Missouri University of Science and Technology

Multi-Port AC-Interfacing Converters with Common High-Frequency Link

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Multi-Port Converters with Embedded Transformer

An extension of the dual active bridge

DC-DC Dual Active Bridge (DAB): Commonly used for isolated bidirectional power flow control, e.g., battery and dc network

AC-AC DAB: Proposed for use to connect two ac networks

- Difficulties with phase shift, reactive power flow

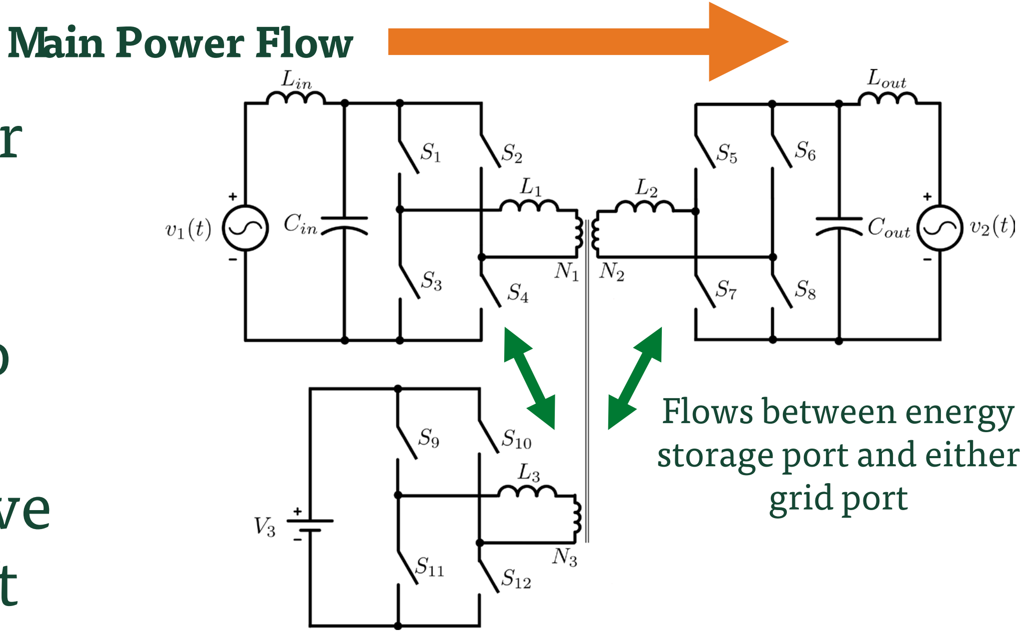
AC-AC-DC TAB: Triple active bridge provides a port to integrate energy storage

Advantages of the Multi-Port Converter

As Compared to AC-AC Converter or Multi-Stage Converters

Single-stage power conversion for main power flow → higher efficiency

Single-stage connection to energy storage → higher efficiency, manages reactive power flow and phase shift



Challenge: Effective Modeling

Requires development of Extended Generalized Average Model

Conventional dc-dc converters: classical average model that ignores switching frequency completely

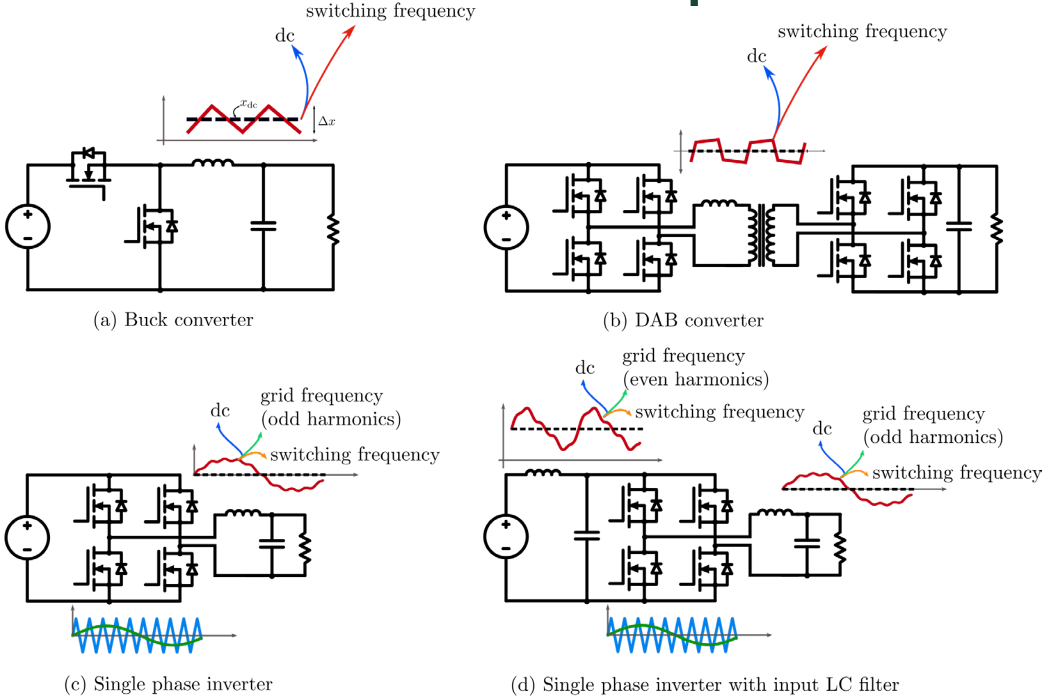
DC-DC DAB: generalized average model (GAM) that incorporates switching frequency effects

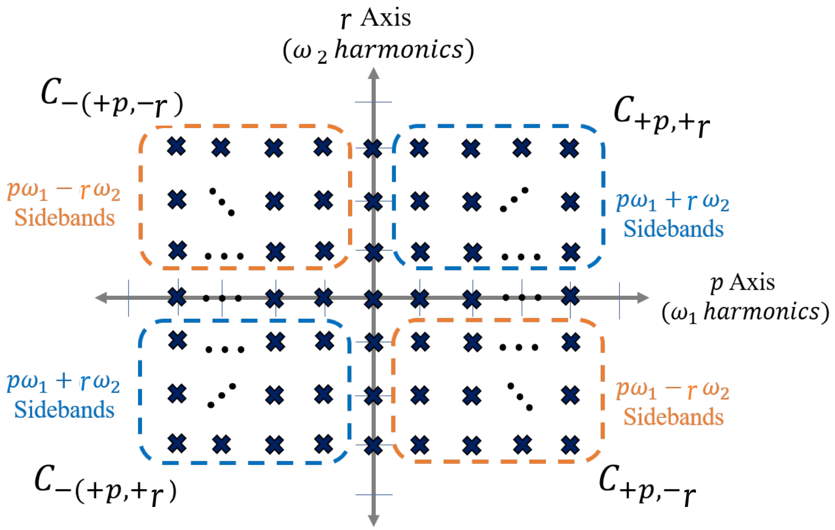
AC-AC DAB or AC-AC-DC TAB: extended GAM that incorporates switching *and* grid frequency effects

- This is also important for other converter topologies, like an inverter with a soft source

Extended Generalized Average Modeling

New method that incorporates multiple frequencies



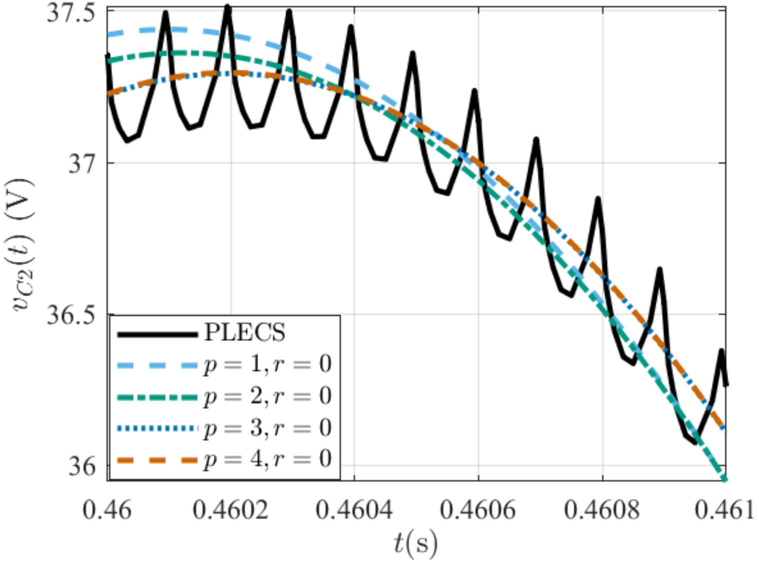


p-axis → grid frequency harmonics
r-axis → switching frequency harmonics

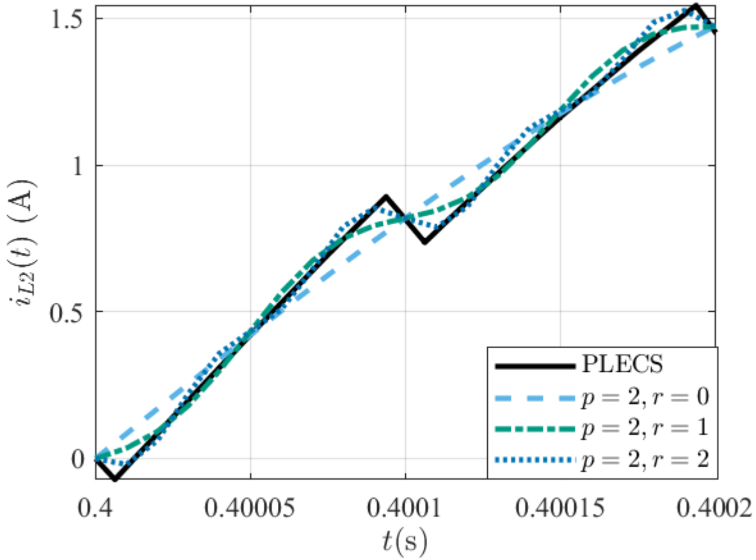
EGAM Results on Single-Phase Inverter

Including harmonics increases accuracy, fidelity

Increasing grid frequency harmonics



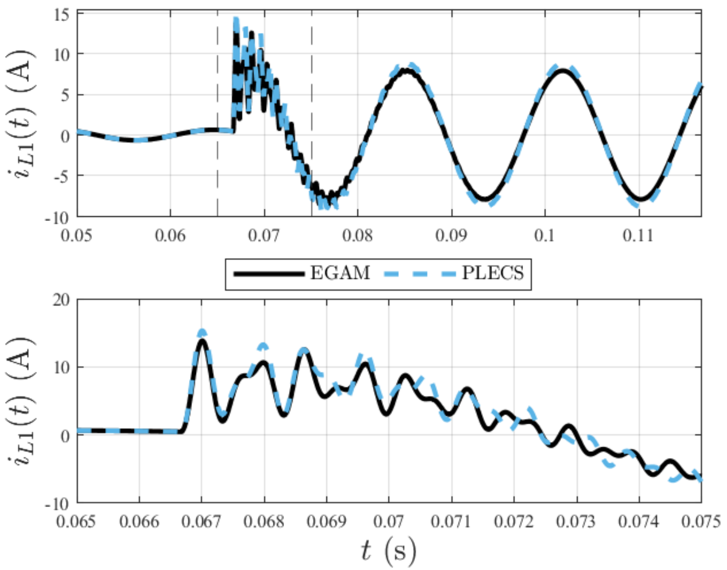
Increasing switching frequency harmonics



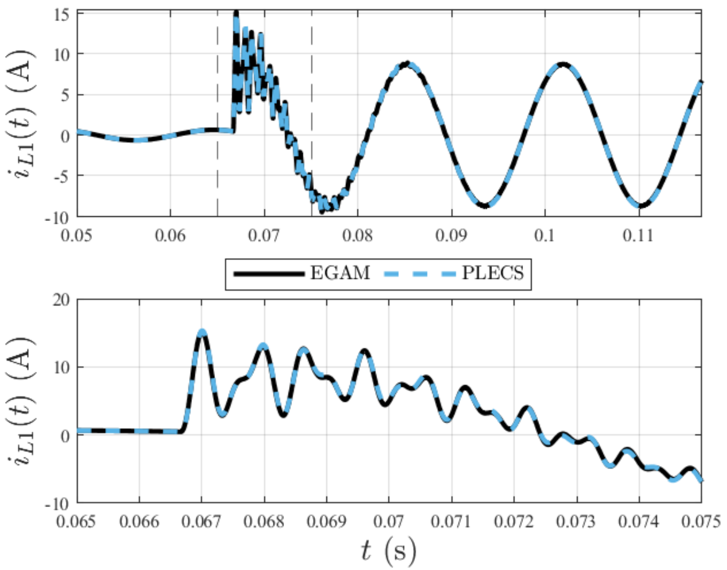
Preliminary EGAM Results: AC-AC DAB

Grid inductor current; p = 1 (grid harmonics)

Switching harmonics: r = 1



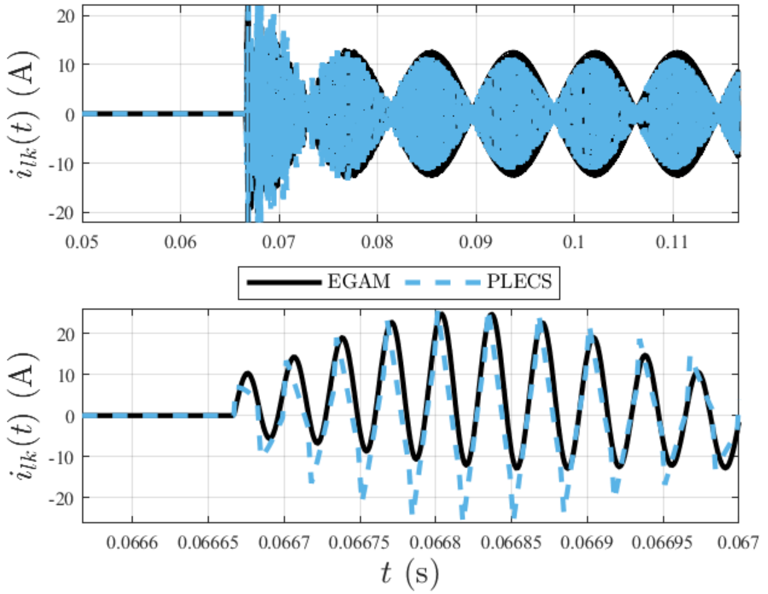
Switching harmonics: r = 3



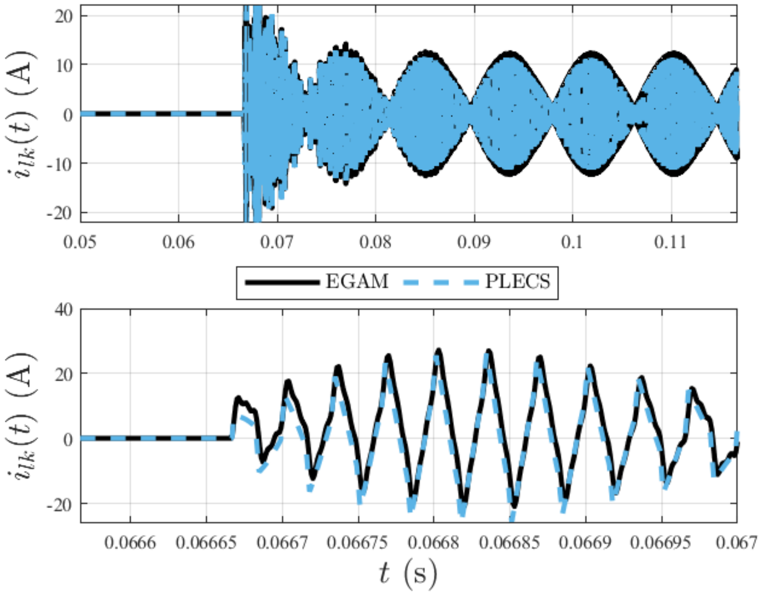
EGAM results (cont.)

Leakage inductor current; p = 1 (grid harmonics)

Switching harmonics: r = 1

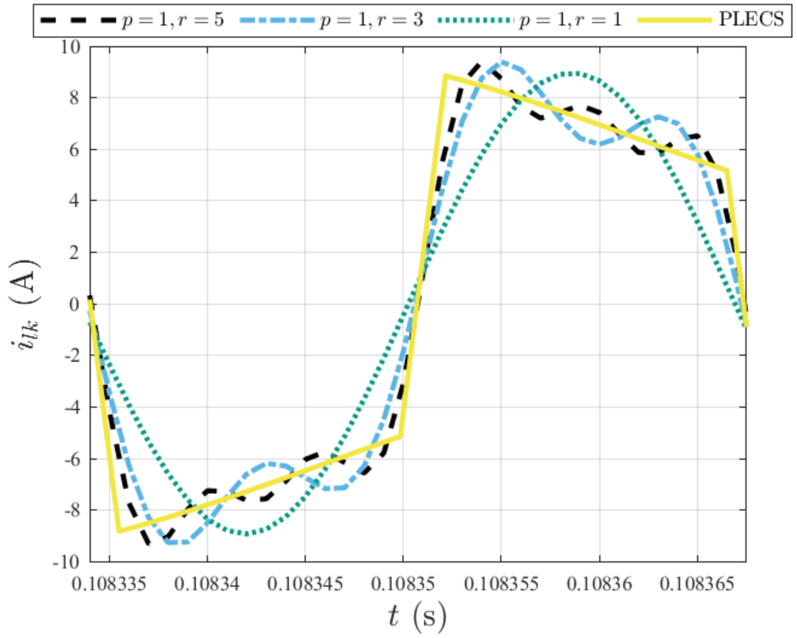


Switching harmonics: r = 3



EGAM results (cont.)

Cases with p = 1, r = {1,3,5}



r (Switching Harmonics)	MAE	Improvement
1	1.1	-
3	0.681	38.12%
5	0.411	62.68%

Application to AC-AC-DC TAB

Additional port gives additional flexibility

Steady-state analysis: With additional degrees of freedom, optimization can improve efficiency

EGAM analysis

- Improves controller design
- Decreases simulation time without loss of fidelity

Future Work

- Will demonstrate behavior with varying grid power flow demands

Acknowledgements

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