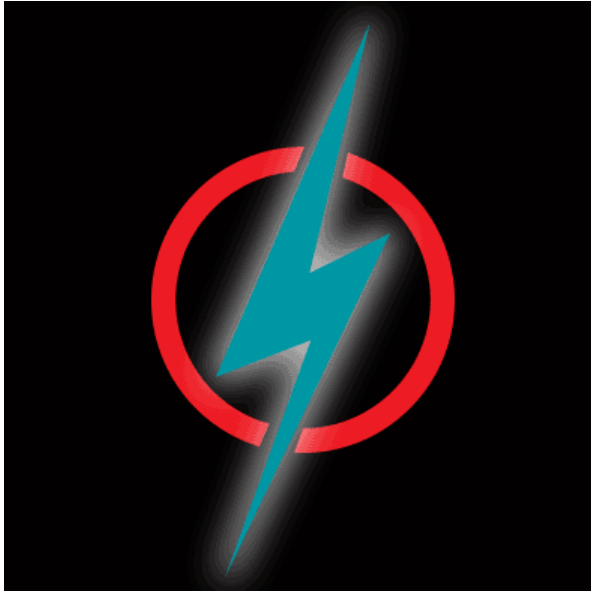


The Top Trends in High-voltage Power, from Isolation to Wide-bandgap Technologies



What do you, me and your second cousin twice removed have in common? Together, we are directly and indirectly influencing technology. More specifically, together we are creating a need for high voltage. Two trends drive the need for high voltage: electrification and (an insane amount of) energy consumption.

Various applications including automotive and power tools require electrification, defined as the conversion of a system to the use of electrical power. In the automotive world, heavy and expensive cabling leads to fuel inefficiencies and increased emissions. High-voltage batteries help carmakers meet stringent environmental regulations by getting more power through cable wires. In addition, driving loads electrically instead of mechanically increases efficiency and allows drivers to travel farther. Loads that are inherently electric, like wireless charging and *Bluetooth*®, are becoming more common.

Power tools are also entering the world of electrification. My lawn mower is battery-powered! Gone are the days where gasoline left in the mower over the winter clogged up the carburetor. High-voltage controllers and gate drivers are found in the charger, which requires AC-to-DC and DC-to-DC conversion. In the power tool itself, you'll find high-voltage electronics in the power stage of the motor drive.

The second trend driving the need for high voltage is energy consumption. Powering refrigerators, thermostats, speakers, laptops and TVs efficiently requires shrinking power supplies, or at least keeping them the same size. The name of the game is power density. Higher-current gate drivers mean higher efficiency because of minimized switching losses. Higher efficiency means higher power density.

Trends like electrification and energy consumption create opportunities to improve the infrastructure needed to bring these systems to life. Examples in the semiconductor world include isolated gate drivers, wide bandgap technologies and the proliferation of robustness specifications, all of which are major parts of TI's portfolio.



Isolation, whether it's an isolated gate driver or a digital isolator, protects users from power coming from the grid. This is mandatory in applications like power supplies and solar inverters that boost their voltages to 400V. [Isolated gate drivers](#) significantly influence solution size by replacing the bulky transformers found in traditional designs. The system's power level dictates the level of isolation needed and even the number of channels in a given device. For example, high-power motor-drive designs may require single-channel drivers to accommodate the printed circuit board (PCB) layout.

Wide-bandgap technologies like [gallium nitride \(GaN\)](#) are finding their way into and elevating well-known topologies. Compared to the more common dual-boost bridgeless PFC, continuous-conduction-mode totem-pole bridgeless power factor correction (PFC) with GaN can reduce semiconductor switches and boost inductors by half and still [push efficiency past 98.5%](#). This is due to GaN's zero reverse recovery and low parasitic capacitance.

Reducing component count while boosting efficiency specifications enables designers to increase power density by accommodating higher power levels in smaller spaces. [Silicon carbide \(SiC\)](#), another wide-bandgap technology, can also achieve higher switching frequencies at even higher voltages and operate in higher operating temperatures, not only achieving high power densities but also surviving harsh environments. This makes SiC a great candidate for systems in automotive powertrain. Essentially, we can now accomplish more with less.

Robustness and greater control over the system are critical for successful operation at higher voltages and switching frequencies. Features like negative voltage handling and delay matching, and architectures like split outputs and undervoltage lockout (UVLO) control make this possible. Here's how:

- Parasitic inductance caused by switching transitions, leakage or poor PCB layout can create negative voltages. An integrated circuit's (IC) ability to survive negative voltages at both the input and outputs pins is important for a reliable solution.
- Delay matching (the matching of internal propagation delays between two channels) ensures that field-effect transistors (FETs) can be driven in parallel (to double-drive current, which means switching at higher frequencies), with minimal turn-on delay difference. Dead-time control and interlock prevent shoot-through.
- [Split outputs](#) allow control over both rise and fall times to better manage the switching characteristics of power FETs.
- Some isolated gate drivers have unique features, like an [emitter pin](#) that allows for accurate monitoring of the UVLO. This means understanding exactly when a system is on or off.

Regardless of application, fundamentals (especially power fundamentals) are constant. The ideas creating demand for high voltage are simply influencing topology evolution. TI recently held [a power conference that centered around high voltage](#). There were over 110 participants, 25 sessions and hours of collaborative and technical dialogue. There were power engineers with varying levels of experience. Applications of interest included many of the ones I've mentioned here: automotive, power tools, appliances, even audio. Attendees challenged each other's approaches to designing over two days. One concept we could all agree on, though: high voltage is here to stay.

Additional Resources

- Read the white paper, "[Driving the future of HEV/EV with high-voltage solutions.](#)"
- Download the Power Supply Design Seminar paper, "[GaN FET-Based CCM Totem-Pole Bridgeless PFC.](#)"

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