

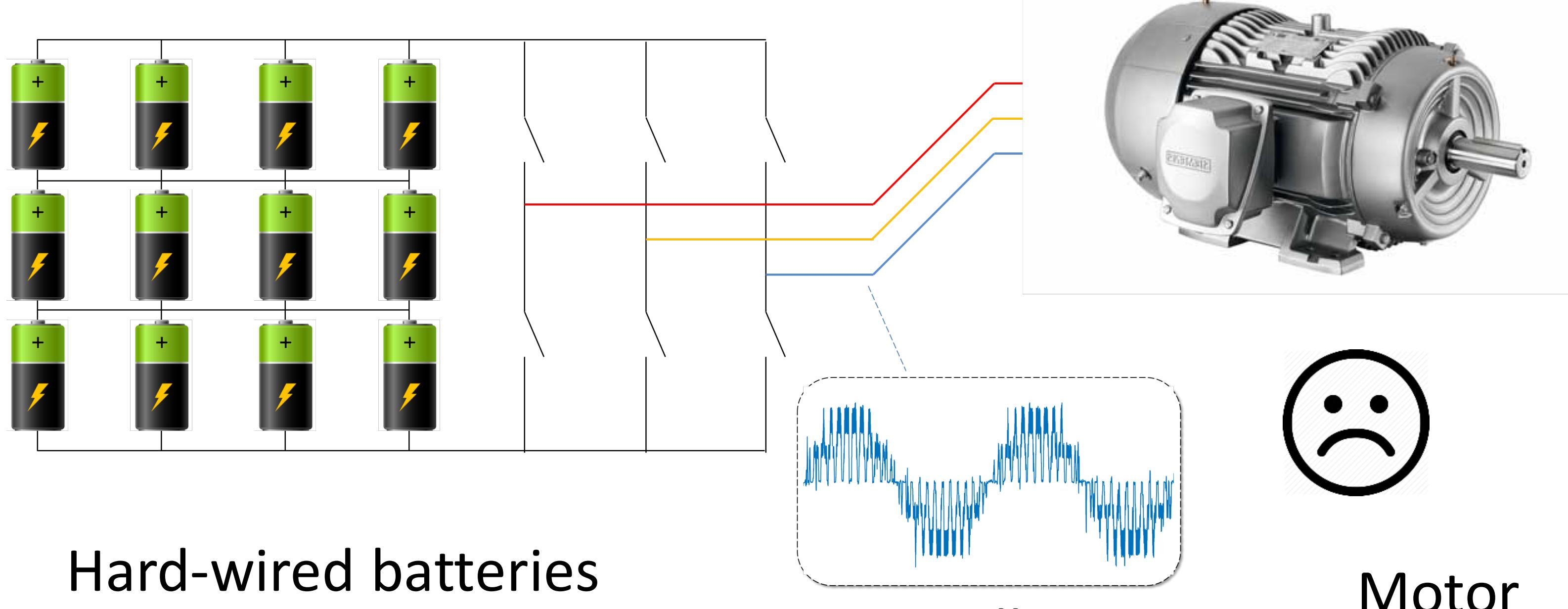


Automotive Application of an Advanced Power Conversion for Brushless Motor Control

Gerry Chen, Zhongxi Li, Carol Xia, Raj Borra, Sam Osheroff, Angel Peterchev Stefan Goetz
Duke University, Durham, USA



State of Art Electrical Vehicle and Problems



Hard-wired batteries

- Bad fault-tolerance
- Needs complex battery management circuit

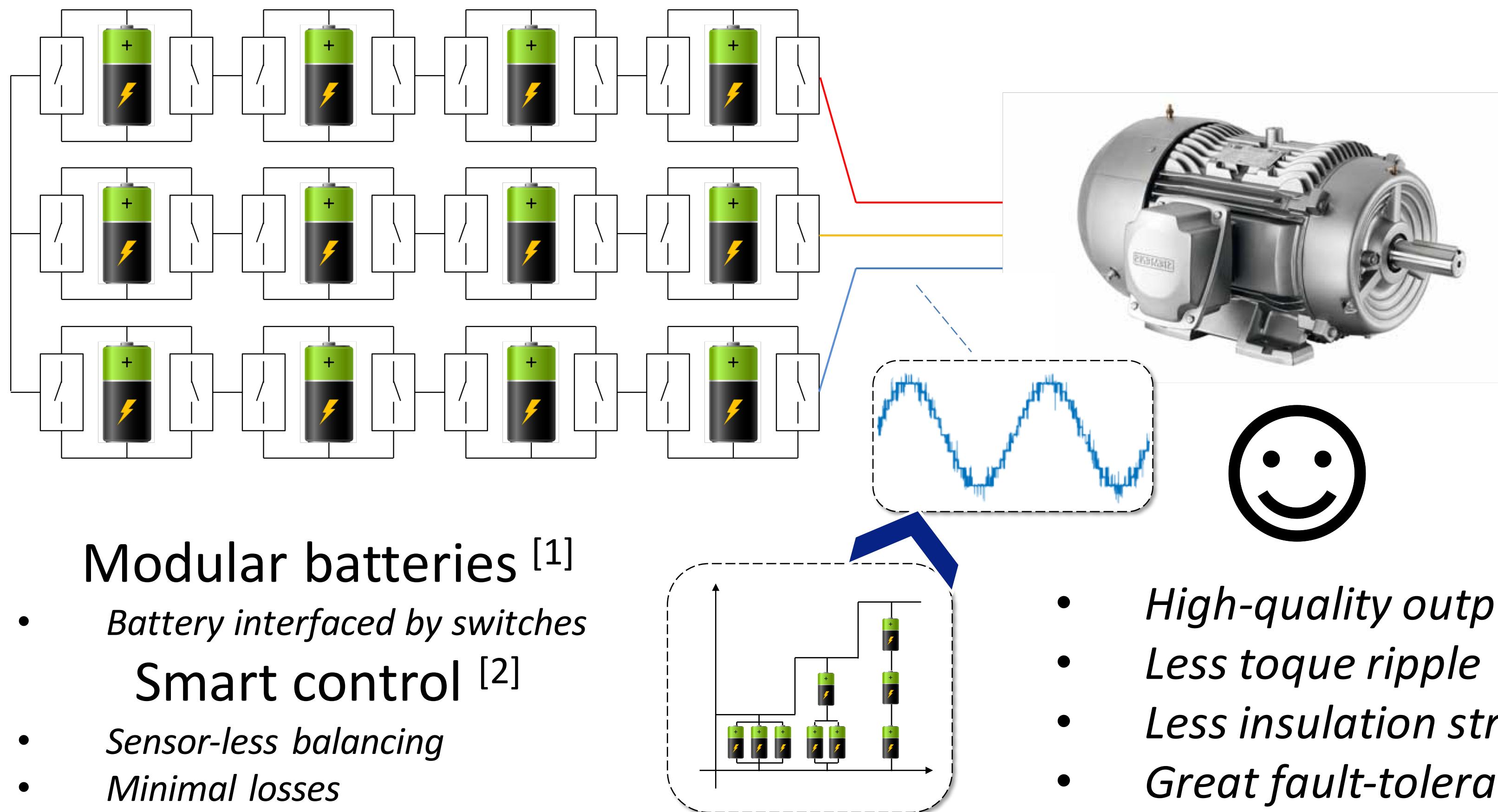
- Output distortion
- Large EMI
- Large torque ripple
- Large noise
- Large insulation stress



Motor



Our Solution : Intelligent Battery Modules



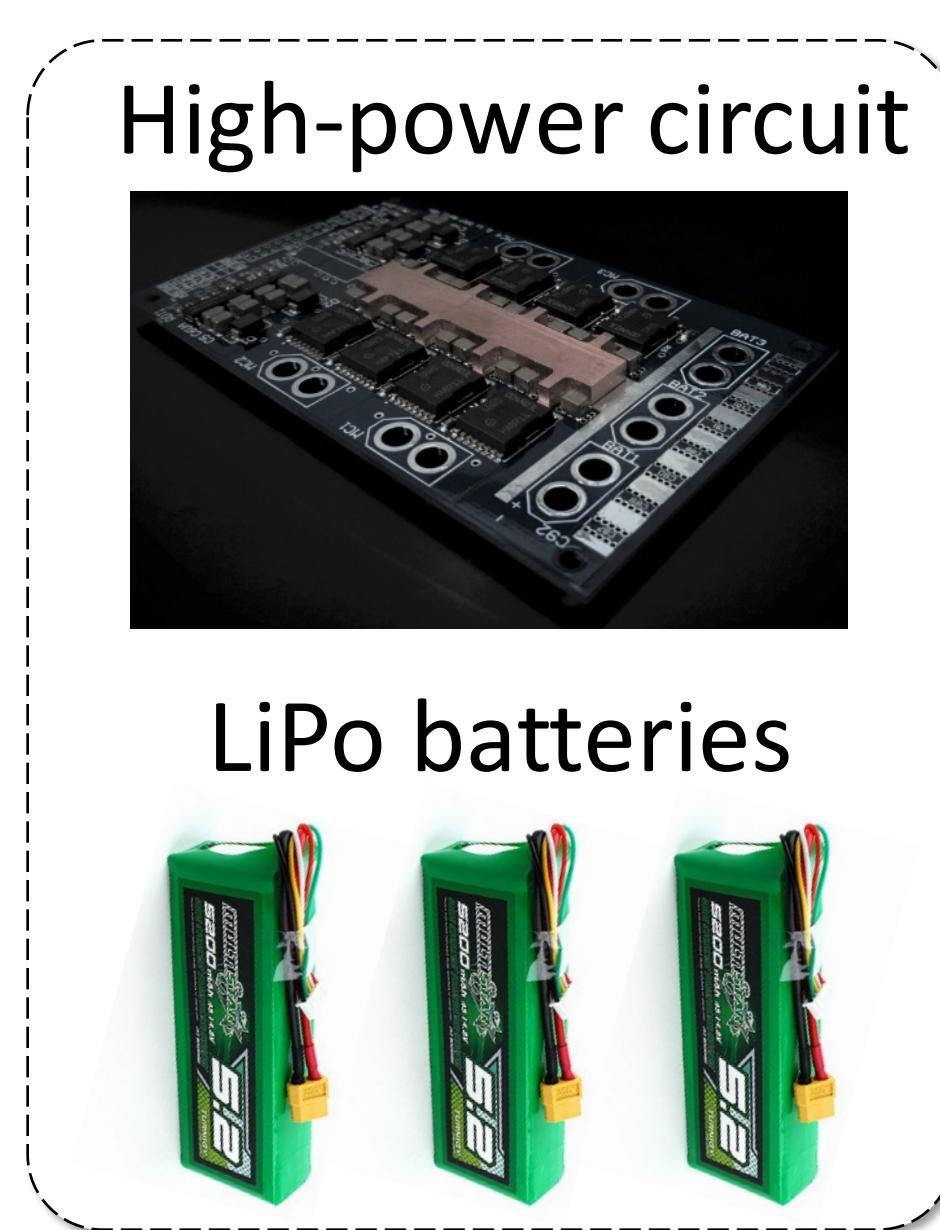
Modular batteries [1]

- Battery interfaced by switches
- Smart control [2]
- Sensor-less balancing
- Minimal losses

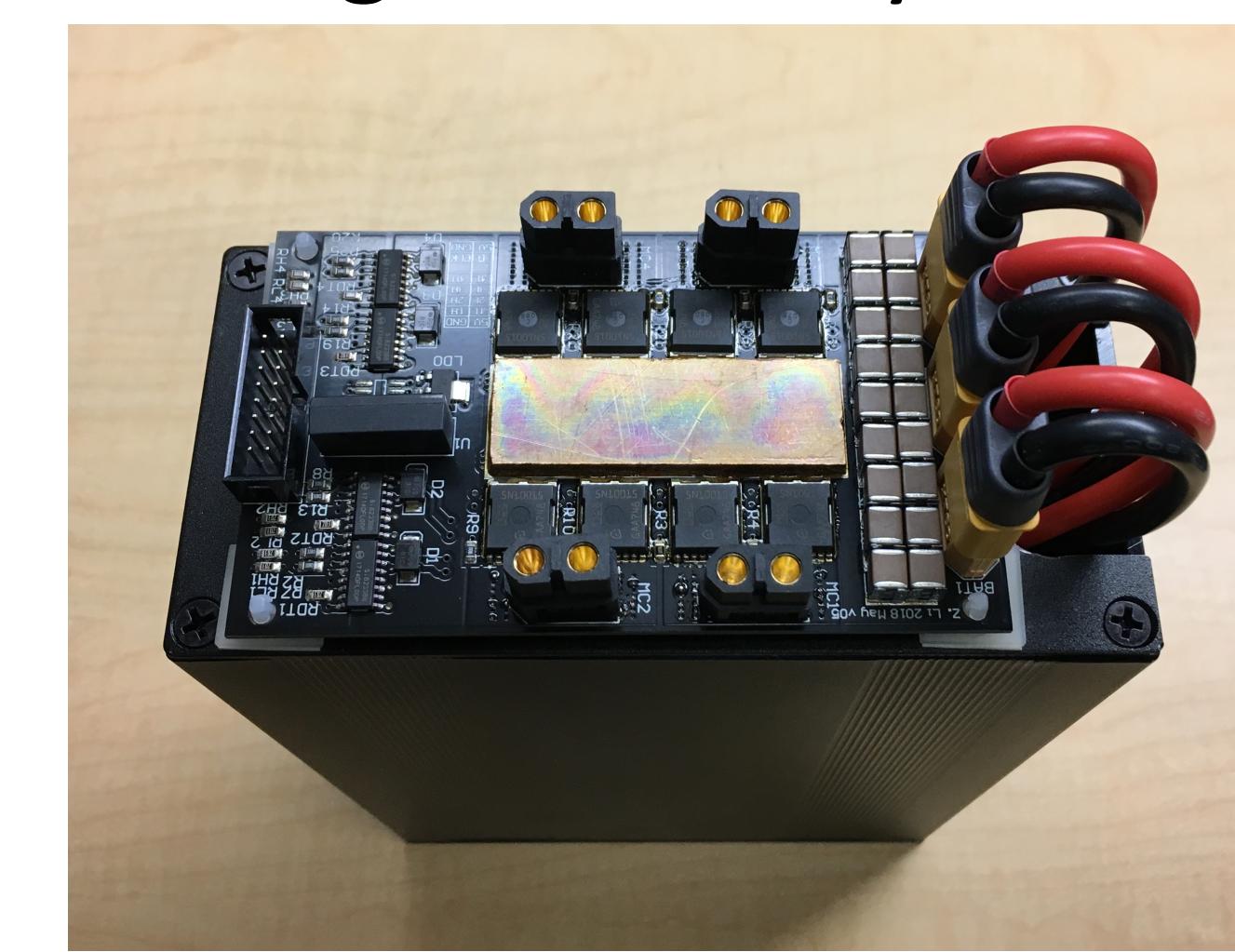
- High-quality output
- Less torque ripple
- Less insulation stress
- Great fault-tolerance



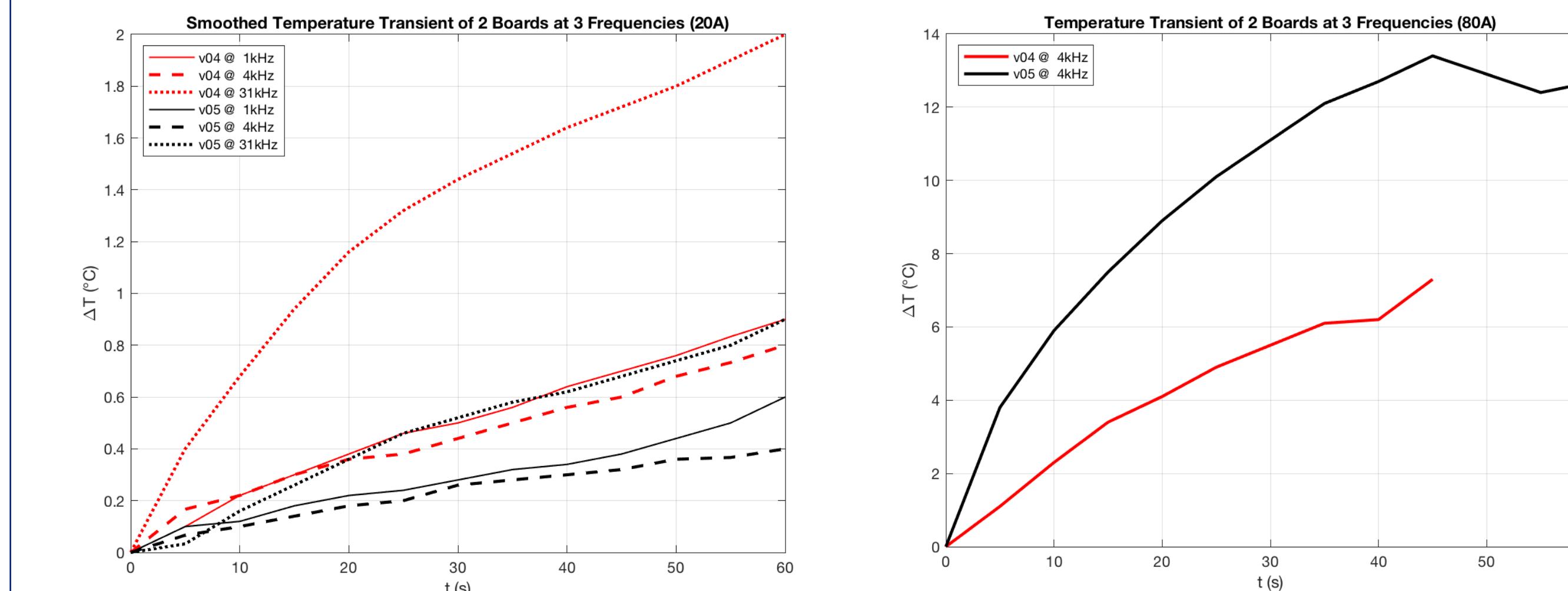
Module Design



Intelligent battery module



Electrical & Thermal Testing



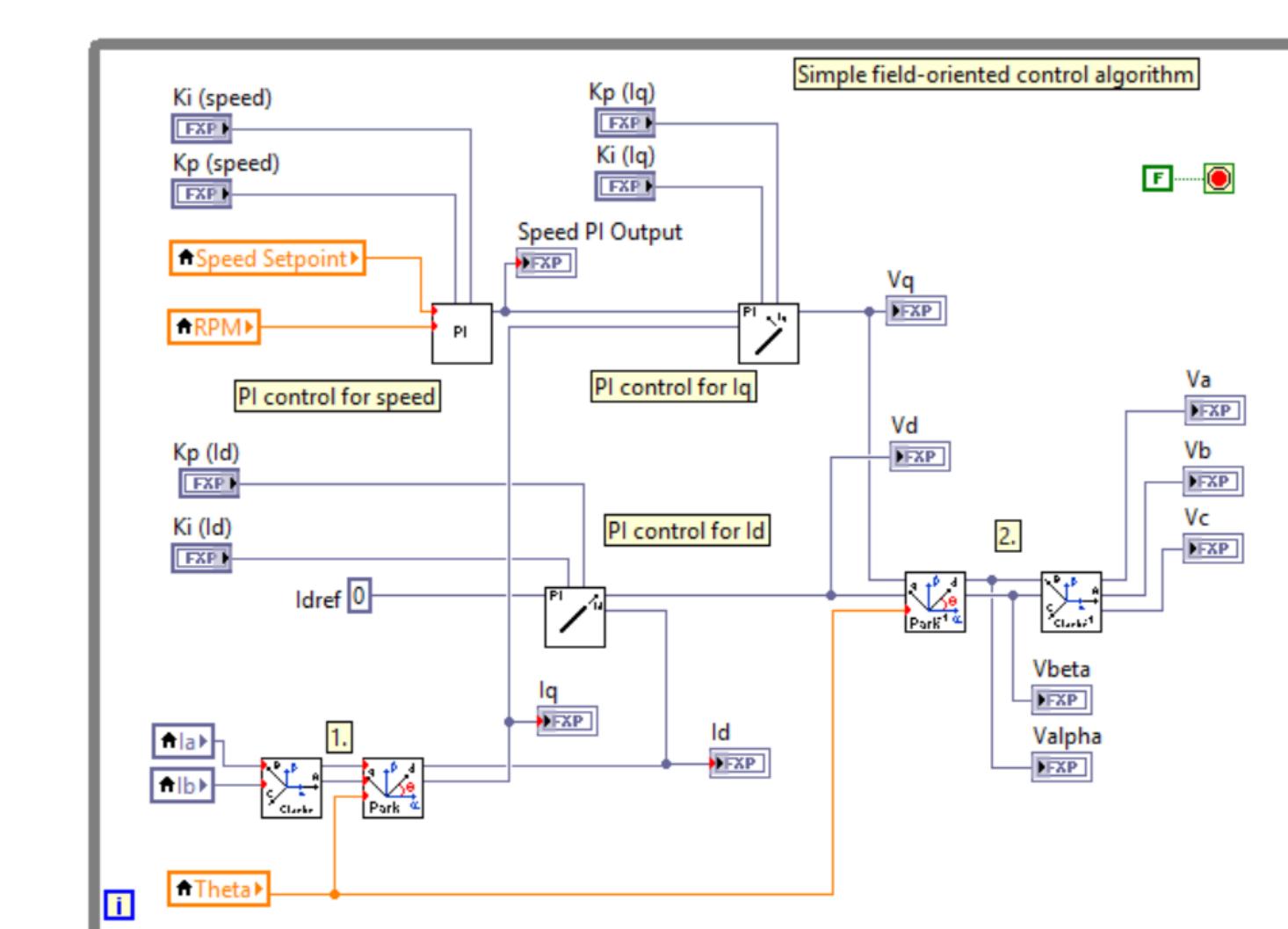
MOSFET selection:

- Frequency and dead-time: ~4kHz optimal
- Losses dominated by R_{DS}
- Thermal capacity of copper sufficiently large

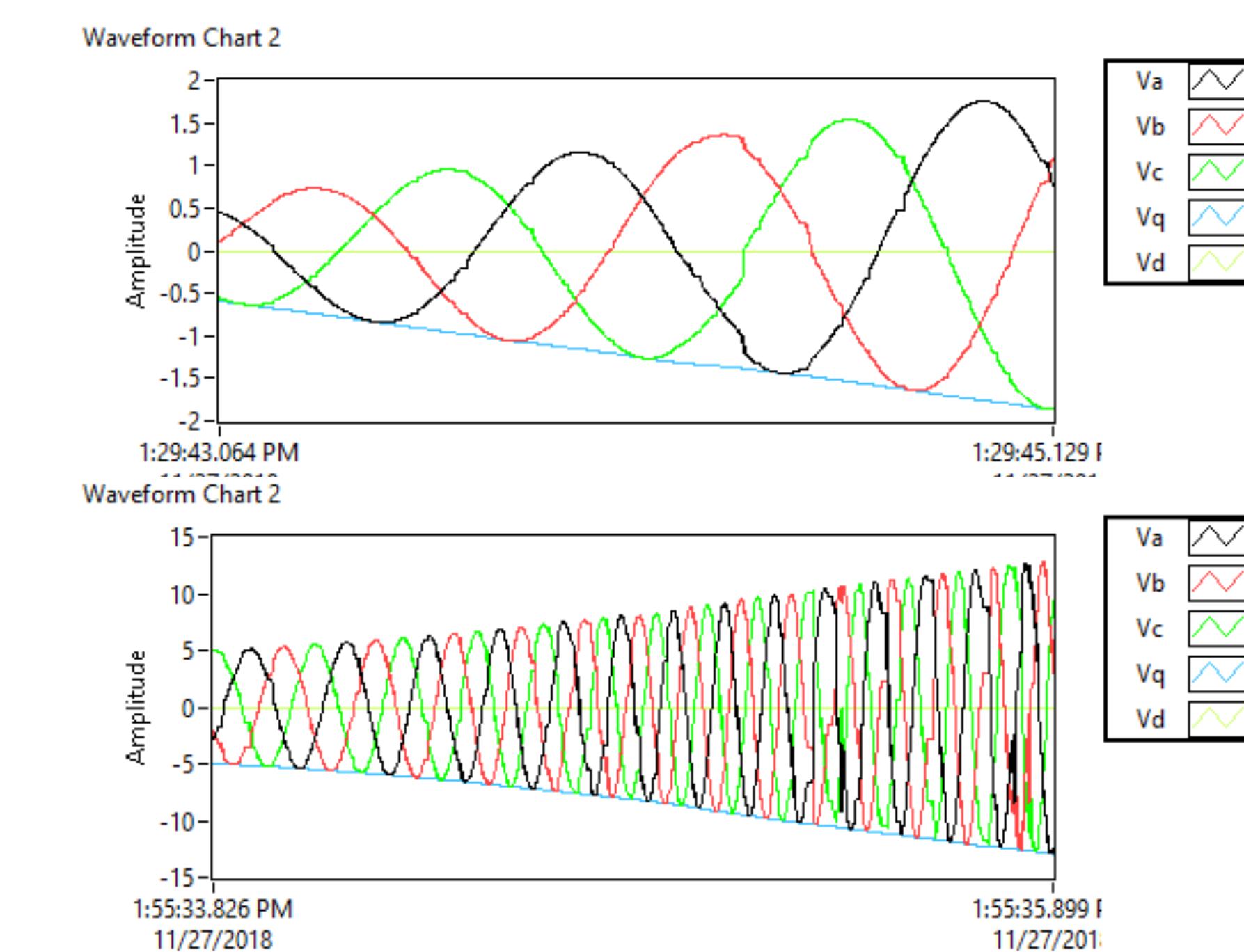
Thermal Pad Comparison

Thickness (mm)	k (W/mK)	ΔT (°C)	Cost / board	Digikey PN
0.127	1.8	0.24	\$4.28	1168-1384-ND
0.5	1.5	1.11	\$4.70	BER161-ND
1	1.0	3.33	\$2.67	3M156051-ND
2	1.5	4.44	\$8.05	BER164-ND

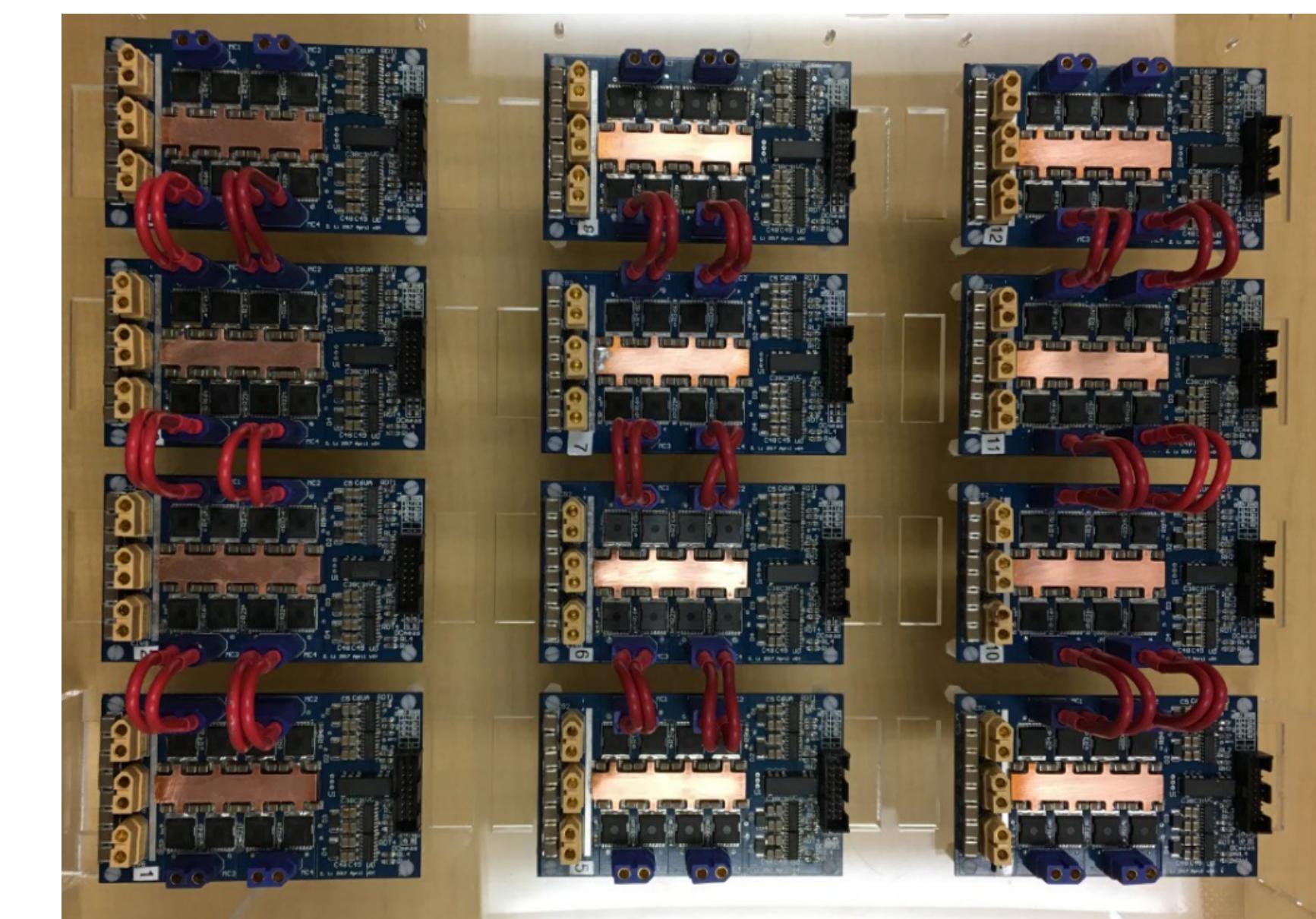
Motor Control



Field-Oriented Control takes full advantage of precise current control ability



Future Work : Assembly



References

- [1] Goetz, Stefan M., et al. "Control of Modular Multilevel Converter With Parallel Connectivity—Application to Battery Systems." *IEEE Transactions on Power Electronics* 32.11 (2017): 8381-8392.
- [2] Z. Li, A. V. Peterchev, R. Lizana, and S. M. Goetz, "Distributed Balancing Control for Modular Multilevel Series/Parallel Converter with Capability of Sensor-less Operation," in *Energy Conversion Congress and Exposition (ECCE), 2017 IEEE*, 2017.