

Advanced Synchronous Reverse Blocking



Reduction of Switching Losses

Advanced Synchronous Reverse Blocking (A-SRB™)¹ is a new Toshiba circuit technology that dramatically reduces switching losses in bridge circuits such as inverters, DC/DC converters or PFC. In order to improve efficiency, there is a trend of making use of transistors based on wide bandgap materials such as Gallium Nitride (GaN) or Silicon Carbide (SiC). However, the costs of such technologies remain considerably higher than for Silicon (Si) based components. For a cost-effective system, innovations in circuit design are therefore required to achieve the maximum possible efficiency when using today's silicon-based components. Toshiba now offers a 4kW H-Bridge evaluation board for easily testing the A-SRB™ technology within a customer system environment.

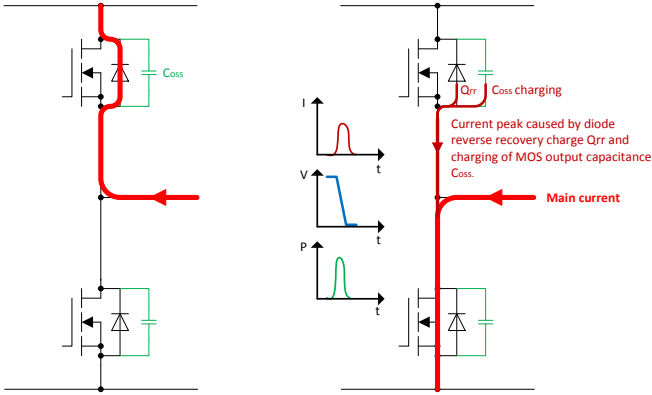
Application

- Renewable energy
- Power supplies
- Uninterruptible Power Supply (UPS)
- Electrical drives

Features	Advantages	Benefits
<ul style="list-style-type: none"> • Circuit technology for reducing switching losses in bridge circuits • Switch transistors are replaced by a new circuit topology which is controlled by a smart driver IC in a way that reverse recovery losses and charging losses are eliminated • The technology can be utilized for power levels up to 6kW • A new evaluation system is available for testing A-SRB™ on customer side 	<ul style="list-style-type: none"> • The reduction of switching losses leads to a significantly increased system efficiency • Reduced switching losses allow less cooling effort and operation with higher switching frequency, leading to smaller passive components • The very flexible technology can be utilized for a wide range of power levels and for several different applications • Simplified PCB manufacturing and reduced PCB footprint • Testing of the new technology and the design-in process are simplified 	<ul style="list-style-type: none"> • Energy savings can lead to significant life cycle cost reduction • Increased product competitiveness • Increased power density and system cost reduction due to smaller passive components and less cooling effort • A-SRB™ enables simultaneous improvement of multiple parameters (e.g. switching frequency and efficiency) • Reduced development cost and faster time to market are supported by an evaluation system

¹Toshiba Corporation Energy Systems & Solutions Company, 2016. Semiconductor switch and power conversion apparatus. Europäische Patentschrift EP 2 600 527 B1. 03.02.2016

Switching losses

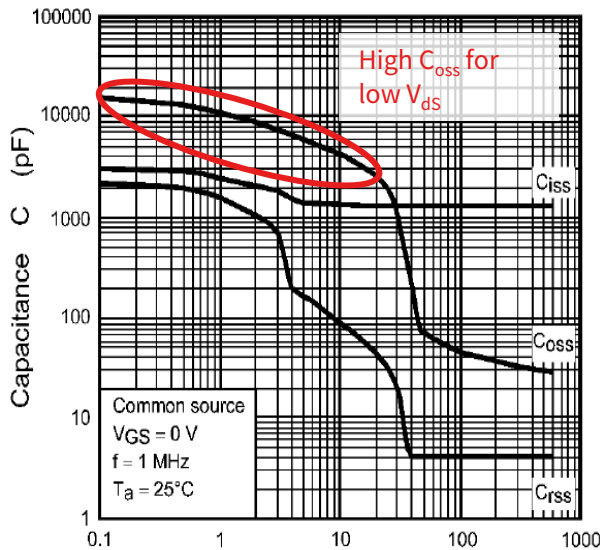


Origin of switching losses

The switching losses occurring in a half bridge are determined by two loss mechanisms.

Firstly, the reverse recovery charge (Q_{rr}) causing a peak current in the currently activated and conducting switching transistor. Secondly, the charging current peak flowing when the blocking switching transistor's output capacitance (C_{oss}) is being reloaded.

A-SRB™ Operation principle

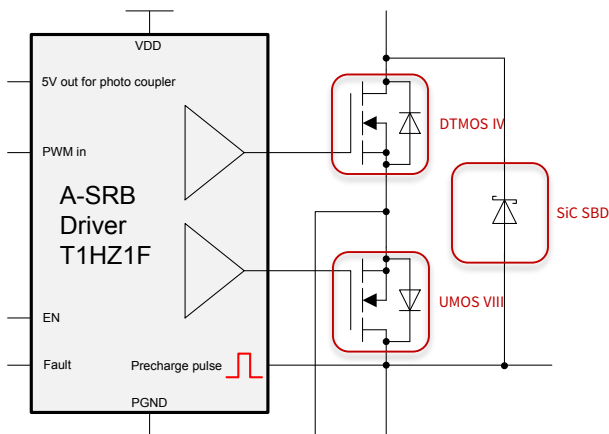


Background

As an example, we review the commutation of the current flow according to the upper diagram.

- C_{oss} is strongly voltage dependent.
- The charging current flows mainly for low high-side Drain-Source Voltage (V_{ds}).
- To avoid high turn-on losses in the low-side switch, a pre-charging of the high-side switch C_{oss} with a low voltage is done.
- Pre-charging is realized by a charge pump inside the gate driver IC.
- The effect of Q_{rr} is eliminated by an auxiliary series switch which blocks the reverse current, and a high performance SiC SBD, which takes over the reverse current.

A-SRB™ Key components



Key components

The main switch is realized by a high voltage DT MOS IV device with low $R_{DS(on)}$ (e.g. 650V type).

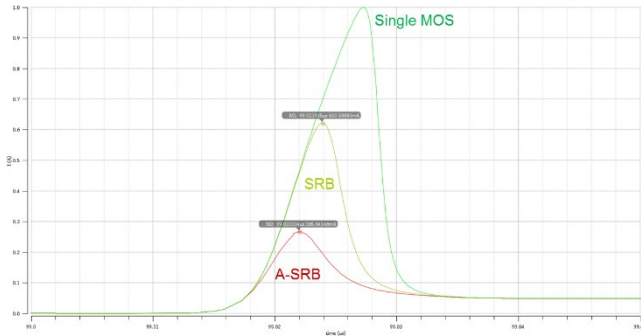
A SiC Schottky diode with extremely low reverse recovery charge takes over the reverse current.

The auxiliary switch for blocking the reverse current is realized by a low voltage UMOS VIII device with low $R_{DS(on)}$ (e.g. 60V type).

The smart driver IC T1HZ1F generates all necessary control signals, including the pre-charge pulse, from a simple Pulse-Width Modulation (PWM) signal.

Each half-bridge switching device is replaced by the topology shown on the left.

A-SRB™ Performance



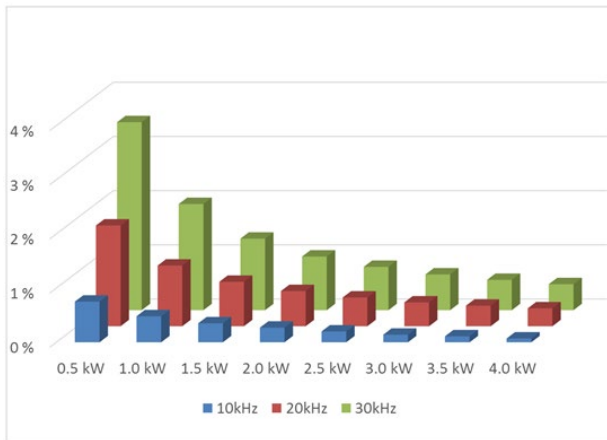
Simulated turn-on peak current reduction

The current peak is drastically reduced by the utilization of A-SRB™ resulting in reduced switching losses.

Single MOS: Half bridge configuration as shown on the previous page.

SRB: Synchronous Reverse Blocking. The reverse current is blocked as shown in the image “A-SRB™ Key Components”, but pre-charging is not yet included.

A-SRB™: Advanced Synchronous Reverse Blocking. The functionality of SRB in combination with pre-charging.

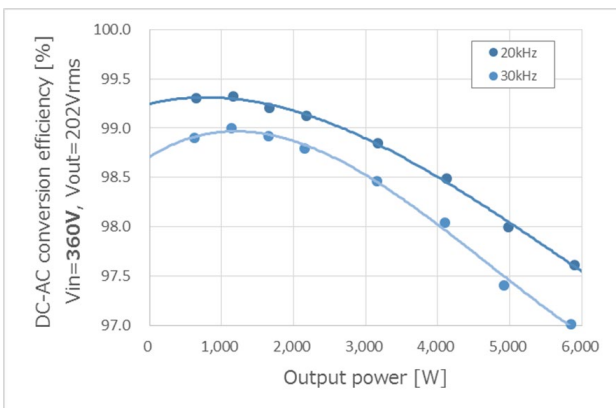


Simulated inverter efficiency improvement

Simulated efficiency improvement for the example of an H4 inverter utilizing A-SRB™.

Conditions:

- Bipolar modulation, 360V DC rail voltage, 202V AC grid voltage, TK62N60W switching device.
- Depending on switching frequency and output power, inverter efficiency is improved by up to 3.5% for this application example.



Measured inverter efficiency

Measured efficiency for the example of an H4 inverter utilizing A-SRB™.

Conditions:

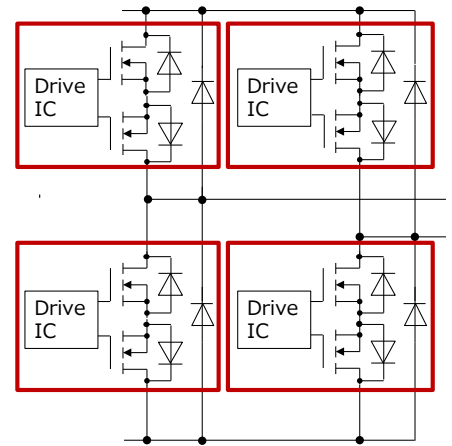
- Bipolar modulation, 360V DC rail voltage, 202V AC grid voltage, TK62N60W switching device.
- The maximum efficiency of 99.3% is achieved for an output power of about 1 kW.

Options for A-SRB™ implementation

Depending on the required power rating, the power converter providing the A-SRB™ functionality can be realized utilizing three different device kits. A device kit contains a full set of components for replacing a standard switching device, including gate driver and power devices.

	Kit 1	Kit 2	Kit 3
Main switch (DTMOS)	TK100L60W (18mΩ)	TK62N60W (40mΩ)	TK39N60W (65mΩ)
Aux switch (UMOS)	TPH1R306PL (1.3mΩ)	TPH1R306PL (1.3mΩ)	TPH1R306PL (1.3mΩ)
SiC SBD	TRS12E65F	TRS12E65F	TRS6E65F
Driver IC	T1HZ1F	T1HZ1F	T1HZ1F

Inverter circuit utilizing 4 x full set of components, including T1HZ1F gate driver IC's, DTMOS, LV MOS, SiC SBD



New A-SRB™ evaluation kit



4KW A-SRB™ evaluation kit

Toshiba now offers an A-SRB™ evaluation kit that includes all necessary mechanical and electrical parts for building up an A-SRB™ H-Bridge.

The three PCB's include power devices and gate drivers as well as photo couplers and dedicated power supplies for low-side and high-side drivers.

The evaluation system can be easily operated by applying the necessary voltages and pwm signals for controlling the switches.

The kit can be utilized for evaluating the performance of A-SRB™ for different power conversion applications, such as H4 inverter, Totem Pole PFC, DCDC converter.