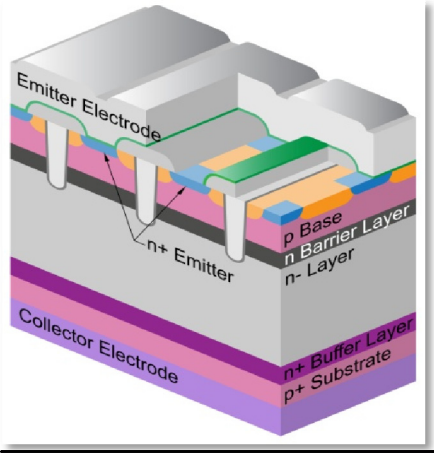
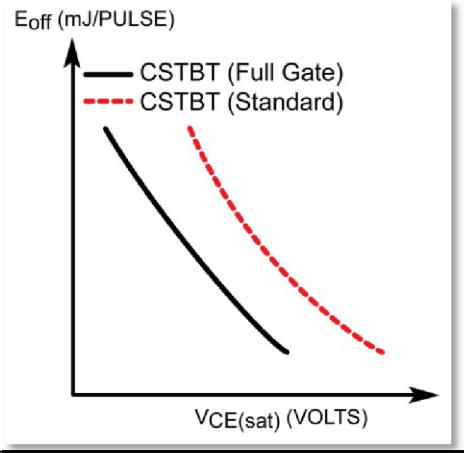
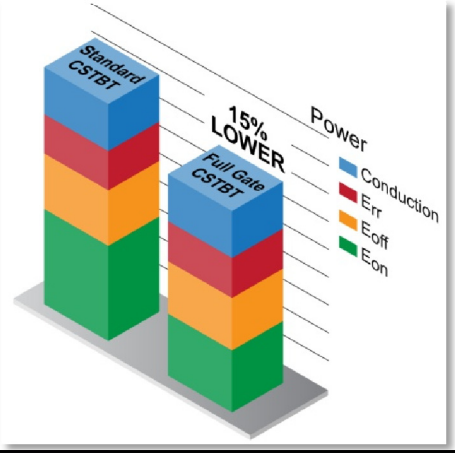
POWEREX Quick Study

Efficiency Benefits of Full Gate CSTBT™ in PV Applications







Executive Summary

- Full Gate CSTBT™ allows you to harvest more energy than competing technologies.
- Powerex Intelligent Power Modules include gate drivers that are optimized for Full Gate CSTBT.

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Characterization Of 1200V CSTBT Optimized for Industrial Applications
(Key Word 870)

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Mitsubishi Power Module Loss Simulator available at www.pwrx.com/home.aspx

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There are two major reasons that consumers of PV inverters focus on efficiency. First, having low power losses is a measure of the "green-ness" of a particular technology. Second, there is a real economic benefit to harvesting more of the available energy.

The power semiconductors used in the inverter play a key role in the overall system efficiency. There are two ways in which semiconductors, like IGBTs, differ from an ideal switch:

1) Conduction losses, and
2) Switching losses.

The idea is not to simply trade off one for the other, but rather to find innovative ways to reduce both.

Conduction Losses – The conduction losses of an IGBT occur when it is turned on. The figure that is typically used to characterize conduction losses is the saturation voltage, or $V_{CE(sat)}$. The non-ideal power that is lost in the on-state is equal to the output current multiplied by the saturation voltage.

Switching Losses – The switching losses of an IGBT are actually a collection of different types of losses. These are generally categorized as turn-on energy (E_{on}), turn-off energy (E_{off}), and diode reverse recovery energy (E_{rr}).

The non-ideal power that is lost due to switching is equal to the switching frequency multiplied by the sum of the energies. Carrier Stored Trench-gate Bipolar Transistor (CSTBT) technology was introduced to provide a rugged semiconductor that also reduced overall power losses. The unique feature of CSTBT is the "carrier stored" layer that consists of n-type semiconductor material. The carrier stored layer helps to prevent holes that are injected from the collector from penetrating into the emitter. This increases the hole density in the n- layer, which helps to lower the on-state (conduction) losses.

Full Gate CSTBT increases the cell density, which both allows the IGBT to have lower on-state losses and reduces the drain to source capacitance. To take full advantage of this technology requires careful design of the IGBT drive circuit, in order to ensure oscillation-free short-circuit withstand capability. That is why Powerex Intelligent Power Modules include optimized gate drive ICs that are designed for operation with Full Gate CSTBT.

The result is better than a simple trade-off between conduction and switching losses. Full Gate CSTBT moves the marketplace another step closer to the ideal switch.