Rethinking inductor structures across broad application ranges

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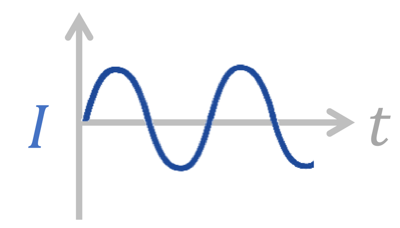
Research Approach

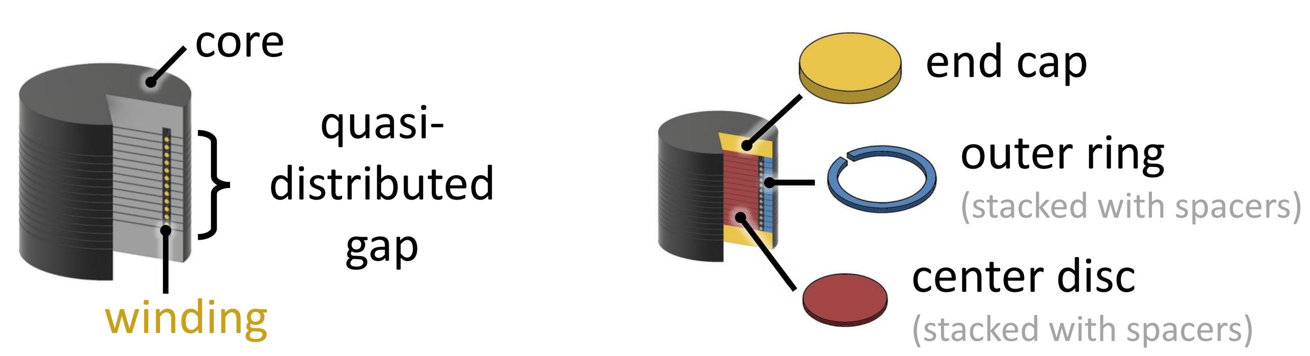
Develop new inductor designs optimized for different design cases

Modular Pot Core Inductor

Inductor design case: currents with **large ac** ripple
(e.g. resonant converters, DCM/BCM converters)

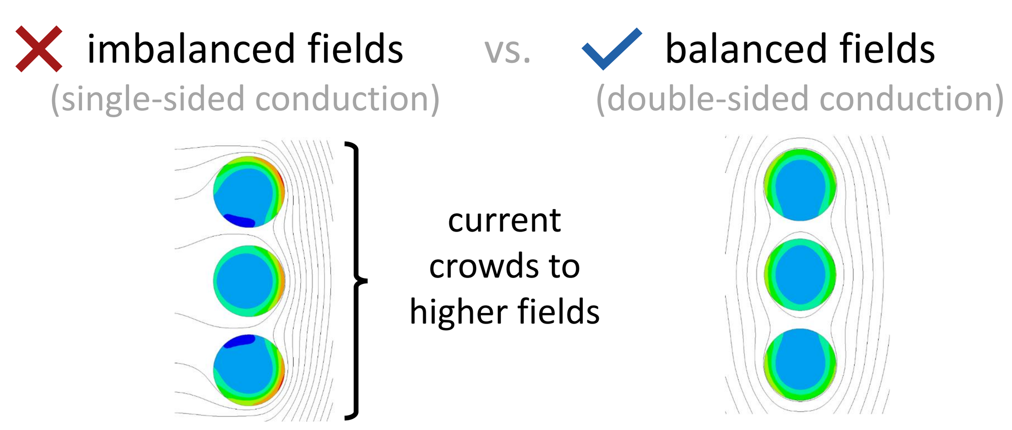


Inductor design:

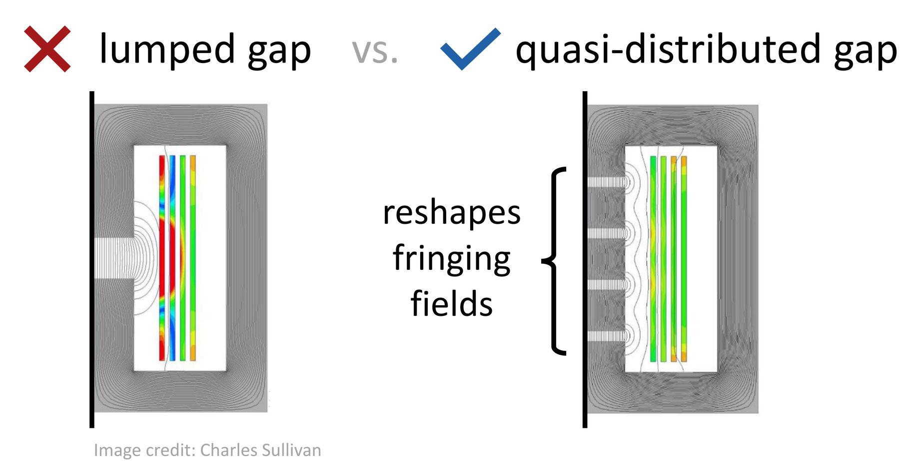


Major design goal: **reduce ac sources of loss** through three main features

1. reduce ac winding loss via **field shaping**



2. reduce fringing field loss via **quasi-distributed gaps**



3. reduce core loss via **larger core-to-window area ratio**

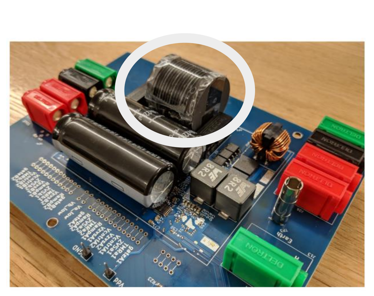
Results: **50% less** loss (vs. conventional designs)

Experimental comparisons between MP and EQ cores at 3 MHz
(Core material: Fair-Rite 67)

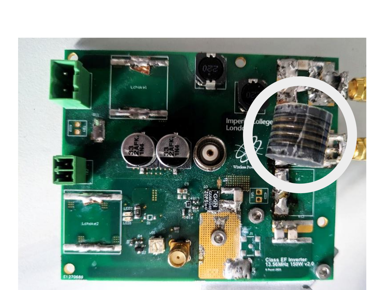
Volume	Power	Core	L	Q – sim (solid wire)	Q - meas (solid wire)	Q - meas (litz wire)
3700 mm^3	280 VA (2.0 – 2.1 A)	EQ #1	7.8 µH	–	**270**	**370**
		MP #1	6.8 µH	520	**520**	**700**
7400 mm^3	520 VA (1.8 – 2.0 A)	EQ #2	16.5 µH	–	**280**	**340**
		MP #2a	12.9 µH	590	**590**	**780**
		MP #2b	15.8 µH	570	**500**	**610**
14800 mm^3	910 VA (2.7 A)	MP #3	13.4 µH	680	690	960

Demo in systems:

660W PFC
98% efficiency, 80W/in^3
1-3 MHz operation

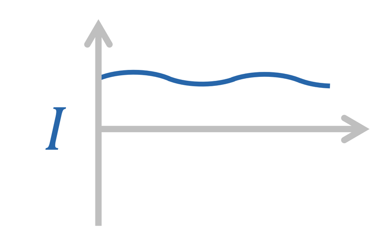


70W wireless power system
94% efficiency
13.56 MHz operation

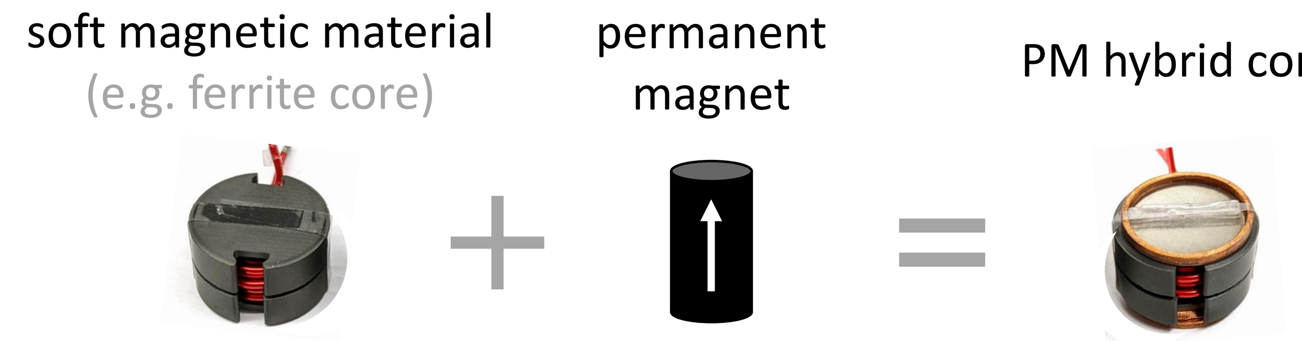


Permanent Magnet Hybrid Core Inductor

Inductor design case: currents with **large dc** and small ac ripple
(e.g. input/output filters, deep CCM converters)

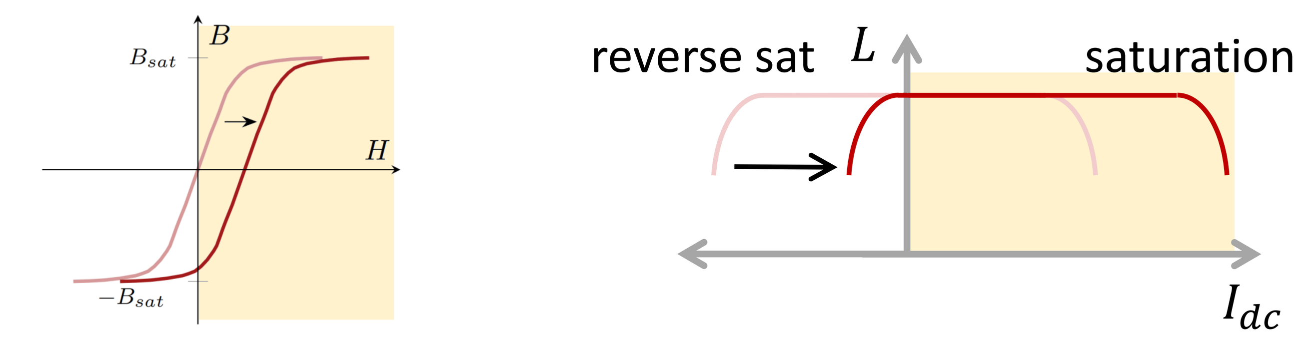


Inductor design:



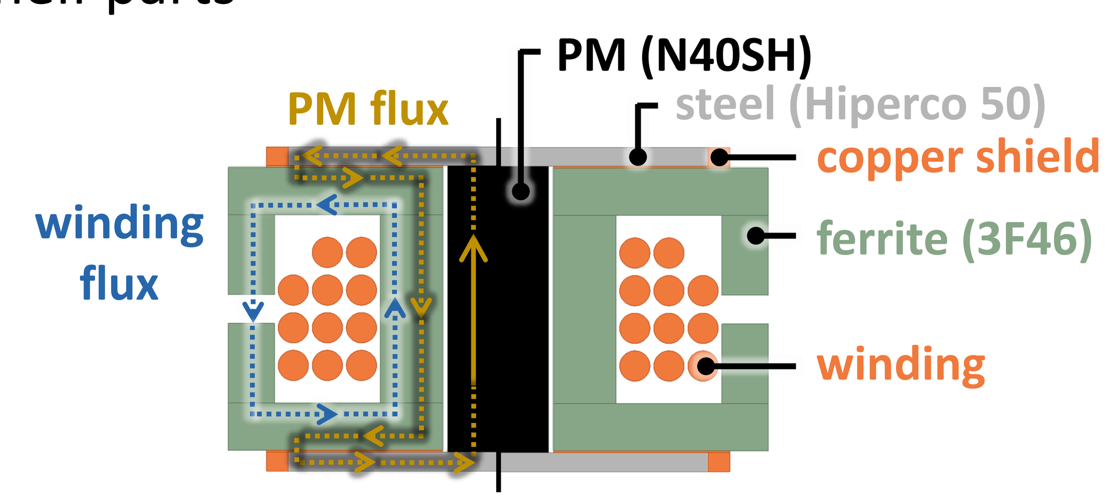
Major design goal: improve **saturation** of the core

- use PM to **offset** winding flux



Prototype: using off-the-shelf parts

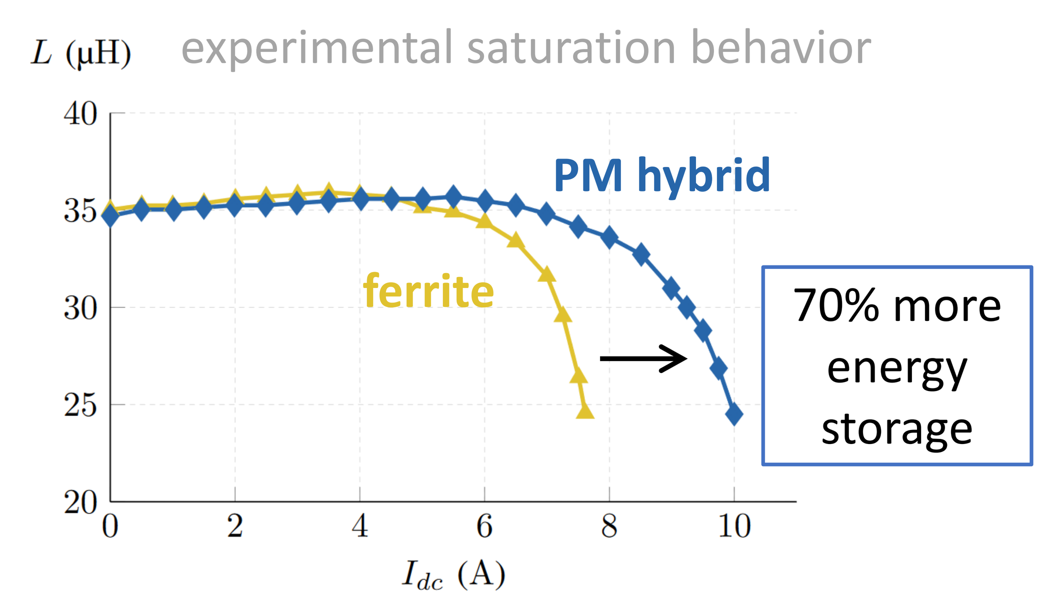
- place PM outside winding flux path to **reduce demagnetization risk**
- **guide PM flux** to ferrite region with smallest core area



Results: compare pure ferrite core to PM hybrid core
(same total core volume and cross-sectional area)

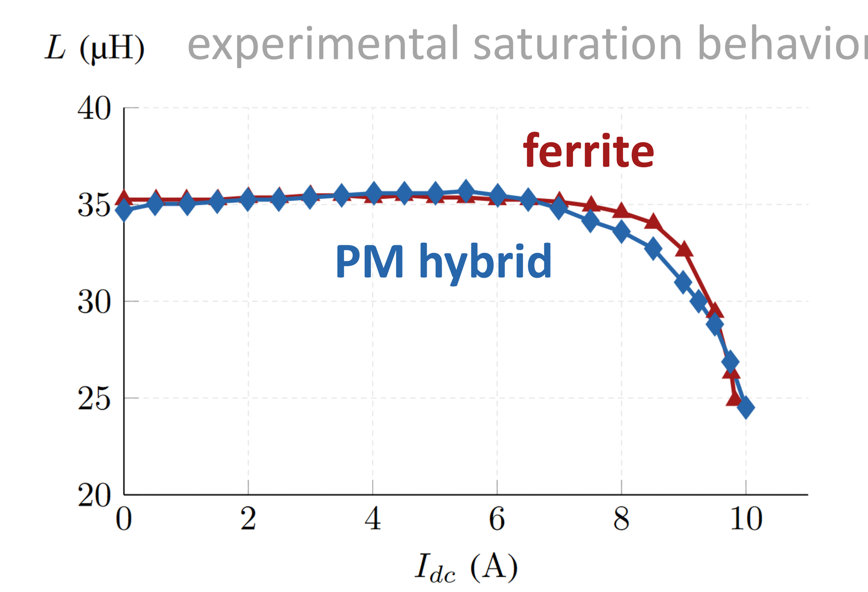
70% more energy storage

Both at R_{dc} = 7 mΩ



50% less dc loss

R_{dc} = 14 mΩ → R_{dc} = 7 mΩ



The work featured on this poster was done in collaboration with folks at MIT (David Perreault, Mansi Joisher, Alex Hanson–now at UT Austin), Dartmouth (Charles Sullivan, Andrew Nadler, Thomas Guillod, Bradley Reese), and Imperial College London (Paul Mitcheson, Ioannis Nikiforidis, Nunzio Pucci, Prateek Wagle)

Links to relevant papers here: