GeckoMAGNETICS

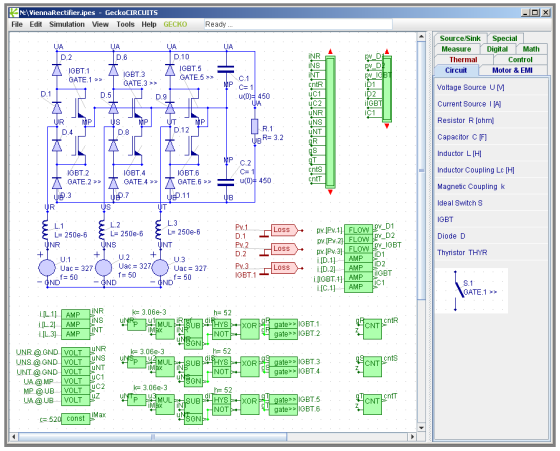
An Easy and Accurate Way of Modeling and Designing Your Magnetic Components

Dr. Jonas Mühlethaler

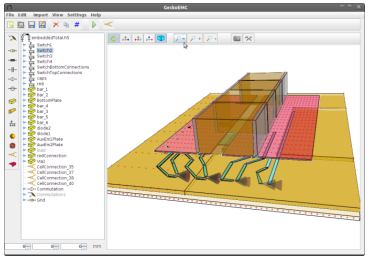
Gecko-Simulations AG

Products

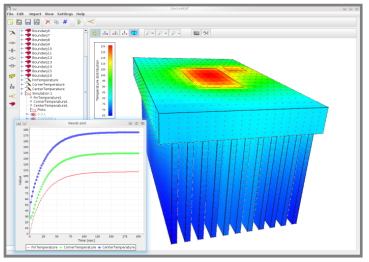
GeckoCIRCUITS (open-source)



(GeckoEMC)



(GeckoHEAT)



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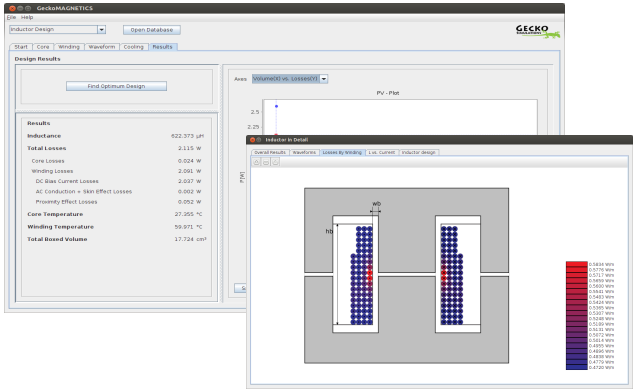

GeckoCONSULTING
(e.g. design of inductors)

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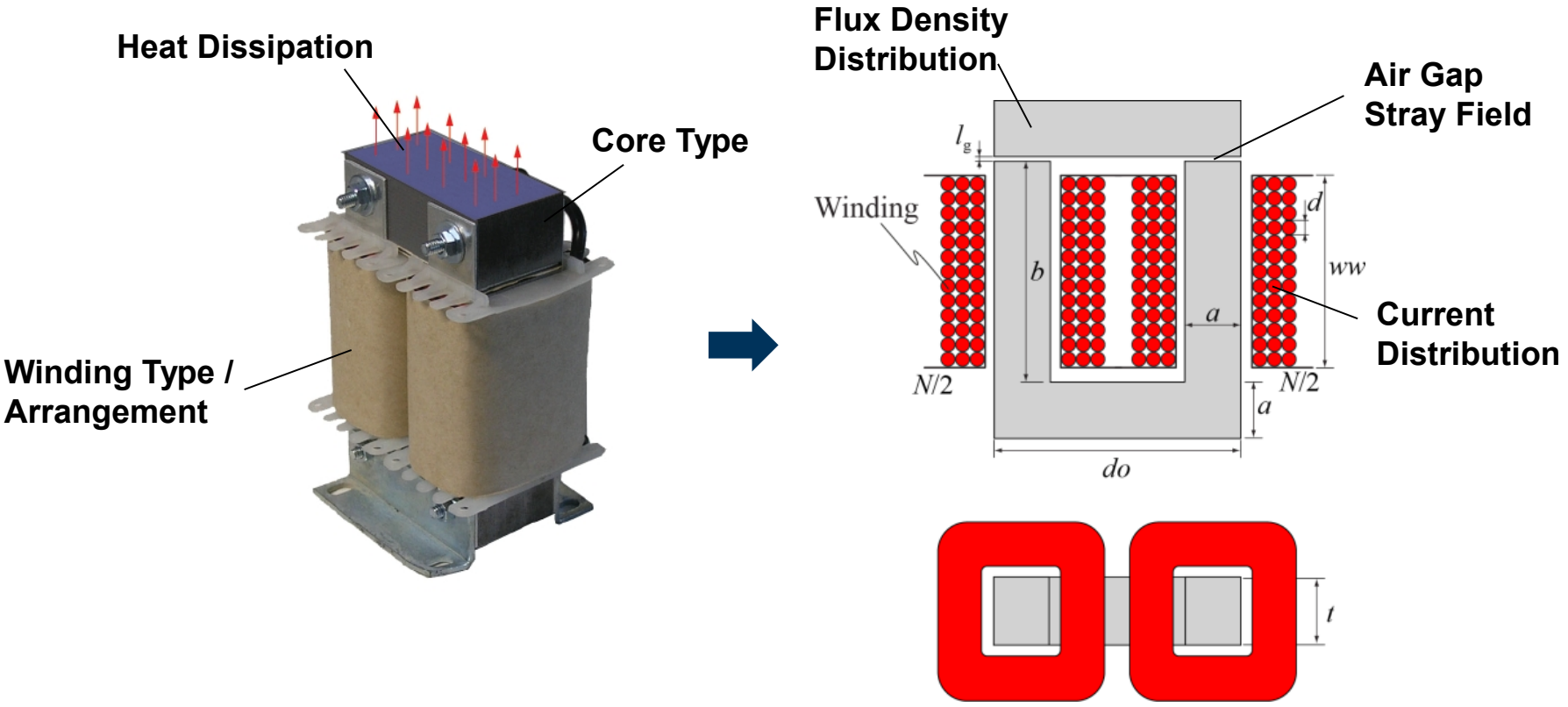
Motivation



Losses in Core Materials
- DC Premagnetization
- Relaxation Effects
- Different Flux Waveforms

Losses in Windings
- Solid Round
- Litz Wires
- Prox. Effect in Foil
- Prox. Effect in Rectangular

Thermal Modeling
- Natural Convection
- Forced Air Cooling

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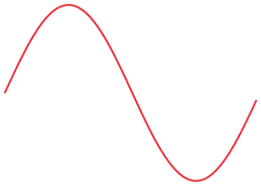
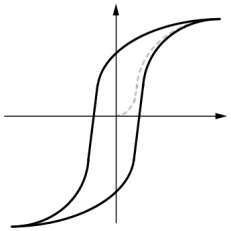
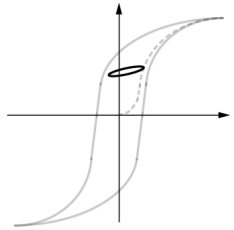
Typical Flux Waveforms in Power Electronics

Sinusoidal

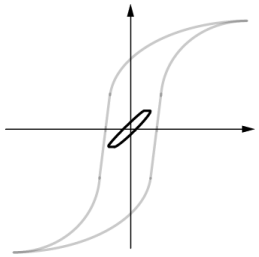




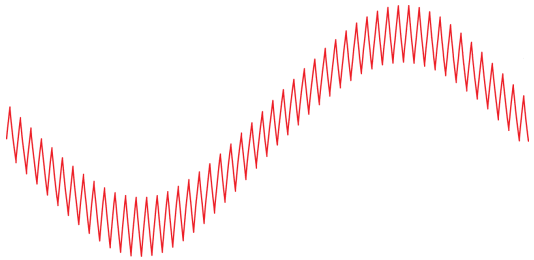
DC Current + HF Ripple

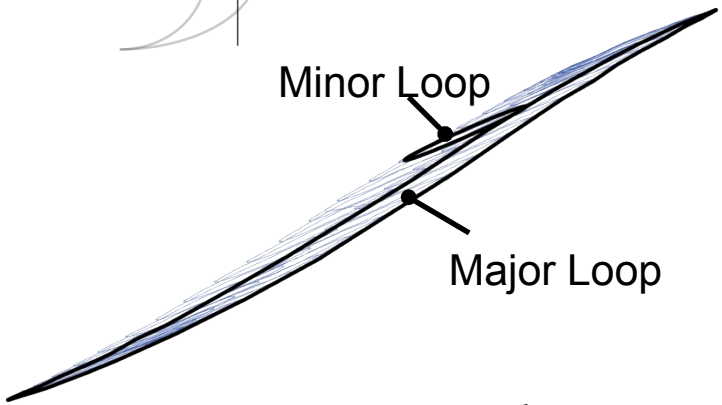


Non-Sinusoidal AC Current



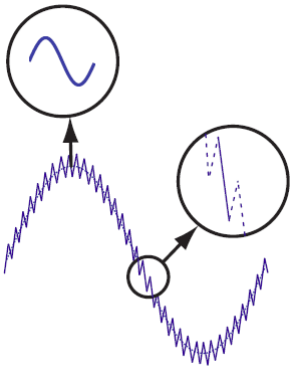
Sinusoidal Current + HF Ripple





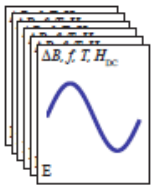
Steinmetz & Loss Map Approach

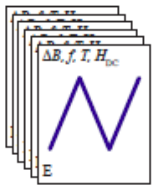
“The best of both worlds” (Steinmetz & Loss Map approach)



Loss Map

(Loss Material Database)





$$k, k_i, \alpha, \beta, \alpha_r, \beta_r, q_r, \tau$$

$$P_v = \frac{1}{T}\int_0^T k_i \left|\frac{dB}{dt}\right|^{\alpha} (\Delta B)^{\beta-\alpha} dt + \sum_{l=1}^{n} Q_{rl} P_{rl} \longrightarrow \frac{P}{V}$$

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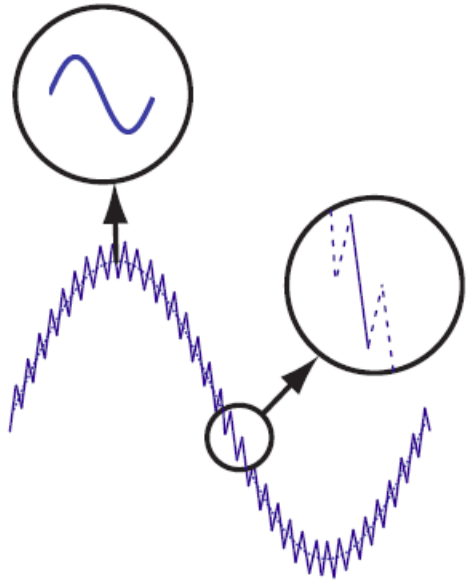
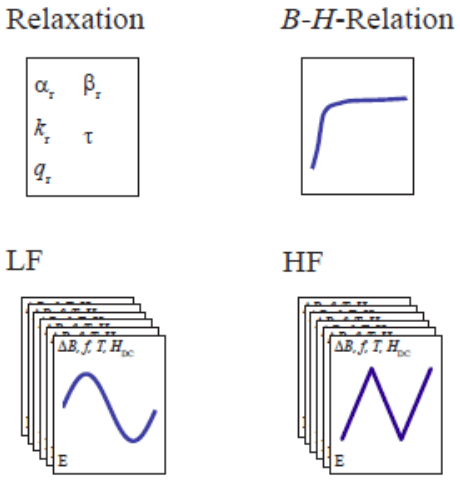
Loss Map

Typical flux waveform

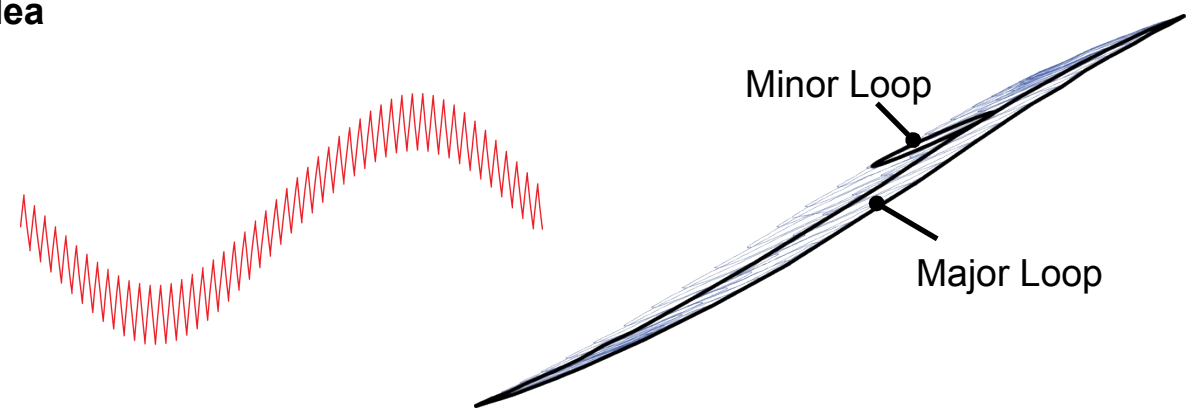


Content of Loss Map



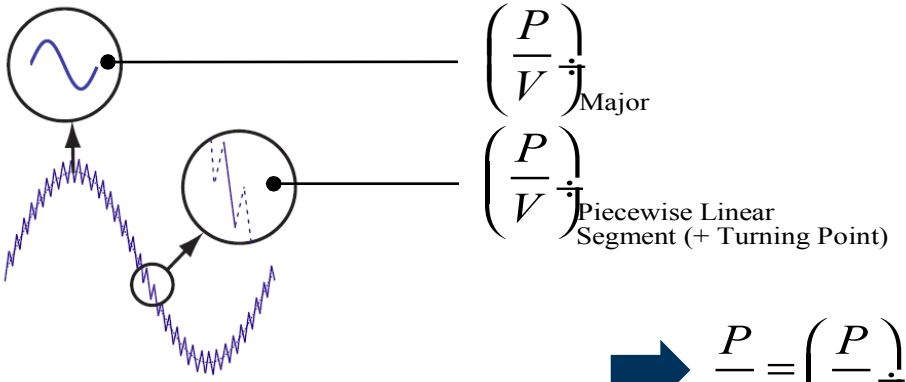
Hybrid Loss Modeling (1)

Idea



Losses due to Minor and Major Loops are calculated independent of each other and summed up.

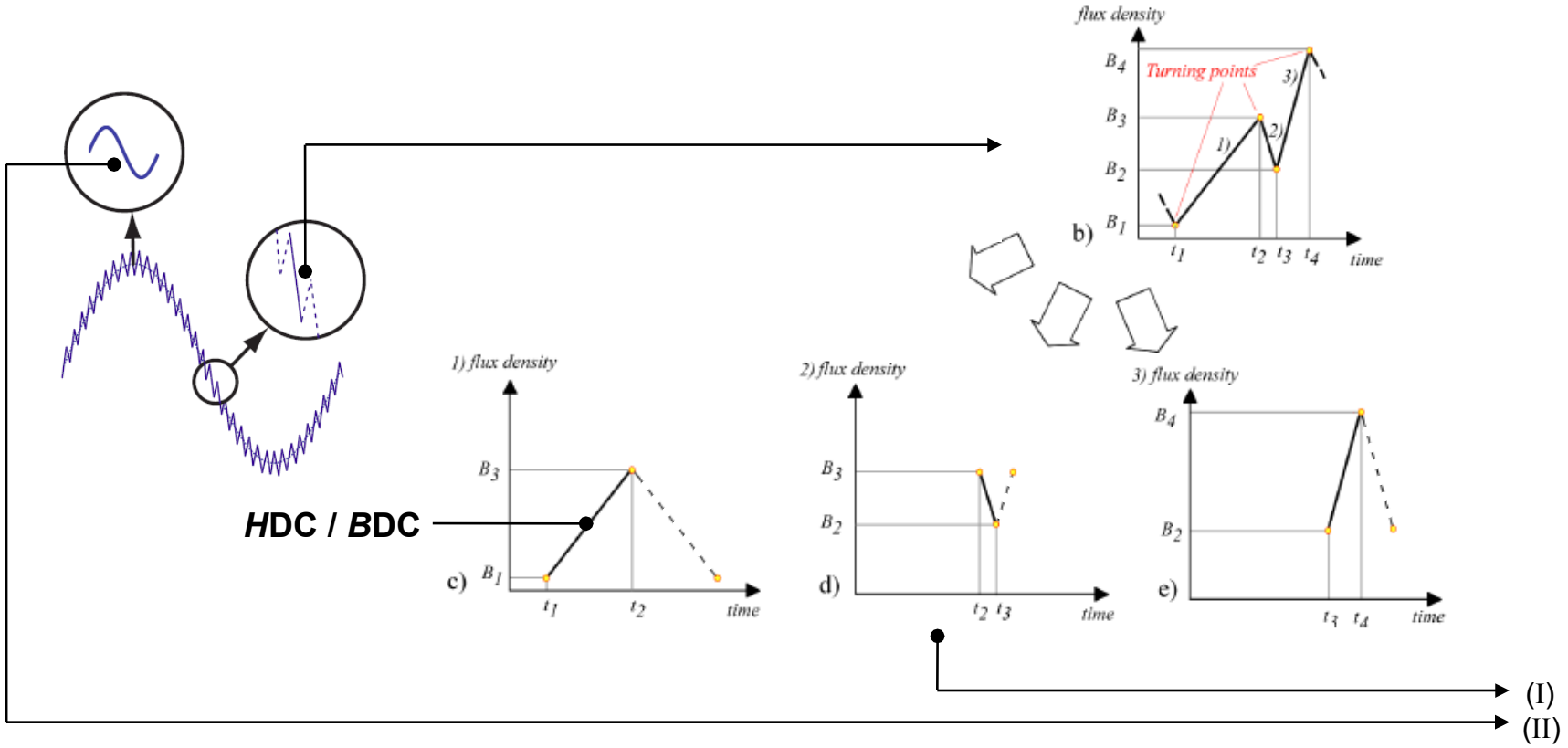
Implementation



Actually, it is not considered how the minor loop closes: each piecewise linear segment is modeled as having half the losses of its corresponding closed loop (cf. next slides).

$$\frac{P}{V} = \left(\frac{P}{V}\right)_{\text{Major}} + \sum \left(\frac{P}{V}\right)_{\text{Piecewise Linear Segment (+ Turning Point)}}$$

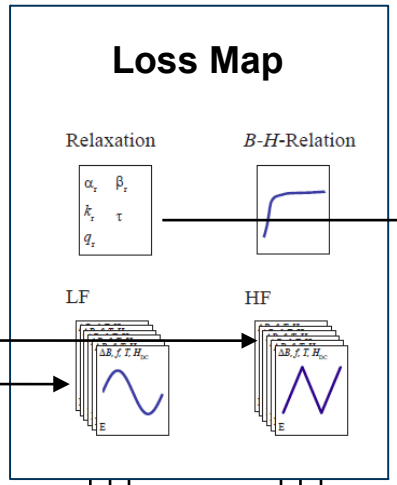
Hybrid Loss Modeling (2)



Hybrid Loss Modeling (3)

Evaluated for the according corner point in a piecewise-linear flux waveform.

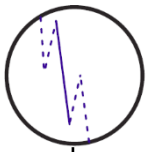
Evaluated for the according piecewise-linear flux segment



(I)

(II)

$$P_{\mathrm{v}} = \frac{1}{T}\int_0^T k_i \left|\frac{\mathrm{d}B}{\mathrm{d}t}\right|^{\alpha} (\Delta B)^{\beta-\alpha}\,\mathrm{d}t + \sum_{l=1}^{n} Q_{\mathrm{rl}} P_{\mathrm{rl}}$$



$$\frac{P}{V}$$

Three loss map operating points are required in order to extract the parameters α, β, and k (or ki).

$$P_{\mathrm{v1}} = k_i (2f_1)^{\alpha} (\Delta B_1)^{\beta}$$
$$P_{\mathrm{v2}} = k_i (2f_2)^{\alpha} (\Delta B_2)^{\beta}$$
$$P_{\mathrm{v3}} = k_i (2f_3)^{\alpha} (\Delta B_3)^{\beta}$$

These equations arise when one evaluates the i2GSE for symmetric triangular waveforms.

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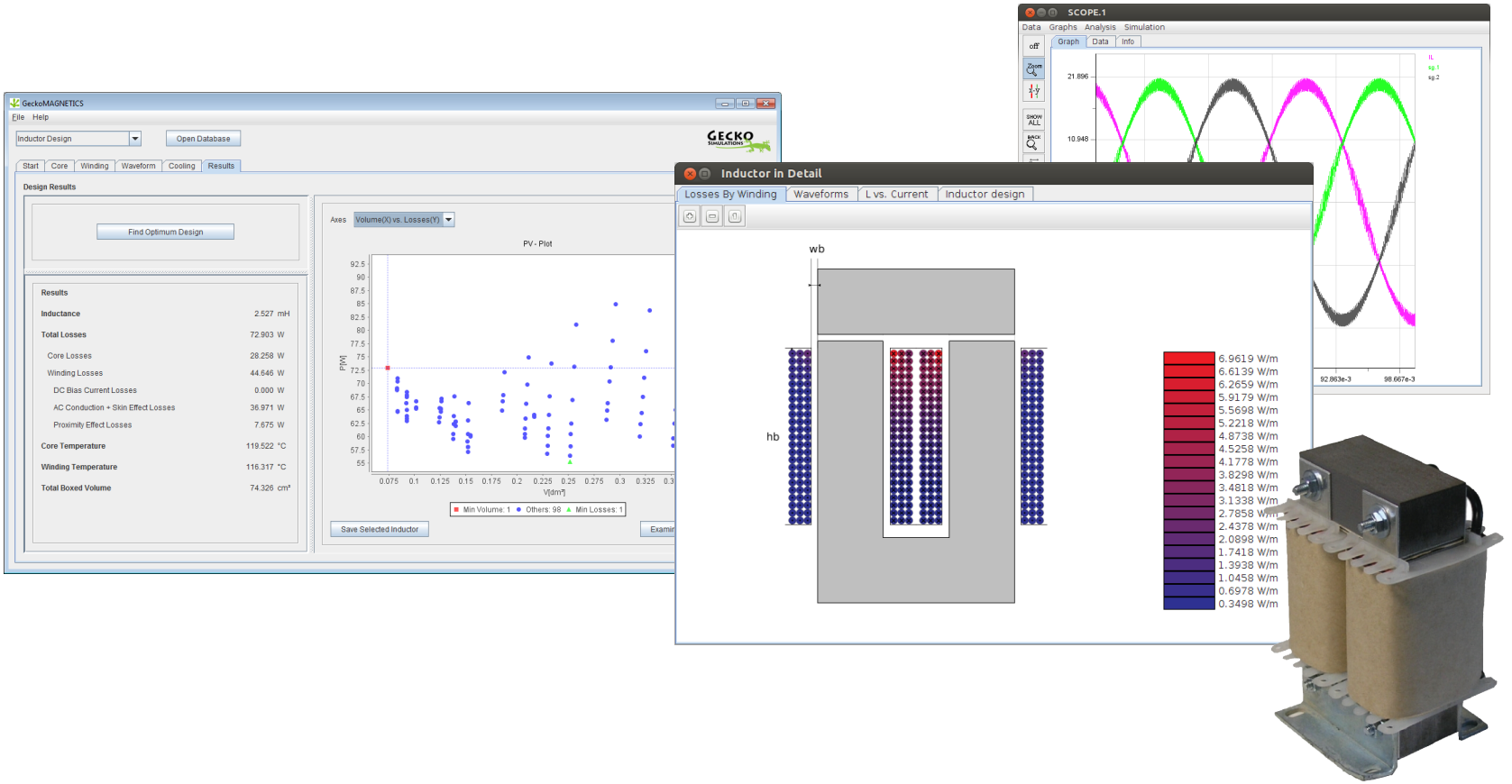

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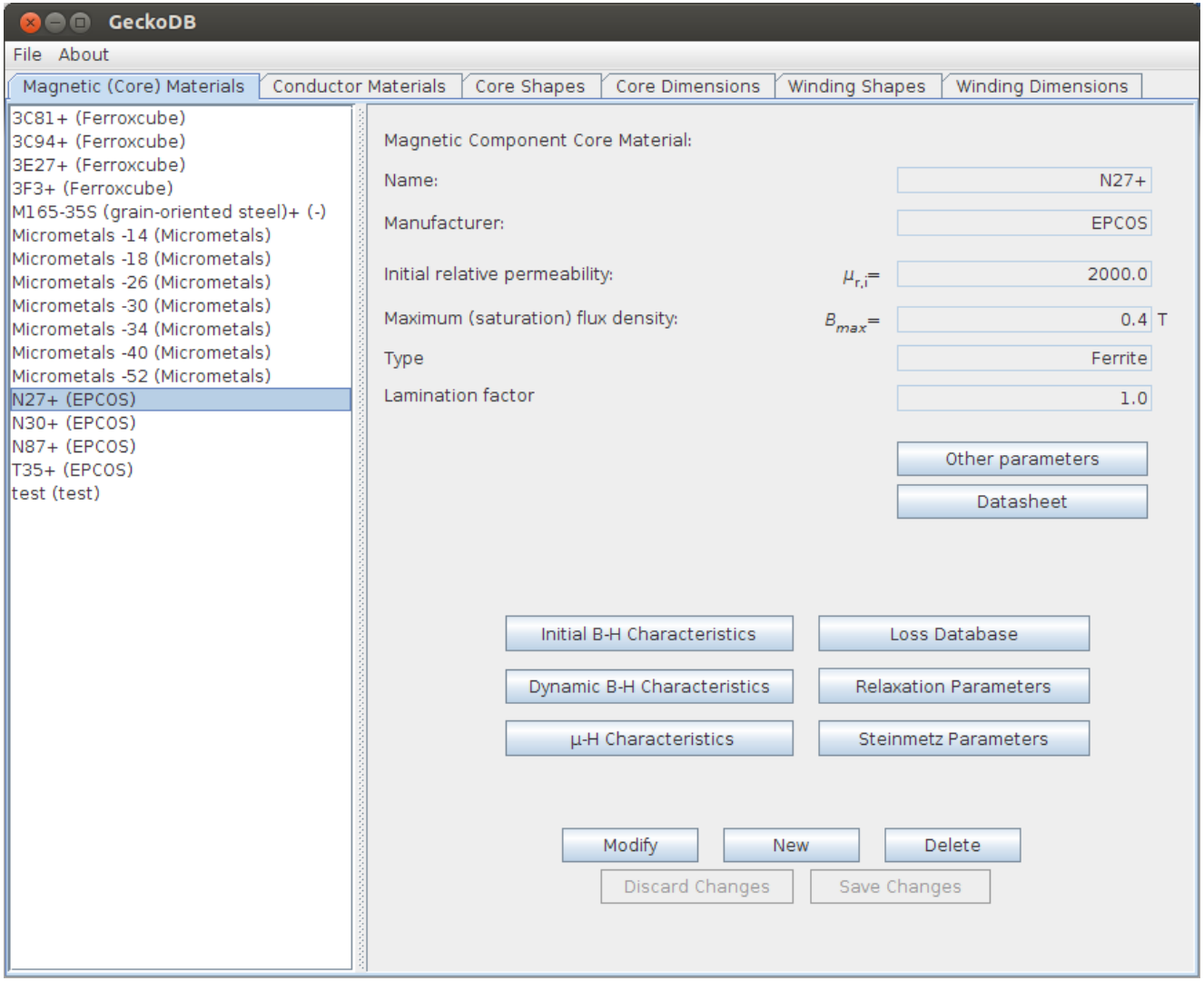
Database



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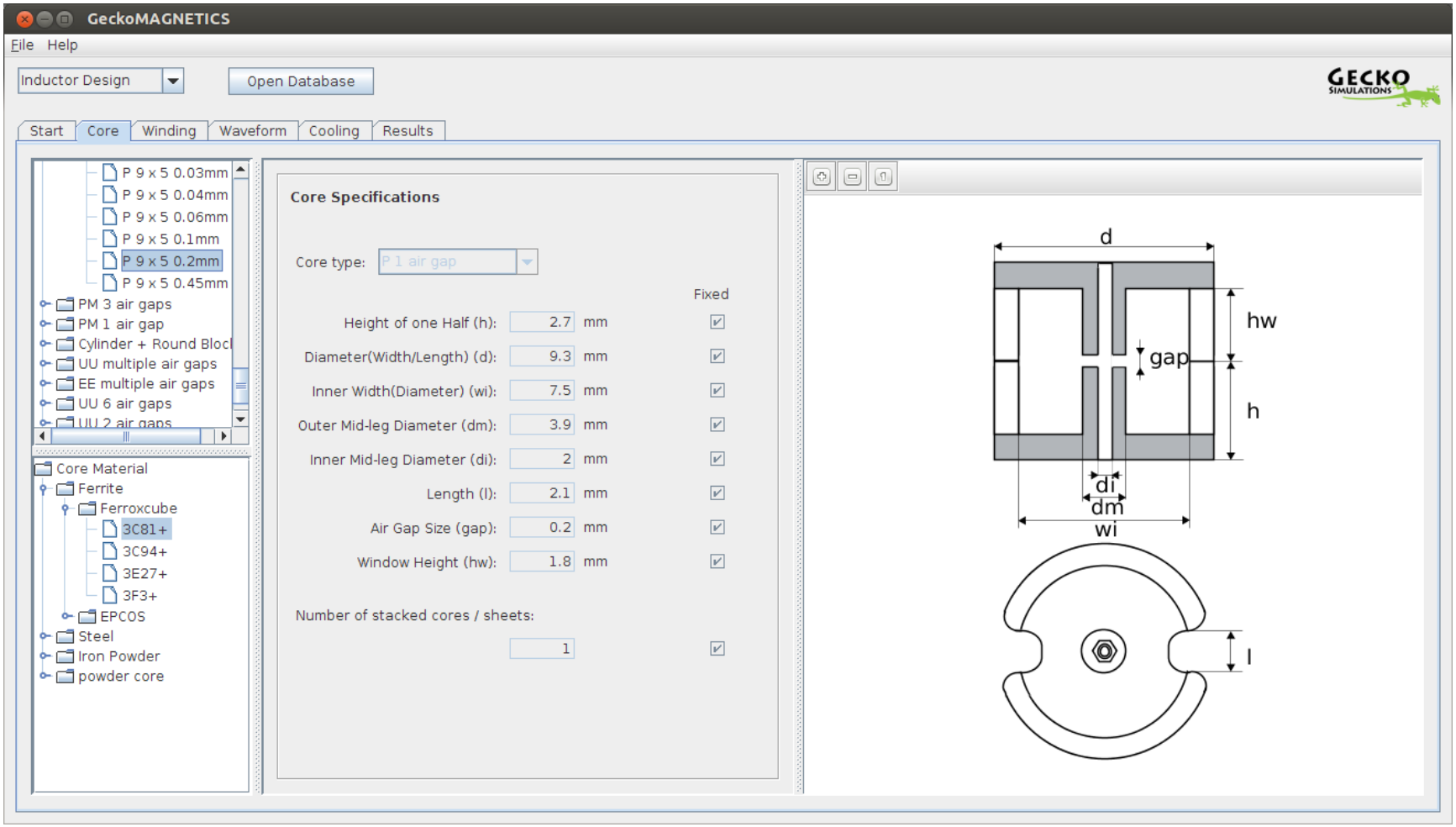
Core Tab



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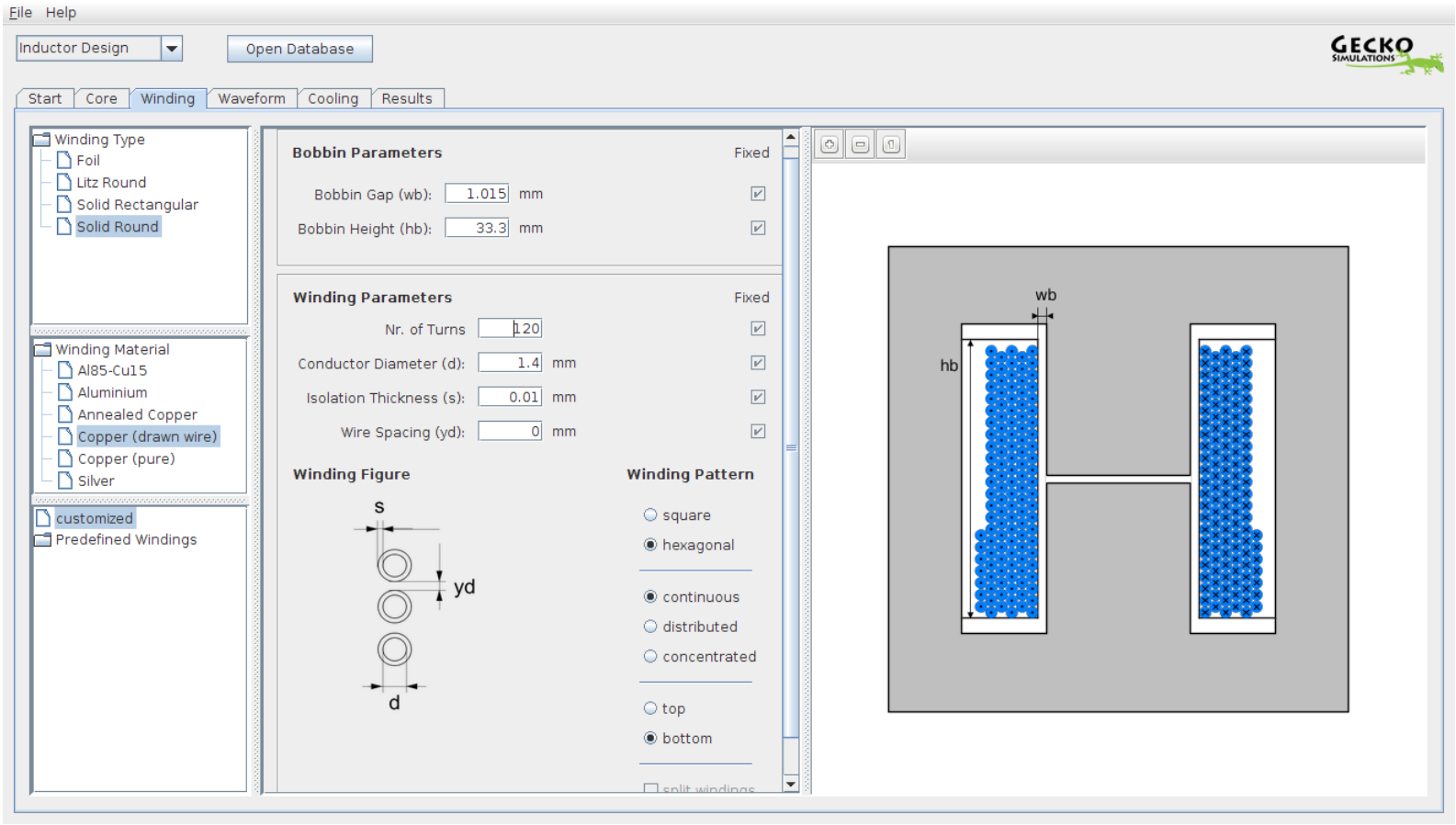
Winding Tab



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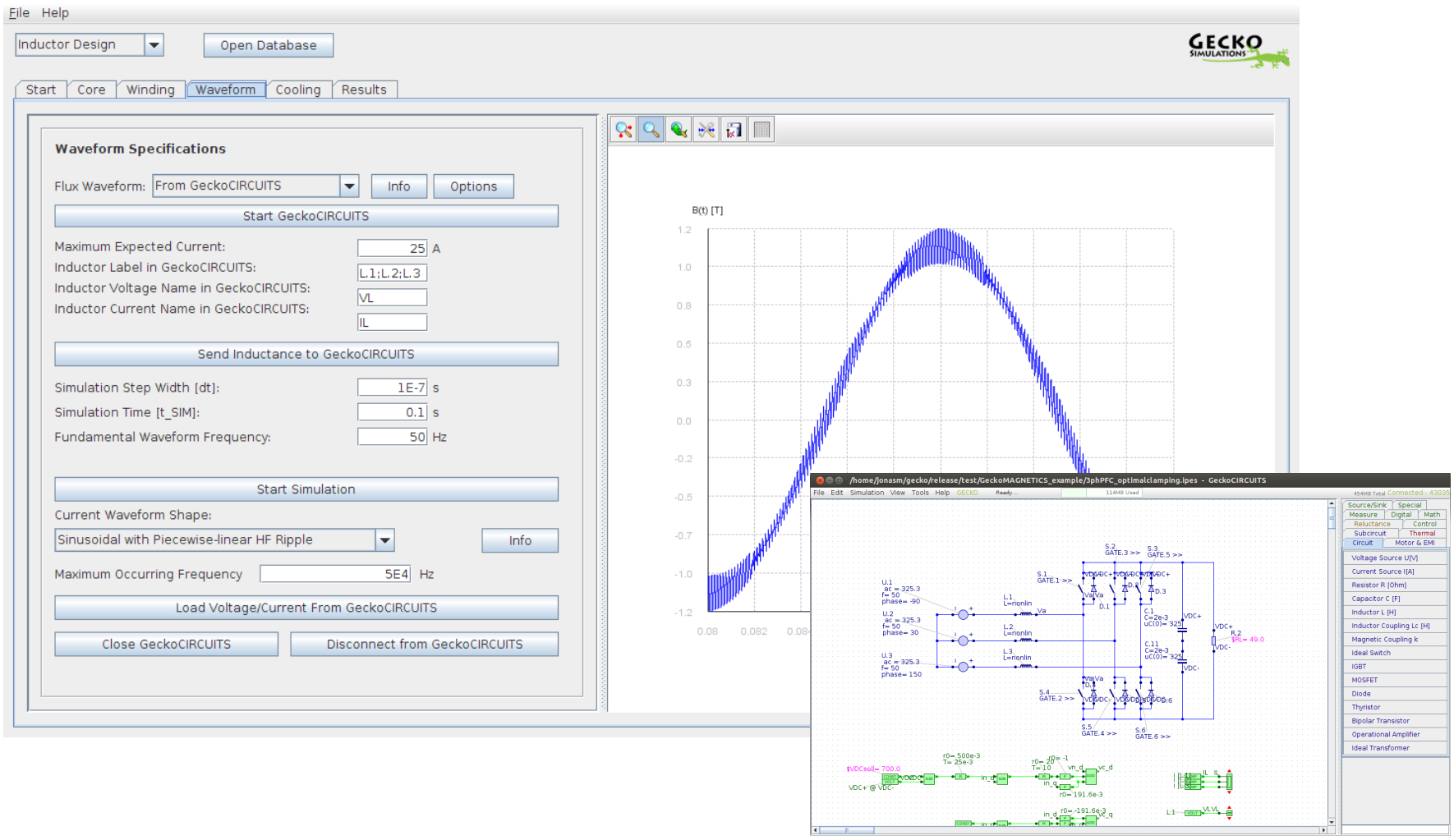
Waveform: Link to GeckoCIRCUITS



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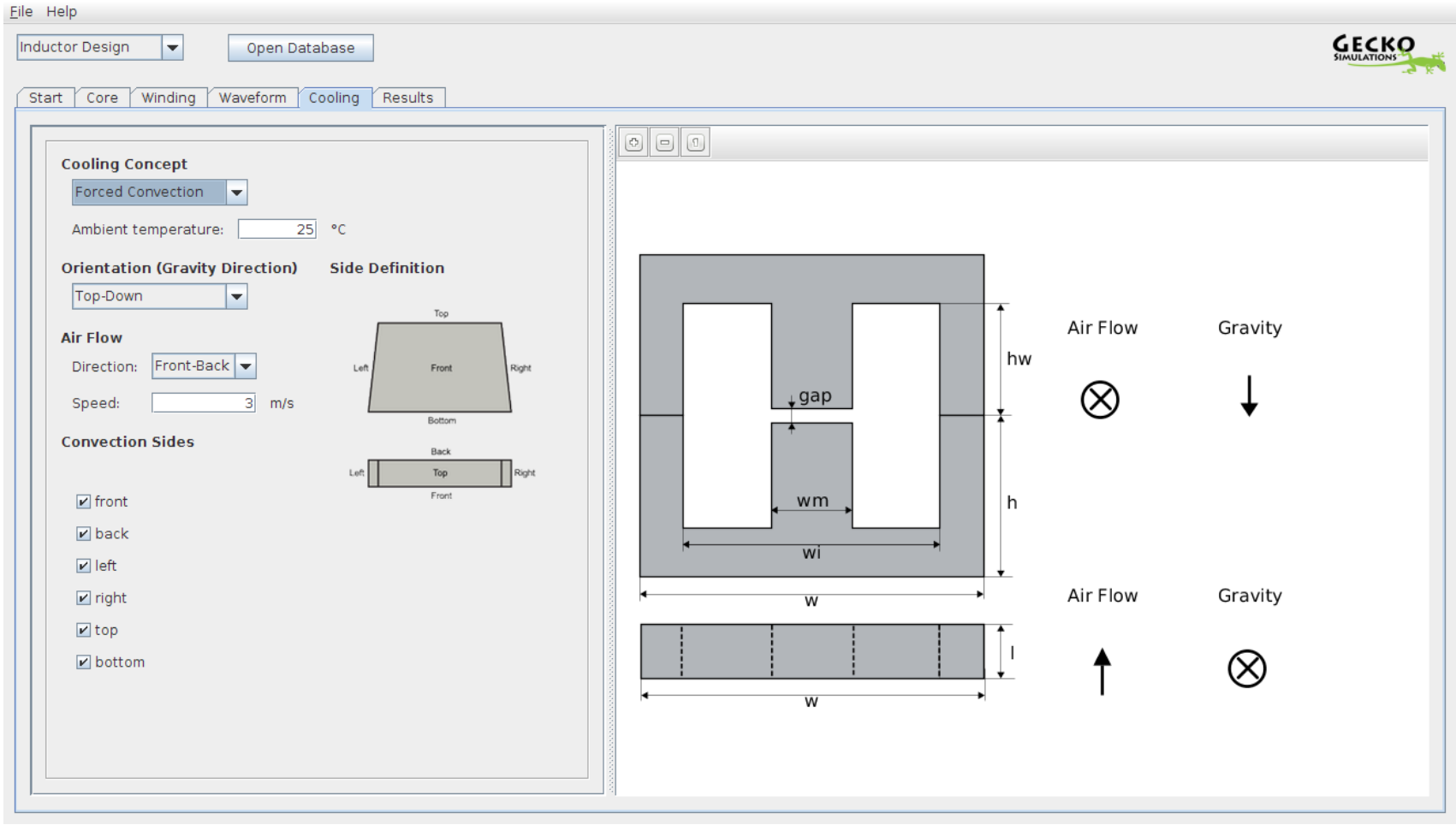
Cooling Tab



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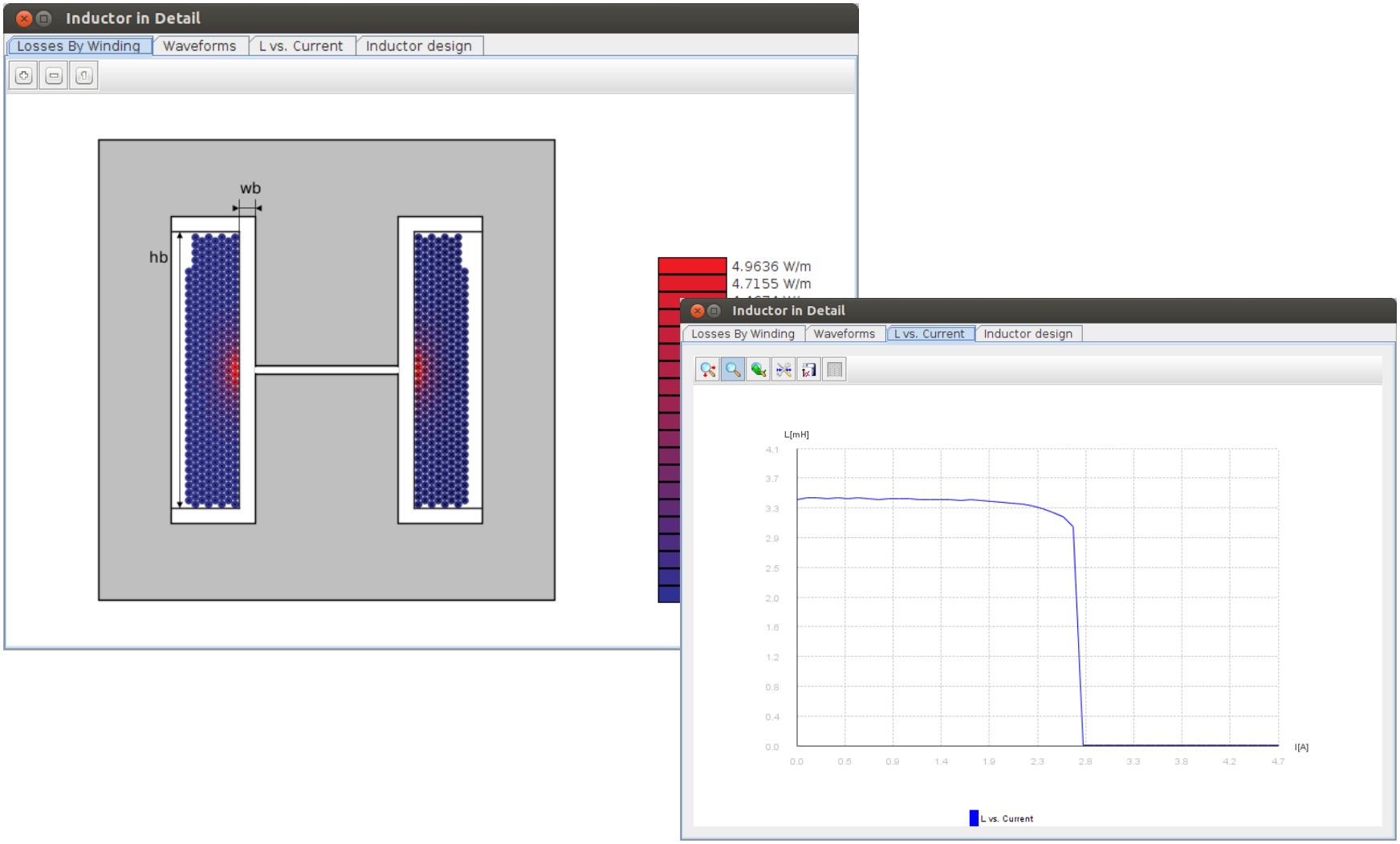
Results Tab (1)

GeckoMAGNETICS
Results Tab (2)



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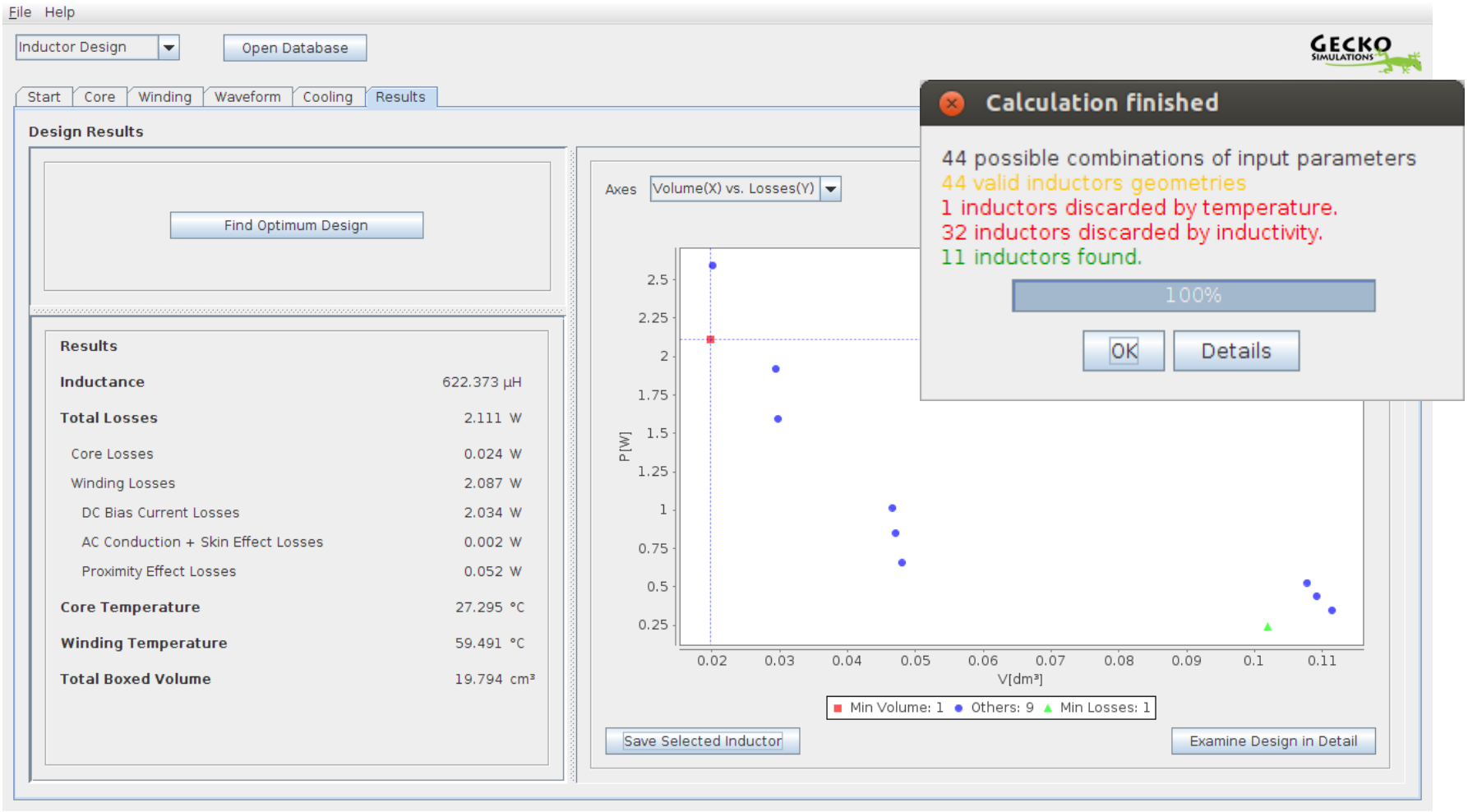
Design Mode

APEC 2014



GECKO SIMULATIONS

THANK YOU !!!

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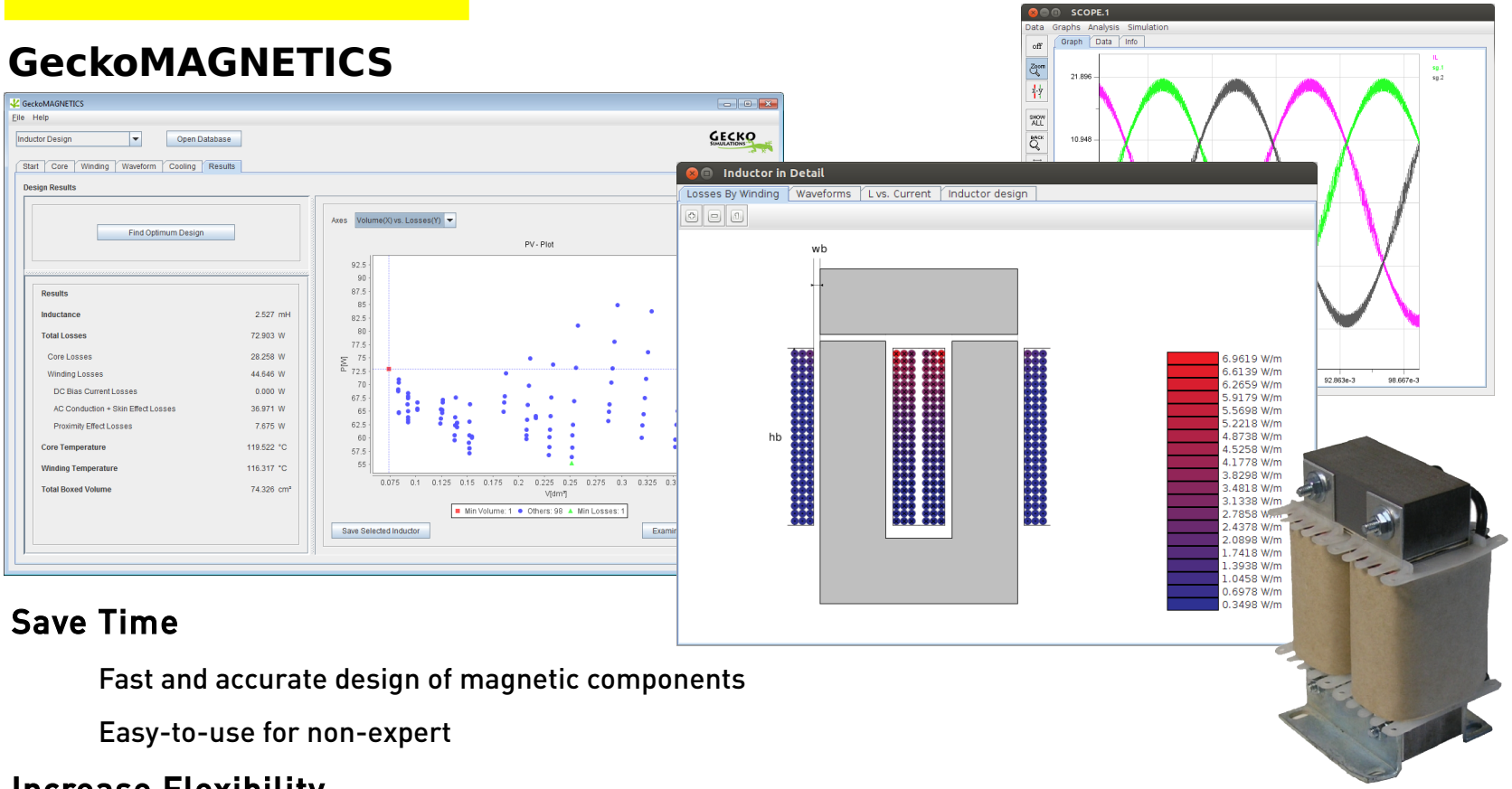

Save Time

Fast and accurate design of magnetic components

Easy-to-use for non-expert

Increase Flexibility

Tool shows more than one realization possibility

In-house design of magnetics crucial for optimal designs.

Most Loss Effects are Considered

Skin- and proximity losses in litz, round and foil windings, air gap stray field losses, DC bias core losses, thermal model, ...