650-V GaN FETs Enable High-Density Power Conversion In Multi-Kilowatt Applications

Renesas Electronics' TP65H030G4PRS, TP65H030G4PWS and TP65H030G4PQS are 650-V 30-mΩ GaN FETs for AI data centers and server power supply systems including the new 800-V HVDC architecture, e-mobility charging, UPS battery backup devices, battery energy storage and solar inverters. Designed for multi-kilowatt-class applications, these fourth-generation plus (Gen IV Plus) devices combine high-efficiency GaN technology with a silicon-compatible-gate-drive input, significantly reducing switching power loss while retaining the operating simplicity of silicon FETs.

Offered in compact TOLT (TP65H030G4PRS), TO-247 (TP65H030G4PWS) and TOLL (TP65H030G4PQS) packages, the devices give engineers the flexibility to customize their thermal management and board design for specific power architectures for power systems ranging from 1 kW to 10 kW, and even higher with paralleling of devices (Fig. 1).

The TP65H030G4PRS, TP65H030G4PWS and TP65H030G4PQS leverage the company's robust SuperGaN platform, a field-proven depletion mode (d-mode) normally-off architecture pioneered by Transphorm, which was acquired by Renesas in June 2024. Based on low-loss d-mode technology, the devices offer superior efficiency over silicon, silicon carbide (SiC), and other GaN offerings, according to the vendor (Fig. 2).

The three new GaN FETs also outperform the company's previous Gen IV devices. Built on a die that is 14% smaller than the previous Gen IV platform, the three Gen IV Plus products achieve a lower $R_{DS(ON)}$ of 30 mΩ, reducing on-resistance by 14% and delivering a 20% improvement in on-resistance output-capacitance-product figure of merit (FOM). The smaller die size reduces system costs and lowers output capacitance, which results in higher efficiency and power density.

Moreover, these GaN FETs minimize power loss with lower gate charge, output capacitance, crossover loss, and dynamic resistance impact, with a higher 4-V threshold voltage, which is not achievable with today's enhancement mode (e-mode) GaN devices, says the vendor. In addition to the 30-mΩ GaN FETs being introduced now, the company has 50-mΩ, 240-mΩ, 480-mΩ devices in development as well as an AEC-Q101 version of the 30-mΩ GaN FET in the works.

These advantages make the Gen IV Plus devices well suited for cost-conscious, thermally demanding applications where high performance, efficiency and small footprint are critical. According to the vendor, they are fully compatible with existing designs for easy upgrades, while preserving existing engineering investments.

"The rollout of Gen IV Plus GaN devices marks the first major new product release milestone since Renesas' acquisition of Transphorm last year," said Primit Parikh, vice president of the GaN Business Division at Renesas. "Future products will combine the field-proven SuperGaN technology with our drivers and controllers to deliver complete power solutions. Whether used as standalone FETs or integrated into complete system solution designs with Renesas controllers or drivers, these devices will provide a faster path to designing products with higher power density, reduced footprint and better efficiency at a lower total system cost."

Like previous d-mode GaN products, the new Renesas devices use an integrated low-voltage silicon MOSFET—a unique configuration that achieves seamless normally-off operation while fully capturing the low loss, high efficiency switching benefits of the high-voltage GaN. As they use silicon FETs for the input stage, the SuperGaN FETs are easy to drive with standard off-the-shelf gate drivers rather than specialized drivers that are normally required for e-mode GaN. This compatibility simplifies design and lowers the barrier to GaN adaptation for system developers.

GaN-based switching devices are quickly growing as key technologies for next-generation power semiconductors, fueled by demand from electric vehicles (EVs), inverters, AI data center servers (Fig. 3), renewable energy, and industrial power conversion. An emerging data center power architecture with an 800-V bus will offer opportunities for 650-V bidirectional GaN devices as well as the 650-V GaN FETs in production and the low-voltage GaN FETs that Renesas is currently developing (Fig. 4).

According to Parikh, the company will start production of 40-V to 200-V devices in 2026. The company is also scaling from 6-in. to 8-in. wafers to drive down device cost.

Renesas says that it is uniquely positioned in the GaN market with its comprehensive solutions, offering both high- and low-power GaN FETs, unlike many providers whose success in the field has been primarily limited to lower power devices based on customers' end systems in the field. To date, the 650-V GaN market has been dominated by devices for low-power applications such as adapters for smart phones and laptops.
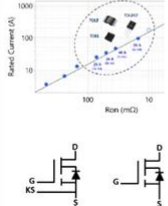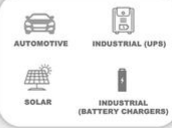
While various suppliers of these devices have shown 650-V GaN devices for the higher-power applications in servers or other areas, most of these competing devices are technology demonstrators, according to Parikh. In contrast, "our GaN has been in the field in the multi-kilowatt applications for years," says Parikh (Fig. 5).

According to Renesas, its diverse GaN portfolio enables the company to serve a broad range of applications and customer needs. To date, Renesas has shipped over 20 million GaN devices for high- and low-power applications, representing more than 300 billion hours of field usage.

The TP65H030G4PRS (TOLT), TP65H030G4PWS (TO-247) and TP65H030G4PQS (TOLL) are available now, along with the 4.2-kW totem-pole PFC GaN evaluation platform (RTDTTP4200W066A-KIT). For more information, see the TP65H030G4PRS, TP65H030G4PWS and TP65H030G4PQS product pages and the evaluation platform product page.

Fig. 1. The TP65H030G4PRS, TP65H030G4PWS and TP65H030G4PQS 650-V 30-mΩ GaN FETs are d-mode devices that incorporate a co-packaged low-voltage silicon MOSFET for compatibility with standard gate drivers. They offer multiple packaging options including those with bottom-side (TOLL) and top-side (TOLT) thermal conduction paths for cooler case temperatures, allowing easier device paralleling when higher conduction currents are needed. Further, the commonly used TO-247 package provides customers with higher thermal capability to achieve higher power.
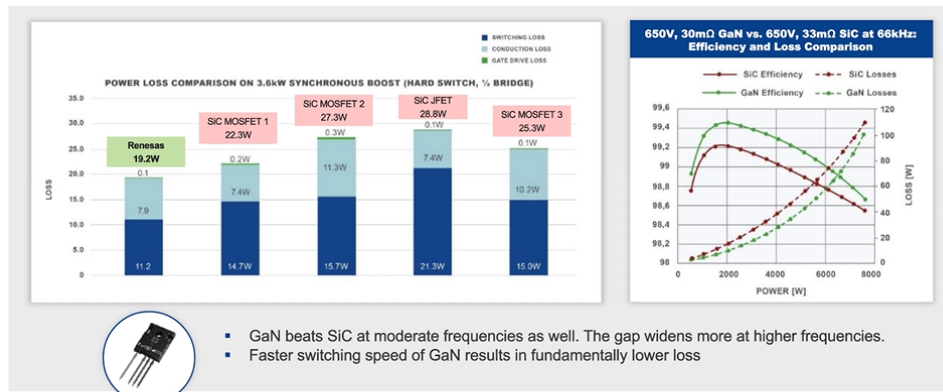
Fig. 2. Comparing power losses and efficiency of Renesas' 30-mΩ GaN FETs versus SiC MOSFETs and a SiC JFET with comparable on-resistance in a hard-switched, half-bridge boost PFC application. According to the vendor, losses are 10% to 30% lower in this application for the Gen IV Plus GaN FETs.
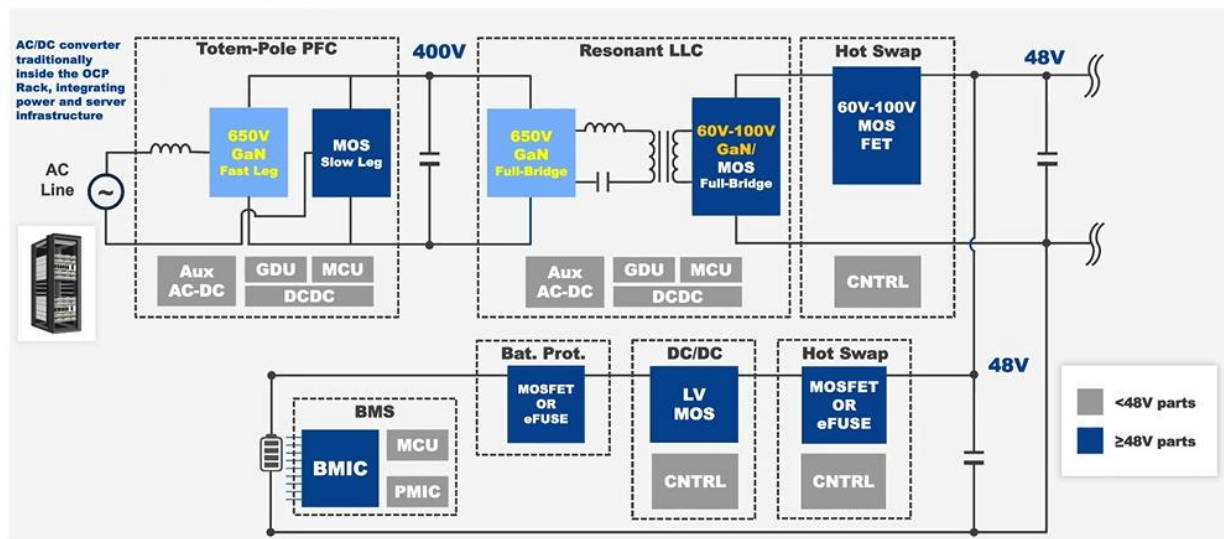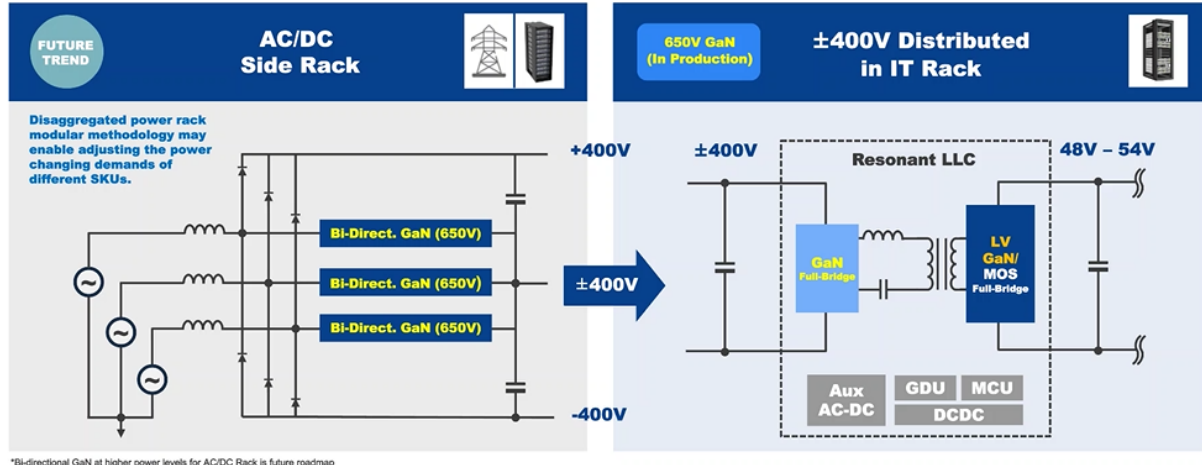
Fig. 3. 650-V GaN power switches are suitable for use in the PFC stage and the resonant LLC dc-dc converter stage in server power supplies.

Fig. 4. The 800-V bus architecture proposed by Nvidia for AI data centers offers opportunities for bidirectional GaN switches, which Renesas is developing, and for the company's existing 650-V GaN FETs and for its soon-to-be-expanded offerings of low-voltage GaN FETs.

Fig. 5. According to Parikh, Transform's GaN FETs, which are now part of Renesas' portfolio, have been on the market and running in server and other high-power applications like UPS and solar inverters for years.