Multilevel Topology for AI System Efficiency: Foundations for the Future

ICERGi's Patented Multilevel Topology, Digital Control and Gate Drive Solutions for Powering AI, Industrial, and EV Charging Applications

By Rytis Beinarys and Garry Tomlins, ICERGi

A standout advancement in the power system space is the Multi-Level (ML) topology. The ML topology delivers two paramount advantages – highest power density and industry-leading efficiency. ICERGi's leadership in this ML space is underpinned by a patent-backed product ecosystem covering advanced isolated gate drive technology, digital control solutions designed specifically for multilevel applications and ownership of the principal patent for the ML topology itself (Figure 1).

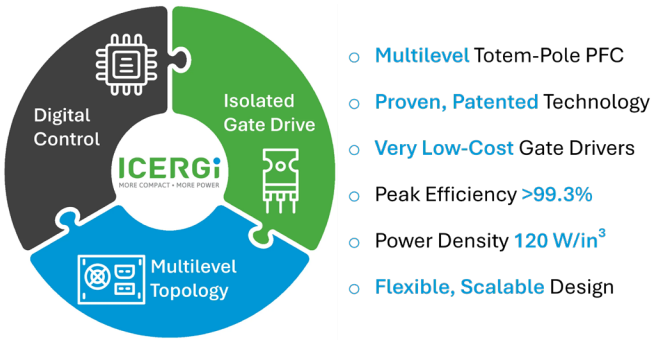


Figure 1: ICERGi Multi-Level Ecosystem – Products & IP

ICERGi's patent portfolio is a fundamental ecosystem for multilevel power conversion systems with its associated gate drive silicon, designed for all switching devices such as Si, SiC, GaN and IGBT. Furthermore, this patent portfolio includes control techniques in multilevel converters which can be embedded in any digital controller format [1]. By integrating ICERGi's patented Flying-Capacitor Multilevel (FCML) topology with its patented isolated gate driver and digital control technologies, manufacturers can unlock new levels of efficiency, power density and cost-effectiveness which are all essential for scaling AI-driven computing, powering next-generation industrial systems, and meeting the rigorous requirements of modern electric vehicles. ICERGi's innovations thus form the backbone of tomorrow's intelligent, sustainable power infrastructure.

The Three-Level Flying-Capacitor Bridgeless Totem-Pole PFC (3L-FC-BTP-PFC) has become an attractive solution for the latest generation of power supplies, where both high efficiency and compliance with emerging standards are critical. By combining the benefits of the bridgeless totem-pole structure with multilevel operation, this topology reduces voltage stress across each device which enables lower switching losses and higher effective operating frequencies (Figure 2). The result is improved efficiency at high load while also maintaining superior performance at light load, both of which are essential for meeting the demanding requirements of ORv3 as well as the 80 PLUS Titanium and Ruby certification levels [2], [3].

Recent industry developments highlight the increasing adoption of multilevel architectures in high-performance power systems. Infineon Technologies, for instance, has released several application notes and reference designs highlighting 3-level bridgeless totem-pole PFC implementations [4], [5]. A notable example is the *REF_3K3W_3LFC_PSU* reference design – a 3.3 kW high-frequency, high-density PSU for server and data center applications that employs a 3-level flying-capacitor totem-pole PFC front end. Such work demonstrates the broader industry recognition of multilevel PFC topologies as an effective means to enhance efficiency and improve overall power density in next-generation server and data center systems.

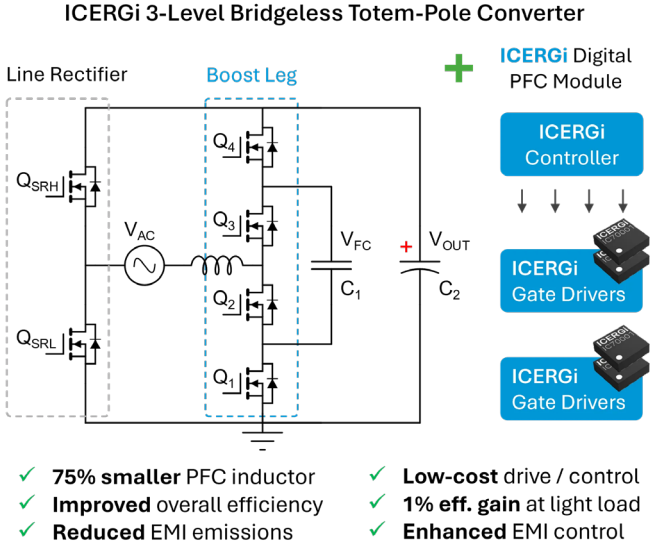


Figure 2: 3-Level Flying Capacitor Bridgeless Totem-Pole PFC enabled by ICERGi's Control and Drive Solutions

Isolated Gate Driver Overview for Multilevel Power Converters

ICERGi's isolated gate drivers provide floating, isolated drive for each multilevel switch at extremely low cost per driver. The IC70-001 is designed for Si MOSFETs, while the IC70-002 is optimized for SiC devices, with GaN and IGBT drivers currently in development [6].

At the core of ICERGi's gate driver are two small transformers (Figure 3). These convert input pulse edges (rising and falling) into isolated drive signals. This method allows precise pulse-width modulation (PWM) to drive power switches. The structure ensures interlocked operation by design, which means that if no input pulses are present, the output will safely revert to a low state.

ICERGi's isolated gate drive technology offers the following key features and advantages:

- Compatible with all switch types (GaN, SiC, Si, and IGBT)
- Extremely low cost per gate driver
- Galvanically isolated up to 5 kV
- Low quiescent current consumption <700 µA
- Fast, precise switching with typical propagation delay <15 ns
- Supports both planar and standalone transformer designs
- Optimized for lowest switching losses and drive power

ICERGi's gate drivers are versatile and can drive low-side and high-side switches, as well as any floating power MOSFETs used in multi-level converters. They are equally suited for complementary switch pairs and support both traditional PWM and ICERGi's pulse-drive methods (Figure 4). These drivers are ideal for switching applications that require level-shifting, high-side, or floating operation. They can be used with controllers for PFC, LLC, or asymmetric half-bridge designs, and are compatible with Si and SiC MOSFETs across a wide range of voltages.

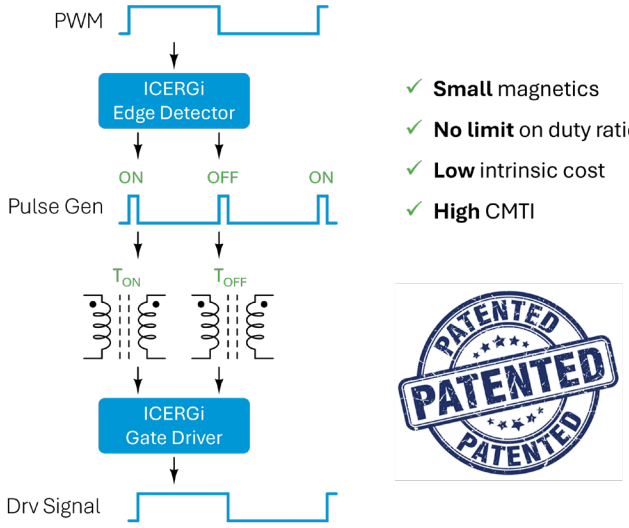
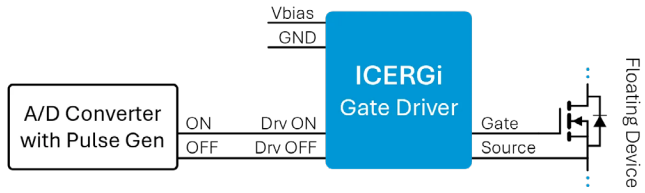


Figure 3: ICERGi's Isolated Gate Driver Functional Overview

- Pulse Input **Single** Drive



- Pulse Input **Complementary** Drive

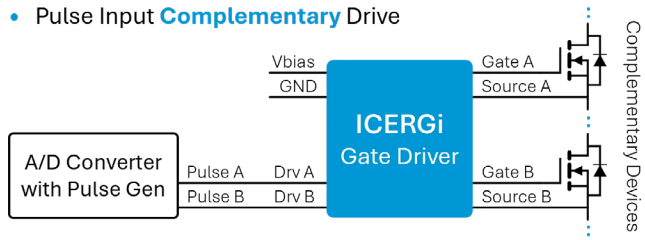


Figure 4: ICERGi Gate Driver Implementation Examples

Digital Control for Multilevel Converters

ICERGi specializes in advanced digital control of PFC converters, leveraging high-performance, cost-effective ARM® Cortex™-M0+ microcontrollers with rich peripheral sets and a mature development ecosystem. This platform provides a robust and efficient foundation for implementing precise, real-time control of PFC systems. Combined with ICERGi's proprietary control algorithms and scalable, low-cost hardware architecture, it enables compact, reliable, and high-efficiency power conversion across a wide range of applications.

Built on the proven ARM® Cortex™-M0+ processor, our solutions are typically implemented on compact, plug-and-play digital control daughter cards. These cards feature integrated gate drivers and auxiliary circuitry, forming a complete control and drive suite for power conversion systems. Designed for seamless integration, they support applications up to 5 kW and beyond. Proven in the field and backed by a robust development framework, ICERGi's controllers deliver exceptional efficiency, flexibility, and scalability across various PFC power levels.

- Enables 99.3% efficiency (*including EMI filter and bias supply*)
- Proven active and passive control techniques protect flying capacitor voltage under steady-state and transient conditions
- Proprietary fast and sophisticated protection for flying capacitor voltage during abrupt events, such as input surge
- Advanced predictive current control with intra-line-cycle compensation to enhance dynamic response and power quality across different operating conditions
- Implemented on the widely popular, low-cost Cortex M0+ processor, with seamless integration and upgrade options to more advanced MCU architectures (ARMv7-M, ARMv7E-M)

ICERGi Multilevel and its Advantages

Multilevel PFC improves power conversion by using multiple voltage levels to achieve lower total harmonic distortion (THD), reduced switching losses and improved electromagnetic interference (EMI). Compared to conventional two-level PFC, flying capacitor multilevel PFC distributes voltage stress more evenly across semiconductor

Feature / PFC	Conventional	Interleaved	Multilevel
Circuit Complexity	Low	Medium	Higher[1]
Efficiency	Moderate	High	Very High
Input Current Ripple	High	Low	Very Low
EMI	Moderate	Improved	Excellent
Thermal Distribution	Single Path	Spread	Distributed
Component Stress	High	Reduced	Much Lower
Control Complexity	Low	Medium	Higher[1]
Scalability	Limited	Good	Excellent
Size / Weight	Moderate	Larger	Compact

Table 1: PFC Topology Comparison

[1] Higher circuit/control complexity is managed by ICERGi's turnkey control and gate drive technology which enables practical adoption of multilevel PFC

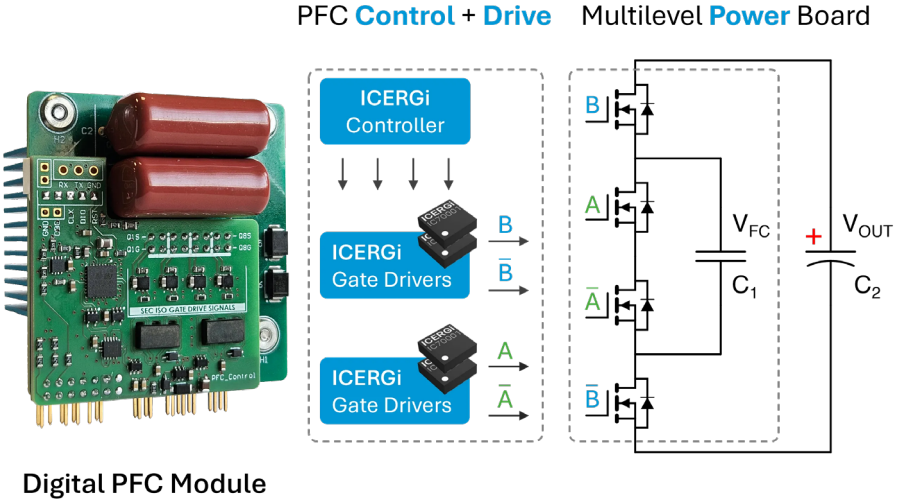


Figure 5: ICERGi's Digital PFC Module (Control + Drive + Power)

devices, enabling the use of lower voltage-rated components and boosting overall efficiency. Moreover, by supporting higher effective switching frequencies and improved waveform shaping, multilevel PFC can shrink passive components such as PFC main inductor and EMI filter stage leading to a more compact and thermally optimized power stage. For a more detailed comparison of PFC topologies, please see Table 1 below.

ICERGi has created a multilevel boost converter architecture that separates power and control functions for design flexibility. The solution uses a two-board layout: MOSFETs are located on the power board, while the gate driver array and digital microcontroller ecosystem sit on a daughter control board (Figure 5). This modular design simplifies integration, optimizes thermal performance, and allows for a compact layout. Supported by proprietary IP, ICERGi's multilevel approach is compatible with a wide range of Si and SiC switching devices. It enables broader adoption of multilevel power technologies and unlocking new value opportunities for high-efficiency, high-power AC/DC converter designers.

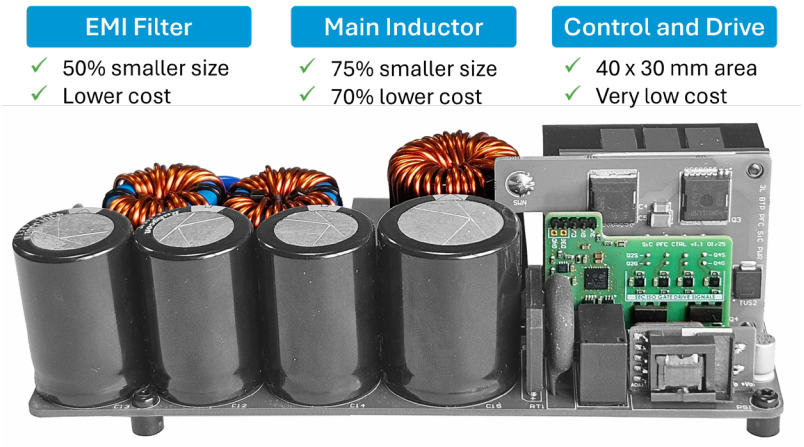


Figure 6: 3.3 kW 3L-FC-BTP-PFC Evaluation Board with 400 V SiC

Advancing Multilevel PFC with 400V CoolSiC™ MOSFETs

With the push for higher efficiency and power density in modern power electronics being driven by AI edge computing, advanced industrial loads, and next-generation applications there is growing demand for innovative solutions. At the forefront of this evolution, Infineon Technologies has launched CoolSiC™ Gen2 400V MOSFETs devices which are specifically optimized for multilevel PFC topologies. These new switching devices enable designers to achieve superior performance in power conversion systems, addressing the challenges of efficiency, thermal management, and reliability [7].

Building on this advancement, Infineon has also introduced multilevel PFC reference designs featuring their 400V CoolSiC devices. These designs leverage ICERGi's patented multilevel technology, combining Infineon's advanced semiconductor capabilities with ICERGi's expertise in high-performance AC/DC converters. ICERGi further highlighted these breakthroughs at APEC 2025 by introducing its own reference design (Figure 6, Figure 7) and sharing technical insights into performance and scalability [8].

- **Higher efficiency:** reduced switching and conduction losses
- **Lower system complexity:** simplified gate driver circuitry
- **Enhanced robustness:** higher blocking voltage capability
- **Higher power density:** more compact and scalable design

Key improvements compared to 150V stacked Si MOSFET variant

Conclusion

ICERGi has established a robust position in intellectual property and product ownership within the realm of multilevel power conversion which delivers unparalleled efficiency and cost-effectiveness for AI, industrial power, and EV charging applications. The recent introduction of advanced 400V SiC components by Infineon, combined with the adoption of ICERGi's patented technology in new power module developments by leading industry players, demonstrates the pivotal significance and future opportunity of ICERGi's IP and product ecosystem. These advancements not only validate ICERGi's approach but also highlight the transformative impact of achieving the highest efficiency at the lowest cost in power systems.

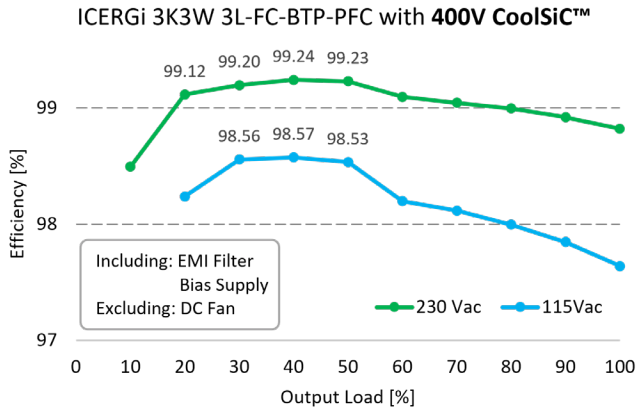


Figure 7: 3.3 kW Bridgeless Totem-Pole PFC Efficiency Data

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