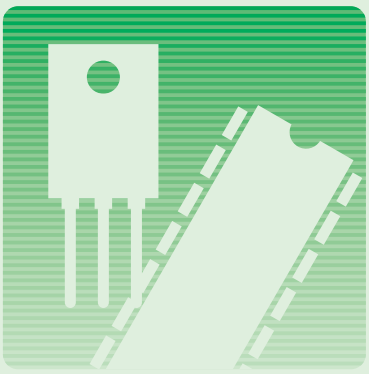
Semiconductors



Industrial
Automotive

Efforts to achieve a decarbonized society are accelerating as a means of solving the global climate change problem. The electrification of automobiles and the improvement of the efficiency of power electronics equipment for the stable and efficient use of energy are effective approaches to decarbonization, and Fuji Electric's power semiconductors are key devices that contribute to the achievement of this goal. Specifically, Fuji Electric has created products that meet the needs for higher efficiency, reduced size, higher reliability, and more, as well as numerous innovative technologies with a focus on power semiconductors typified by insulated gate bipolar transistors (IGBTs).

Industrial

Fuji Electric has expanded the application of its 7th-generation IGBT technology, which is well known for its use in industrial modules, and promoted the expansion of its lineup of products with low loss and guaranteed high-temperature operation, completing the creation of a lineup of 7th-generation IGBT standard modules. Furthermore, as part of recent efforts toward achieving a decarbonized society, we have promoted a new lineup of the "HPnC" high-capacity modules to meet market demands in line with the expansion of electric railways and renewable energy markets for solar and wind power, among other sources. Such demands include increases in the capacity of power conversion equipment and reductions in the size and weight of equipment. The HPnC greatly reduces internal inductance and is a package suitable for high-speed switching and multiple parallel connections. In this way, it contributes to the reduction of size and increase in power density of equipment.

In addition, we will complete the creation of a lineup of the 7th-generation intelligent power modules (IPMs) with built-in drive and protective functions for applications such as FA, machine tools, and air conditioning equipment to contribute to increased efficiency, reduced size, and higher reliability in power conversion equipment. In addition to the conventional package lineup, we have established a new lineup of small "P639" packages that employ the 7th-generation IGBT and reverse-conducting IGBT (RC-IGBT) technology. Through these products, we will further increase efficiency and reduce size, thereby contributing to space-saving as a result of smaller equipment.

At the same time, we are expanding the application of SiC devices, which are expected to be the next generation wide-bandgap (WBG) devices. We will also follow up with a lineup of SiC modules equipped with the 2nd-generation SiC metal-oxide-semiconductor field-effect transistors (SiC-MOSFETs), contributing to increased efficiency and reductions in the size and weight of power conversion equipment.

In terms of IC products, we have developed the "FA6C60 Series" of 4.5th-generation LLC control ICs designed to reduce costs for power supply systems. In conventional products, a series regulator composed of an external circuit supplied power to the IC. By contrast, this series incorporates this circuit into the IC to reduce the number of power supply components, thereby contributing to the reduction of costs for power supply systems.

Automotive

In the automotive field, we have developed and released power modules that incorporate three-phase inverter bridge circuits for inverters used in motor control for electrified vehicles (xEVs). Two types of newly developed products are described below.

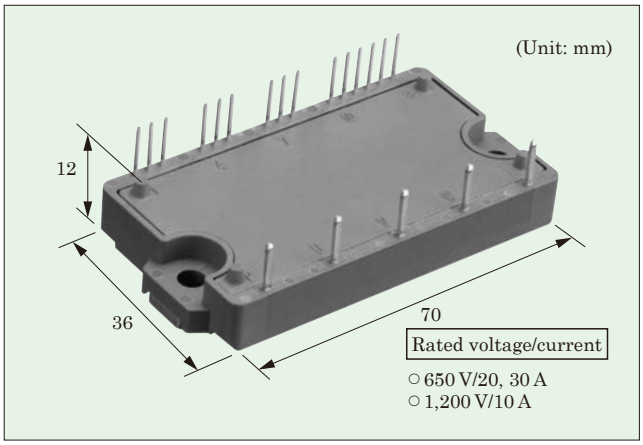
We have developed the "M675" for the Chinese market, where xEV demand is increasing as a result of the new energy vehicle (NEV) regulations. This product features improved output performance and heat dissipation while maintaining the same main unit size and fastening hole and water channel hole positions as the previously released "M653." In addition, it has been designed to be high-performance and easy to replace. Furthermore, we have developed a series of extended models that has the same profile as the currently mass-produced M660 (190-kW motor capacity), but with a current rating that corresponds to a motor capacity of 150 kW. Like the M660, this product uses the RC-IGBT chips, and the resin molding and lead frame structure enable high power cycle capacity. Both products use a direct liquid cooling system with a closed-type cooler, which improves cooling efficiency to reduce size and increase power density.

Industrial

1 Lineup of "P639" 7th-Generation IGBT-IPMs

Intelligent power modules (IPMs) are used to save power and space in power conversion equipment, and further reductions in loss and size are required. By applying 7th-generation technology, Fuji Electric has reduced the losses of the 7th-generation IPMs by 10% compared to that of the 6th-generation IPMs and has increased the allowable chip temperature during continuous operation from 125°C to 150°C. With these improvements, the 7th-generation IGBT-IPM has reduced package size even under the same current conditions. We have developed a new lineup of the "P639" 7th-generation IGBT-IPMs, which are 27% smaller than the existing package, the "P629." For these products, we employed an RC-IGBT chip featuring integrated IGBT and FWD chips to reduce the thermal resistance in addition to the footprint size. Due to this feature, the "P639" lineup can help reduce the size of power conversion equipment without enhancing the heat dissipation performance.

Fig.1 "P639"

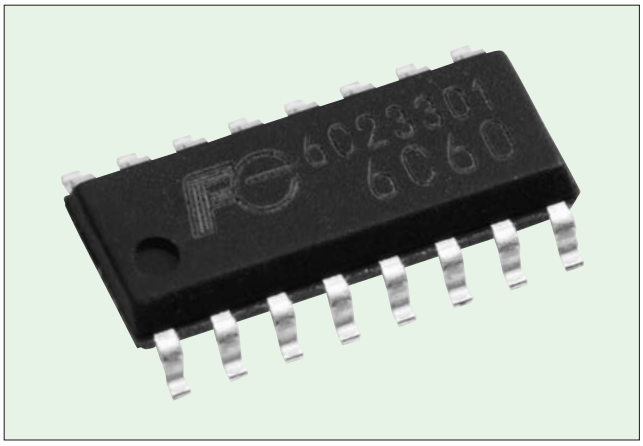


2 "FA6C60 Series" 4.5th-Generation LLC Control ICs

LLC current resonant circuits are widely used for power supplies used in flat-screen TVs and LED lightings, for which standby power and cost reductions are required. In response to this demand, Fuji Electric has developed the "FA6C60 Series" 4.5th-generation LLC control ICs. The main features are as follows:

(1) Its burst control suppresses sudden changes in the output current at the start of switching under light loads by adjusting the ON width using a soft start function, preventing transformers from making audible noise. The ON width can be configured optimum with the state setting function, also lowering standby power.
(2) This control IC includes input power supply circuits for driving MOSFETs and controlling PFC, which were previously attached externally, to reduce power supply components, saving costs.

Fig.2 "FA6C60 Series"

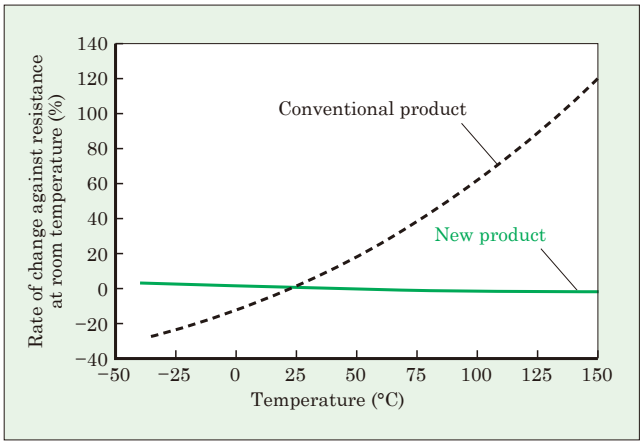


3 Built-in Gate Resistor Chips for High-Power Modules

High-Power semiconductor modules are required to inhibit both short circuit oscillation and turn-on loss at high temperatures. Therefore, for the gate resistor driving the semiconductor chip in the module, not only the resistance value must be optimized, but the resistance increase must also be suppressed as the temperature rises. In response to these needs, we have developed a gate resistor chip to be built into modules with a low temperature change rate for the resistance value by combining Poly-Si resistor manufacturing technology with a Si substrate with low specific resistance. The main features are as follows:

(1) A rate of change within ±2.5% (conventional products: up to 120%) with respect to the resistance at room temperature in the range of −40°C to +150°C
(2) Capable of adjusting the optimum resistance value without changing the semiconductor chip size by changing the dimensions of Poly-Si
(3) Can be manufactured in the Si power semiconductor manufacturing process

Fig.3 Temperature dependence of resistance



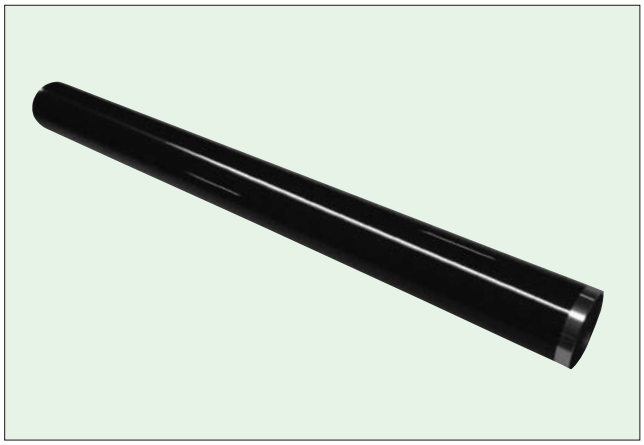
Industrial

4 Highly Durable Positive Charging Organic Photoconductors for Fast Printing

Photoconductors are key components responsible for image quality in electrophotographic printers and copiers, which are seeing advancements in size reduction, speed, and colorization. In addition, since a color machine requires accurate color reproducibility, it must suppress the fluctuations in characteristics over long periods of time. In particular, as the equipment becomes smaller and faster, improving the surface potential stability against the retention of the discharge generation gas has become a challenge.

Fuji Electric has improved the ability to transport charges generated by exposure light by combining multiple high-mobility charge transport materials, thereby achieving a printing speed of 1.5 times that of the conventional product. In addition, we optimized the amount of additive to fill the space of the photosensitive layer, and improved the gas resistance twofold. As a synergistic effect of these improvements, the stability of the surface potential has improved, and small, medium-speed color machines are able to retain color reproducibility for about three times longer.

Fig.4 Positive charge organic photoconductor



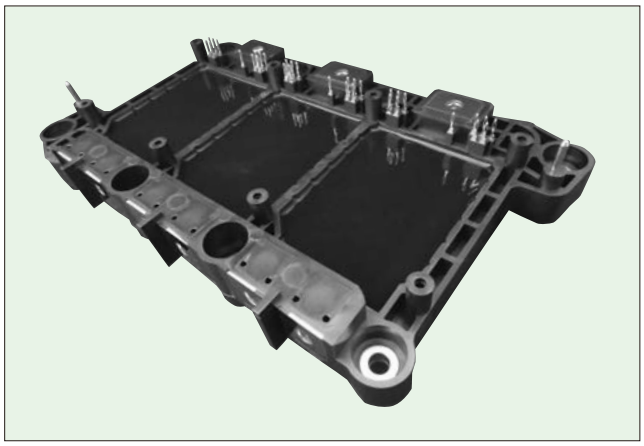
Automotive

1 Expansion of the “M660” Automotive Power Semiconductor Modules

In recent years, as the lineup of electric vehicles has expanded rapidly, and power modules are required to accommodate various inverter capacities. For this reason, Fuji Electric has expanded its “M660” lineup of automotive power semiconductor modules (with a motor capacity of 190 kW), which is currently in mass production. We have changed the chip size and redesigned the internal structure to enable the same package as the 190 kW product to support 150 kW (rating: 800 A / 750 V). The main features are as follows:

(1) Use of RC-IGBT chips has reduced size and loss.
(2) Closed-type direct water cooling system has downsized the cooling unit.
(3) Plastic molding and lead frame connection has increased high power cycle capability.

Fig.5 “M660” (150 kW)



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