Storage Integrated AC-AC Converters

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PROJECT PROFILE
Topic: Power Electronics Vertical: Grid Integration & Field Validation Strategic Pathway: Grow Project start and finish: FY23-FY26

PROBLEM

Energy storage integration on ac distribution networks poses significant challenges. Existing solutions break the problem into several sub-problems, increasing the overall complexity. A better solution would directly combine both ac power flow control and dc energy storage in a single power conversion device.

APPROACH

An ac-ac dual active bridge converter can directly control power flow between two single-phase circuits, as in a common distribution network. This simplicity can lead to quantum improvements in power system resiliency and flexibility.

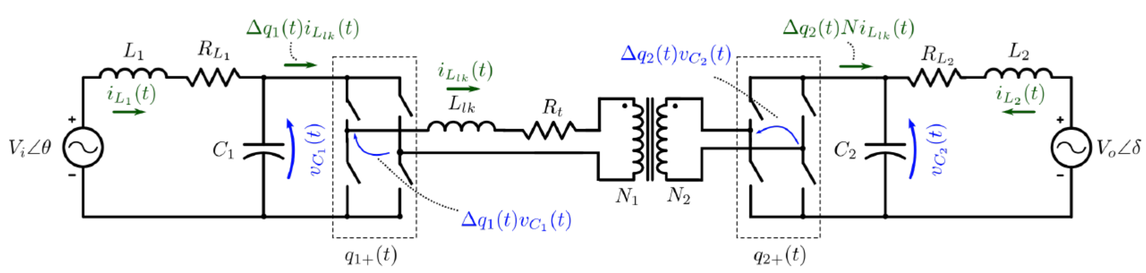

Fig. 1. AC-AC DAB with ac-side filters, parasitic elements, and control and state variables labeled.

The addition of a dc port, creating a triple active bridge (TAB) dc-ac-ac converter, inherits the advantages of an ac-ac converter, adds the capability of integrating energy storage, and improves the flexibility and performance of the converter.

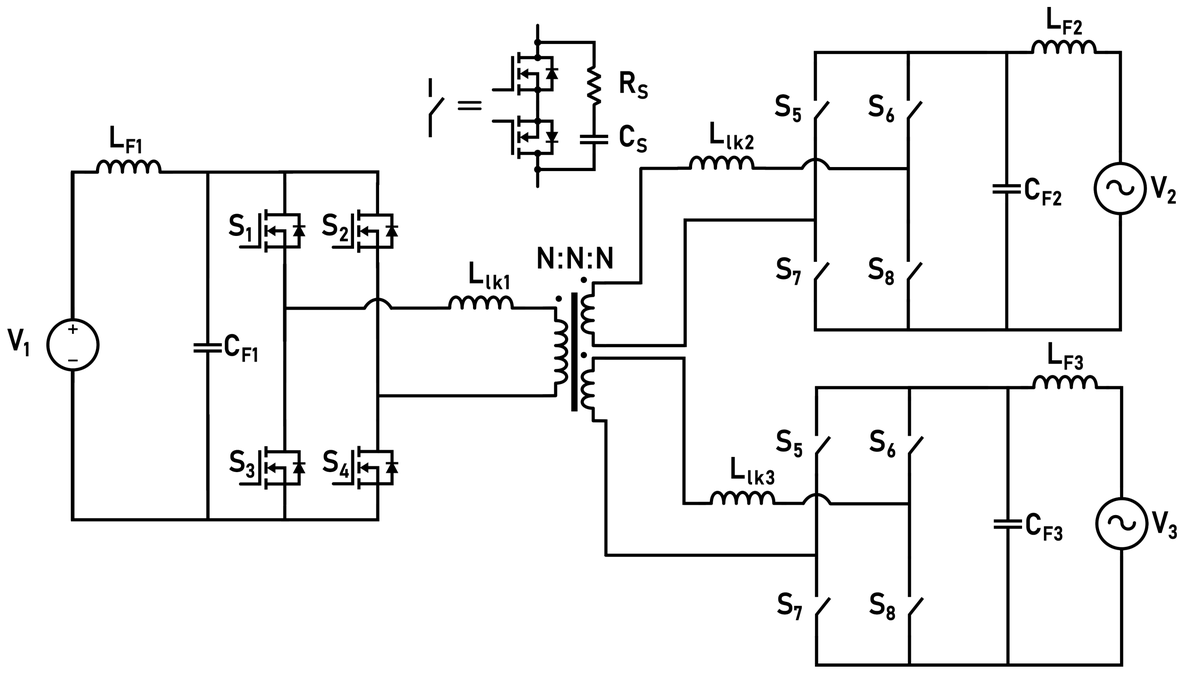

Fig. 1. DC-AC-AC TAB converter.

RESULTS

Using extended generalized average modeling (EGAM), a sophisticated controller was designed for an ac-ac DAB.

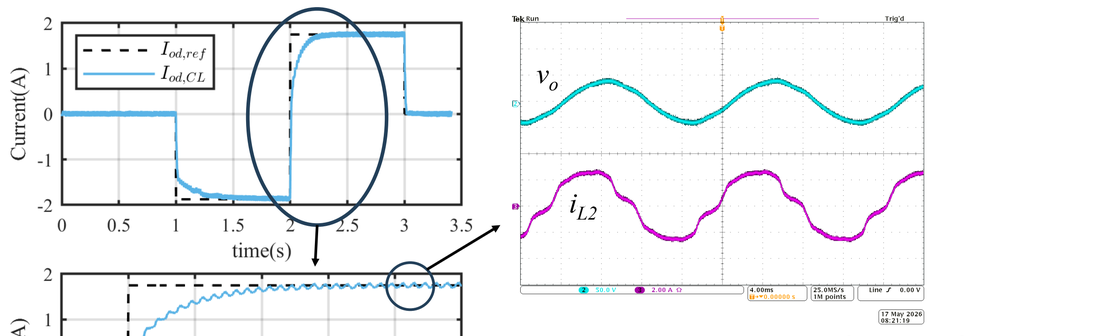

Fig. 3. Experimental AC-side waveforms, d-axis current (reference vs. actual) calculated in the controller; original voltage and current from an oscilloscope.

A combination feedback-feedforward controller enables a dc-ac-ac TAB to accurately track commanded active and reactive power (represented here as currents on the d & q axes, respectively).

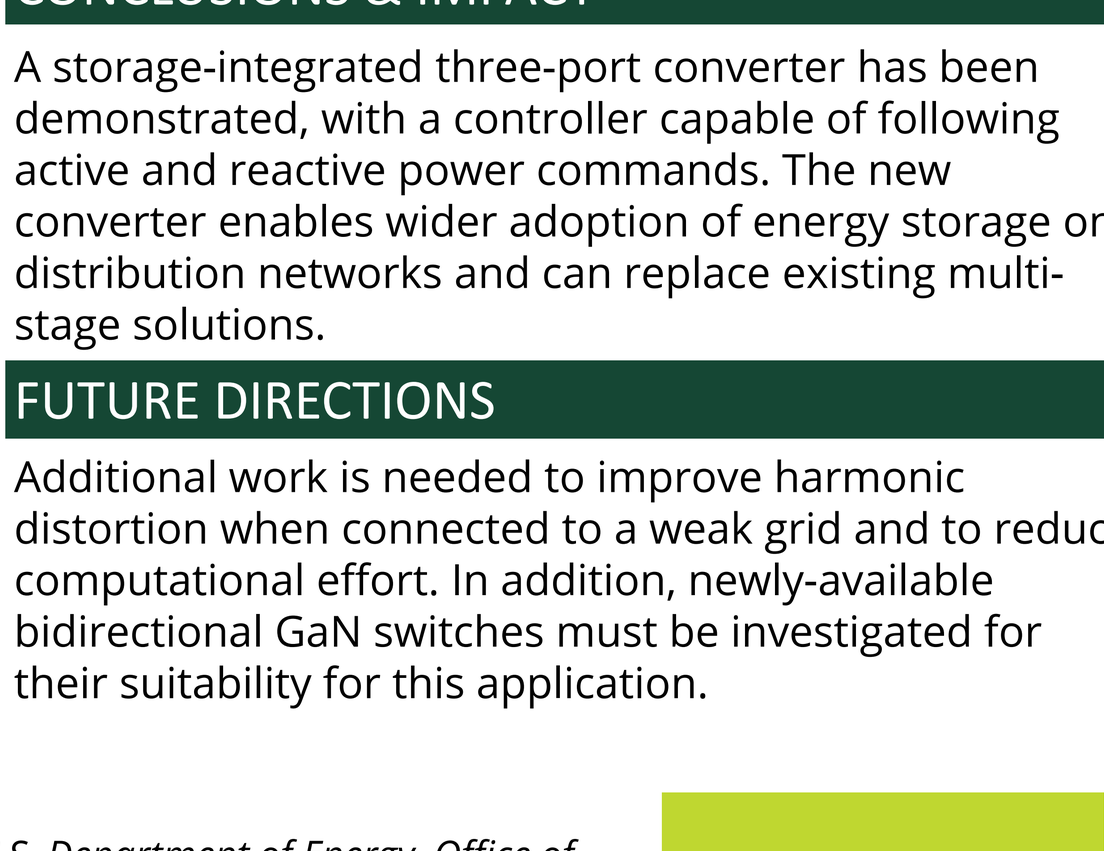

Fig. 4. Bridge 3 (ac output) current command and actual, on d axis (active power) and q axis (reactive power).

CONCLUSIONS & IMPACT

A storage-integrated three-port converter has been demonstrated, with a controller capable of following active and reactive power commands. The new converter enables wider adoption of energy storage on distribution networks and can replace existing multi-stage solutions.

FUTURE DIRECTIONS

Additional work is needed to improve harmonic distortion when connected to a weak grid and to reduce computational effort. In addition, newly-available bidirectional GaN switches must be investigated for their suitability for this application.

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