

Power Transformer Hysteresis Measurement

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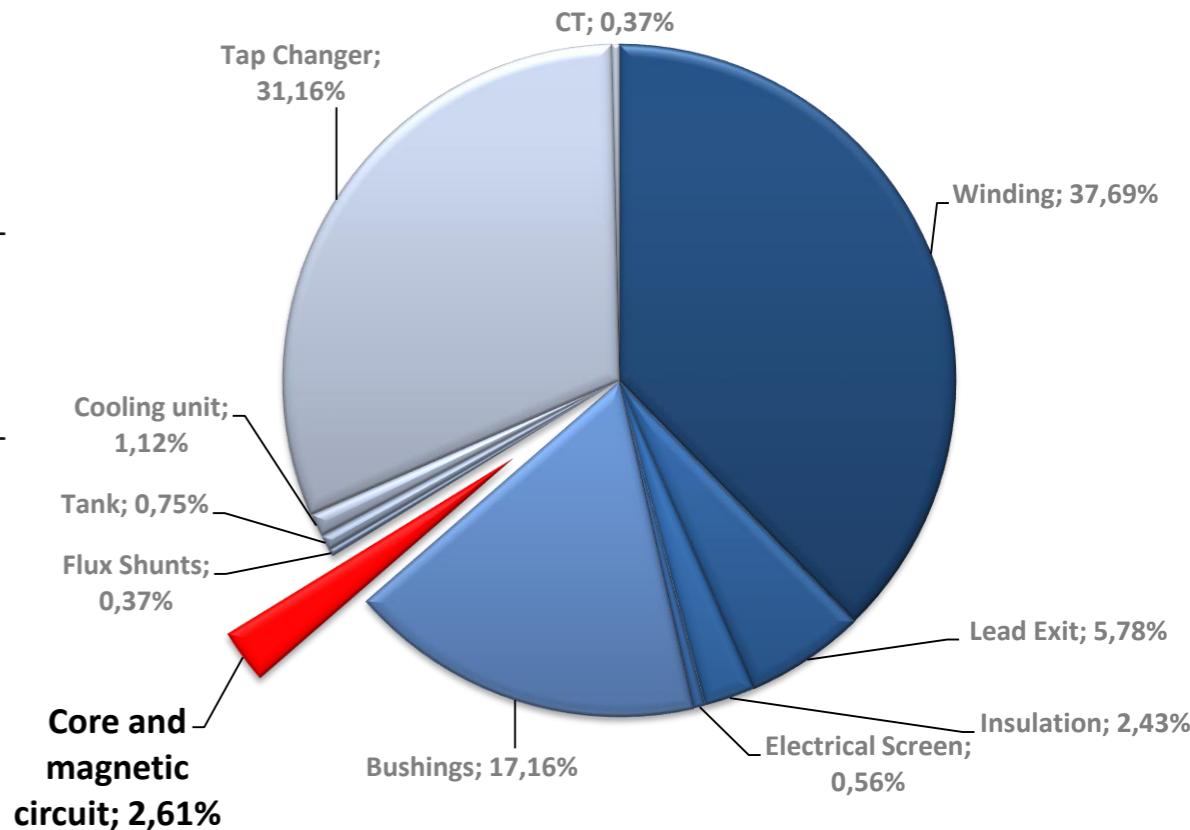
⁴ Austrian Power Grid, Wien

⁵ Siemens Energy, Weiz

Motivation

Failures 2000 - 2009			
Tx Type	Failures	Failure Rate	Tx Years
Substation	799	0.53 %	150,072
GSU	166	0.95 %	17,387

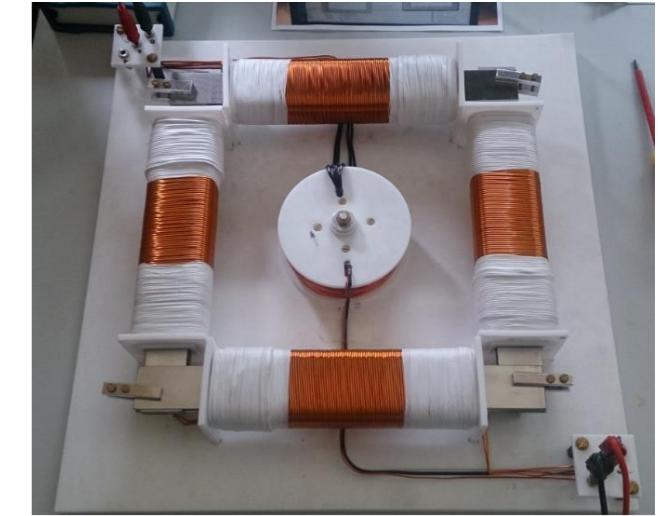
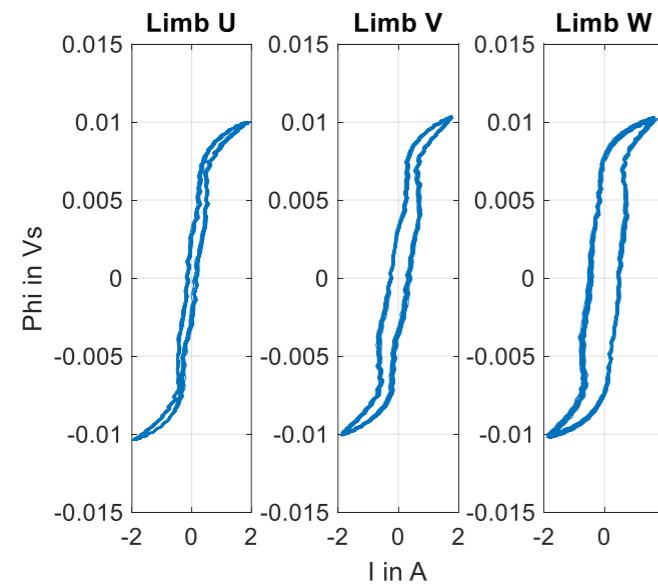
- Few information about inadequate core design
- Can cause circulating currents
→ increased losses
→ additional costs



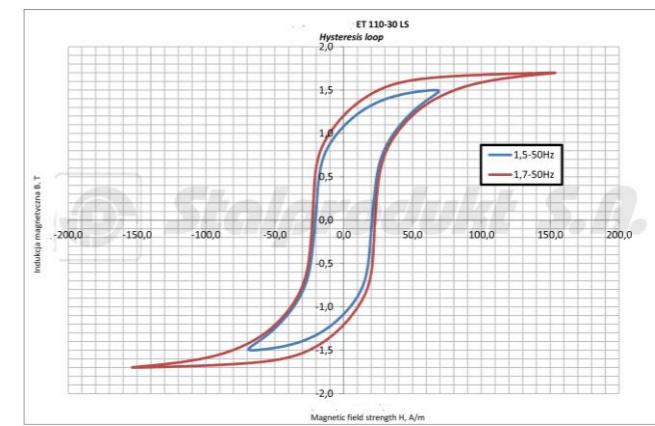
Credit: Cigre WG A2.37, Transformer Reliability Survey, 2015

State of the Art

- Epstein frame measurements of core material
 - ❖ Magnetic coupling of phases
 - ❖ Windings capacitance



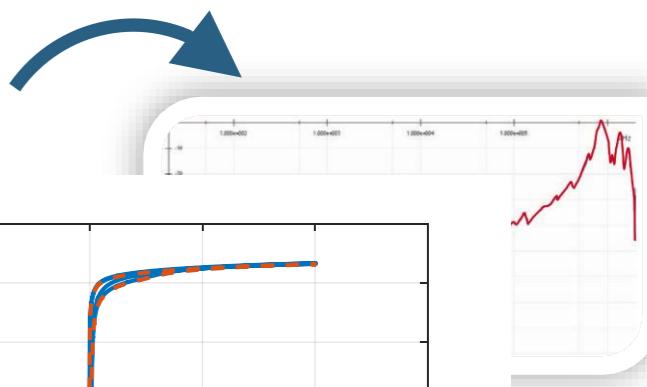
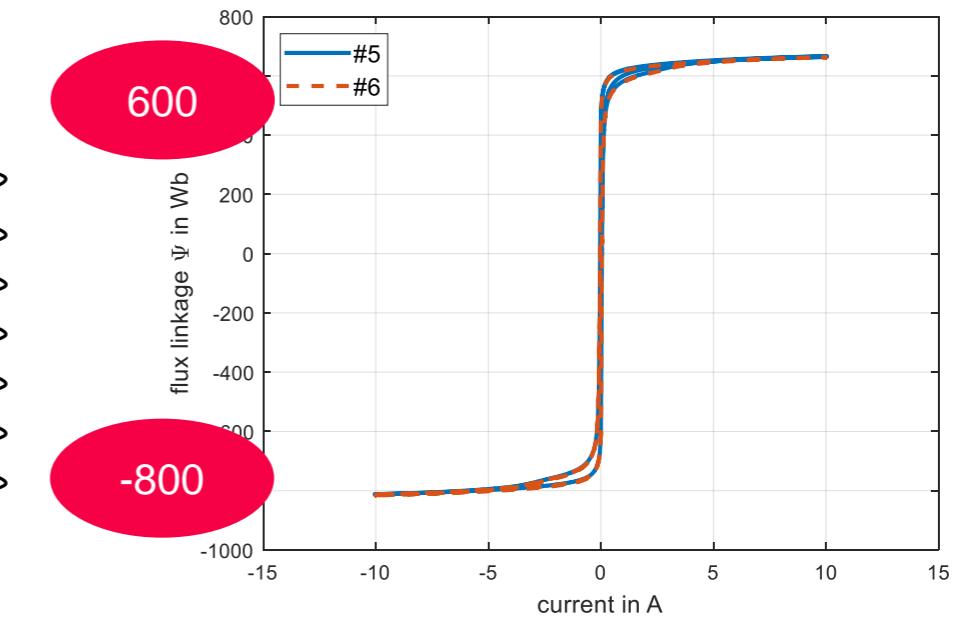
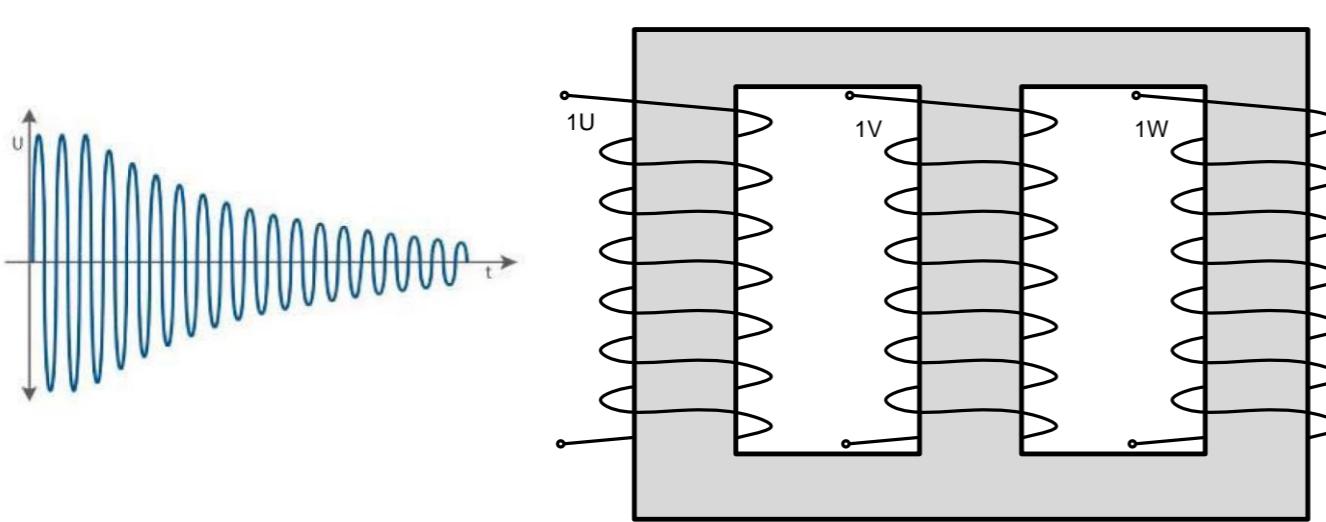
Credit: Roppert, K., Institute of Fundamentals and Theory in Electrical Engineering, Graz University of Technology



Credit: Stahlprodukt S.A.

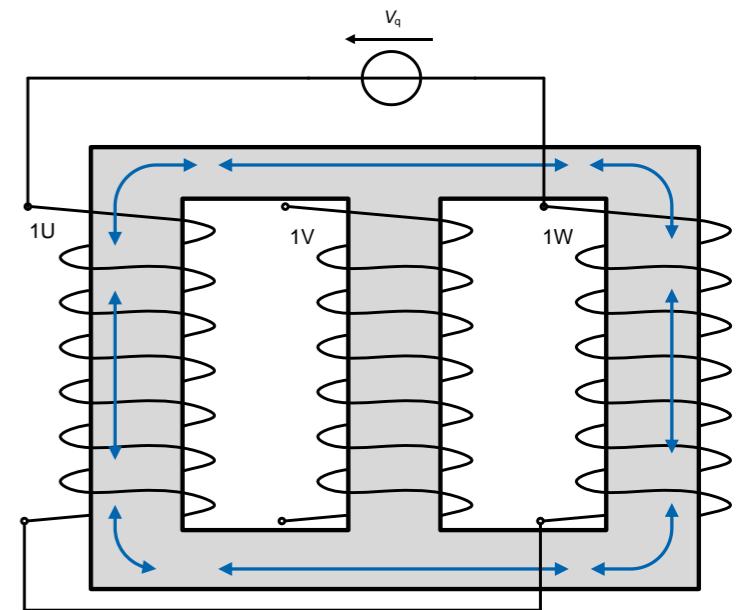
Demagnetization of Transformer Cores

- Remanez flux offsets the hysteresis measurement
- Shifts **Sweep Frequency Response Analysis (SFRA)**

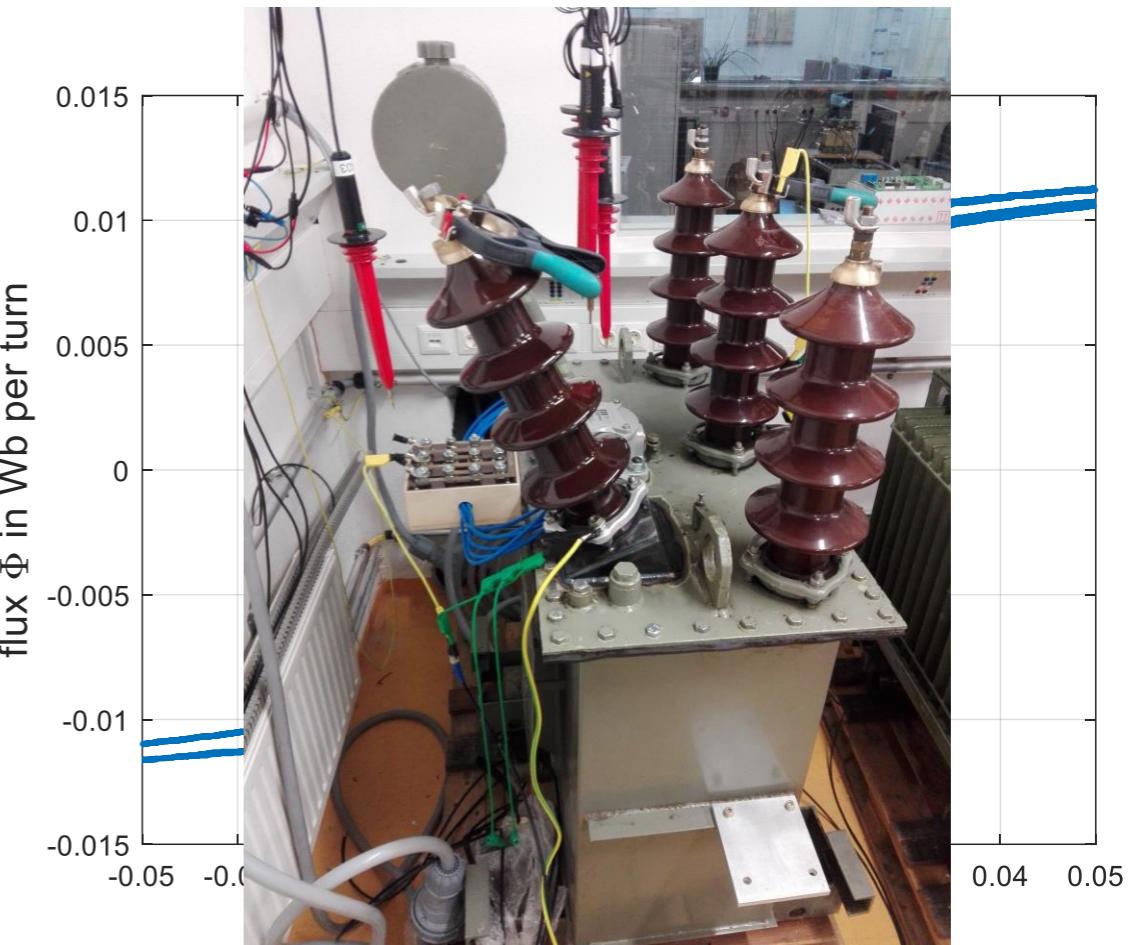
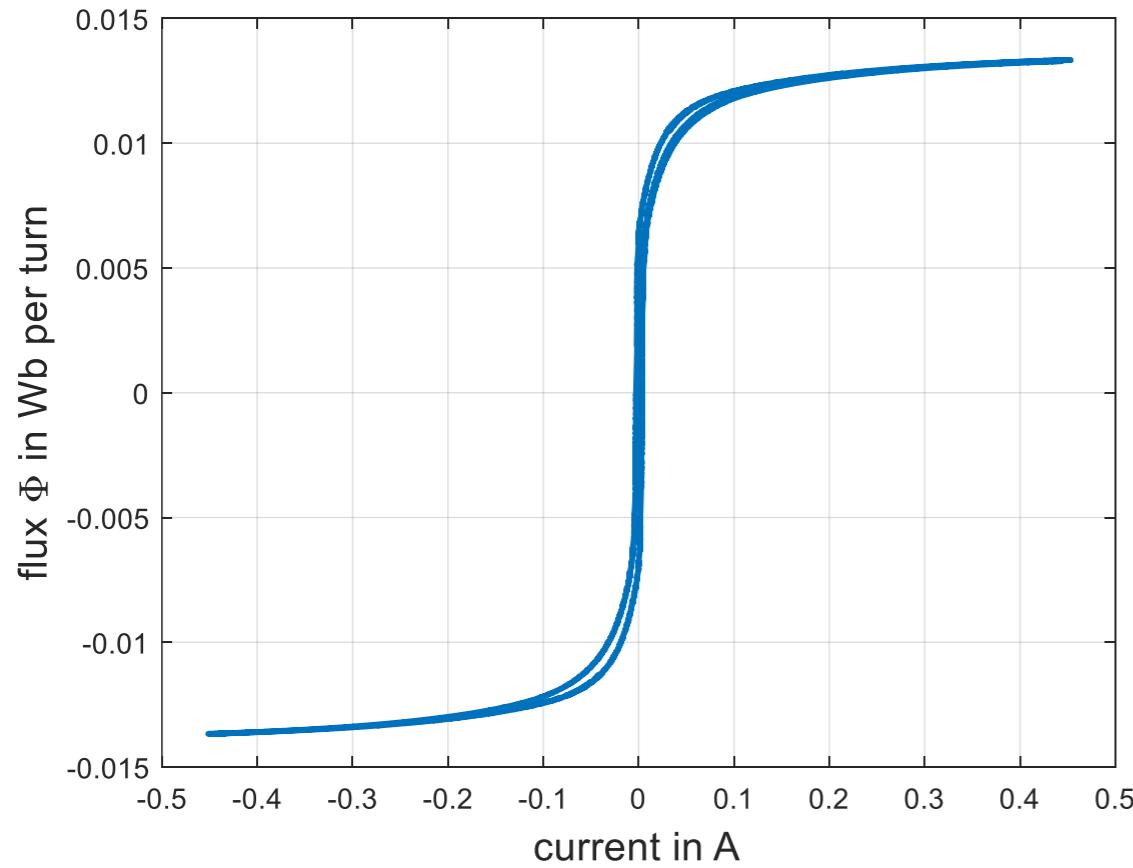


Hysteresis Measurement Setup

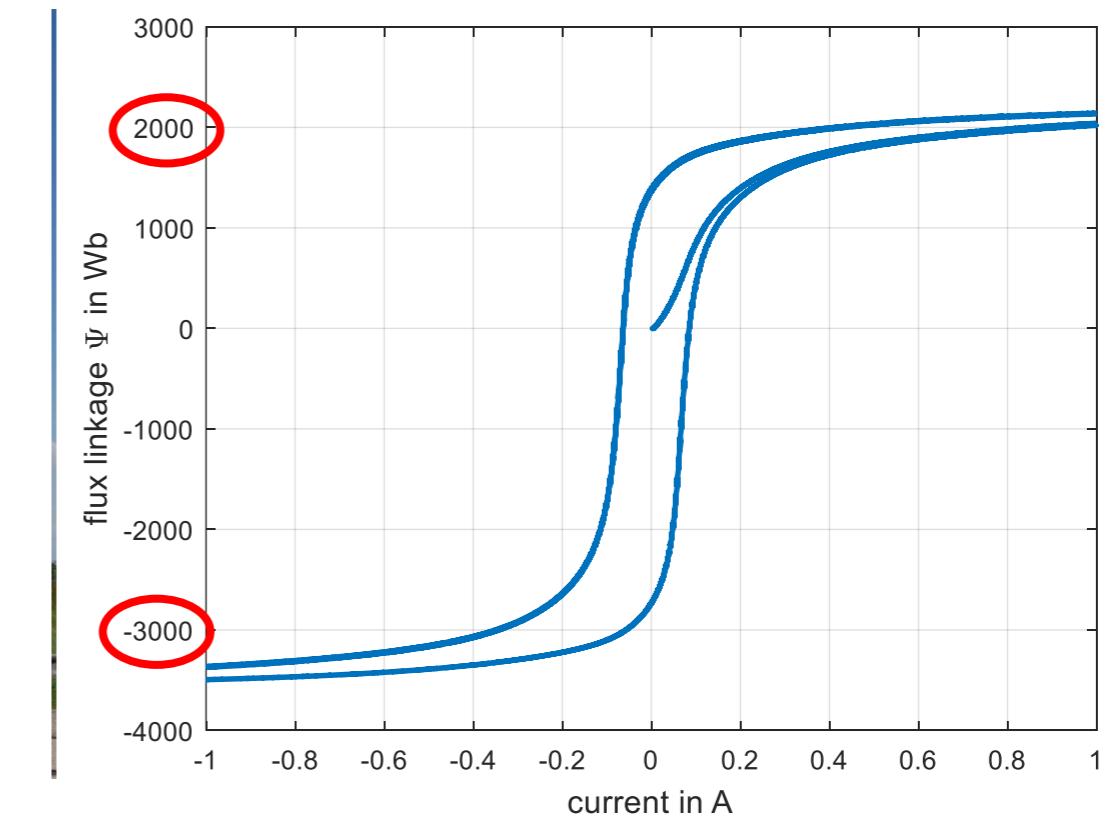
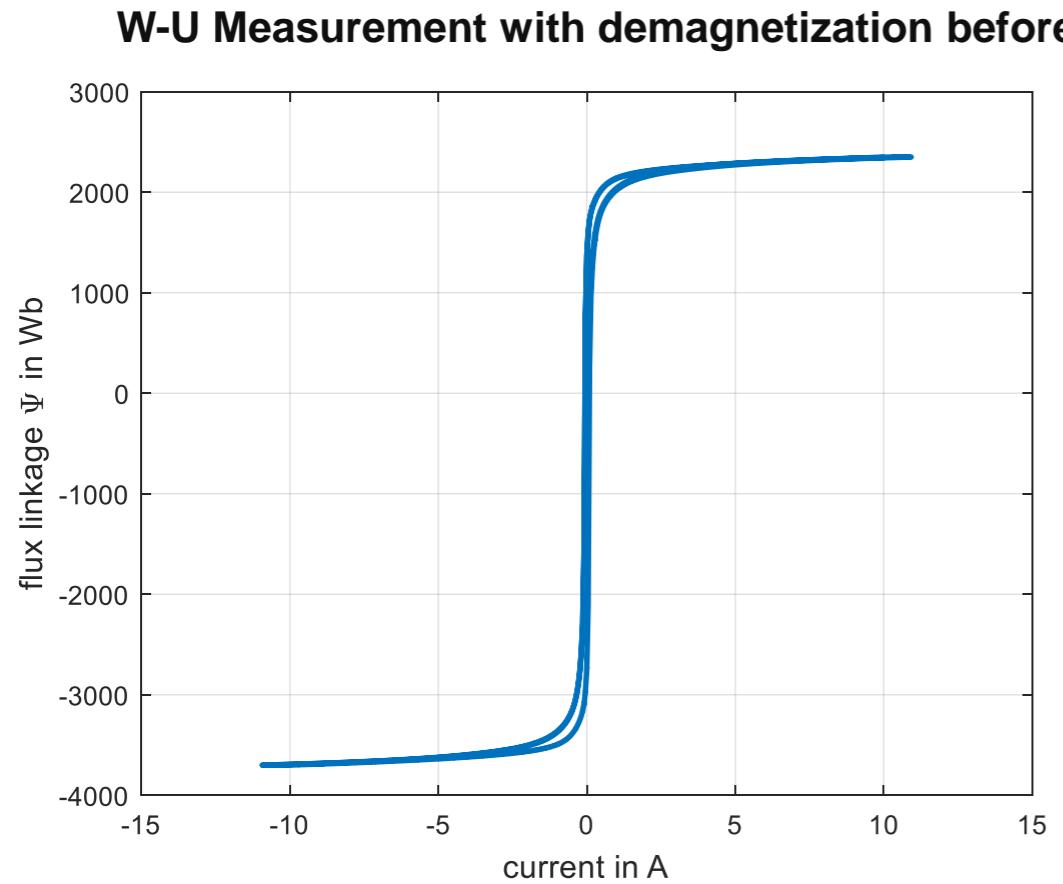
- (prevent) magnetic coupling of phases
- Assumption: $B_{\text{limb}} \geq B_{\text{yoke}}$; $B < 1.95 - 2.0 \text{ T}$
- Usage:
 - Core ‘fingerprint’
 - Electromagnetic modelling



Example | 3-limb 3-phase 50 kVA



Example | 5-limb 3-phase 300 MVA

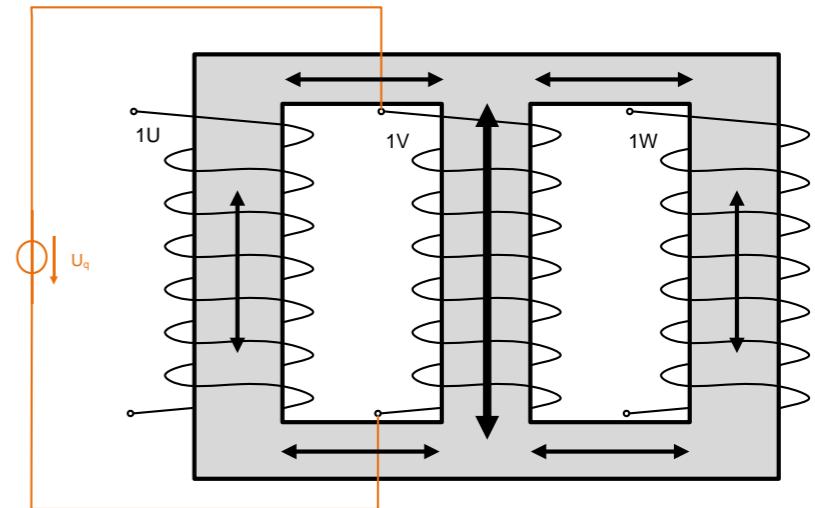
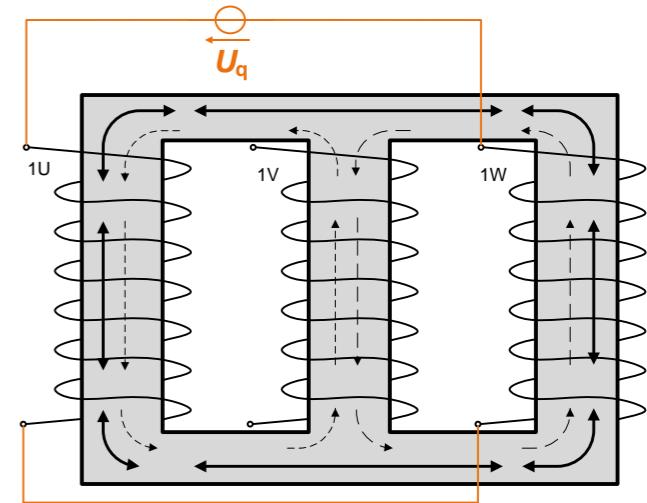


Proposed Demagnetization

Option 3/5-limb 3-wounded limbs

#1

- 1) Demag U-W
- 2) Demag V-N



SC...Short-Circuit
Demag...Demagnetization

Summary & Further Work

Summary

- available transformer demagnetization procedures can be insufficient
- DC hysteresis measurement could be used for core fault detection

Further Work

- Laboratory and field tests of proposed demagnetization procedures
- Data base of transformer hysteresis measurements & recurring hysteresis measurements

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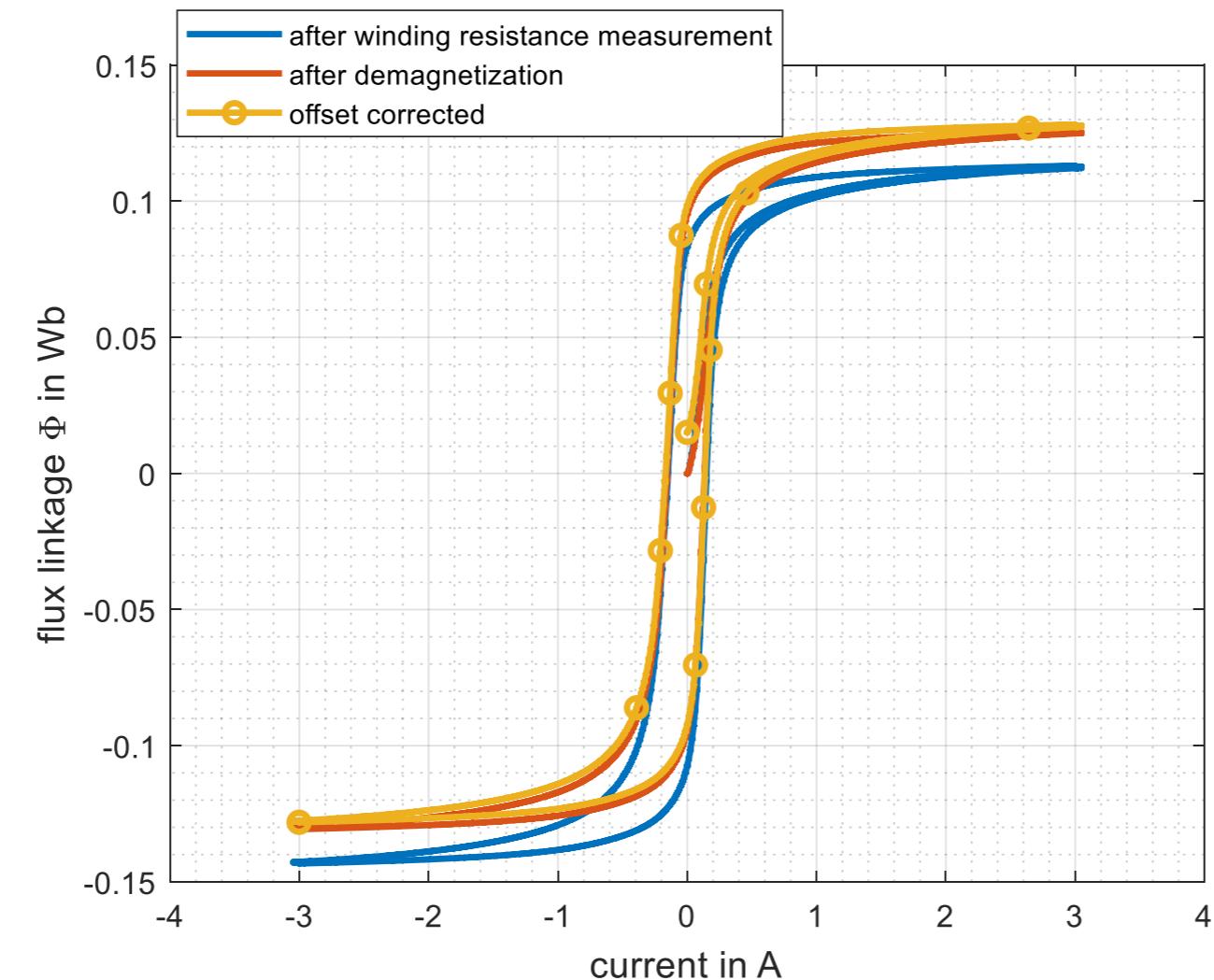
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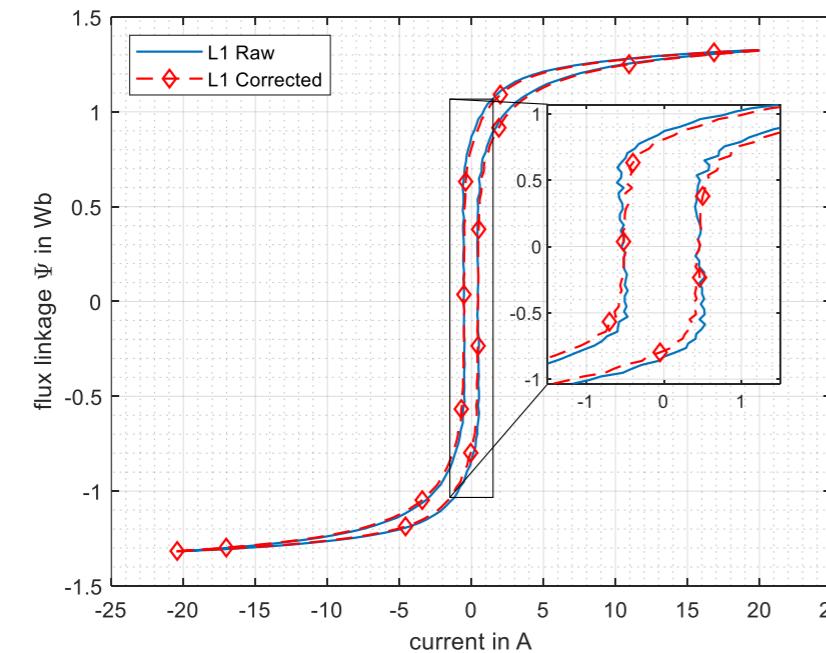
Offset Correction of Ψ -i characteristic



Comparison DC Ψ -i \leftrightarrow AC Ψ -i

1) Capacitive current correction:

$$I_c = C \cdot \frac{dV}{dt}, \text{ whereas } C \sim 2.4 \mu\text{F}$$



2) Use frequency as scaling factor:
50 Hz

