New Product: RJK60S5DPK High-Voltage Power MOSFET with Super Junction Structure

First Device in New Line of 600V Power MOSFETs Establishes Industry Benchmark for Low On-Resistance and Fast Switching Performance

The outstanding characteristics of the RJK60S5DPK power MOSFET make possible energy-saving power supply designs for TVs, solar panels, and many other products.

Renesas Electronics Corporation now is shipping samples of the RJK60S5DPK, the first device in a new line of N-channel power metal-oxide-semiconductor field effect transistors (MOSFETs) with a voltage tolerance of 600V. The chip is manufactured in our own production facilities using an advanced super junction (SJ) process technology we have developed. Tests have shown that the device sets a new industry benchmark for this class of semiconductor switch by demonstrating a very low, efficiency-boosting on-resistance of only 150mΩ, as well as a low, speed-enhancing internal capacitance of just 6nC. These exceptional electrical characteristics are the essential for implementing improved, energy-saving power supplies for diverse high-volume AC-powered applications such as flat-panel TVs, wireless-communication base stations, and solar power generators. Especially, our SJ MOSFET is an excellent choice for the inverter-based home appliances that are forecast to be in high demand in China and other Asian countries.

Implementing an improved, 600V-capable super junction technology that enables both high efficiency and fast switching

In years past, engineers designing AC-input switching power supplies who needed switching devices in the 400V range generally used insulated-gate bipolar transistors (IGBTs). More recently, they had tended to shift to power MOSFETs for high-voltage power circuits, even though the planar structure of conventional power MOSFETs mandates a trade-off between the low on-resistance (RDSon) essential for efficiency and the requisite high-voltage tolerance. A better way was needed to achieve both a low on-resistance and a voltage rating above 400V, and semiconductor engineers provided a solution in the form of power MOSFETs that employ a super junction (SJ) structure.

SJ MOSFETs typically are manufactured by creating on an N+ substrate multiple columns of P-type material within a low-impurity N material. A multi-step epitaxial growth process builds up the columns layer by layer, thereby increasing the total implanted layer thickness until the required voltage tolerance is obtained (see Figure 1, left side). However, the low throughput of epitaxial growth and the complicated production steps of this process make it difficult to enhance productivity or cut cost. These limitations prompted Renesas to initiate research to find an improved method.

To overcome the problems inherent to the multi-level epitaxial growth approach, Renesas engineers have created an SJ structure with a deep-trench technique. Our proprietary technology entails etching trenches in the low-impurity N-type material to form P-type regions (see Figure 1, right side). The Renesas method uses highly precise mask alignment and impurity implantation to simplify the production process and thus boost manufacturing throughput and reduce cost. Moreover, our successful deep-trench R&D program has succeeded in miniaturizing the P-type columns (see Figure 2). Besides the economic benefits our SJ process technology delivers, two circuit design benefits derive from this miniaturization achievement: extremely low on-resistance and reduced internal capacitance.
Reducing MOSFET on-resistance by 52% compared to conventional chips

By producing the RJK60S5DPK power MOSFET with the SJ-structure using deep-trench technology, we gave this 600V/20A device industry-leading on-resistance and switching performance. Specifically, its on-resistance between the drain and source pins is only 150mΩ, typ. (at ID=10A, VGSS=10V), for an on-resistance per unit area of 1.63 Ω/mm². This low value, which is about 52% less than conventional devices, gives power supply engineers an unprecedented opportunity to make substantial reductions in the energy that is lost when performing power conversions.

Additionally, the gate-drain charge capacitance (Qgd) of our new SJ MOSFET, a key characteristic governing switching speed, is approximately 80% lower than conventional products: typically just 6nC (at ID=10A, VGSS=10V). This enables the RJK60S5DPK MOSFET to achieve a rapid switching speed that, in turn, lets power supply engineers build smaller products that achieve greater power-conversion efficiency.

When the values for RDSon and Qgd, are taken together, they comprise a Figure of Merit (FOM) for power MOSFETs for switching applications. The circuit design advantages offered by the RJK60S5DPK become readily apparent when its values are plotted against data for conventional devices from other manufacturers (see Figure 3). In fact, the new Renesas device delivers performance indicators that reach the industry’s highest level, exceeding those of our previous models by approximately 90%.
To facilitate power-supply upgrades, the RJK60S5DPK power MOSFET has the same type of exterior shape as the conventional standard package, the TO-3P. Also, it follows the industry standard for pin placement, so the device will fit right into the circuit boards of many existing switch-mode power sources. Yet compared to a Renesas power MOSFET built with a planar construction, the new SJ MOSFET has nearly 80% less on-resistance per unit area, enabling a lower chip surface area for a device with the same RDSon. That, in turn, allows power supply designs that previously had required a TO-3P to make use of smaller packages, such as the TO-220FL.

Figure 3: Comparison of RDSon and Qdg performance characteristics among various power MOSFETs.