AN APPRATUS AND METHOD FOR IMPROVING CURRENT PROFILE OF MEDIUM VOLTAGE GRID CONNECTED CONVERTER

IITM Technology Available for Licensing

Problem Statement

- For successful **Medium Voltage (MV) grid integration of renewable energy**, high power density and efficiency are crucial for **minimizing space requirements, maximizing energy utilization, and ensuring grid stability.**
- **Solid-state transformers** use high-frequency transformers for compact size but **suffer from power quality issues at low loads**.
- Moreover, **conventional solutions** fail to address high **Total Harmonic Distortion (THD) and inefficiencies in medium-voltage** grid-connected converters.
- There is a need for **a method of hybrid modulation** to achieve sinusoidal currents, reducing THD, losses, and enhancing grid stability **across load conditions.**

Intellectual Property

- IITM IDF Ref 2672
- **IN 202441043307 Patent Application**

TRL (Technology Readiness Level)

TRL 5 Technology validated in Relevant Environment

Technology Category/ Market

Category- Electronics and Circuits

Industry Classification:

Renewable energy; Electric power generation; Electrical Equipment and Component Manufacturing

Applications:

Renewable Energy Systems Integration; Electric Vehicle (EV) Charging Stations; Smart Grid and Micro grid Applications; Data Centers and Industrial Power Systems; Traction and Marine Applications

Market report:

The global Solid-State Transformer market was valued at USD 100 million in 2024 and is projected to grow to USD 241 million by 2030, registering a CAGR of 15.8%

Research Lab

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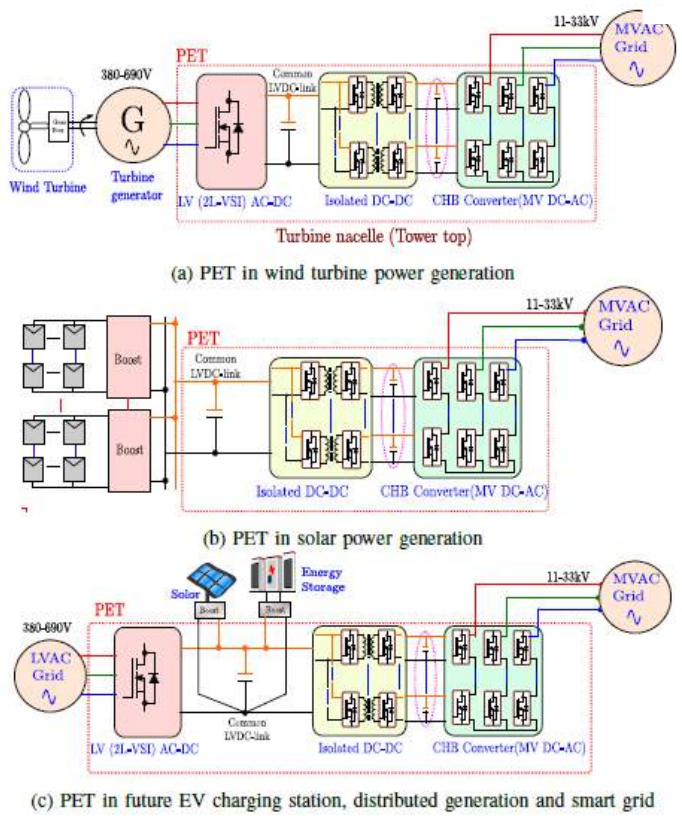

Figure: Schematic overview of the Power Electronic Transfer (PET) application

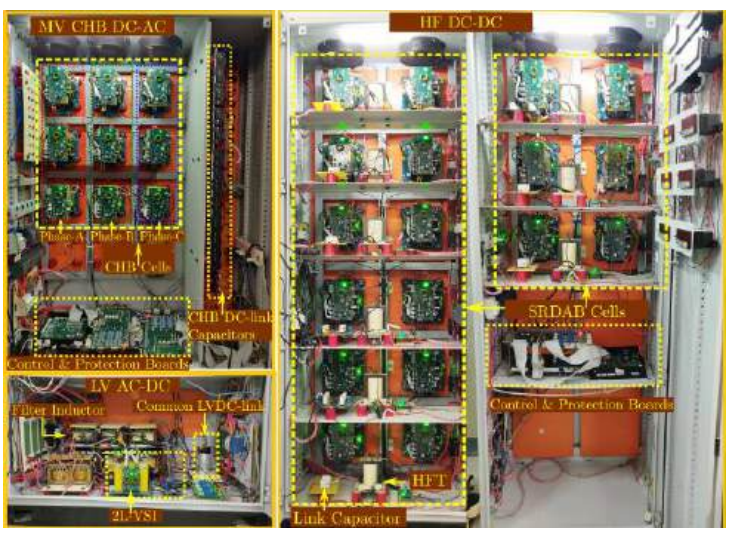

Figure: The Hardware Prototype- The proposed control is verified on a developed 1.2kV(MVAC)/400V(LVDC)/200V(LVAC), 20kW CHB-based PET prototype setup. The entire control architecture is implemented on a DSP and FPGA-based hybrid control board..

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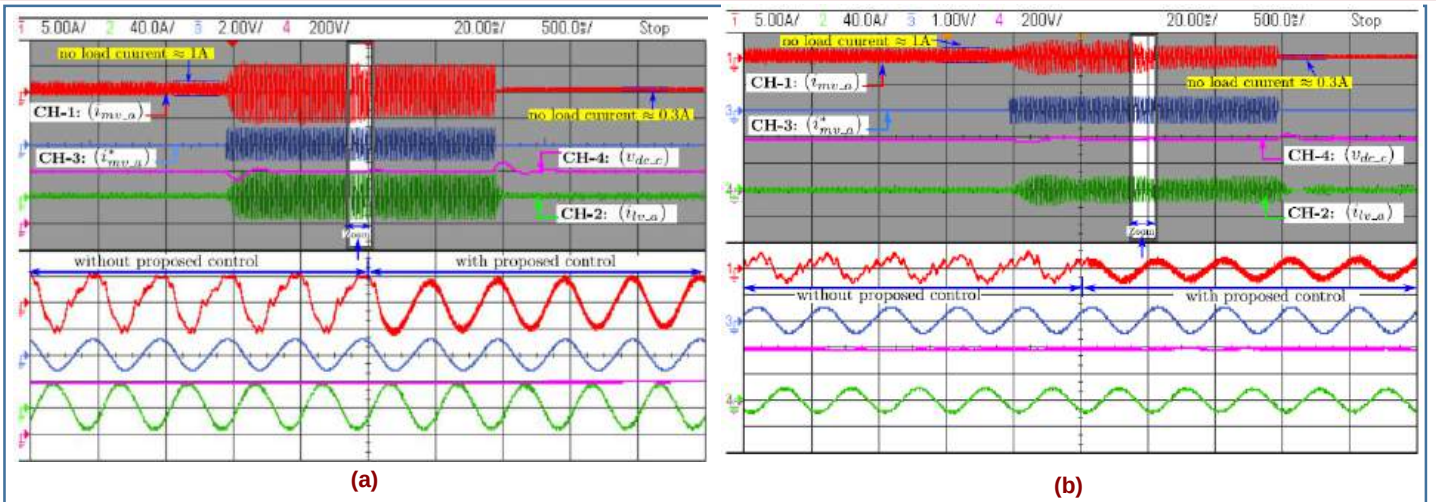

Figure: One to One comparison of the Experimental results for MV grid current profile at light load with current reference of (a) 3.5A and (b) 1.75 A . The profile of the MV grid current for the proposed control is perfectly sinusoidal for the same light load condition. The experimental waveform clearly shows the effectiveness of the proposed approach when compared on to one with conventional control.

Technology

A hybrid modulation technique enhances current profiles in Cascaded H-Bridge (CHB) based Power Electronic Transformers (PET) for Medium Voltage (MV) grid integration, reducing harmonic distortion and system losses under all loading conditions.

Combines voltage and current control modulation for CHB cells, ensuring sinusoidal MV grid currents, even at light loads, by utilizing SPWM for initial cells and hysteresis control for the last H-bridge cell.

Operates at 1.2kV (MVAC), 400V (LVDC), and 200V (LVAC) with a 20kW CHB-based PET prototype, integrating MV grids with high efficiency and minimal harmonic distortion.

Achieves improved Total Harmonic Distortion (THD), reduces no-load currents by 70%, and eliminates complex voltage balancing with inherent cell voltage regulation using Series Resonant Dual Active Bridge (SR-DAB) converters.

Suitable for smart grids, EV charging stations, renewable energy systems, and industrial use; validated through hardware testing with reliable sinusoidal output and dynamic performance in active/reactive power transitions.

Key Features / Value Proposition

- The invented technique achieves low THD and sinusoidal current profiles across all conditions. Whereas, conventional approaches fail at light loads.
- The inventions does not require external voltage balancing, unlike traditional multilevel converters that require complex algorithms.
- Decreases no-load current by 70%, and minimizes energy wastage often overlooked by conventional solutions.
- Seamlessly integrates with renewable energy, EV charging, and industrial systems, outperforming less versatile conventional solutions.
- Offers Zero Voltage Switching (ZVS) and Zero Current Switching (ZCS) in the DC-DC stage, enhancing efficiency and device longevity compared to alternatives.

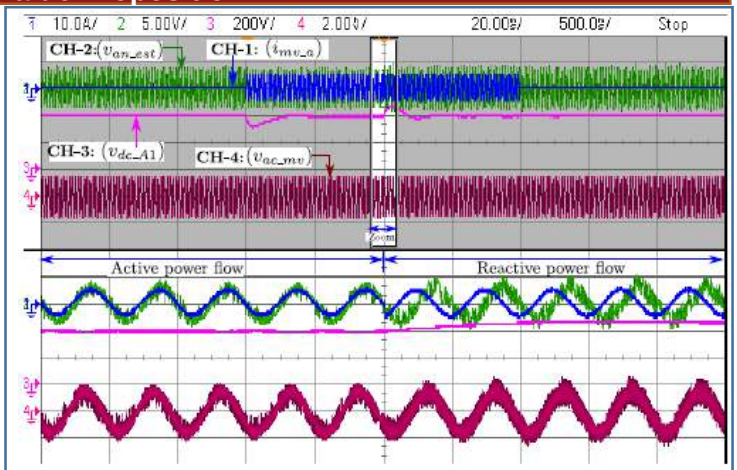

Figure: To see the reliability and effectiveness, the proposed hybrid modulation technique for the MV CHB stage of SST is also tested for active and reactive loading. It is evident that the MV grid current is perfectly sinusoidal under all loading scenario.

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