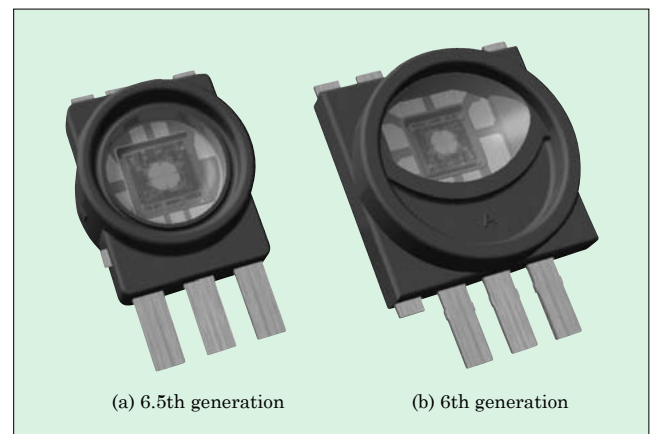
### 2 6.5th-Generation Automotive Pressure Sensor

Currently, automobiles are strongly required to reduce the environmental load, and Fuji Electric has developed the 6.5th-generation automotive pressure sensor that contributes to the improvement of engine efficiency and the purifying of exhaust gas. This product achieves compact size (volume ratio of about 48%) and is guaranteed to operate at 150 °C while providing electrification resistance and corrosion resistance to measuring medium and having an output voltage clamp function. The main features are as follows:

- (1) Product size (resin part): W 7.5 × H 10 × D 5.6 (mm)
- (2) Operating temperature range: -40°C to +150°C
- (3) Operating pressure range (intake pressure sensor): 20 to 120 kPa
- (4) Output voltage (at power supply voltage of 5 V): 0.5 to 4.5 V
- (5) Corrosion resistance: In accordance with JASO M611-92/B type (gasoline/diesel components)
- (6) Clamp function: Clamp voltage 0.3 V/4.7 V (typ.)

➡ Reference: FUJI ELECTRIC REVIEW 2017, vol.63, no.4, p.232

Fig.2 Automotive pressure sensor



## Semiconductors

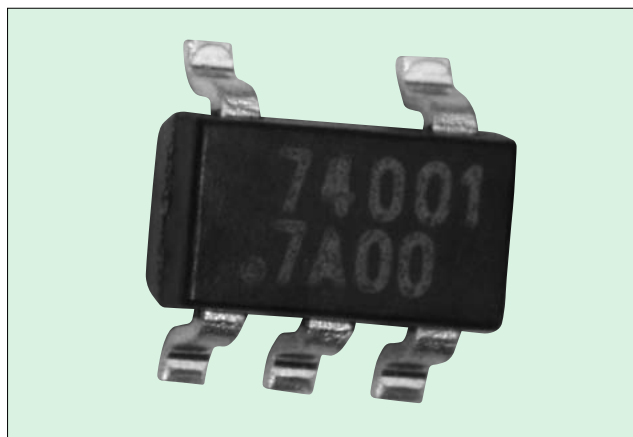
**③ “FA7A00Y Series” Light Control IC for Power Supply of LED Lighting**

The LED lighting market is rapidly expanding since LEDs offer energy saving and a longer service life, and the need for dimmable LED lighting equipment is especially growing. Therefore, power supplies for LED lighting are also required to offer an accurate light control function. In addition, safety standard IEC 61347-1 has been revised (insulation of light control circuit), and the power supply also needs to be compliant with this standard.

To meet these demands, Fuji Electric has developed the “FA7A00Y Series” light control IC for the power supply of LED lighting. The main features are as follows:

- (1) Supports three types of inputs (DC voltage, variable resistance, PWM), and the error of output duty is  $\pm 5\%$  with respect to the target value
- (2) Allows high-speed response within a response time of 50 ms when luminance is changed
- (3) Conforms to the safety standard IEC 61347-1

Fig.3 “FA7A00Y Series”

**④ “Super J MOS S2 Series” and “Super J MOS S2FD Series” for DFN 8 × 8 Packages**

Fuji Electric has made a new surface mount package (DFN 8 × 8) series to meet the demand for smaller and thinner power supplies. The product has a square shape of 8 × 8 mm and is very thin at 0.85 mm. All electrode pads are arranged on the rear surface of the package, allowing higher density packaging on a printed circuit board compared with the conventional D2-PACK. A sub-source terminal is provided in the terminal arrangement; therefore, the back electromotive force that is generated in a common source inductance affecting the drive voltage is kept to the minimum. The product is also capable of high-speed switching. The product is equipped with the latest series, “Super J MOS S2 Series” or “Super J MOS S2FD Series” as a switching element. The main features are as follows:

- (1) Breakdown voltage: 600 V
- (2) On-state resistance: 91 to 223 mΩ

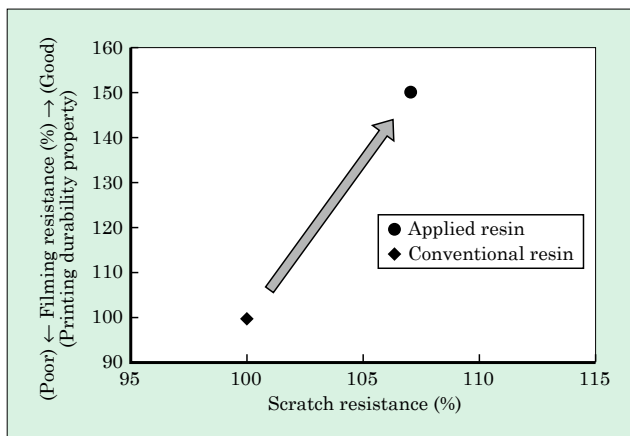
Fig.4 DFN 8 × 8 package

**⑤ Improved Printing Durability Property of Positive Charging Organic Photoconductor**

Electrophotographic printers and copying machines are becoming faster and provide higher image quality and longer service life. Photoconductors mounted on these machines are important components responsible for image quality. Photoconductors need to be very stable so that they are not affected by stress from various peripheral processes. Specifically, paper powder and components of toner that come into contact with a photoconductor adhere and accumulate on the surface of a photoconductor (a phenomenon called filming), and the service life of the photoconductor is thereby reduced. Thus, the photoconductors need to have high mechanical durability.

Fuji Electric has been developing a high-function organic photoconductor that can be used for a long time and that offers stable image quality. We have developed resin with higher scratch resistance by suppressing the sinking of paper powder and toner components, which is the starting point of filming. We thereby succeeded in improving the printing durability property by 50%.

Fig.5 Printing durability property of positive charging organic photoconductor



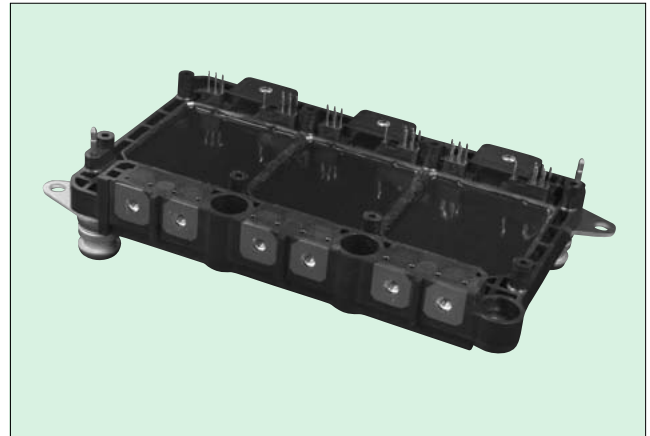
## Semiconductors

### 6 “M660” High-Power, Direct Liquid Cooling IGBT Module for Automotive Applications

Fuji Electric is trying to expand IGBT modules used for the EV and HEV market, which are growing in Japan and overseas.

An automotive IGBT module is mounted in a limited space of an automobile and is required to be small and have large power density. Our high-power, direct liquid cooling IGBT module for automotive applications uses a cooler having a structure in which a water jacket is integrated. The cooler is made of lightweight aluminum and has excellent heat dissipation performance. Area-efficient structure and high power density have been achieved by a lead frame for the internal wiring and reverse-conducting IGBTs (RC-IGBTs) for the power elements. In this way, we have developed a general-purpose 6-in-1 IGBT module having a rating of 750 V/1,200 A, achieving one the best capacities in the world.

Fig.6 “M660”

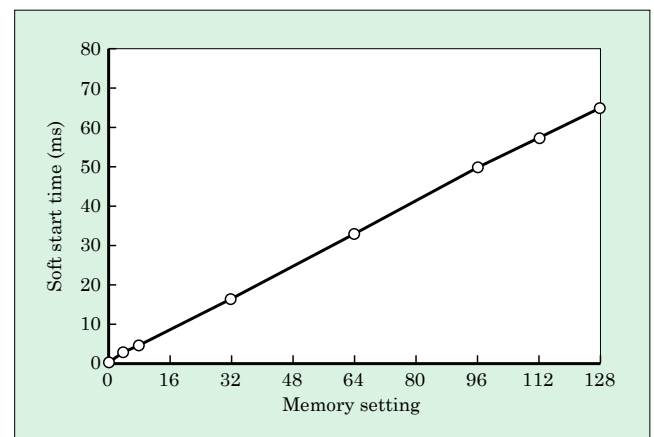


### 7 Digital Power Supply IC Technology Using 0.18-μm Design Rule

Fuji Electric has developed digital power supply IC technology that contributes to high stability and high efficiency of switching power supplies used in electronics. The technology also provides the benefits to customers of easy designing and part reduction.

With this technology, we can mount a rewritable memory and a digital control circuit by applying the design rule of 0.18 μm. We have added devices that have a breakdown voltage of 40 V to the device menu, allowing the products to be used in an analog circuit. The technology allows the digital power supply IC products to feature high-speed response and low power consumption, which are characteristics of an analog circuit, and modify characteristics and select functions by changing the memory settings.

Fig.7 Relationship between memory setting and soft start time of IC



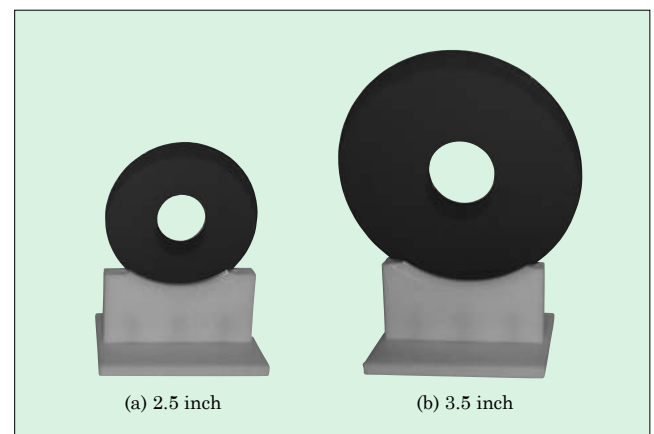
## Disk Media

### 1 Magnetic Recording Media with Large Capacity and High Reliability for Data Centers

IoT, big data and AI are leveraged in lots of industry area currently. It is referred to as the Fourth Industrial Revolution and is shifting into high gear. This requires huge data storage capacity, and the demand for data centers is dramatically increasing. HDDs offer large-capacity inexpensively and, therefore, HDDs are expected to continue to account for more than 90% of the storage capacity in the data center market.

Fuji Electric is currently mass-producing 2.5-inch, 1-TB/platter media (industry's leading recording areal density). With utilizing this technology, 3.5-inch media have been developed for HDDs designed for data centers with capacities reaching 8 TB/unit. In FY2018, we will contribute to the advancement of information-oriented society through continuous improvements of areal density and reliability with the aim of supplying magnetic recording media for 14- to 16-TB HDDs.

Fig.8 Magnetic recording media





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