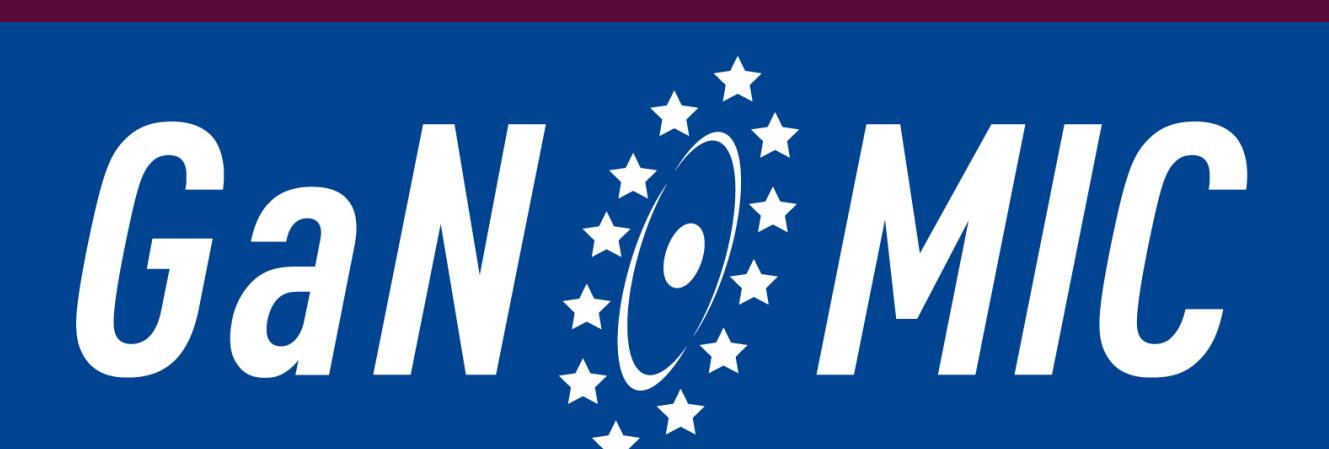


Design of a Low-Capacitance Planar Transformer for a 4 kW/500 kHz DAB Converter



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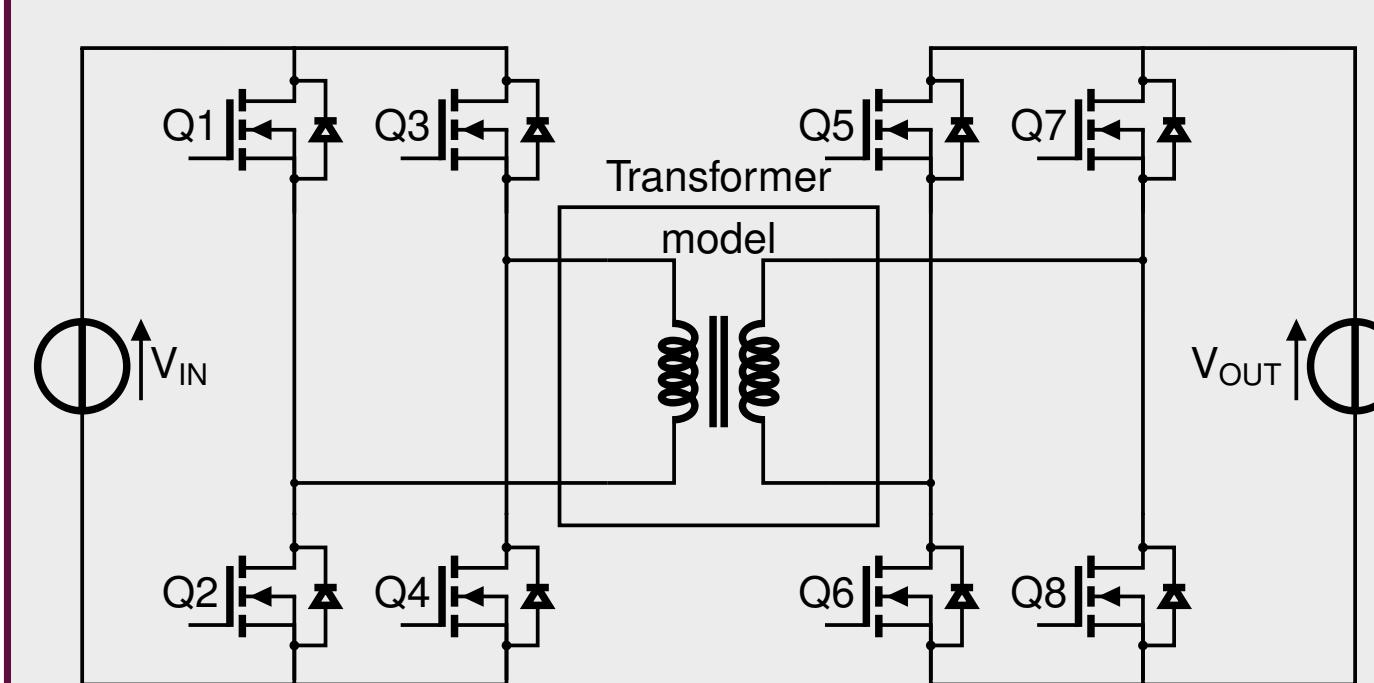
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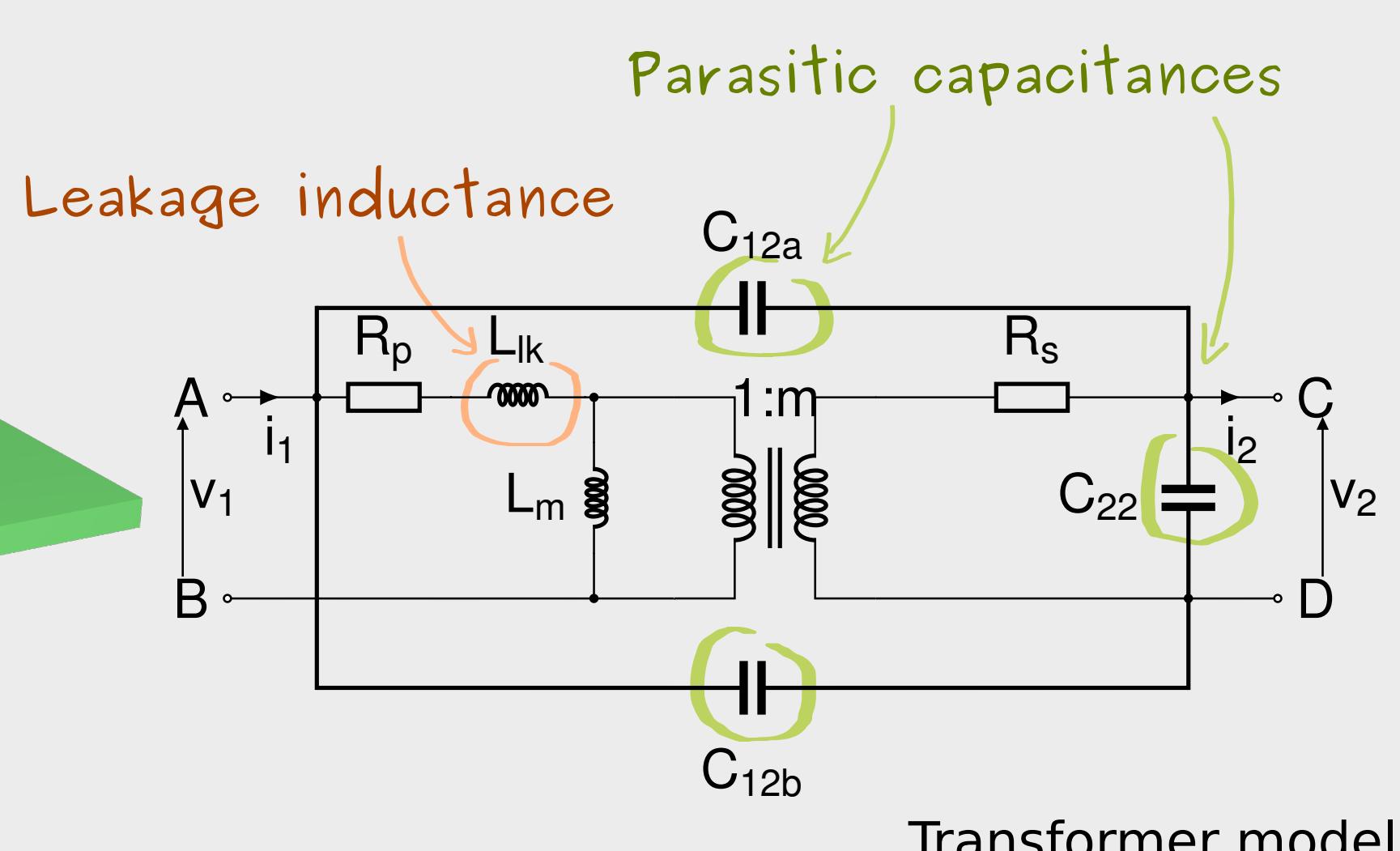
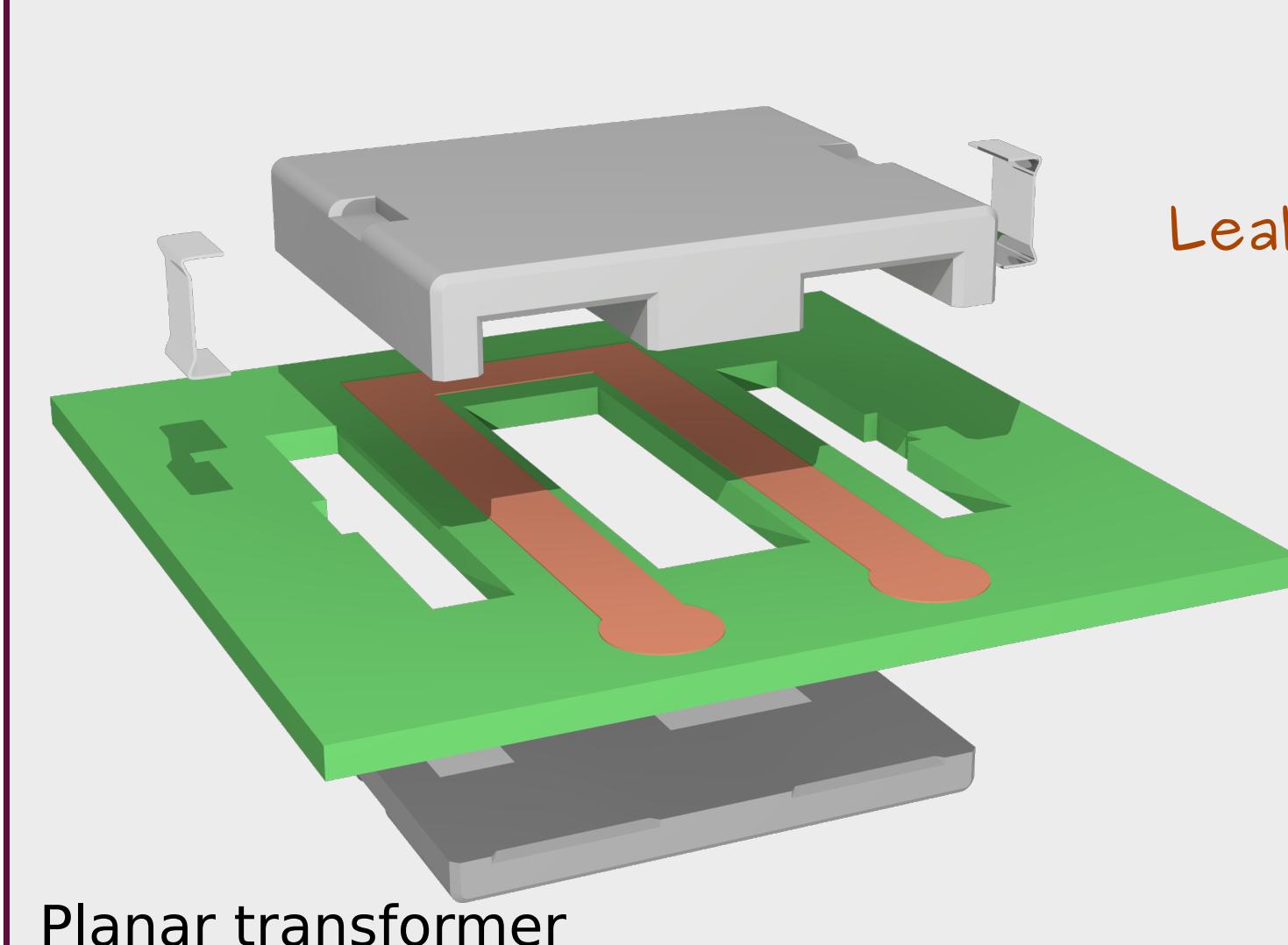
Questions:

- ⇒ How to design a planar transformer for a High Frequency Dual-Active-Bridge (DAB) converter?
- ⇒ What is the effect of inter-winding capacitance?

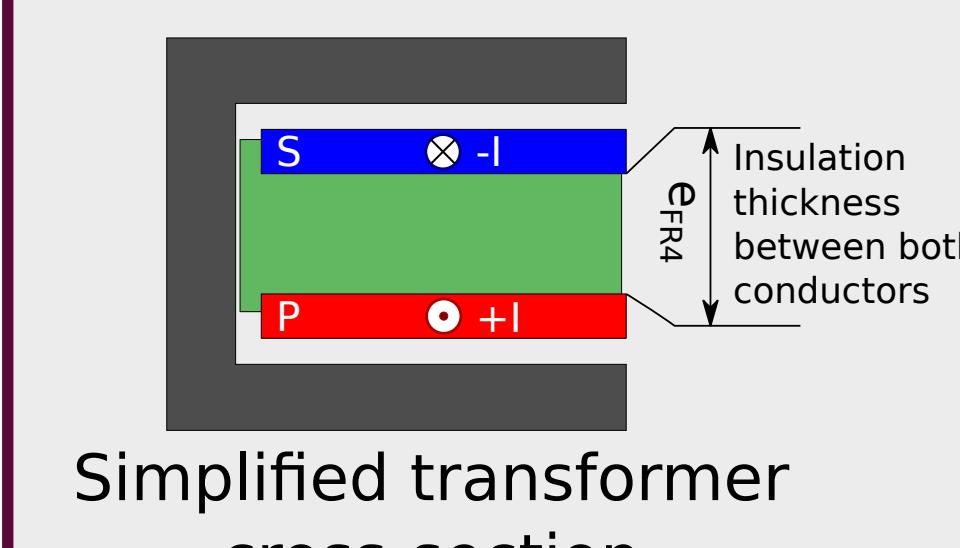
Introduction and context



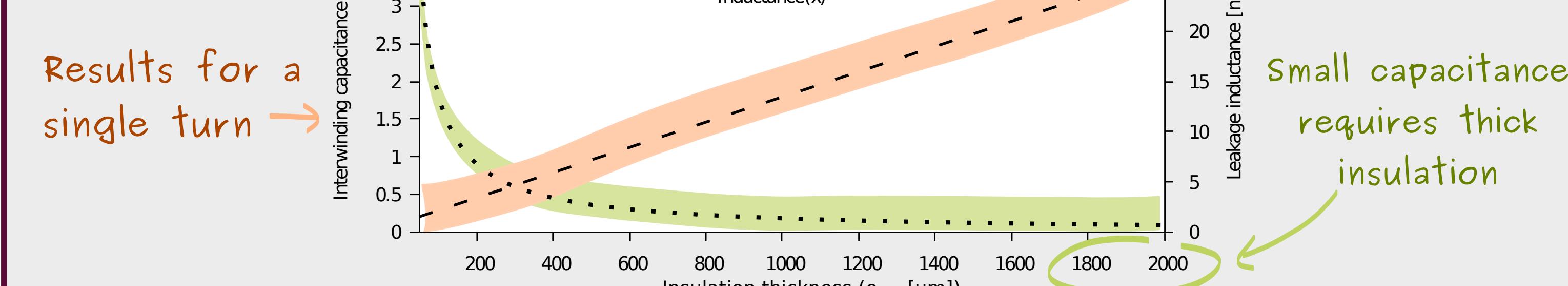
- ⇒ Design of a DAB converter with high frequency GaN switches.
- ⇒ "Full PCB" technology, including transformer windings (planar)
- ⇒ Focus on transformer design



Capacitance/inductance trade-off



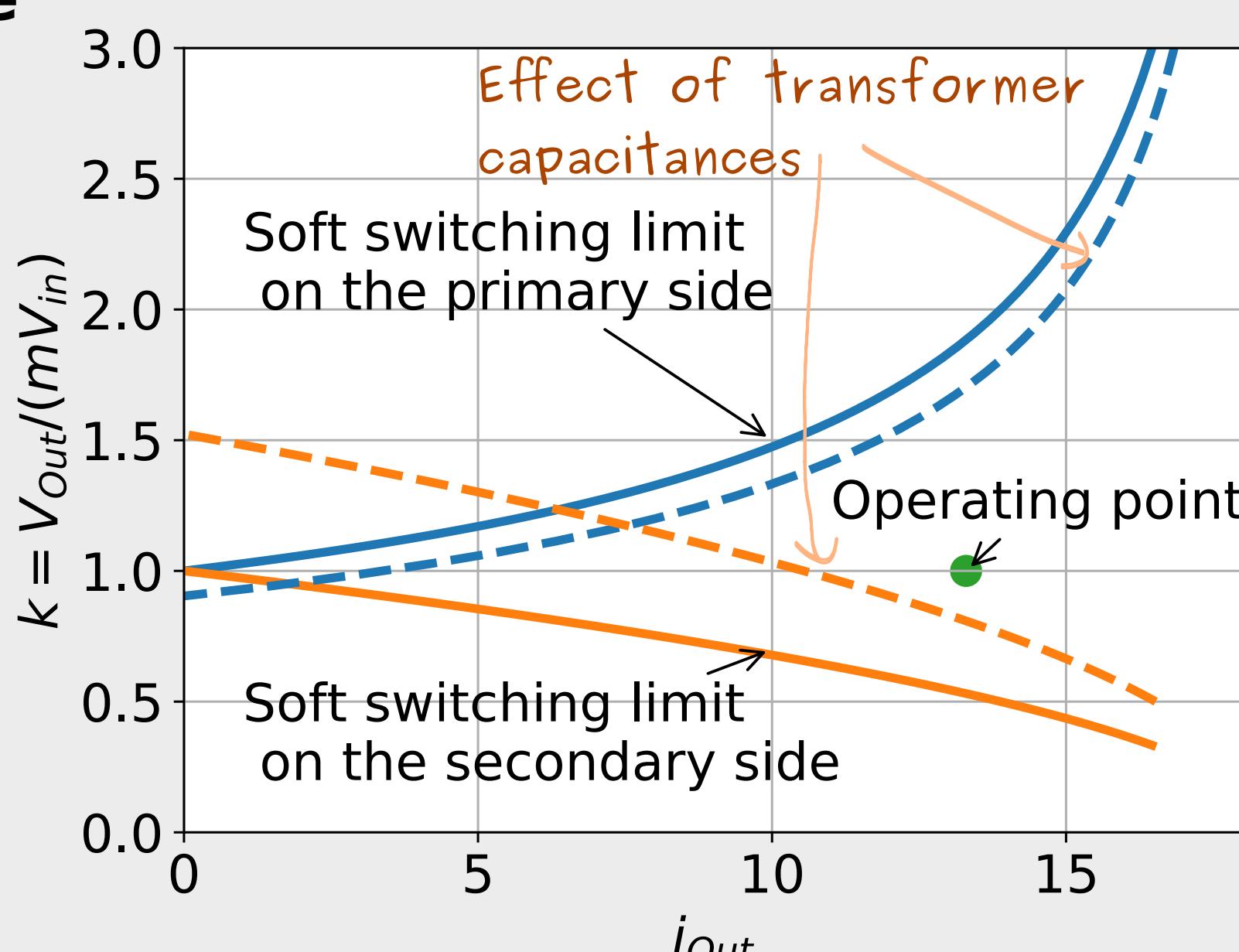
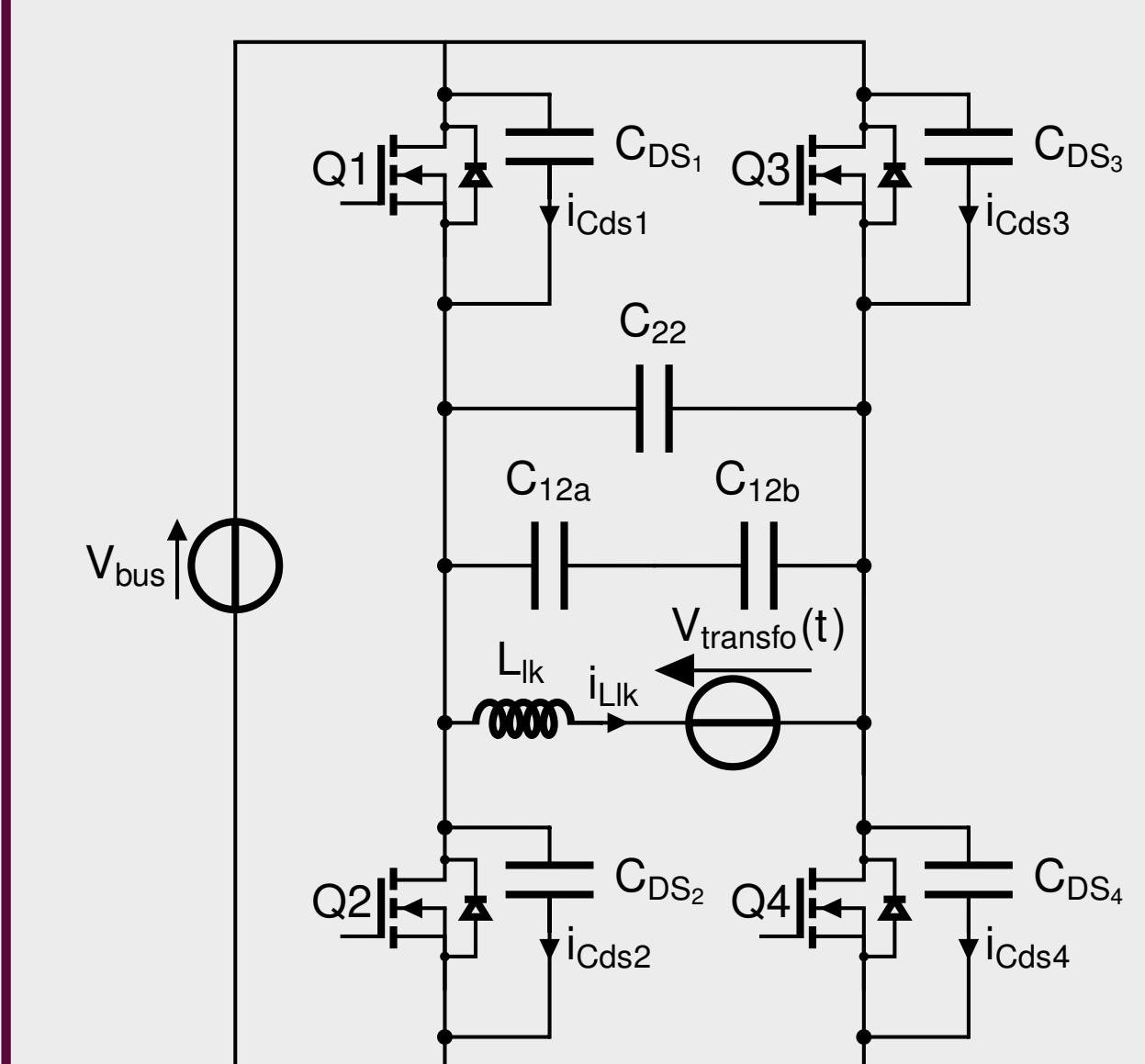
- ⇒ Thin insulation between primary and secondary causes large capacitances
- ⇒ Thicker insulation increases L_{lk} and total transformer thickness



Effect on DAB operation

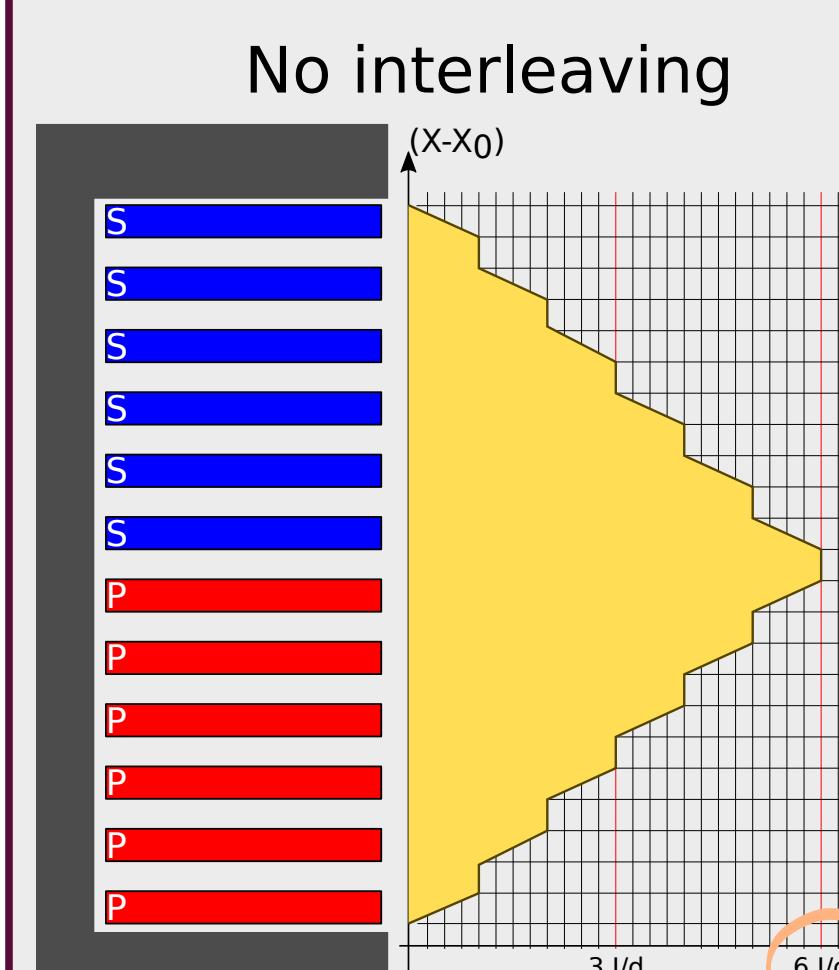
- ⇒ Both inter- and intra-winding capacitances add to devices capacitances
- ⇒ Zero voltage switching requires energy transfer from capacitances to leakage inductance

Reduction of ZVS range

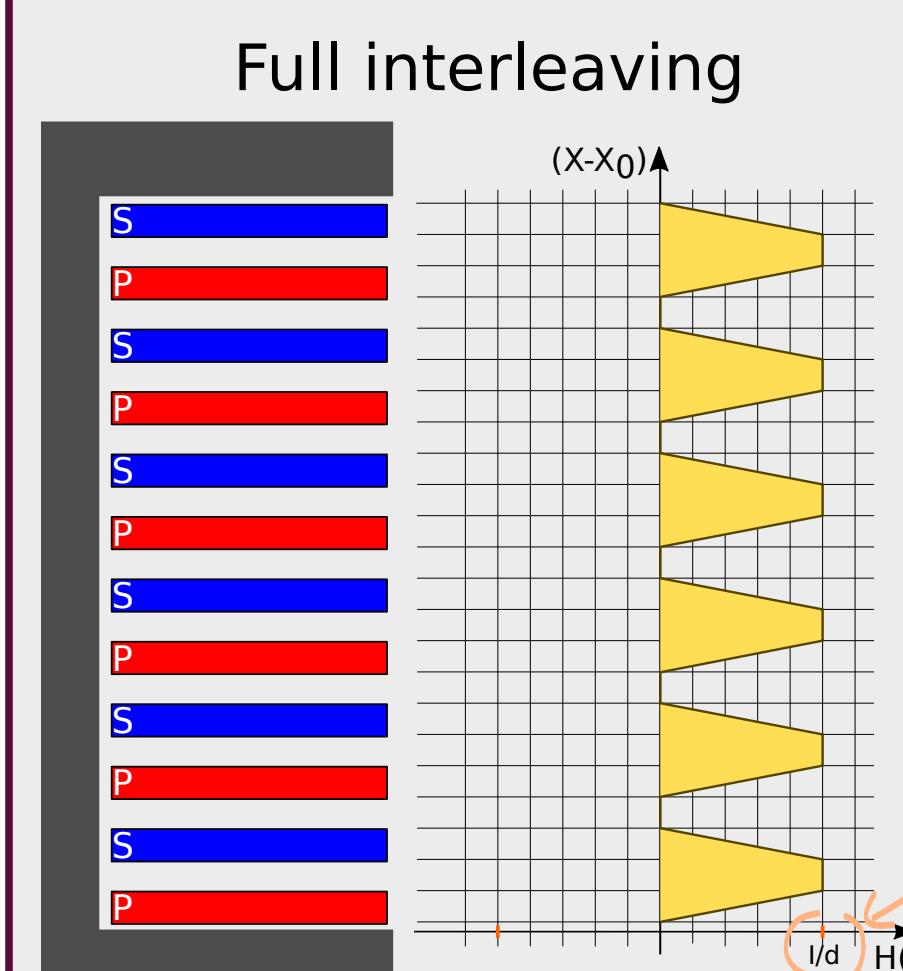


Design parameters

- ⇒ FEM magnetostatic simulations (Ansys Maxwell) used to compute inductance
- ⇒ Alternative interleaving selected
- ⇒ Prototypes built to validate design
- ⇒ Final design: **400 pF** inter-winding capacitance, **450 nH** leakage inductance

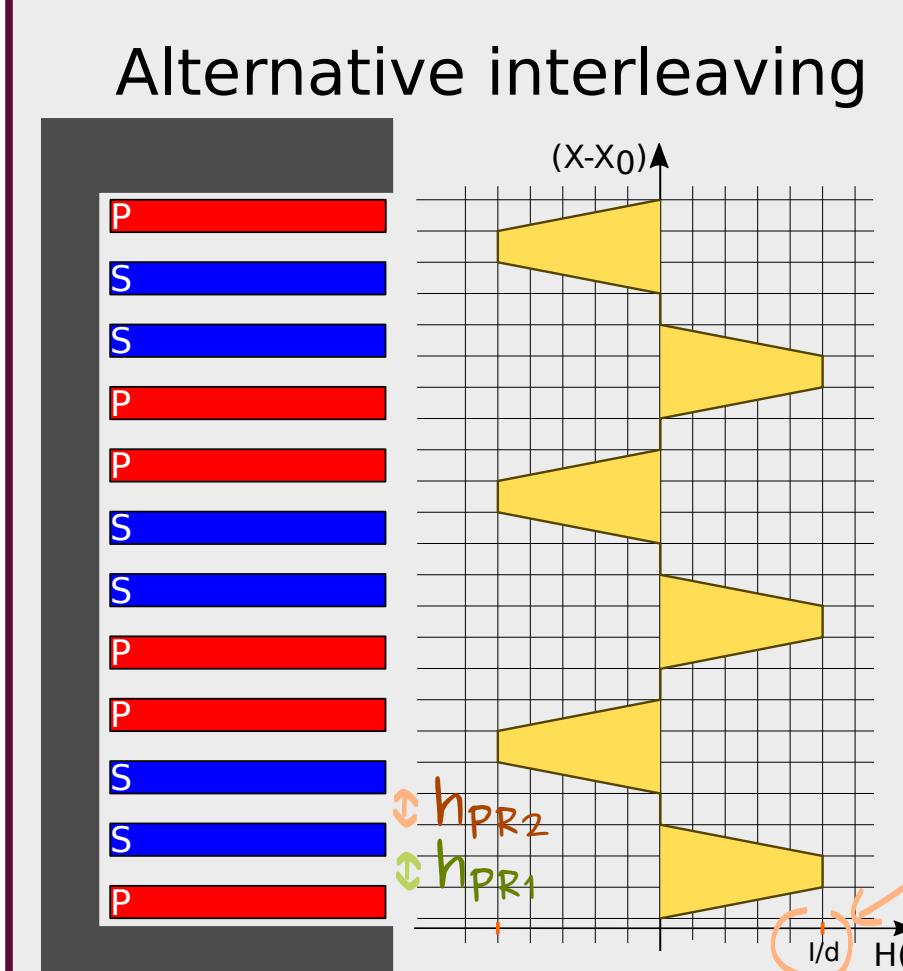
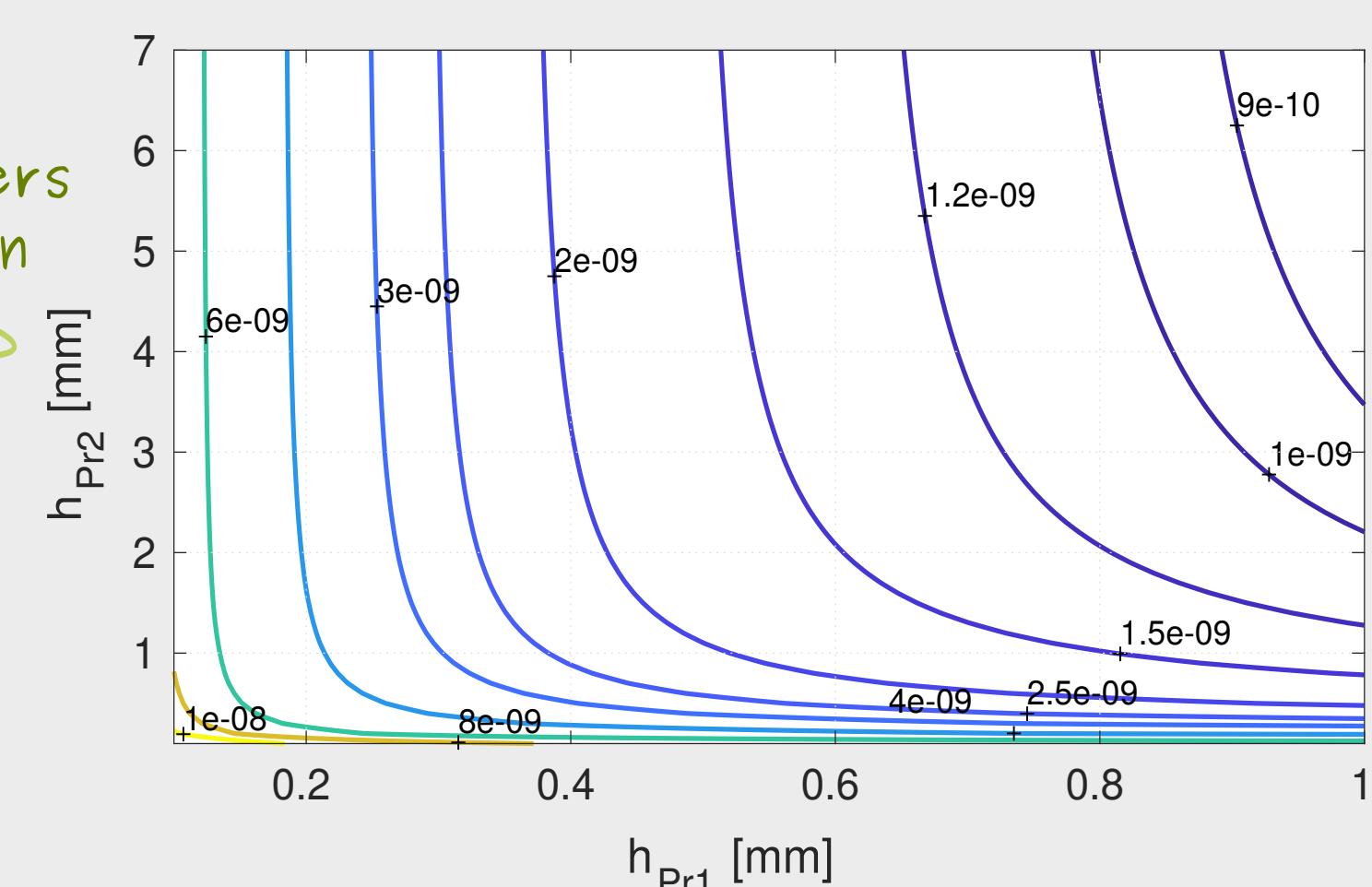


Leakage inductance too high



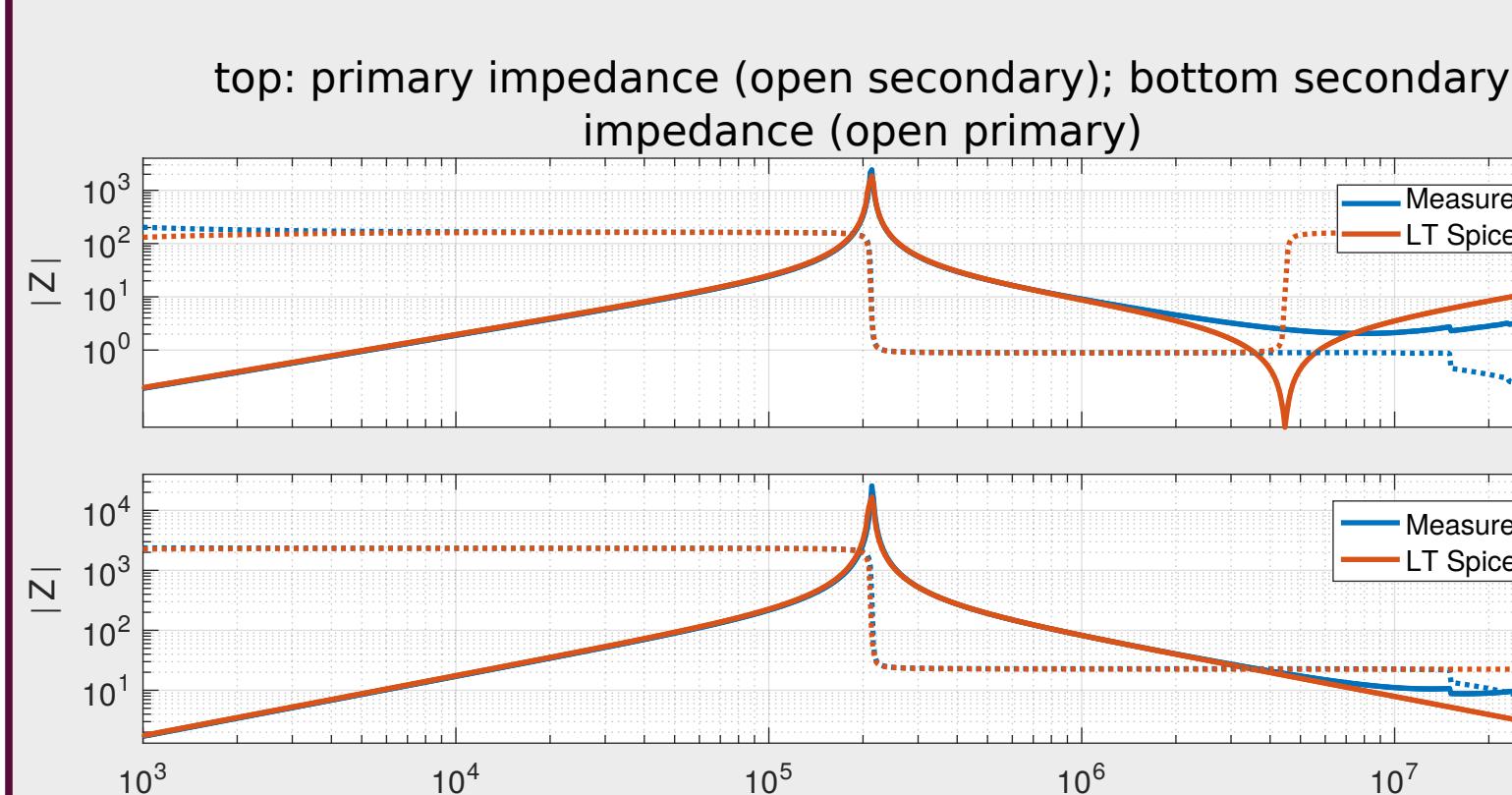
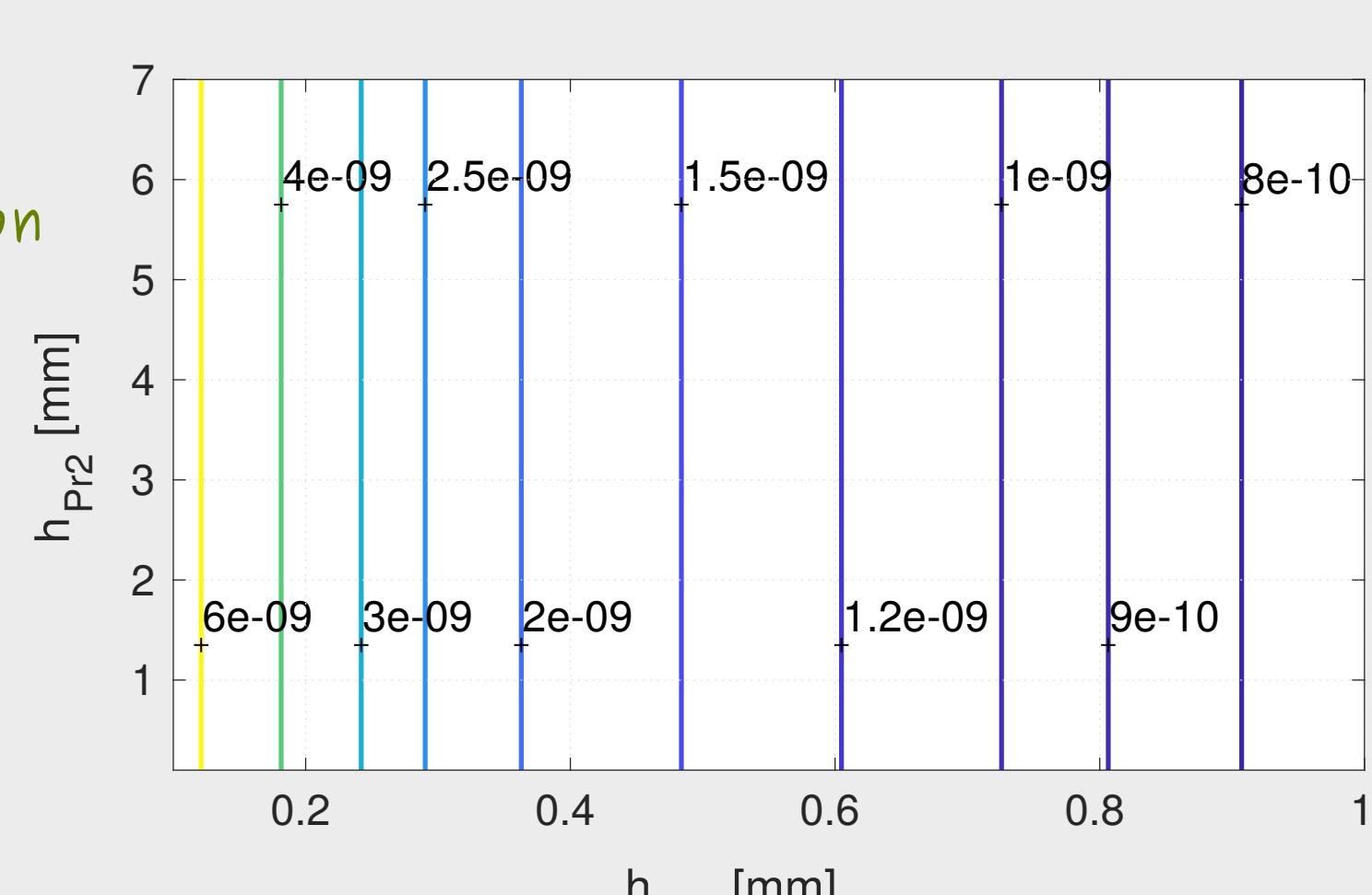
All dielectric layers have an effect on capacitance

Low Leakage inductance



Only half the dielectric layers have an effect on capacitance

Low Leakage inductance



- ⇒ Prototype build and tested with an impedance analyzer
- ⇒ Model proposed
- ⇒ Very good match up to 1MHz

Conclusions:

- ⇒ **Planar transformer structure may be used** for this high frequency DAB application.
- ⇒ **Both low Inter-windings capacitance and leakage inductance are required**: use of alternative interleaving
- ⇒ Even with the low capacitance values achieved, the soft-switching **operating range of the DAB is affected** and special modulations techniques will be used

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