A High Efficiency 750 V/ 100 A Cryogenically Cooled Solid State Circuit Breaker Module for Aviation Applications

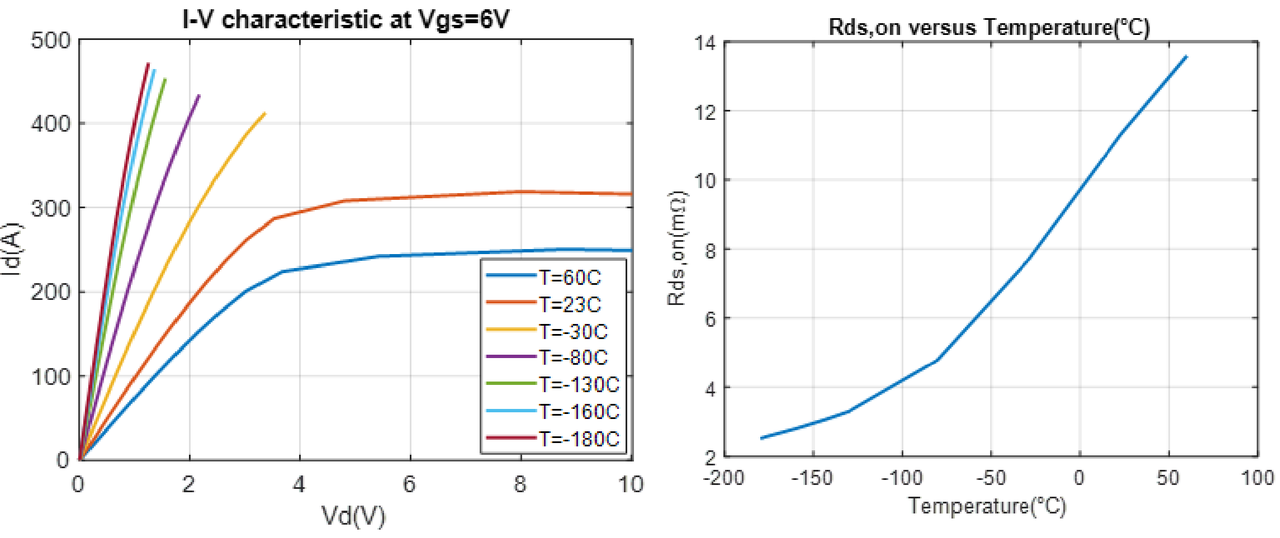
Ching-Hsiang Yang[1], Shimul K. Dam[1] , Zhou Dong[2] , Dehao Qin[3], Ruirui Chen[1], Fred Wang[1,4], Hua Bai[1], Zheyu Zhang[3]
[1]CURENT, University of Tennessee Knoxville, [2]ABB. Inc., [3]Clemson University, [4]Oak Ridge National Laboratory

INTRODUCTION

- The cryogenic cooling in the future Electrified Aircraft Propulsion (EAP) system help reduce the loss and increase the power density of the power electronics systems.
- Solid state circuit breaker (SSCB) has advantages of fast current interruption, size and weight reduction, and providing additional functions, but offers lower efficiency.
- A cryogenically cooled GaN-HEMT based SSCB module is proposed, which can achieve higher than 99.9% efficiency and high over-current interruption capability.

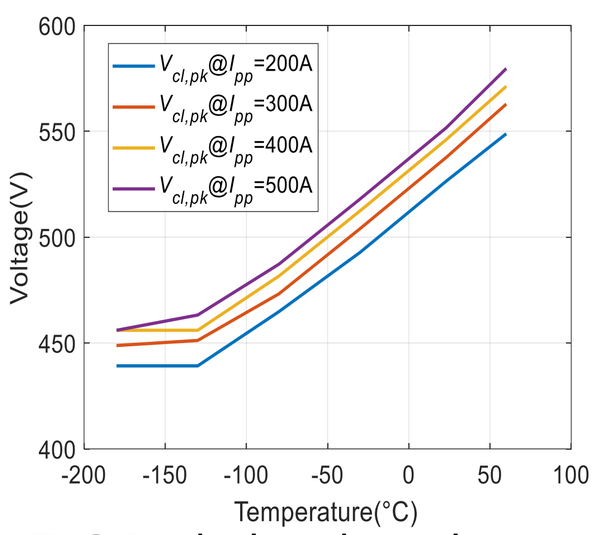
MAIN COMPONENTS SELECTION

- GaN HEMTs at cryogenic temperature:
  - ✓About 5x on-resistance reduction
  - ✓Allow higher current without any saturation

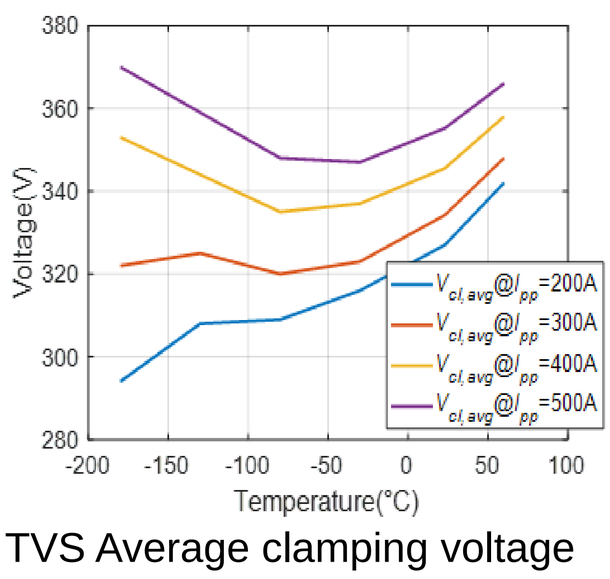


Characteristics of GS-065-150.

- TVS diode at cryogenic temperature:
  - ✓Lower peak clamping voltage
  - ✓Higher average clamping voltage
  - ✓Reduced clamping ratio



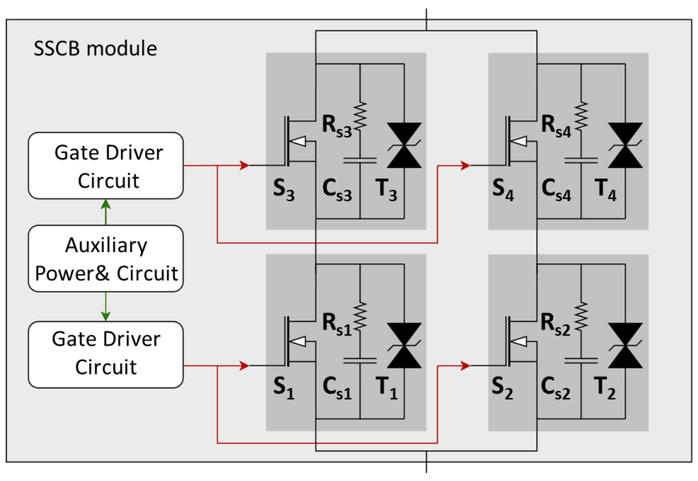
TVS Peak clamping voltage



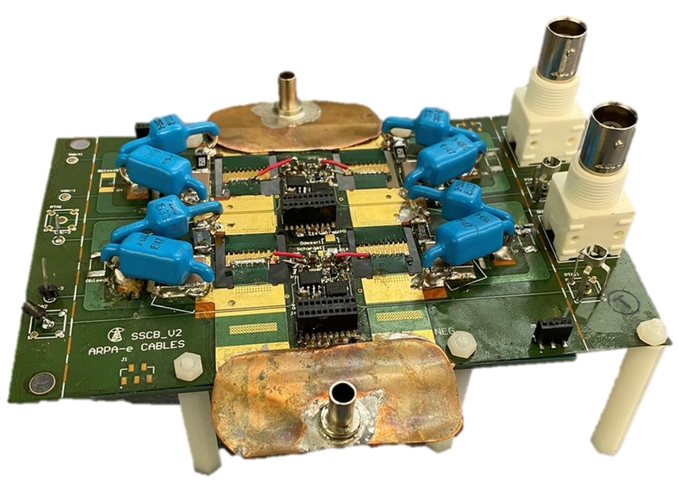
TVS Average clamping voltage

SSCB MODULE DESIGN

- Module ratings: 750V/100A
- Module design key points
  - ✓Cell design to minimized the gate-loop and power-loop inductance
  - ✓TVS diodes in “V-shape” eliminates the extra traces on the PCB to prevent additional stray inductance.



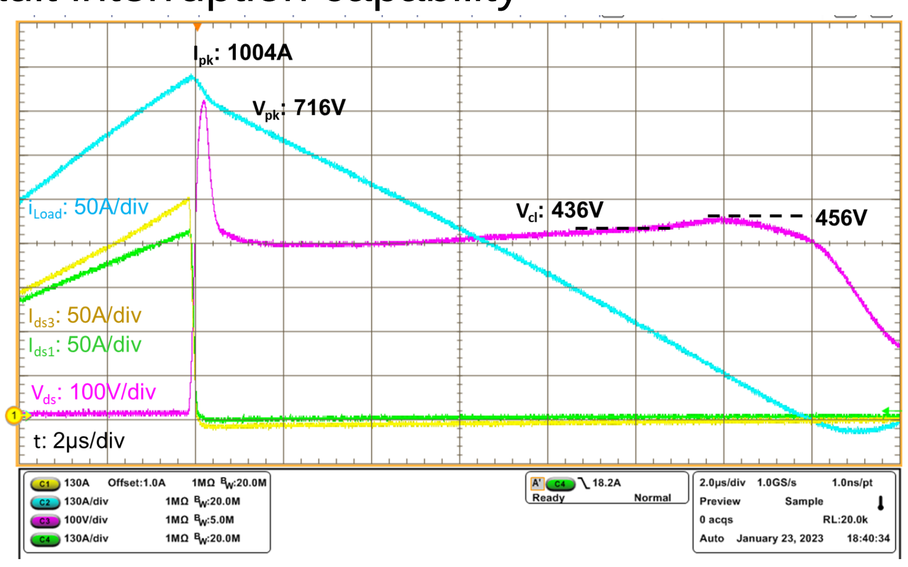
Schematics of SSCB



Designed SSCB module

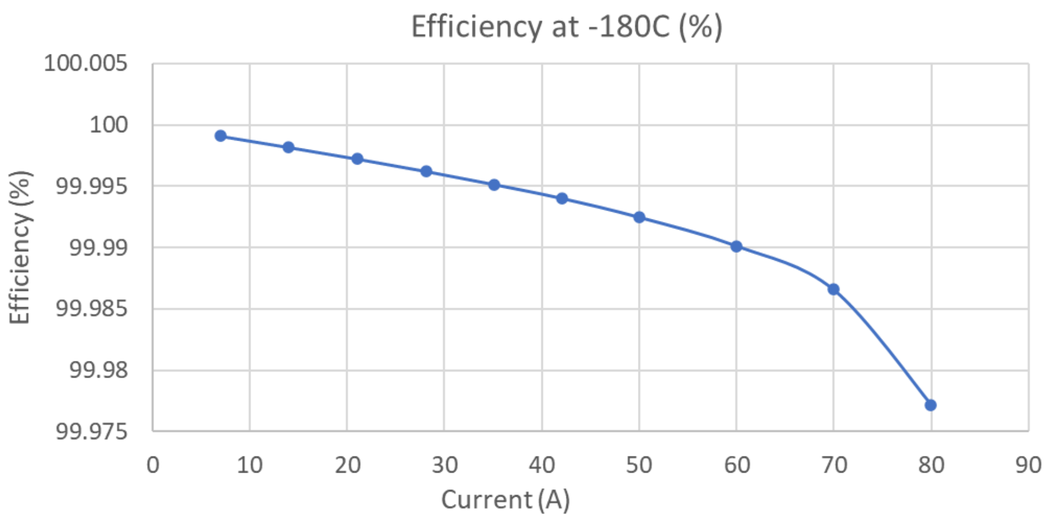
EXPERIMENT RESULTS

- Fault interruption capability



Designed SSCB module interrupt 10x, 1kA at -180°C

- High efficiency



Designed SSCB efficiency at -180°C

CONSLUSION

- A GaN-based cryogenically cooled 750 V/ 100 A SSCB module is proposed based on components characteristics at cryogenic temperature and specification requirements.
- Experimental results validated the capability of the proposed SSCB to interrupt up to 10x (1kA) fault current.
- The measured efficiency is >99.9% up to 80 A for the prototype SSCB module.

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