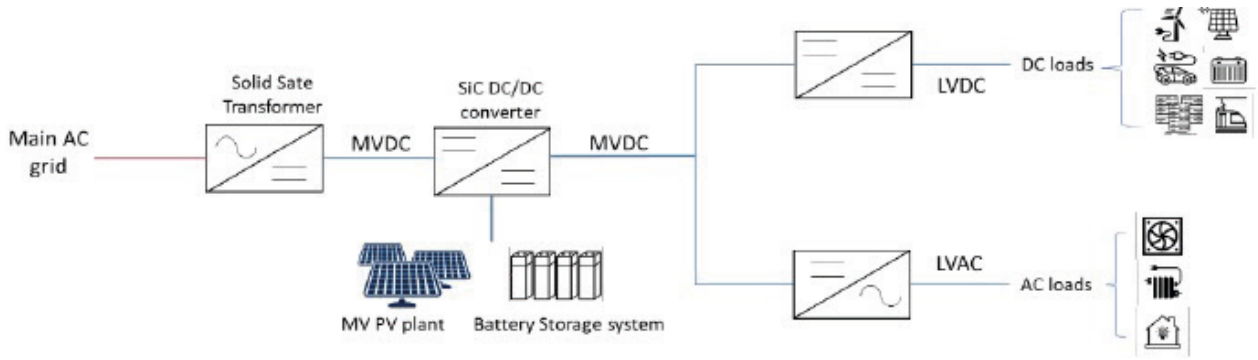
Development of Power Electronics & Hardware Solutions

Abstract

TIGON aims to address the lack of DC microgrids by proposing a modular grid topology as shown below:



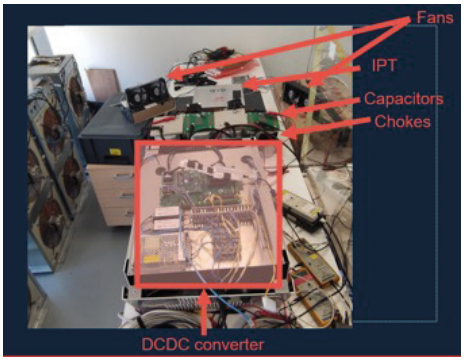
The various innovations introduced and their advantages are discussed below.

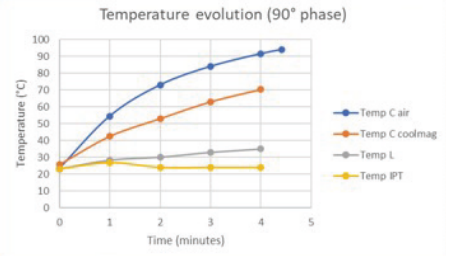
Solid State Transformer

An SST (Solid State Transformer) is a multi-level power electronics device designed to link two electric grids with differing voltage levels and frequencies. It comprises a medium frequency transformer and AC/DC converters, allowing for the control of terminal voltages and currents, as well as the management of active and reactive power flows.

Advantages of using an SST:

- Enhancing system efficiency by directly connecting to a DC supply, the SST is crucial for constructing a DC microgrid, enabling direct connection of DC devices such as electric vehicles, renewable energy generators, and batteries.
- Facilitating interaction with a secure DC microgrid, the SST offers additional features not found in conventional transformers, such as instantaneous protection against overloads and short-circuits through solid-state de-energization.
- Providing additional services from a DC microgrid, including increased flexibility, sustainability, and efficiency, the SST plays a key role in building a controllable DC microgrid, thereby reducing environmental impact and increasing revenues.





The efficiency was 88% and the power transferred was 18 kW.

SiC DC/DC converters

SiC DC/DC converters are medium voltage energy converters that can be either isolated or non-isolated. Their primary advantage is operating with direct current on both sides, making them ideal for microgrid applications, including those involving renewable energy sources.

Advantages of using SiC DC/DC converters

- Enhance efficiency by using a higher voltage, thereby increasing the maximum available power.
- Lower current to reduce losses, conserve energy, and cut costs.

DC protection schemes

The primary aim is to enhance protection schemes in medium voltage (MV) DC grids, particularly in environments with significant renewable energy integration. The proposed DC protection scheme entails a centralized system devoid of breakers, leveraging the IEC-61850 process bus and harnessing the fault current limiting capacity of power converters. Additionally, the objective includes introducing a novel protection scheme to address existing challenges outlined in literature, including high-speed demands, management of DC fault currents, standardization issues, and scarcity of expertise.

Advantages of DC protection schemes

- Providing a cost-effective solution for tested DC grid protection systems in real-world settings, expanding the range of available products.

For the TIGON project demo-sites, a breaker-less protection system is suggested due to the cost inefficiency and insufficient speed of DC circuit breakers identified in the benchmark review. Therefore, the protection scheme utilizes the current limiting feature of power converters to halt short-circuit currents and employs DC contactors to isolate faulted sections within the microgrids, particularly for safeguarding power converters.

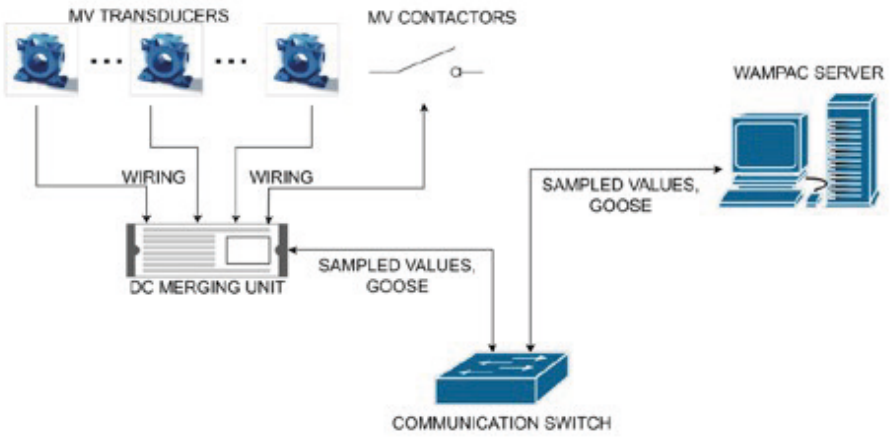


Fig. 1: *Protection Scheme proposed for DC TIGON DC microgrid.*

MVDC PV Plant

The concept of an MVDC PV Plant involves enhancing solar power plants to operate directly at medium voltage in DC, thereby streamlining their configuration and improving production efficiency.

Advantages of MVDC Plant

- By eliminating the DC/AC conversion stage, both CAPEX and performance can be enhanced, leading to greater energy generation.
- Simultaneously, the decrease in CAPEX and the boost in efficiency result in a reduced LCOE (levelized cost of energy).

Fig. 2: *PID outdoor tests on 6 PV modules.*

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