Inverter Eval System Shows >99% Efficiency At 100 kHz With SiC MOSFETs

Pre-Switch's CleanWave200 inverter evaluation system exceeds 99.3% at 100 kHz using only three discrete, low-cost 35-mΩ SiC MOSFETs per switch location. According to the company, this capability will revolutionize EV and renewable energy designs.

The Pre-Switch AI enables users to migrate from lossy, expensive hard-switching implementations to high efficiency, soft-switching designs with a 10X higher switching frequency which produces an almost pure sine wave output. According to Pre-Switch, its controller is the only one in the industry being used to implement zero-voltage switching in an inverter application (Fig. 1).

The Pre-Switch controller analyzes multiple inputs on a cycle-by-cycle basis, making adjustments in real time to small, forced-resonant transistors enabling "perfect" soft-switching in harsh changing environments. Variations in system temperature, device degradation, changing input voltages and abrupt current swings are all accounted for and optimized within the Pre-Switch AI algorithm.

Using the company's AI-based control methods to implement soft switching in an inverter, the company claims to virtually eliminate switching losses, enabling a host of benefits. First, it enables the inverter to switch at higher switching frequencies without lowering efficiency, and the ability to generate pure sinewave outputs at higher switching frequencies, in turn, enables motors to operate more efficiently. It also allows use of lower cost, smaller lower inductance motors.

Secondly, the use of higher switching frequencies in the inverter, enables use of smaller passives and magnetics including the dc link capacitor and output filter (for grid-tied applications, not motor drives). Naturally, shrinking the passives allows cost savings.

However, an even more important cost savings is achieved by Pre-Switch's zero-voltage switching because it enables discrete (packaged) power transistors to share current as well as comparable transistor die in power modules. So in case of an EV traction inverter, in place of SiC MOSFET power modules, packaged, discrete SiC MOSFETs could be used with the latter costing about one half of the cost per die in a SiC power module.

However, Pre-Switch's switching methods also allow use of a SiC cascode (silicon MOSFET + SiC JFET) as the power switch and SiC cascode devices are less expensive than SiC MOSFETs. According to CEO Bruce Renouard, Pre-Switch is the only one who can use a SiC cascode in a dc-ac inverter application. (Fig. 2).

Comments Renouard, "We are shipping the CleanWave200 evaluation systems to initial customers around the world, and the efficiency data we are making public more than justifies our design goals. Customers could use the Pre-Switch technology with even better MOSFETs and expect to get incremental performance gains, but there is no other approach that even comes close to 99.3% efficiency at 100 kHz with so few, low-cost SIC MOSFETs." See Fig. 3.

The published data plots system efficiency for 50- to 100-kHz switching speeds, input voltages, power output and current output, enabling system designers to compare the Pre-Switch results to their own requirements. Adds Renouard: "Switching losses using our Pre-Switch technology are effectively zero. If we put that into perspective, an EV with Pre-Switch technology improves inverter efficiencies, producing a pure sine wave output that dramatically improves motor efficiency at low torques where people drive. This will result in an increase its range by up to 12%."

The Cleanwave200 evaluation system, reference design and design files can be ordered from Pre-Switch (Fig. 4). The company has the ability to offer its technology in different formats. It can adapt it reference design to customer-specific applications with NRE costs, providing either a board-level implementation of its controller for low-volume orders or a chip-level implementation for high-volume commitments (>100,000 units). For more information, see the company website or email Bruce Renouard.

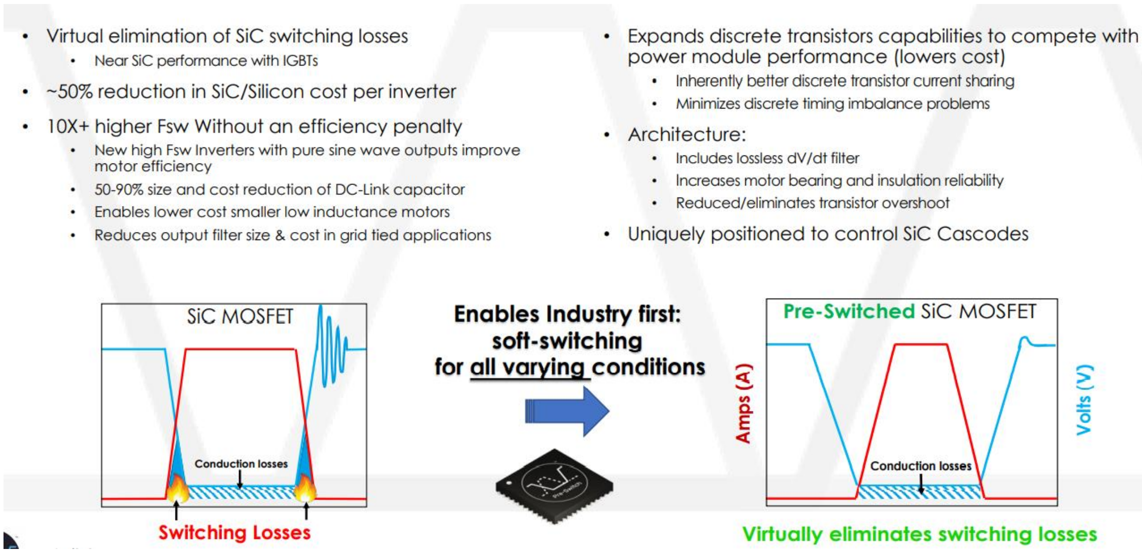


Fig. 1. The Pre-Switch AI-based controller enables users to migrate from lossy, expensive hard-switching implementations to high efficiency, soft-switching designs. By virtually eliminating switching losses, the AI-based zero-voltage switching enables a host of benefits through higher frequency switching including reduced motor losses, smaller magnetics and passives, and use of discrete SiC MOSFETs (or even SiC cascodes) in place of more-expensive SiC power modules.

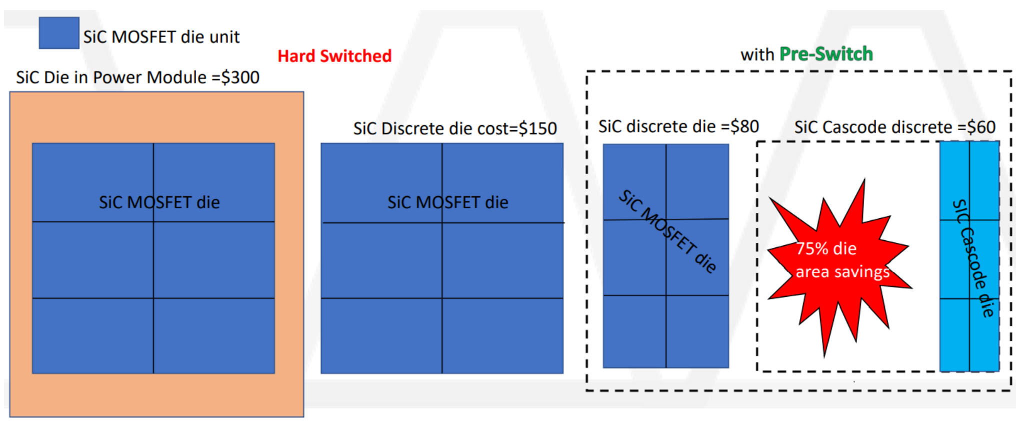


Fig. 2. By enabling inherently better current sharing with discrete transistors, Pre-Switch's AI-based ZVS enables inverters to be built using discrete SiC MOSFETs rather than the more expensive SiC power modules. The cost per die of SiC MOSFETs is half that of the same die when packaged in power modules. Even further savings can be achieved by using SiC cascodes as the power switches.

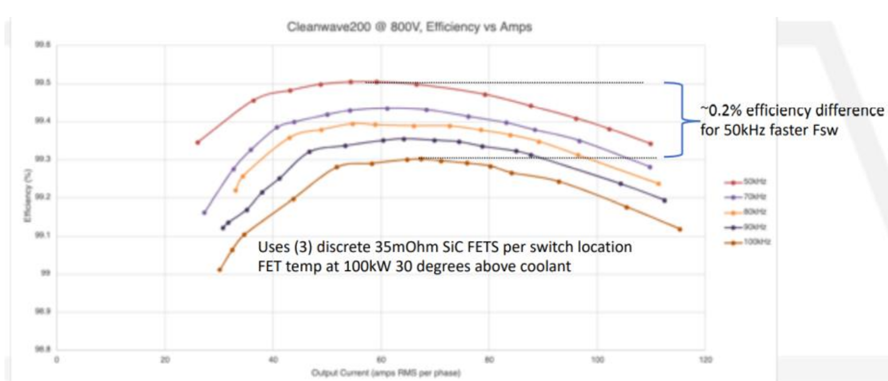
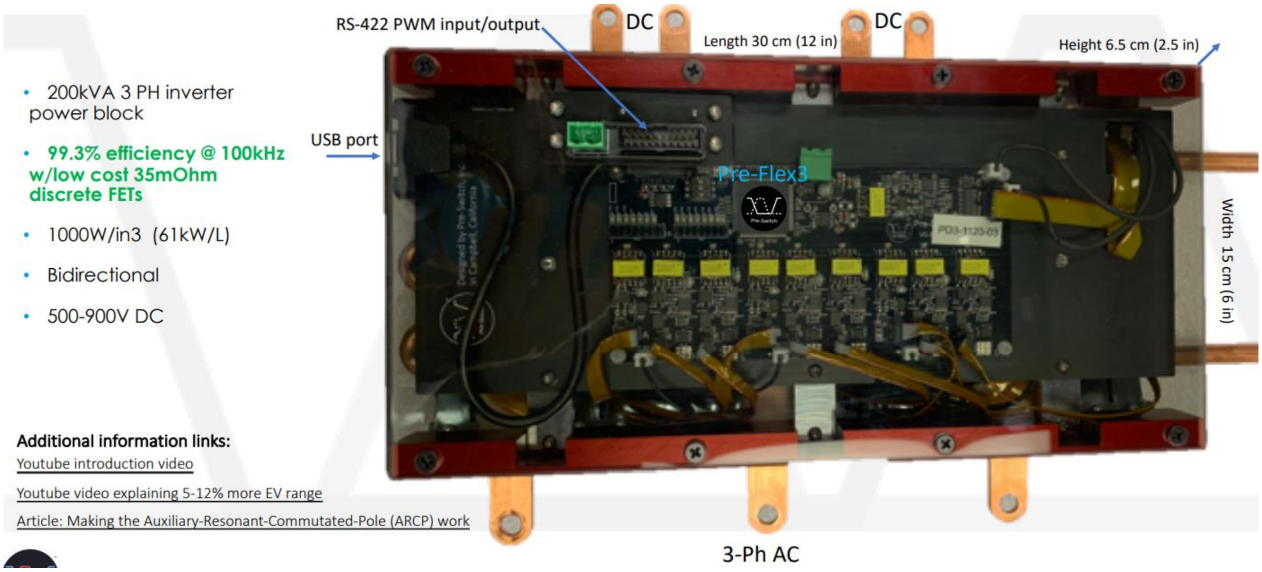
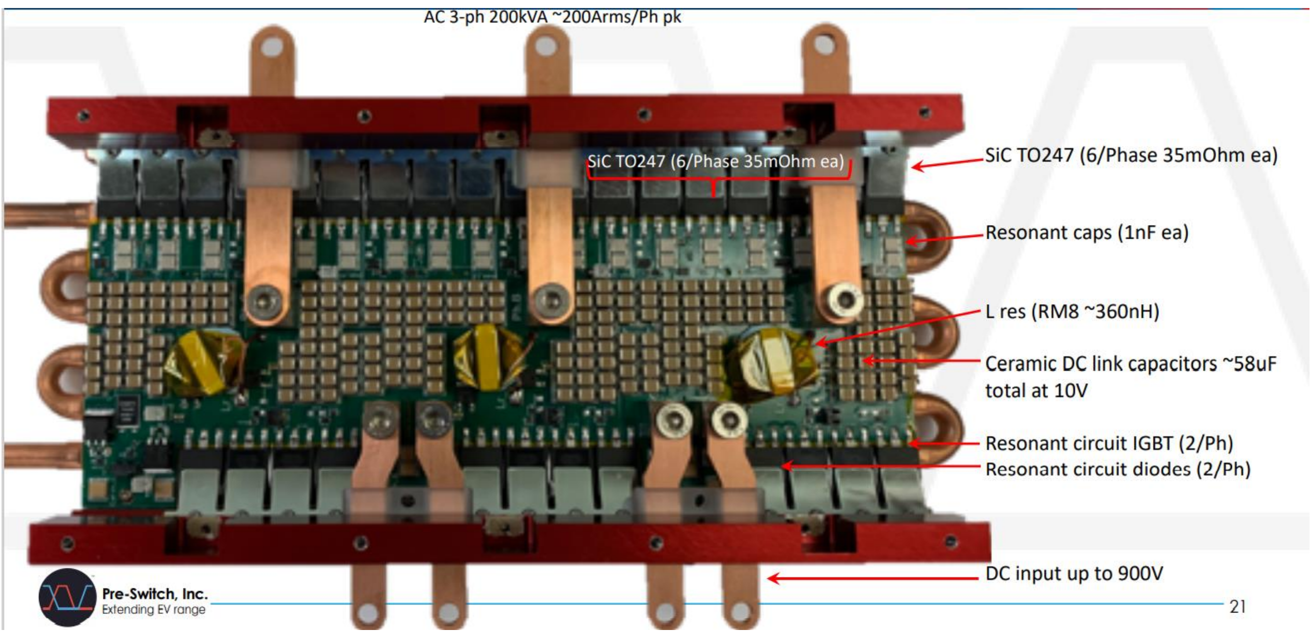


Fig. 3. The Cleanwave200 inverter evaluation system demonstrates that the company's AI-based ZVS achieves very high efficiency (99.3%) using only three 35-mΩ SiC FETs at 100 kW. Note how this represents only a 0.2% reduction in efficiency versus 50-kHz switching using the same design.



(a) The CleanWave evaluation system (top view).



(b) Closeup-of the CleanWave's RPGi subsystem

Fig. 4. The CleanWave inverter eval system allows customers to evaluate Pre-Switch's implementation of a soft-switching 200-kW dc-ac inverter that achieves high efficiency using just a few SiC FETs (cascode devices). This implementation is simply a proof of concept, suitable for customer evaluation. It's not suitable for use in production because its cabling produces EMI beyond the acceptable levels for compliance. However, the company is developing a sized reduced version that will eliminate the cabling and EMI issues, and therefore be production ready.