Technical Article

Driving innovation in power-supply designs with integrated TOLL-packaged GaN devices

Srijan Ashok

Today's power-supply designs require high efficiency and power density. As a result, designers are using gallium nitride (GaN) devices across various power-conversion topologies.

GaN can enable high-frequency switching, which reduces the size of passives and therefore increases the density. GaN also lowers switching, gate-drive and reverse-recovery losses compared to technologies such as silicon and silicon carbide (SiC), which increases the power design efficiency.

You can use 650V GaN FETs for the AC/DC-to-DC/DC conversion, or 100V or 200V GaN FETs for DC/DC conversion to implement the power supplies.

If you work on cutting-edge products, it is also important to choose devices with an industry-standard footprint in order to streamline the supply chain for procurement teams. For this reason, in the 650V space, the transformer outline leadless (TOLL) package is gaining popularity in high-power-supply designs.

Apart from choosing industry-standard devices, integrated devices such as TI's LMG3650R035 GaN field-effect transistor (FET) can play a major role in creating designs with high density and reliable operation across various power topologies. This device has an integrated gate driver, and protection circuitry such as overcurrent protection, overtemperature protection and short-circuit protection. The integration of protection circuitry helps reduce external components to implement these features. The device can also support multiple power topologies in the high-voltage space, including totem-pole power factor correction (PFC), inductor capacitor, phase-shifted full bridge and dual active bridge.

Integrating the gate driver helps you create a simple, high-density and clean layout with significantly reduced parasitic coupling, as illustrated in Figure 1. Integration becomes especially important in high-switching-frequency power conversion because circuit parasitic coupling in the gate loop causes an increase in gate noise and overlap losses. By using integrated power stages, the parasitic coupling becomes negligible and simplifies layouts.

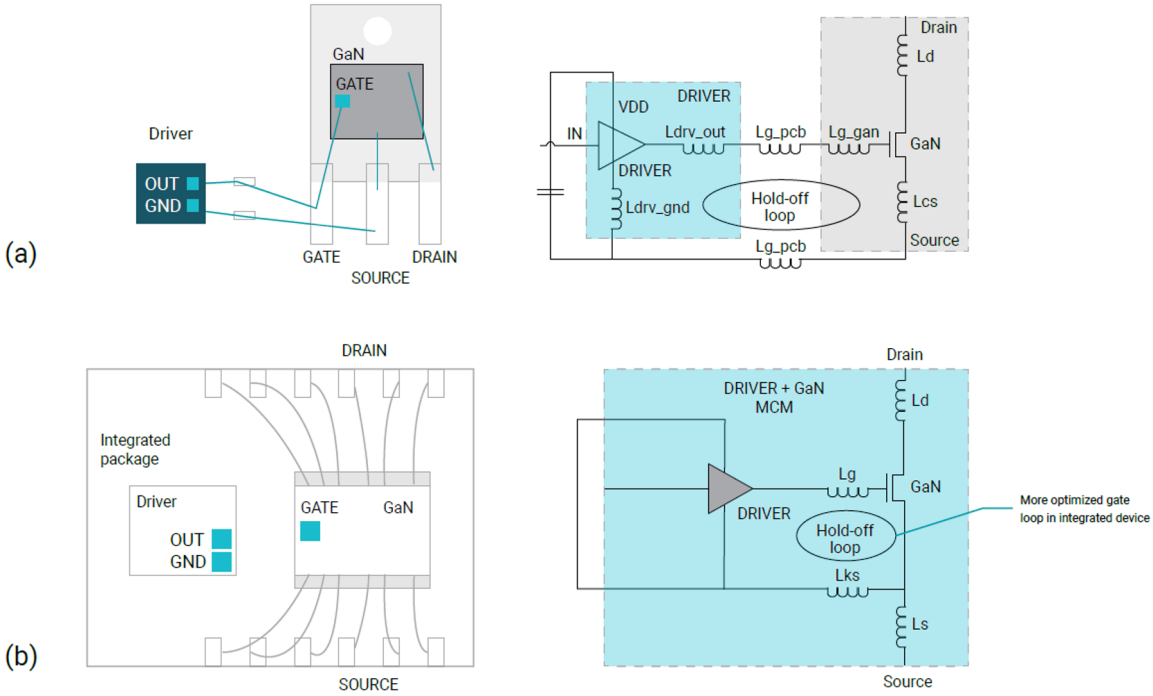

Figure 1. Circuit parasitics integrated GaN power stage vs. discrete GaN

Application areas of the TI high voltage TOLL devices

Let's review several major application areas for TI's TOLL devices where you can leverage the integrated protection features, integrated zero-voltage detection (which reduces third-quadrant losses), and the reduced overlap switching losses caused by negligible parasitic coupling.

PSUs for data center and telecommunication power

As demand for data centers and hyperscale computing increases, the need to create highly efficient, power-dense power-supply units (PSUs) will grow exponentially. Even as the telecommunications space moves from 4G to 5G – and now 6G – the power requirements of the equipment keep increasing, but the form factor remains the same.

This scenario becomes a potent use case for integrated 650V TOLL devices, which primarily convert AC power into a DC bus through the PFC and DC/DC stage, as shown in Figure 2. Our GaN devices in the TOLL package can achieve greater than 99% efficiency in the PFC stage and greater than 98% efficiency in the DC/DC stage across the topologies I mentioned earlier.

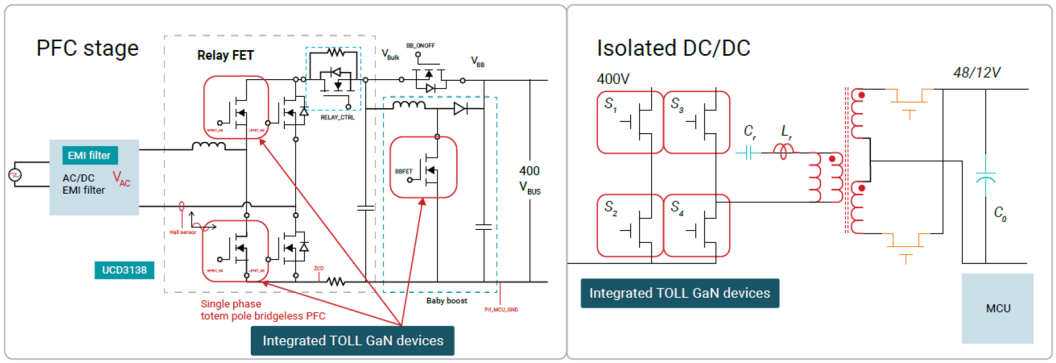

Figure 2. PSU block diagram

Solar microinverters

Solar energy as a power source is on the rise. As shown in Figure 3, both the bidirectional DC/DC and the PFC and inverter stage can use an integrated GaN TOLL device to convert the solar panel voltage to AC power. As clean energy requirements scale rapidly, it's important to deliver high efficiency and high power with a small footprint using industry-standard devices.

A TOLL GaN device can add value with an industry-standard footprint and integrated features. These devices can help you scale to different power levels and with different topologies using different drain-to-source on-resistances while not struggling with layout, since most sensing and optimization features are integrated in the power stage.

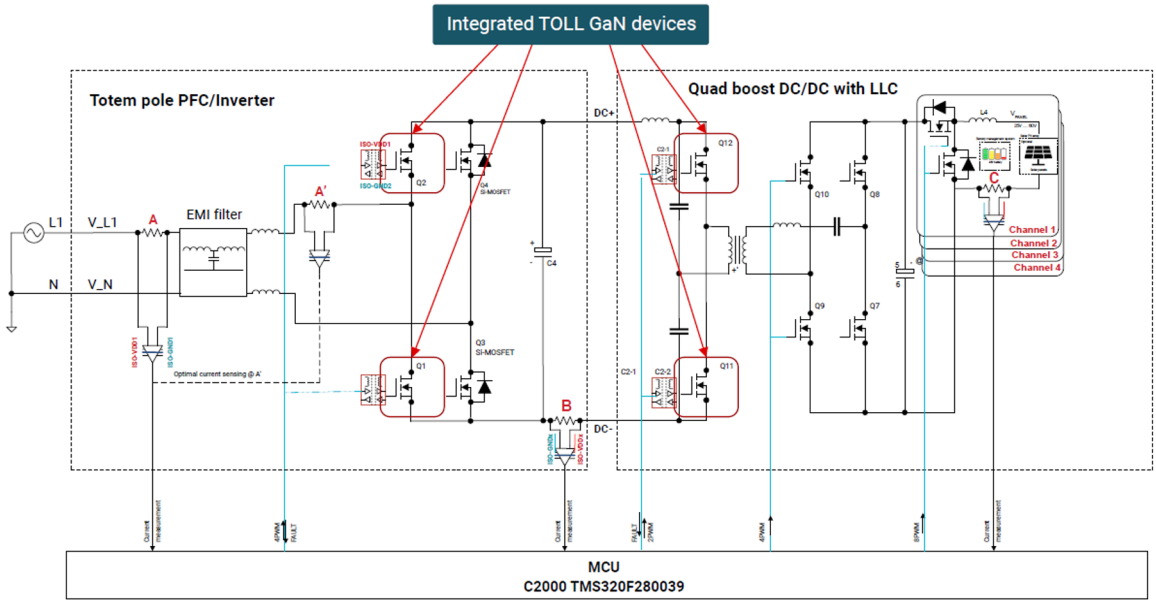

Figure 3. Microinverter block diagram

TV power supplies

There is sizeable growth potential in the large-screen (>40 inch) television market, as well as a trend toward lighter and thinner screens for aesthetic reasons. Because the power requirements increase with larger screens but the size is thinner, it's important to make televisions more power efficient. AC/DC conversion can use the TOLL devices in the PFC and DC/DC stage.

Integrated TOLL GaN devices enable you to keep the size of the passives the same and keep the external circuitry to a minimum with simple routing to deliver thinner printed circuit boards. The design will also be more efficient, while sticking to an industry-standard footprint.

2W, 3W and 4W onboard chargers

Vehicle electrification is always in the news as the world strives toward reducing tail-pipe emissions. Easy access to on-the-go charging necessitates electric vehicle onboard chargers (OBCs). Because its location in an electric vehicle is in the chassis, an OBC should be power dense and efficient in order to occupy minimal space and reduce losses, as there is no active cooling to dissipate losses.

Figure 4 shows a typical OBC block diagram. An integrated TOLL GaN device can help both the PFC and DC/DC stage by optimizing design size through integration and a higher switching frequency, and reduce losses (gate drive and switching losses) for more effective heat dissipation. With TOLL GaN devices, at the device level all protections are enabled as well, which will help with the resiliency of the OBC design while keeping an industry-standard footprint.

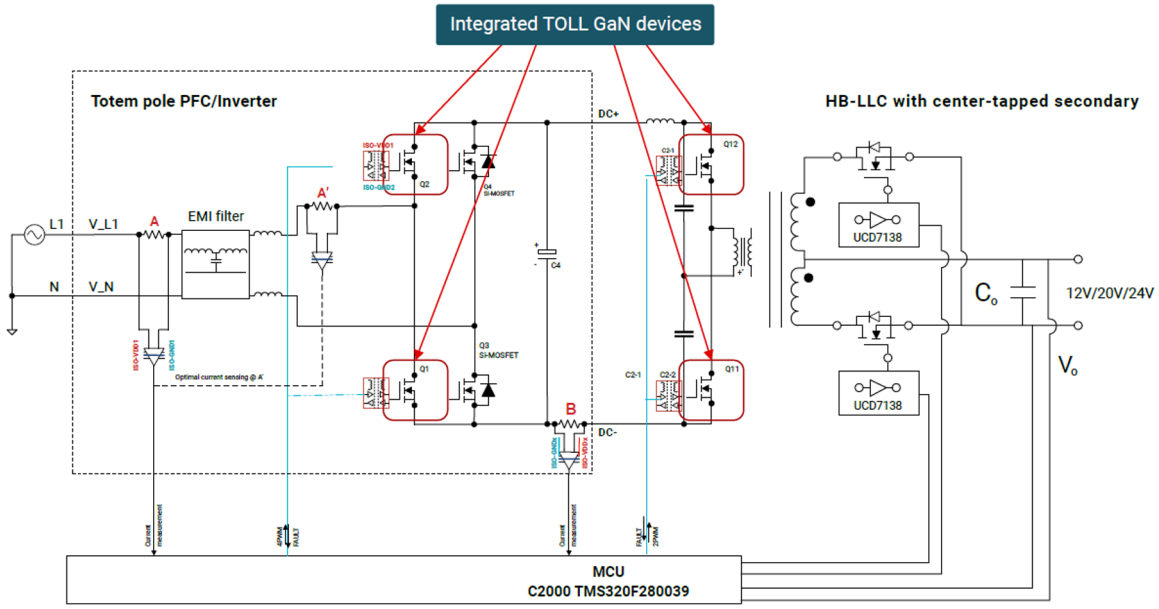

Figure 4. Onboard chargers

Conclusion

One of the biggest design challenges that a power designer of the future will face is to deliver ever increasing power levels at the lowest possible losses with a high-density design. An integrated TOLL GaN device helps here by combining integrated GaN with an industry standard footprint and eliminates the hassle of extra circuitry and complicated PCB layouts. This helps in making the design less cumbersome. Additionally, this will also enhance designs in other end equipment spaces such as motor drives, industrial power supplies and appliance power who also value simple, high density designs.

With the GaN FET technology making leaps, we will keep investing and improving the figure of merit of the TOLL devices in the future, aiding the designers endeavor to deliver even higher power in the same space.

Additional resources

- Check out the *LMG3650R035 Evaluation Module EVM User's Guide*.
- Learn more about LMG3650EVM-113 evaluation module.
- Learn more about our GaN technology.

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265