



Analysis of Over-Current Withstand Capability of Discrete SiC MOSFETs for Interrupting MOV Paths in Solid-State Circuit Breakers

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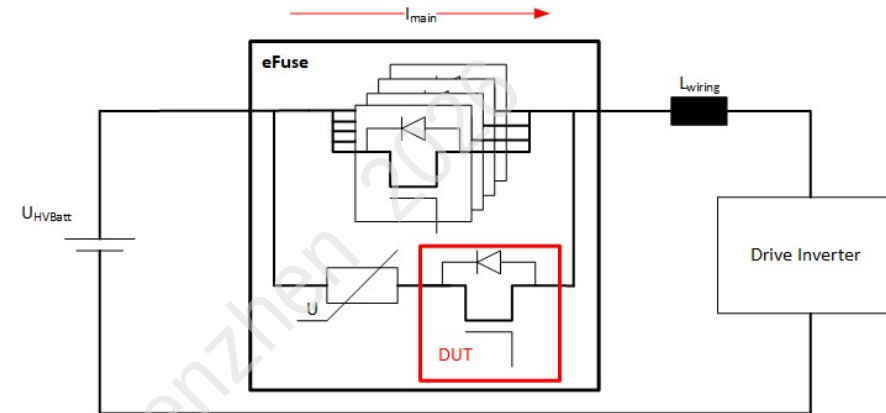


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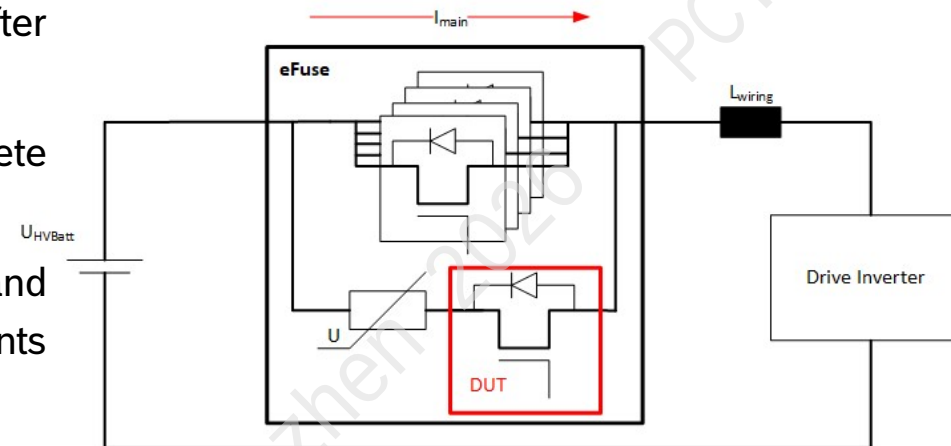
Introduction

- Solid-State Circuit Breakers (SSCBs) integrated into a Battery Disconnect Unit (BDU) offer significant advantages, including microsecond-fast interruption of fault currents, reusability, and enhanced system serviceability.
- Metal Oxide Varistors (MOVs) are essential for clamping overvoltage's. However, to prevent the MOV from thermal runaway and failure after clearing a fault, its current path must be reliably interrupted to avoid leakage currents.
- While the MOV is critical for overvoltage protection, its own long-term reliability and potential for degradation present another challenge. High leakage currents due to a battery voltage of 850 V, especially at elevated temperatures or after numerous switching events, can lead to thermal runaway and catastrophic failure of the MOV itself.



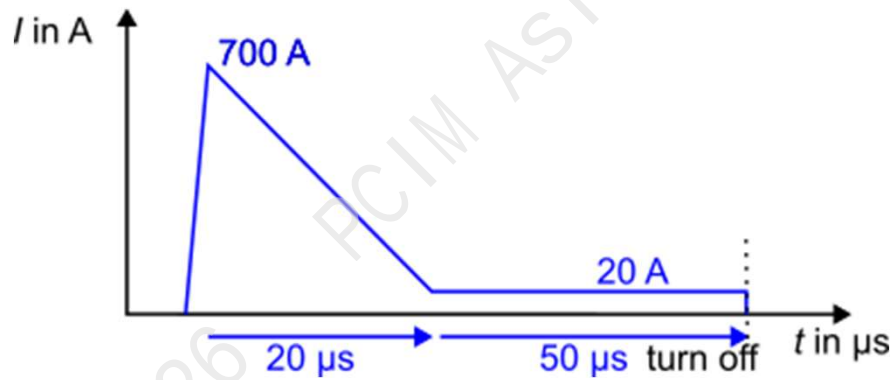
Introduction

- To mitigate this failure mode, a discrete SiC MOSFET is utilized in series with the MOV to isolate it from the circuit after the transient energy has been dissipated.
- This work presents an investigation into the use of discrete Silicon Carbide (SiC) MOSFETs to perform this interruption.
- The study focuses on quantifying the over-current withstand capability of these devices when exposed to the surge currents from the MOV commutation path.
- A characterization setup was developed to evaluate the ruggedness for these operating conditions and analyze the degradation/destruction mechanisms.

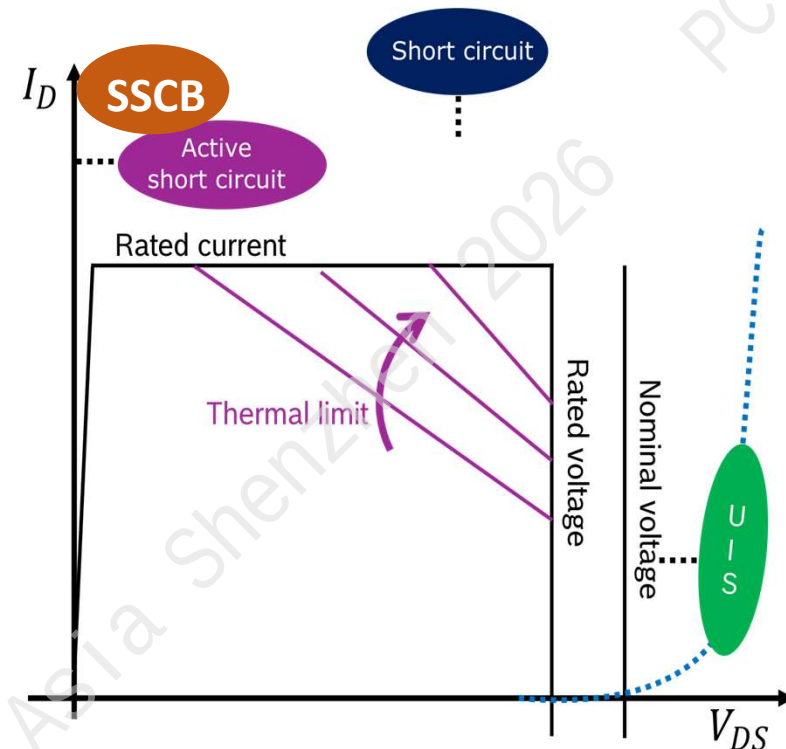


MOV Switch Stress Profile

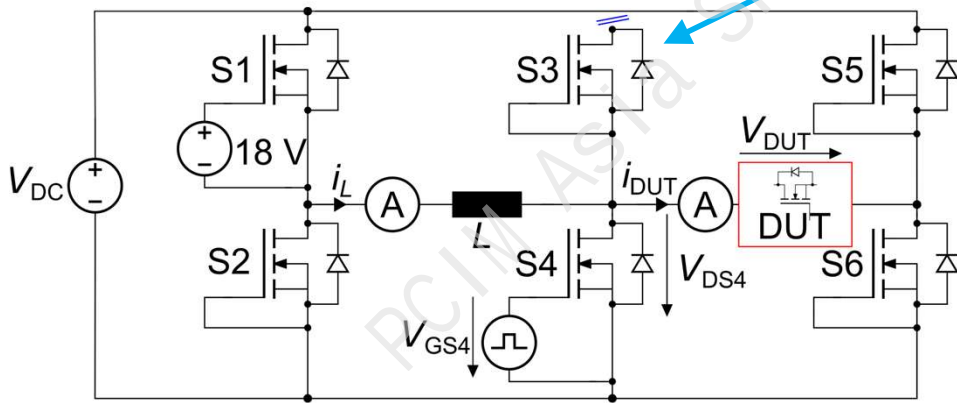
- Current through DUT during interruption



- Safe operating area (SOA) with special operating conditions

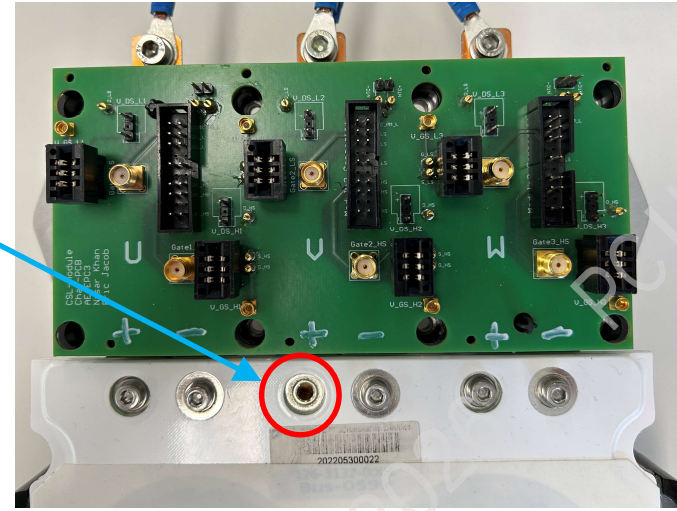


Characterization Setup Topology

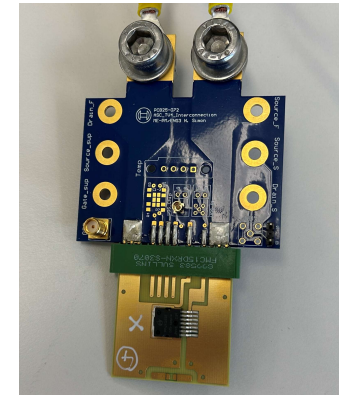


Topology based on B6 power module

S3 disconnected



$\sim 4 \mu\text{H}$

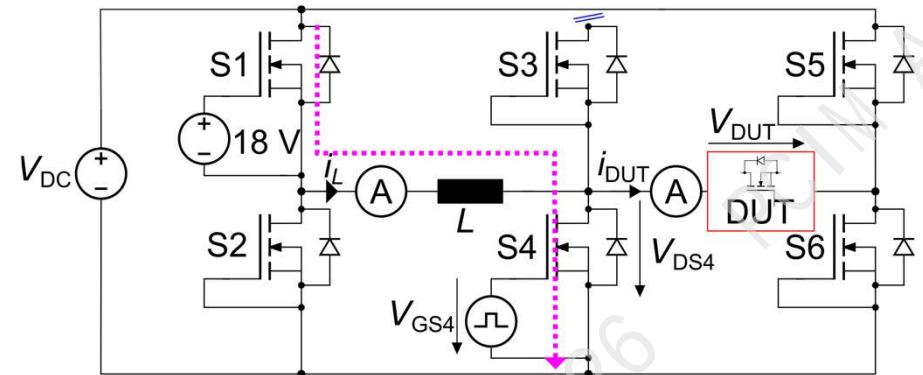


DUT

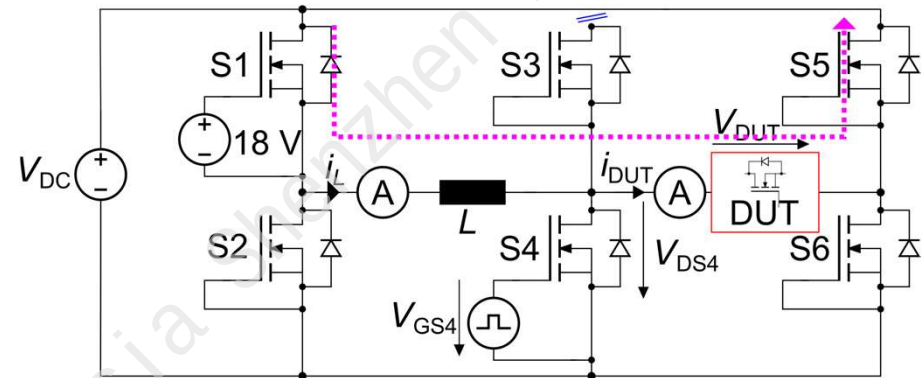
Characterization Setup

Working Principal

Switch	Charging	Testing
S1	on	on
S2	off	off
S3	disconnected	disconnected
S4	on	off
S5	off	off
S6	off	off
DUT	on	on



Charging time

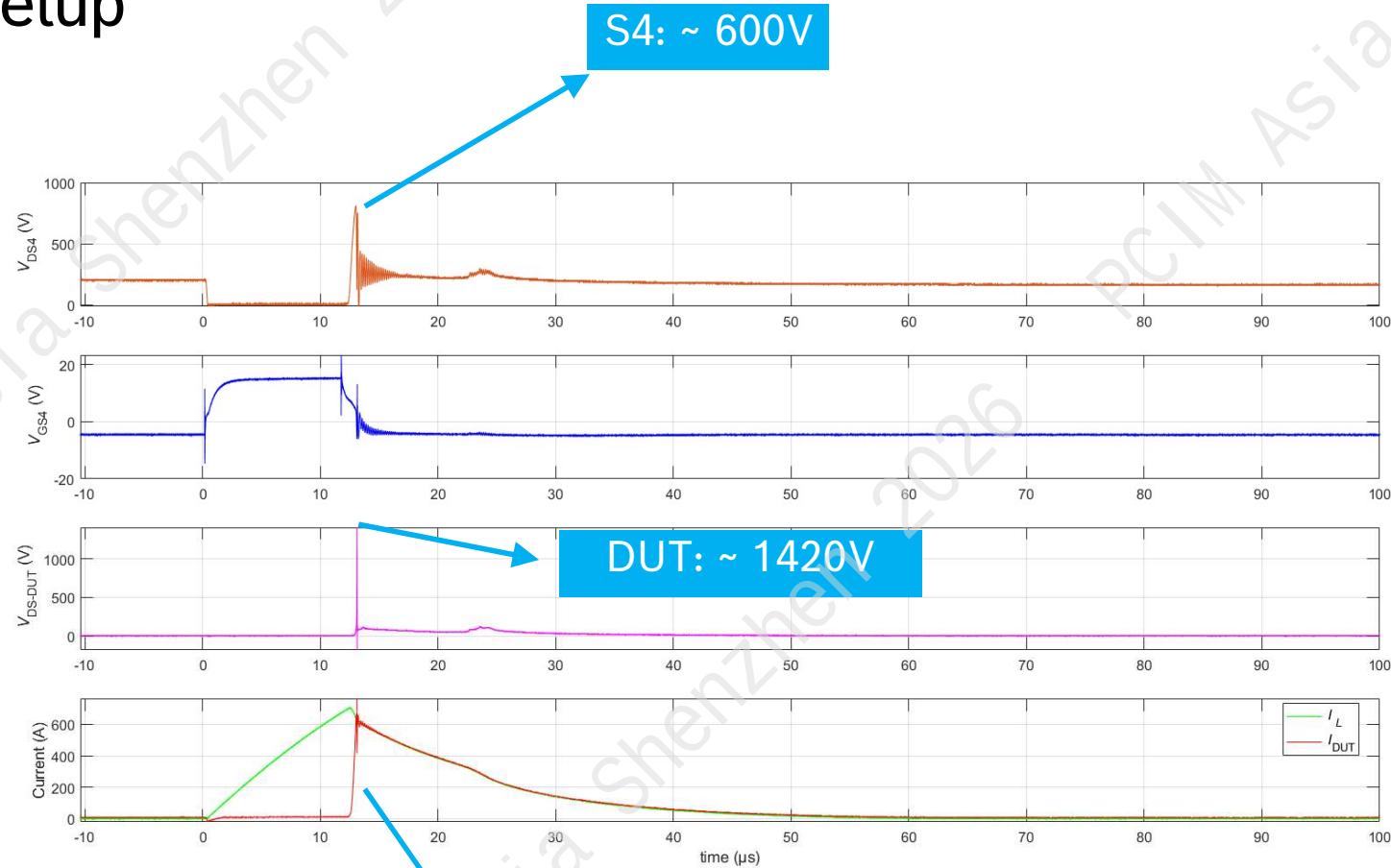


Testing time

Implementation of Setup

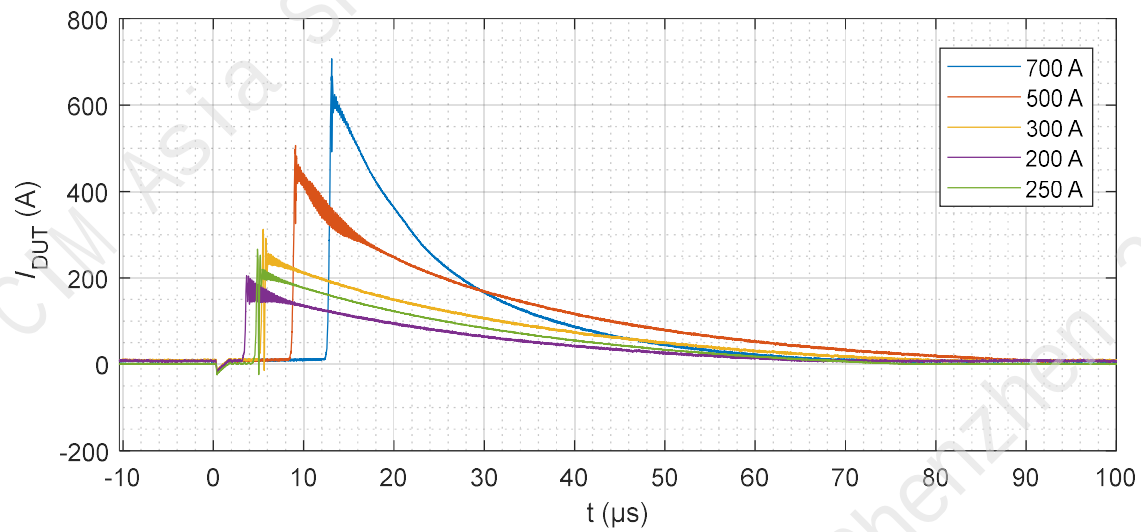
Waveforms

- Key control parameter:
Turn on duration S4 in phase 2
- Vdc: 200V



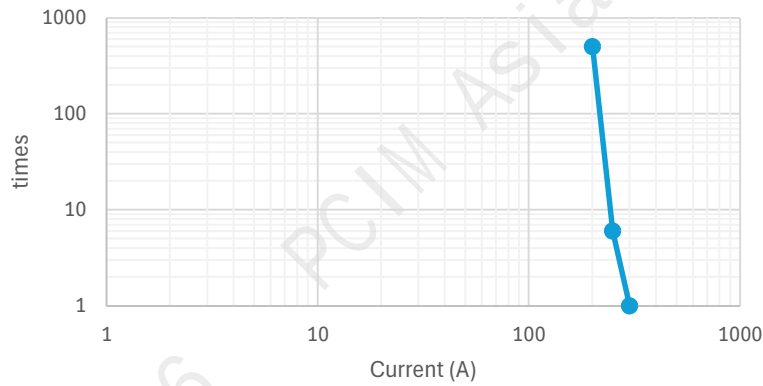
Implementation of Setup

Variation of Charging Time

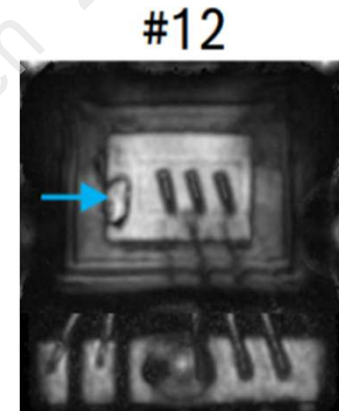


Results

SOA Curve SiC in SSCB



Current	#Events
700 A	0
500 A	0
300 A	3
250 A	6
200 A	Tested up to 500 Pulses



Summary

- A dedicated characterization setup based on a B6 bridge module was developed to characterize the SiC MOSFETs capability with this specific load profile.
- This setup allows for precise quantification of the overcurrent withstand capability when exposed to the surge currents from MOV commutation paths, providing insights into the SiC MOSFETs ruggedness and degradation mechanisms.
- This work significantly contributes to the development of highly reliable SSCBs by validating SiC MOSFETs as a robust solution for this protection function.