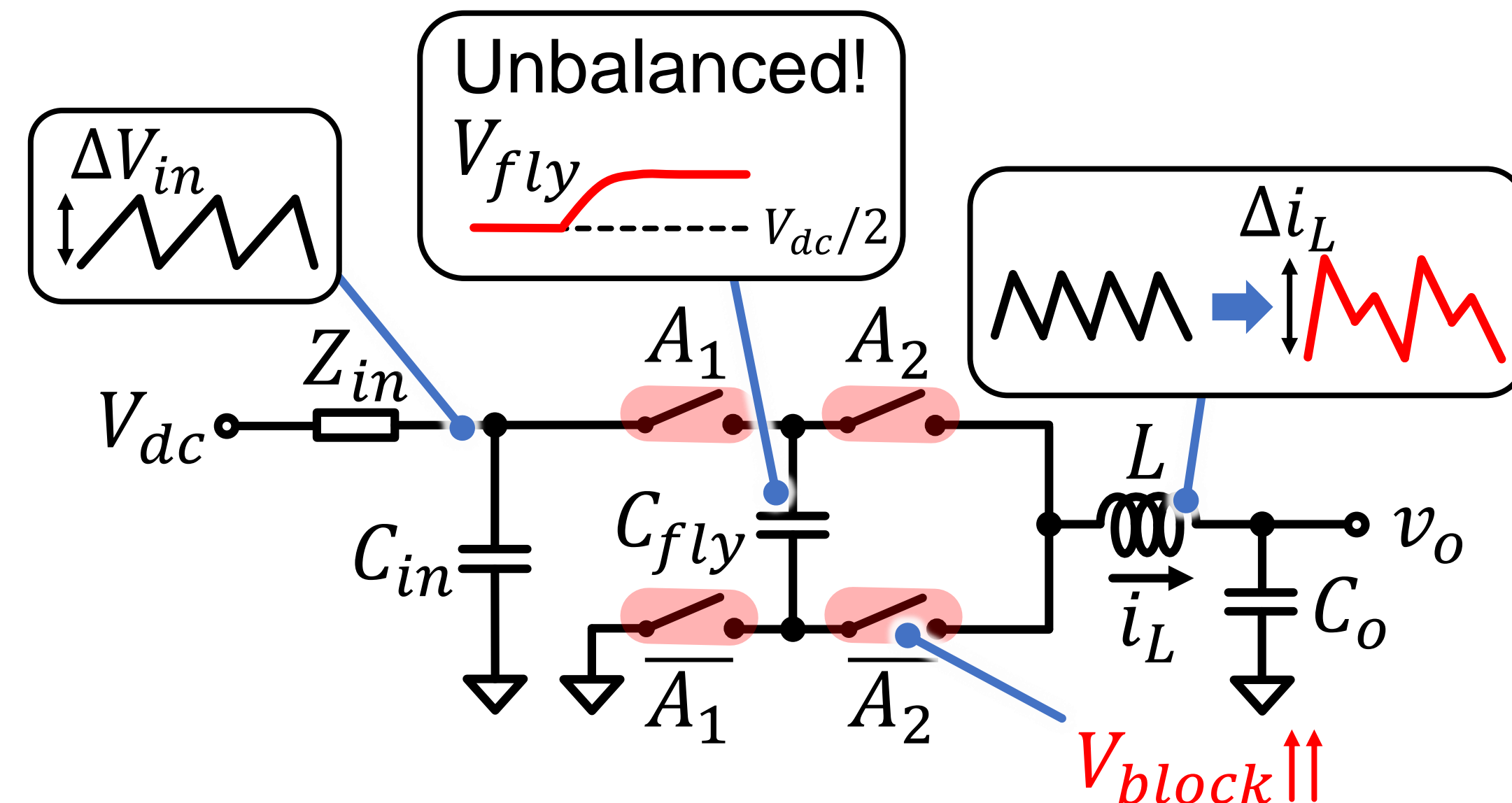


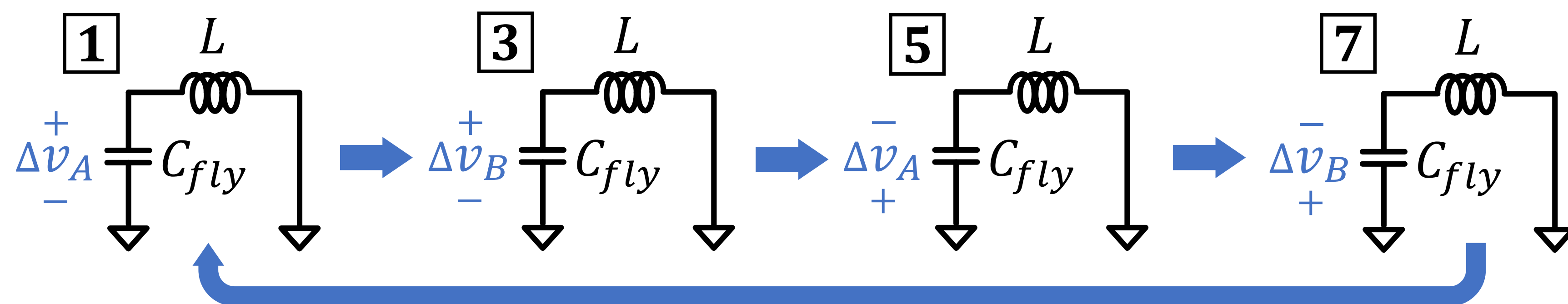
INTRODUCTION

- Disturbances such as input impedances Z_{in} and switching delays cause flying capacitor voltage imbalances [1]
- Imbalances increase switch stress, current ripple, core losses, reduce efficiency [2]
- Need a robust flying capacitor voltage balancing mechanism

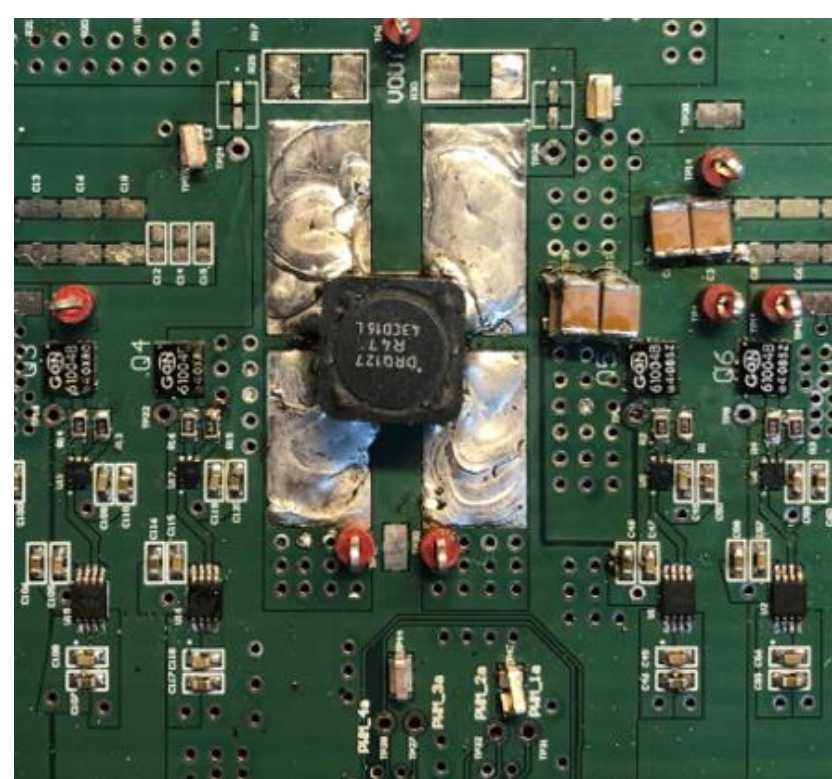


THEORY AND SETUP

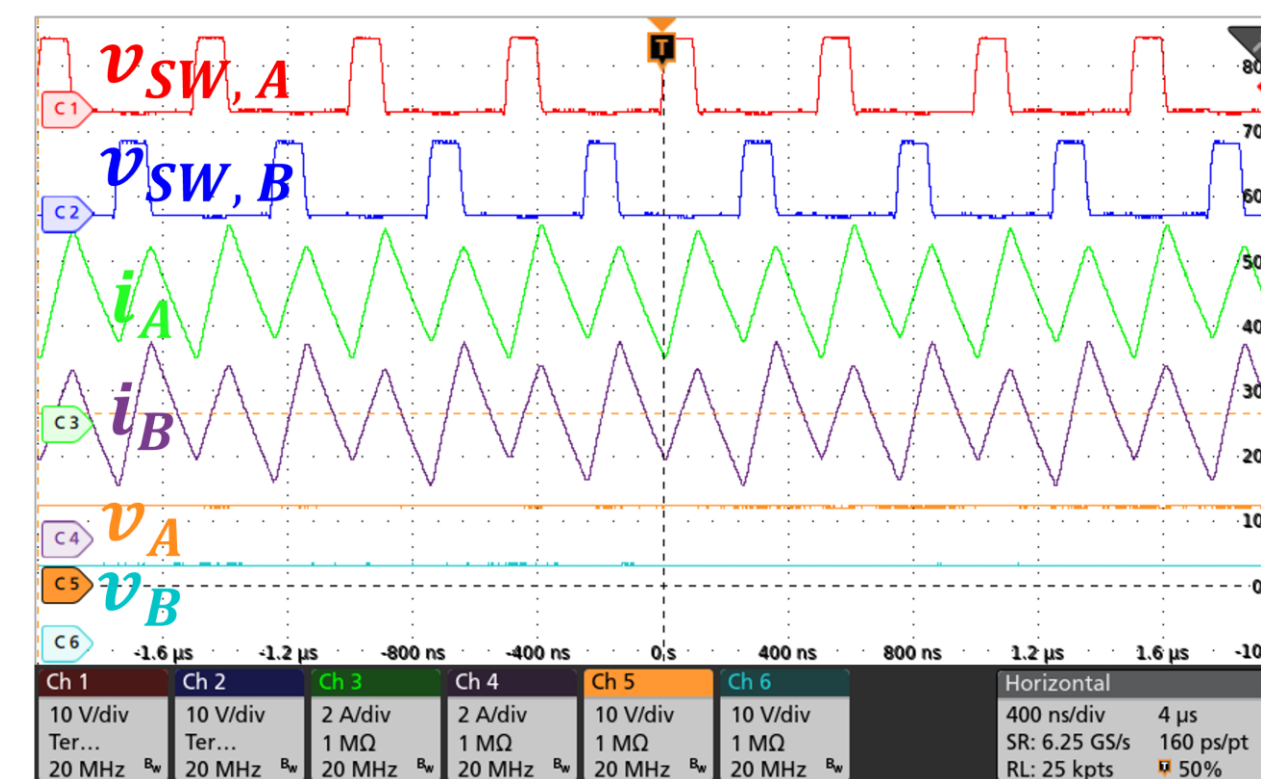
- Coupled inductor alternates flying capacitor connections, allowing each to compensate for the disturbance on the other



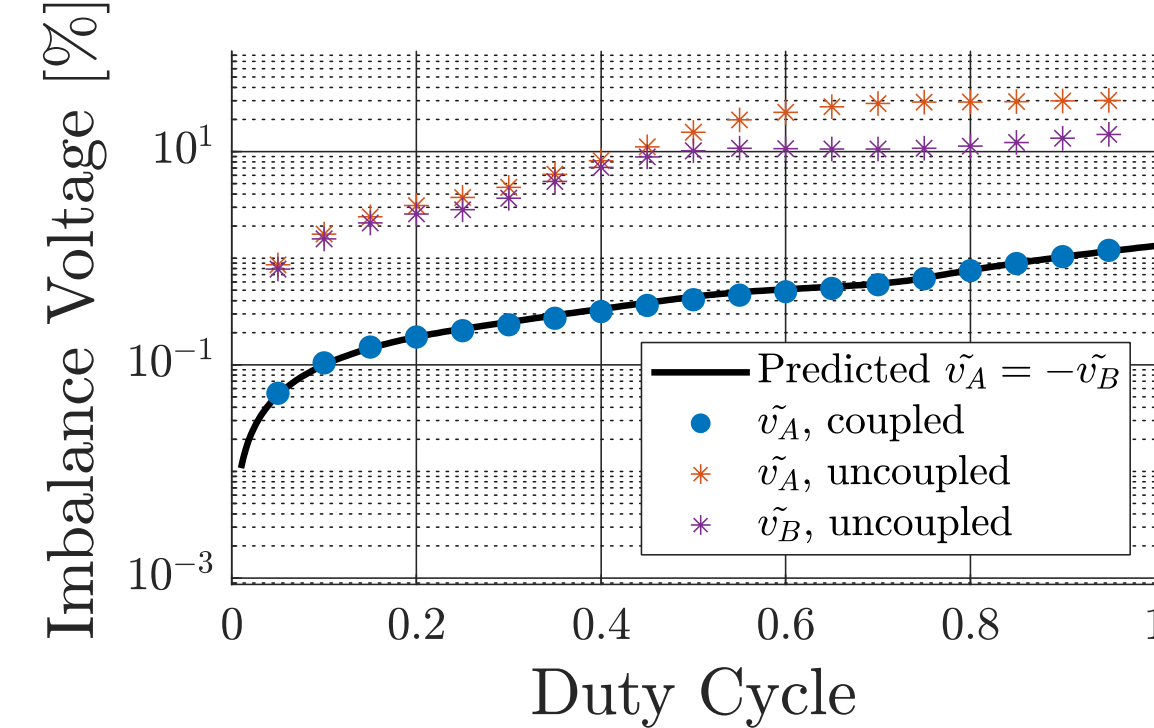
- Interleaving multiple phases with coupled inductors cancels per-phase ripple, improving efficiency, saturation flux requirements



PCB



Switching Waveforms



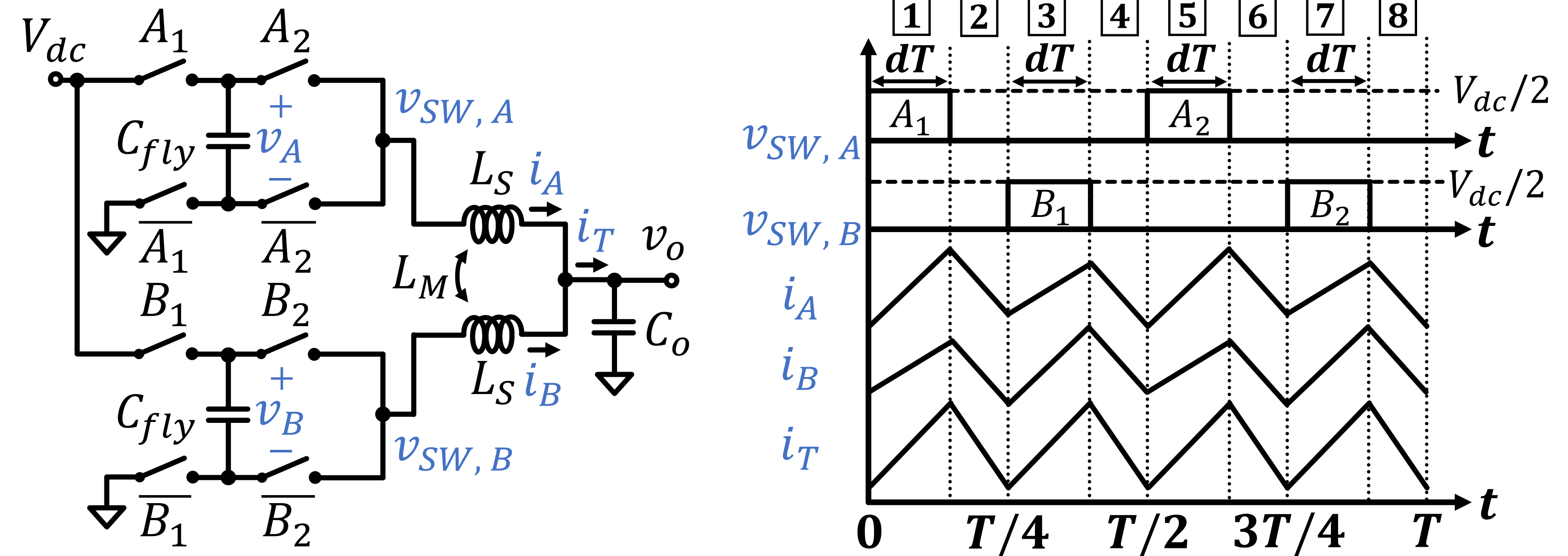
10-100x lower simulated imbalance from Z_{in} with coupled inductors

KEY CONTRIBUTIONS

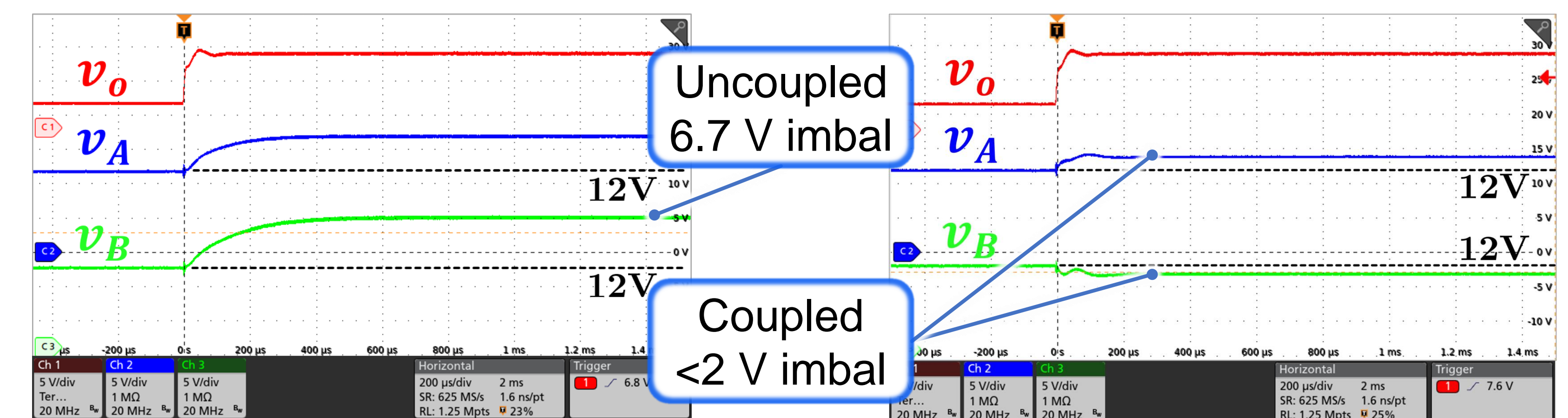
Interleaving multiple FCML phases with coupled inductors cancels per-phase inductor current ripple and significantly reduces flying capacitor voltage imbalance due to periodic disturbances.

PROPOSED SOLUTION

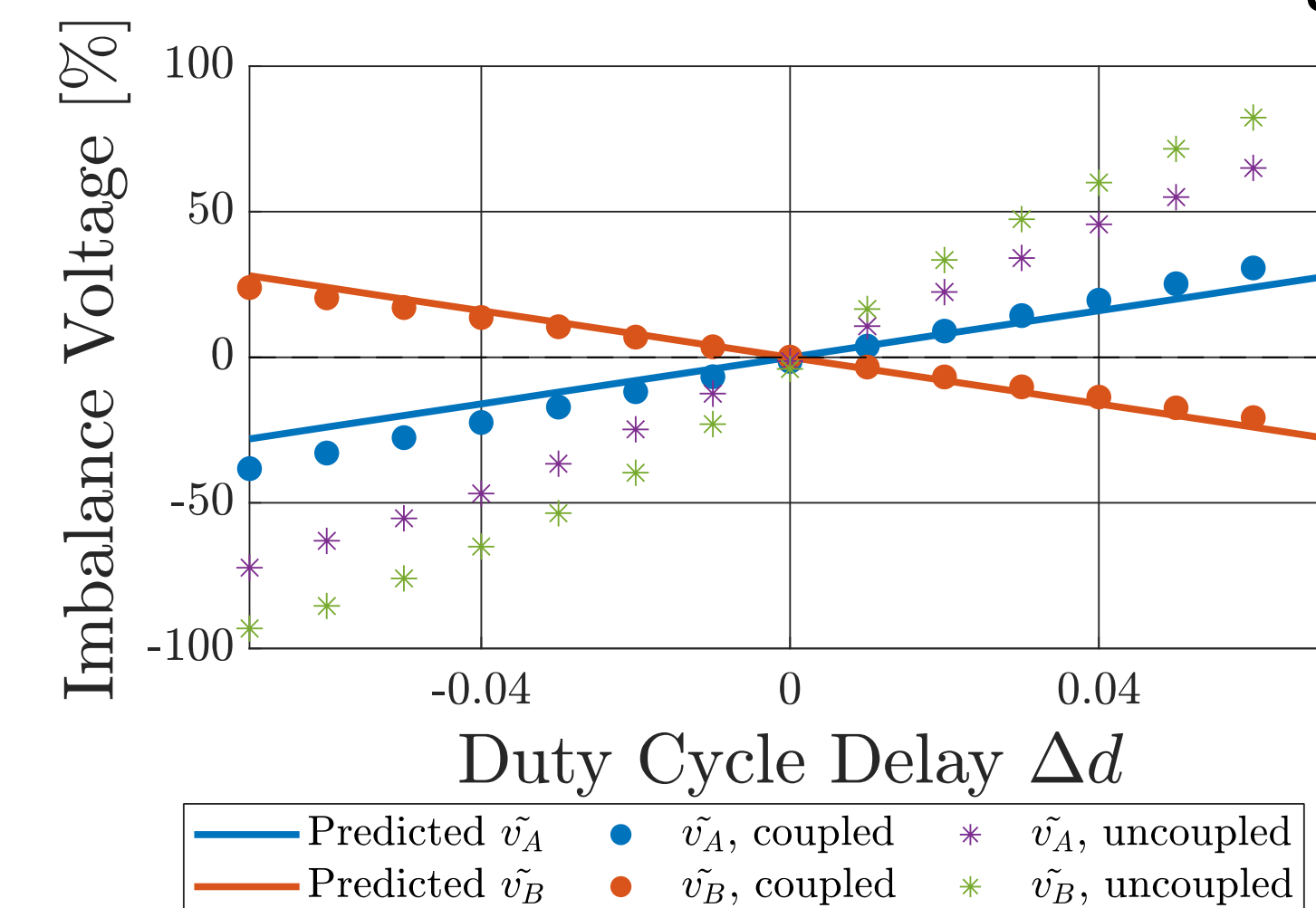
- Multiple interleaved FCML phases with coupled inductors



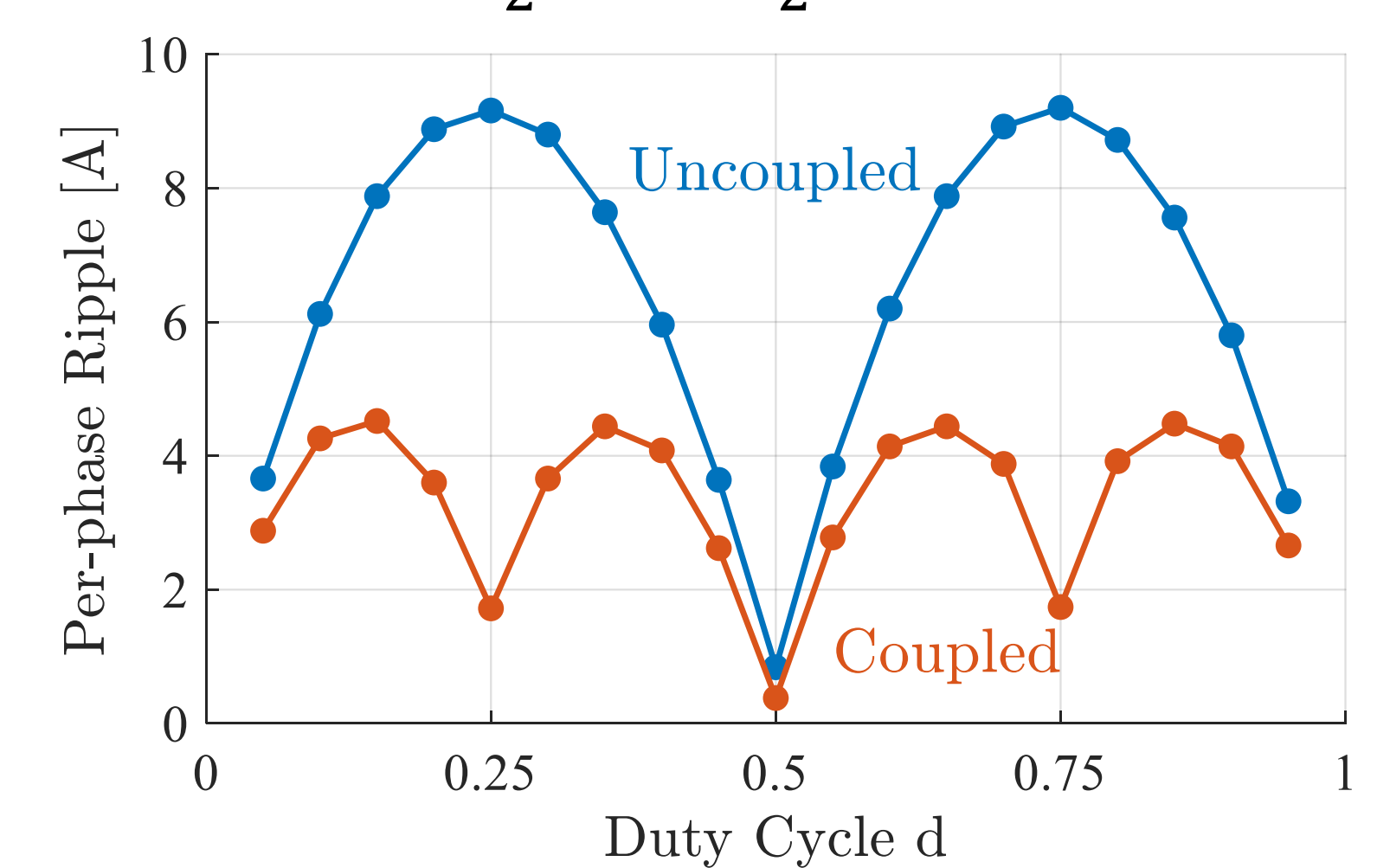
EXPERIMENTAL RESULTS



Coupled inductors significantly reduce voltage imbalance resulting from $\Delta d = 3\%$ switching delay on switches A_2 and B_2



Voltage imbalances vs. switching delay



Per-phase ripple vs. duty cycle

REFERENCES

- [1] Z. Ye et al., "Investigation of Capacitor Voltage Balancing in Practical Implementations of Flying Capacitor Multilevel Converters," *IEEE COMPEL 2017*, pp. 1-7
- [2] B. P. McGrath et al., "Analytical Modelling of Voltage Balance Dynamics for a Flying Capacitor Multilevel Converter," *IEEE PESC 2008*, pp. 1872-1877