Solid State Switch for 3kVDC Railways Applications

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Introduction

Train heating systems require to connect heating resistor to the catenary with a high voltage switch. Over the last decades, electro-mechanical contactors such as HsB from Sécheron SA have been used for this task. Because an arc is created at each breaking, and the number of daily operations is high, aggressive chemical created in the process cause wearing to the contactor and surroundings.

Arc-free solutions are needed to overcome this problem. At lower voltage up to 1.5kV solid state switches have gradually replaced these devices. But no simple system exist at 3kV/8A, provided that high voltage IGBT modules are rated for much greater current and their cost is too high.

The GOAL of this project is to DEVELOP a SOLID STATE SWITCH of limited cost respecting these specific requirements:
- Nominal Traction Voltage: 3kV
- Nominal Control Voltage: 24V to 110V
- Nominal Current: 8A
- Switching cycle: 20s
- Line Inductance: Max 5mH
- Min. lifetime 10M operations
- Overvoltage Category: OV3
- Pollution degree: PD3A
- Ambient temperature: -40°C to 85°C
- Able to be mounted on earth potential

Architecture of the switch

Resonant wireless power transfer (WPT) system provides the supply to the switch circuit through the 45mm of air needed to isolate high and low voltage sides. Switch itself is a multilevel cascode configuration of six 1.2kV SiC MOSFET in series able to withstand the total line voltage and inductive overvoltage at breaking.

Prototype is realized on 3 PCB boards:
1 for the low voltage part,
2 for the high voltage part & the switch itself.

Tests Results

PASS
- WPT steady supply at a working distance of 46mm between coils centres
- Nominal 3kV and maximum voltage 4.2kV operation
- Nominal current 8A switching
- High line inductance switching > 100mH
- Resistive load switching
- Endurance test over 100k operations
- High voltage insulation tests 48kV pulse and 30kV, AC
- Climatic tests from -40°C to 85°C
- EMC emissions and immunity

Conclusion & Perspectives

System design, realization and tests are a success and fulfil all the requirements.
Next step is to work towards commercial product and extend the applications to other fields of HVDC.