

How integrated isolated bias modules improve power density and reliability

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Introduction

Isolated bias supplies are critical building blocks in high-performance power electronics such as traction inverters, solar inverters, and data-center power-supply systems, yet they require trade-offs between power density and development time. Isolated DC/DC designs rely on discrete transformers and switching components, which often introduce challenges in meeting power density, reliability and time-to-market requirements.

Isolated bias power modules with TI's IsoShield™ packaging technology combine switching field-effect transistors (FETs), control circuitry, and a planar isolated transformer in a compact package to address these challenges. In this article, I'll explain how these modules reduce board area while improving immunity to electrical and environmental disturbances, while at the same time simplifying design in modern high-voltage systems.

How increased power density reduces solution size while meeting EMI requirements

The design of isolated bias supplies often involves balancing multiple constraints: board space, thermal performance, and electrical isolation. In applications such as electric vehicle traction systems or data center power architectures, you must provide isolation between high-voltage domains (often $\geq 800\text{V}$) and low-voltage control circuits.

Traditional designs implement isolated bias supplies using a discrete flyback converter topology. In these implementations, the transformer is typically the largest

component on the printed circuit board (PCB), limiting the achievable power density and increasing solution height.

Isolated bias power modules with IsoShield technology address high power density to meet optimized size requirements in system design by incorporating a planar transformer directly inside the package (as shown in [Figure 1](#)), and by using a multiple-chip solution with proprietary bonding connections to create a very compact isolated module.

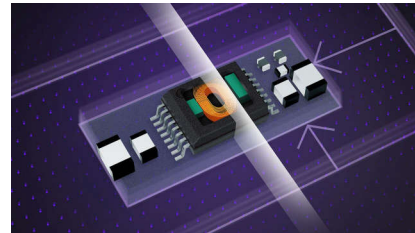


Figure 1. Isolated power module with integrated planar transformer

The mid-voltage **UCC34141-Q1** and low-voltage **UCC33420-Q1** deliver approximately 1.5W of isolated output power – the former in a 5.85mm-by-7.50mm-by-2.65mm small outline integrated circuit (SOIC) package, the latter in a 4mm-by-5mm-by-1mm very, very small outline, no-lead (WSON) package.

By integrating the transformer and switching elements, these power modules can reduce bias-supply solution area approximately 70% compared to discrete flyback implementations and >35% compared to previous integrated transformer solutions. These reductions translate into power-density improvements >300%.

In addition to footprint reduction, the vertical profile is significantly reduced. Removing the discrete transformer – the tallest component in conventional designs – enables module heights as low as 1 mm, which is particularly beneficial in space-constrained applications. **Figure 2** shows the solution area reduction associated with moving from a discrete flyback converter implementation (on the left) to a fully integrated solution (on the right).

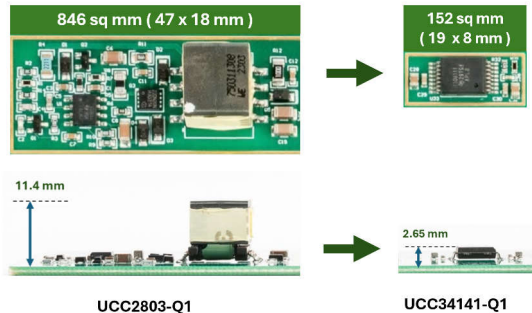


Figure 2. Top and side view comparison of a discrete solution to a fully integrated isolated module

Thermal performance and electromagnetic interference (EMI) are often concerns with high-density solutions. However, optimized packaging and internal layout can improve thermal dissipation as much as 30% compared to previous modules while maintaining compliance with Comité International Spécial des Perturbations Radioélectriques (CISPR) 25 and CISPR 32 standards, using only minimal filtering (**Figure 3**).

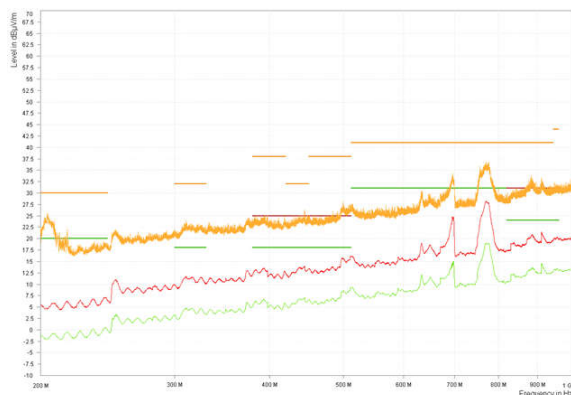


Figure 3. CISPR 25 radiated emission data ($P_{out} = 1W$)

Designing an EMI solution for a standard isolated bias supply is a nontrivial task. Balancing costly filtering components with the unique filtering needs of a discrete implementation takes experience, time and testing. The nature of an integrated solution means that the filtering needs are much more standardized. TI has taken advantage of this fact by developing application notes that describe how to implement EMI solutions that will pass CISPR standards.

The layout shown in **Figure 4** with the solution and small filter size meets the CISPR 25 Class 5 requirement. When combined with a few layout techniques, there are only a few additional bill-of-material components needed to pass CISPR 25 Class 5. In this example we use the highlighted capacitors, inductors, and ferrite beads.

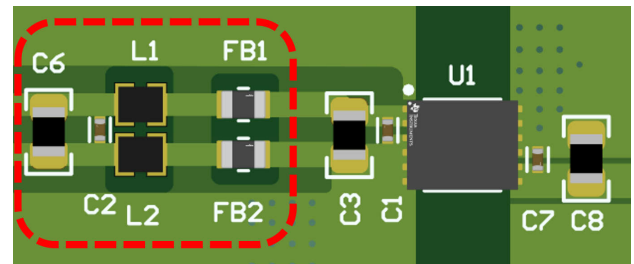


Figure 4. A small solution and filter size meets CISPR 25 Class 5 requirements

Several layout techniques can further reduce the number of filtering components. Placing high-frequency filtering capacitors C1 and C7 very close to the IC minimizes high-frequency noise. Removing any copper beneath the filtering inductors and ferrite beads minimizes leakage through parasitics, and extending the ground plane on the bottom layer of the printed circuit board creates a Faraday cage.

Enhanced system durability and reliability

High-power systems operate in electrically noisy and physically harsh environments. Bias supplies must maintain stable operation despite fast switching transitions, strong magnetic fields, and mechanical vibration. Integrated bias-supply modules with IsoShield

technology address these challenges through several immunity mechanisms.

CMTI

Fast switching transitions in modern power stages, especially those using wide bandgap devices, can produce voltage slew rates exceeding hundreds of volts per nanosecond. Isolation barriers with large parasitic capacitance may couple these disturbances across the barrier.

Modules with IsoShield technology minimize parasitic capacitance between the primary and secondary windings to less than 3pF, enabling common-mode transient immunity (CMTI) of approximately 250V/ns and allowing stable operation in high-voltage slew-rate environments such as traction inverters or motor drives.

Using an integrated solution can significantly de-risk CMTI tests compared to a discrete isolated bias supply because engineers have already completed both device- and system-level testing. CMTI results can vary from application to application when using a discrete solution, whereas an integrated solution produces more consistent results.

Radiated immunity

High-frequency electromagnetic fields generated by nearby switching nodes can disrupt control electronics. Integrated modules with IsoShield technology can withstand strong EMI across a wide frequency range, demonstrating continuous operation in electromagnetic fields exceeding 100V/m across frequencies from 10MHz to 1GHz. These modules meet the requirements of CISPR 25 and exceed limits defined by International Electrotechnical Commission 61000-4-3 without additional shielding or complex filtering.

Magnetic field immunity

High-current conductors, such as bus bars in traction inverters, can generate strong magnetic fields that may affect discrete transformer-based supplies because of

their external magnetic structure. Modules with IsoShield technology operate in magnetic fields exceeding 100mT, ensuring stable performance even when located close to high-current power paths or large magnetic structures such as those found in medical imaging systems.

Vibration immunity

Mechanical vibration is a common challenge in automotive and industrial environments. Large discrete transformers can introduce mechanical stress on solder joints and PCB pads, potentially leading to reliability issues. The compact form factor and low profile of integrated bias-supply modules reduce mechanical torque on solder connections >90% compared to discrete transformer implementations, significantly improving vibration tolerance.

Accelerated design cycles

Selecting and designing transformers is one of the most challenging aspects of isolated power-supply development. You must balance numerous design parameters, including winding configuration and routing, leakage inductance and coupling, parasitic capacitances, thermal characteristics, and mechanical packaging. Custom transformer development can add significant design complexity and extend product development timelines.

Integrated bias-supply modules eliminate many of these tasks by combining the transformer, switching FETs and supporting passive components in a single device. This integration reduces component count and simplifies system design. For server power supplies and battery backup units, such a reduction in design complexity significantly shortens time to market.

Conclusion

As power demands continue to rise across applications such as electric vehicles, artificial intelligence-driven data centers, and renewable energy systems, the pressure to deliver higher performance within increasingly constrained form factors is intensifying. Designers are no

longer optimizing for a single parameter; instead, they must simultaneously balance power density, efficiency, reliability, and development speed.

Integrated isolated bias-supply modules based on IsoShield technology fundamentally shift this design paradigm. By embedding the transformer, switching elements and isolation barrier into a compact, optimized package, these solutions eliminate many of the traditional trade-offs associated with discrete implementations, delivering a significant reduction in solution size and complexity along with improved electrical immunity, thermal performance, and reliability.

Equally important, this high level of integration enables faster and more predictable design cycles. Engineers can reuse a substantial portion of existing architectures while reducing the need for custom magnetics and extensive validation, accelerating time to market without compromising performance.

About the authors

Mark Allen Esquillo is a marketing manager in High Voltage Power business covering highly differentiated isolated gate drivers and bias solutions. He has over 30 years of experience across product development, marketing, systems / application engineering and operations. Mark Allen holds a bachelor degree in Mechatronics engineering from Nippon Engineering University in Japan, and Electrical engineering from Mapúa Institute of Technology in the Philippines.

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