# Getting 99%+ "Extreme Efficiency" with Silicon – an alternative to WBG Device Usage

## 1. Background

The capabilities of wide-bandgap devices have been well communicated. The inherent advantages of GaN and SiC materials relative to silicon have been clearly explained with charts of electron mobility, bulk resistance and other key material performance metrics.

## 2. Helping Silicon to Win

Silicon has the advantage of being a mature core technology with considerable development potential remaining. Silicon power devices are widely available from multiple sources, well qualified and characterised and well understood by users. And silicon can give "extreme efficiency" with an attractive flat plot as in Fig. 1.

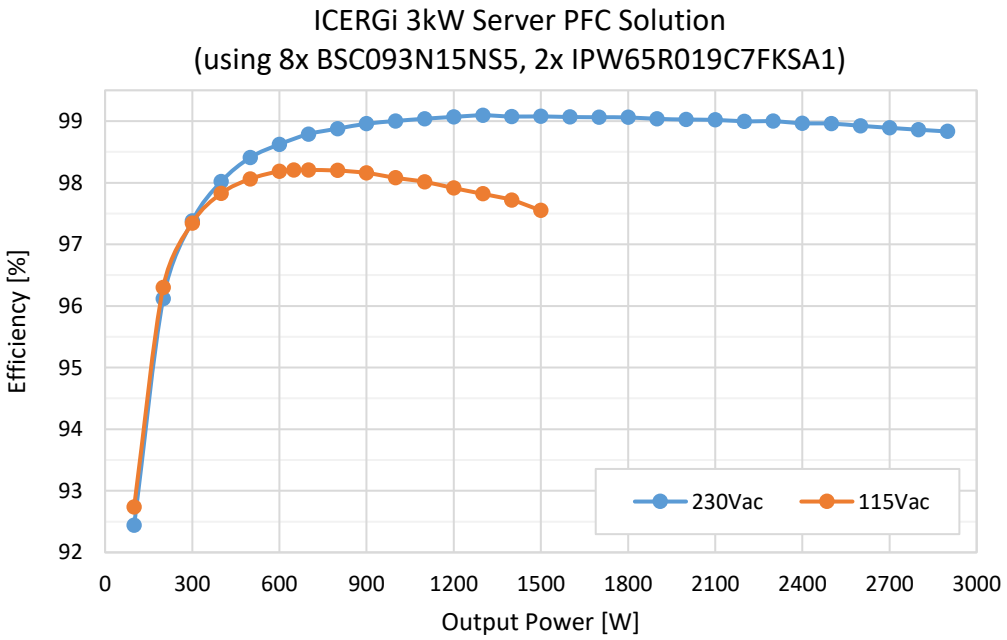


Fig. 1 "Extreme Efficiency" implementation in full-bridge totem pole with Si devices using ICERGi® drive and control components

Silicon competes well when a multilevel approach is used. This allows series "stacking" of lower voltage devices – typically 100V or 150V types. The superior "figures of merit" of lower voltage devices become relevant, with good Rdson – even when stacked – good Qrr, and acceptable capacitance values. 600V overall rating needs series stacking of 4x 150V types. There are many choices of device types here in the 9mR-20mR range, corresponding to 36mR to 80mR aggregate stacked values, and typically lower pricing for the multiple-device solution.

The advantage also is that low Qrr allows usage of these device arrays (with dIdt limiting as needed) in "totem-pole" approaches. This is conceptually the simplest form of "bridgeless" topology for power factor correction, requiring just one inductor. This totem-pole topology

is also well suited to “full bridge” approaches with line synchronous rectification for 99%+ “extreme efficiency”. Or, near-99% efficiency figures can be achieved with “half bridge” approaches using diodes or thyristors. Thyristors can give a particularly easy approach to inrush current management.

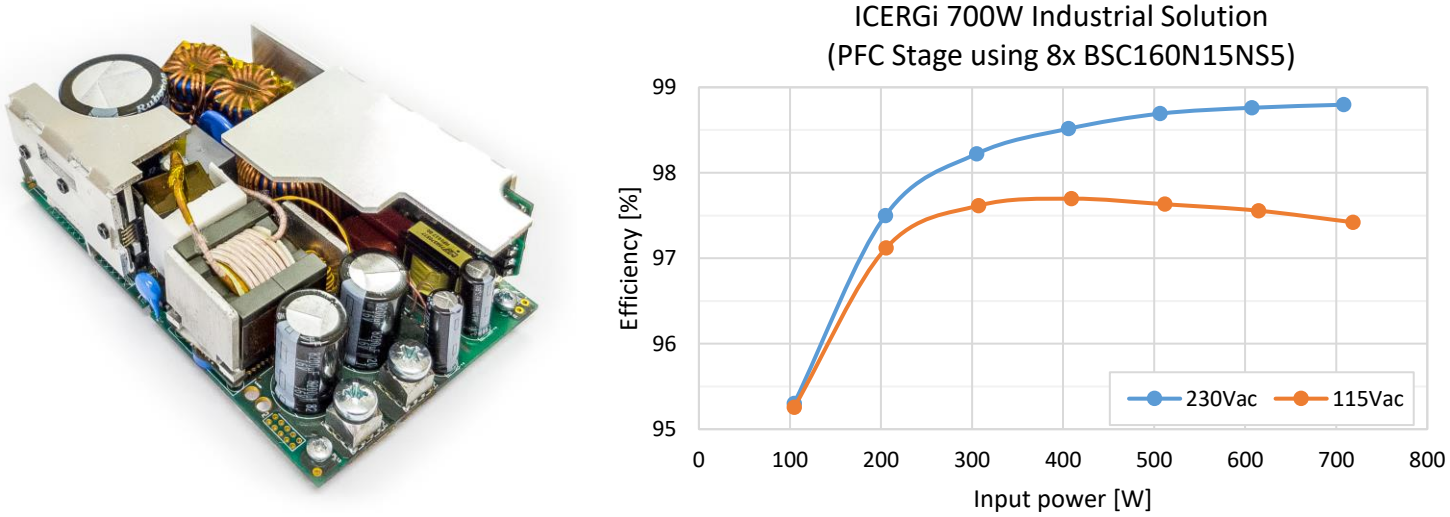


Fig. 2 700W industrial/medical solution in 3”x5” with half-bridge totem-pole topology using ICERGi® drivers and control (left); 700W PFC stage efficiency (right);

A multilevel approach also invites the option of phase-shifting drives, to give ripple-reduction benefits akin to those of interleaving, whilst retaining the “single inductor” approach, indeed with material reduction in inductor size giving a compact design. A three-level approach as in Fig. 3 may be preferred for simplicity and reduced flying capacitance as compared with a 5-level approach.

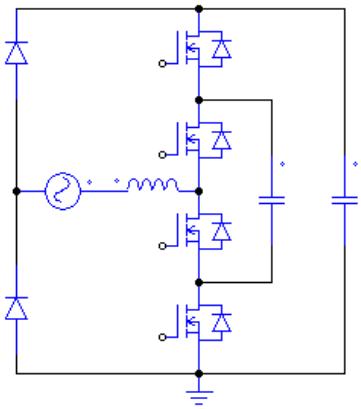

Fig. 3 3-level half-bridge totem-pole circuit for power factor correction, with 300V (usually composite) devices

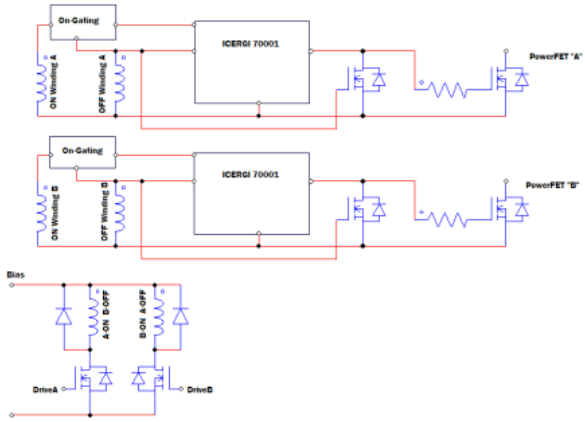


Fig. 4 Showing basis of ICERGi TruDrive™ drive technology, using custom device with miniature PCB-embedded magnetics.

## 3. Driving and Control

For this multilevel solution to be practical and affordable, the need is for low-cost, accurate drives. ICERGi has developed custom devices, working with miniature PCB-embedded magnetics, to meet this need and implement the "TruDrive™" functionality (illustrated in Fig. 4). ICERGi devices effect direct gate drive power transfer, without the need for a plethora of local power sources, thus reducing cost and avoiding common-mode complications associated with these power sources.

These drives work alongside controllers optimised for multilevel/multiphase operation, with again a requirement for low-cost operation, complete with excellent transient management, protection features and other aspects typically demanded of high-end PFC controllers. State machines on ARM Cortex™ M0 devices, initially the ST™ STM32F0 types, are programmed in low-level C.

## 4. Bigger Picture

The AC-DC market is one aspect of power conversion where multilevel technology is very relevant. ICERGi has proven high performance at 3kW, 700W and 200W power levels. DC-AC solutions and areas such as storage interfaces are already areas well served by multilevel technologies from leading vendors. ICERGi controllers and drivers here represent a unique opportunity for reducing cost – avoiding local powering – and enhancing drive precision in these deployments.

## 5. Summary

ICERGi driver and control solutions are proven and readily implemented, to give cost-effect solutions for wide ranges of AC-DC and DC-AC power conversion needs, using readily-available Si power devices.