



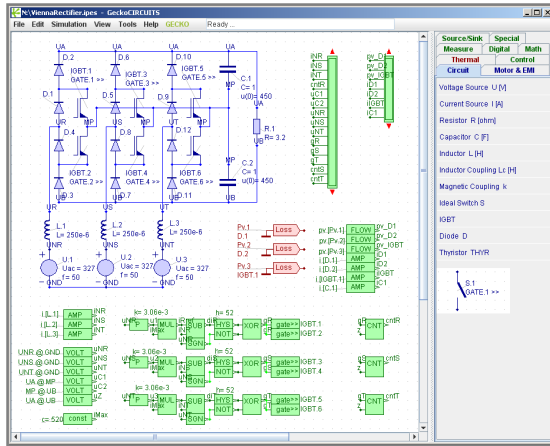
**GeckoMAGNETICS**  
**An Easy and Accurate Way of Modeling and Designing Your  
Magnetic Components**

**Dr. Jonas Mühlethaler**

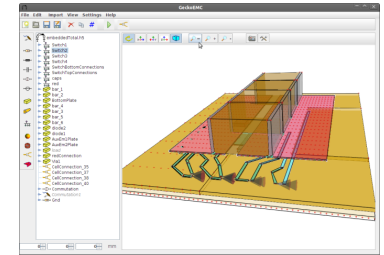
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# Gecko-Simulations AG Products

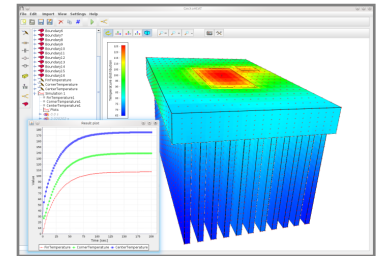
## GeckoCIRCUITS (open-source)



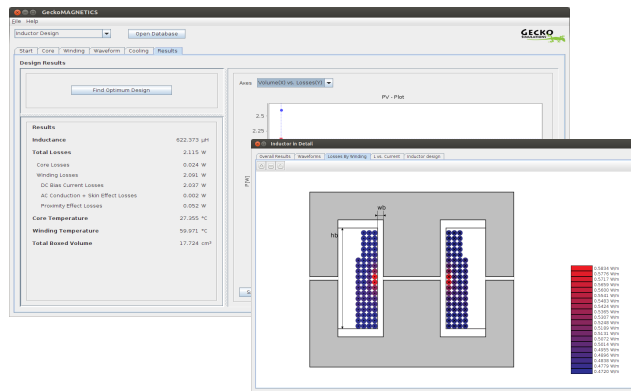
## (GeckoEMC)



## (GeckoHEAT)



## GeckoMAGNETICS

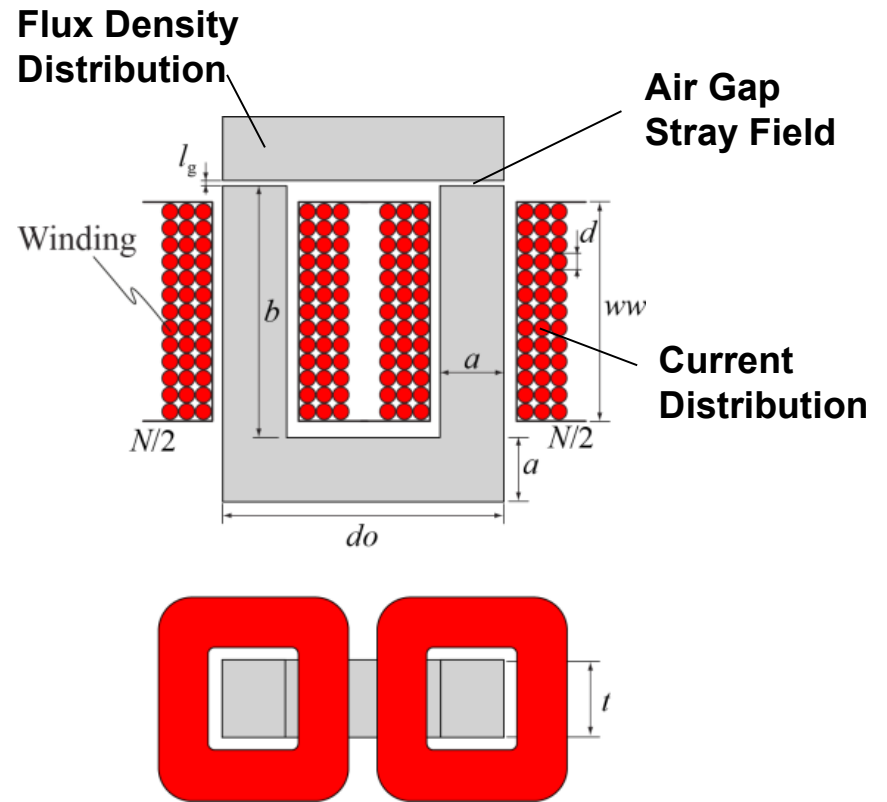
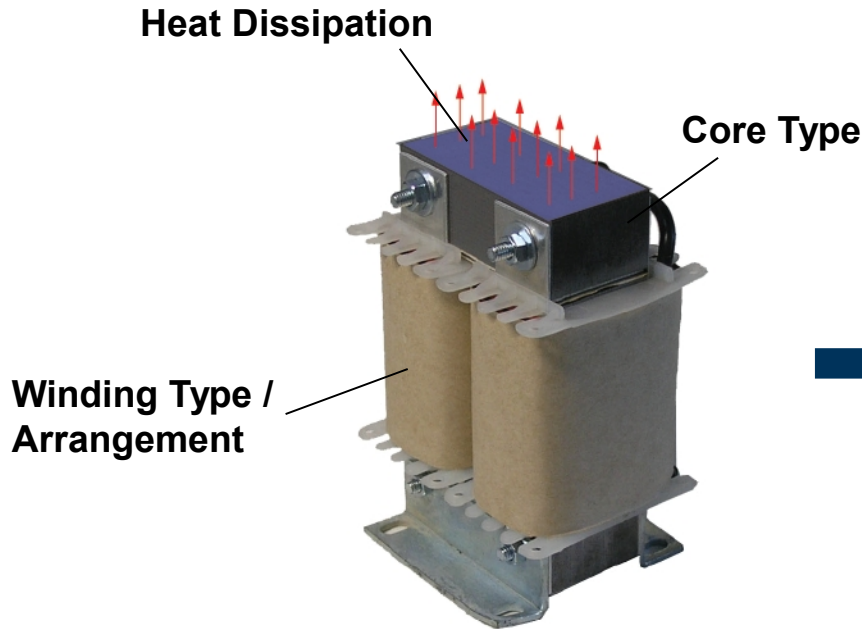


## GeckoCONSULTING (e.g. design of inductors)



# GeckoMAGNETICS

## Motivation



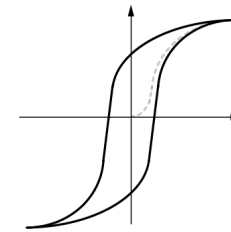
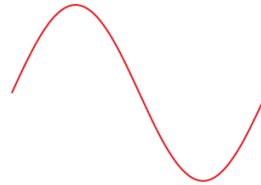
**Losses in Core Materials**  
 DC Premagnetization  
 Relaxation Effects  
 Different Flux Waveforms

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

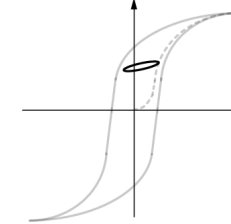
**Thermal Modeling**  
 Natural Convection  
 Forced Air Cooling

# Typical Flux Waveforms in Power Electronics

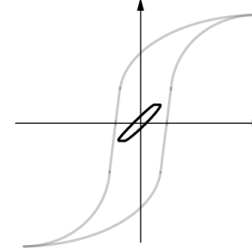
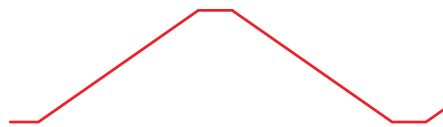
**Sinusoidal**



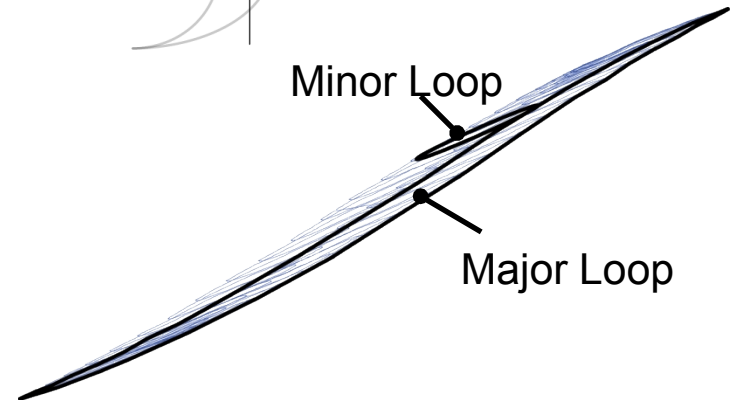
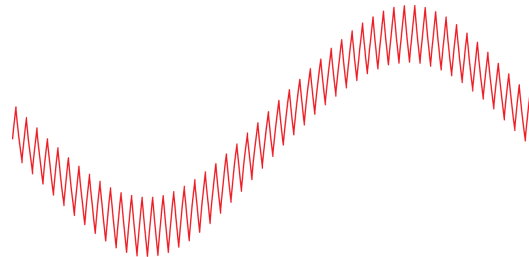
**DC Current +  
HF Ripple**



**Non-Sinusoidal AC  
Current**

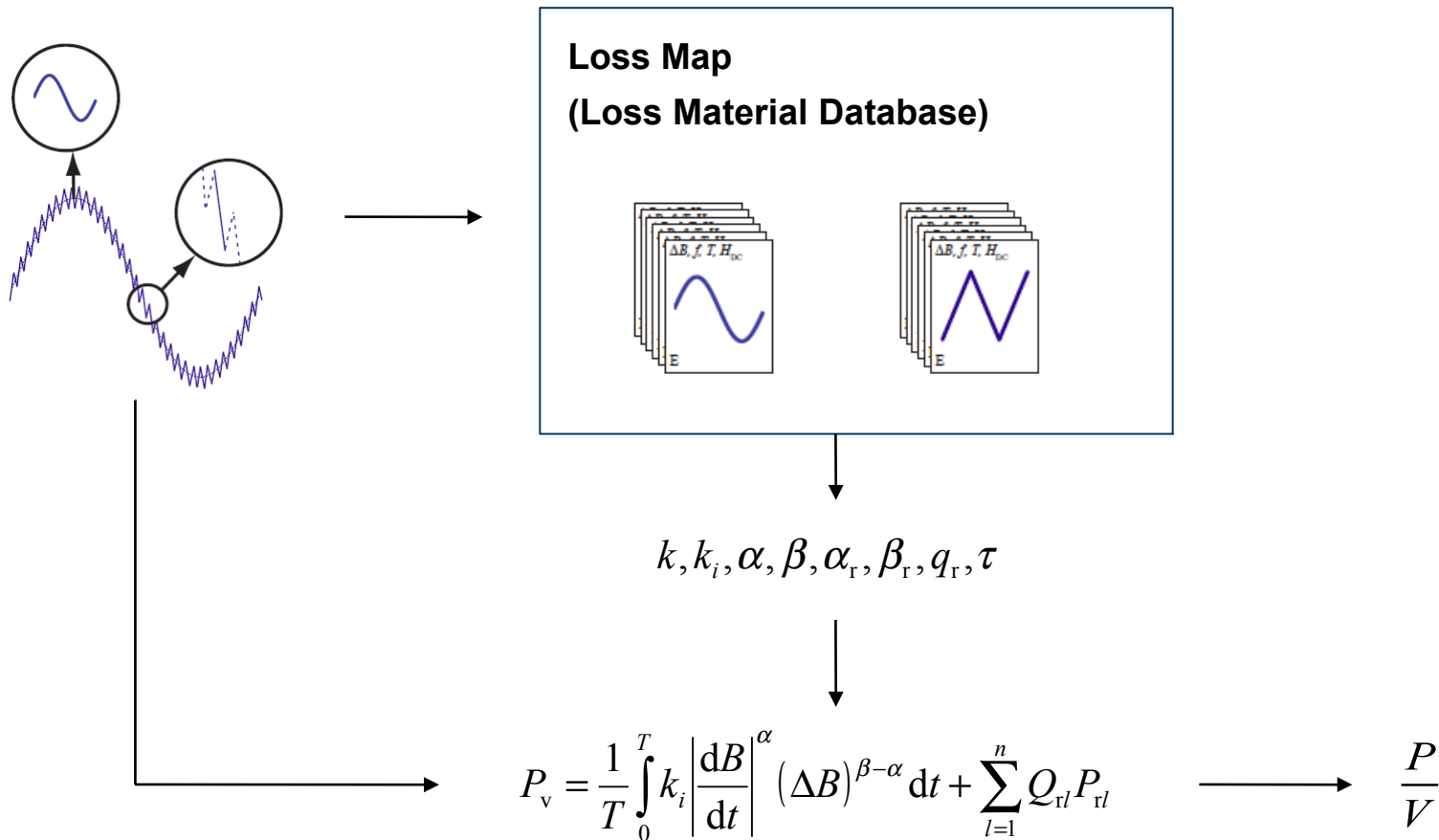


**Sinusoidal Current  
+ HF Ripple**



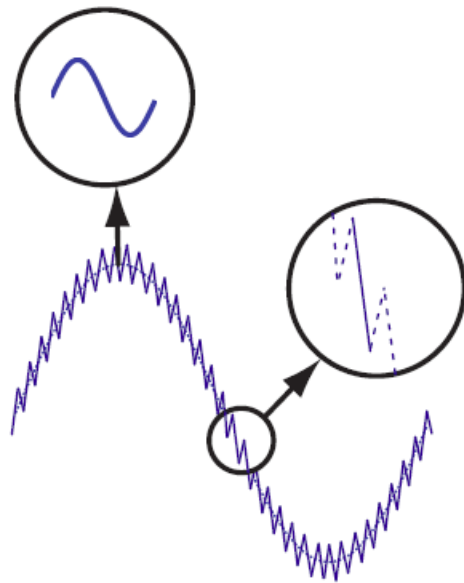
# Steinmetz & Loss Map Approach

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



## Loss Map

Typical flux waveform

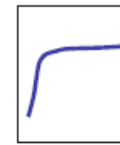


Content of Loss Map

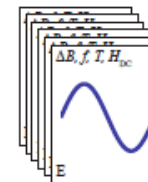
Relaxation

$$\begin{matrix} \alpha_r & \beta_r \\ k_r & \tau \\ q_r \end{matrix}$$

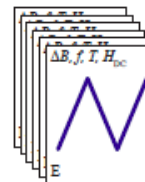
*B-H-Relation*



LF

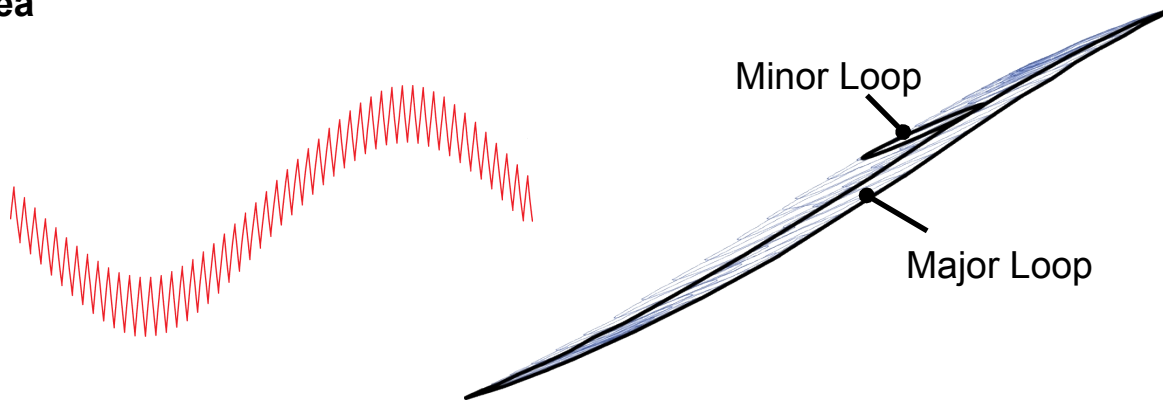


HF



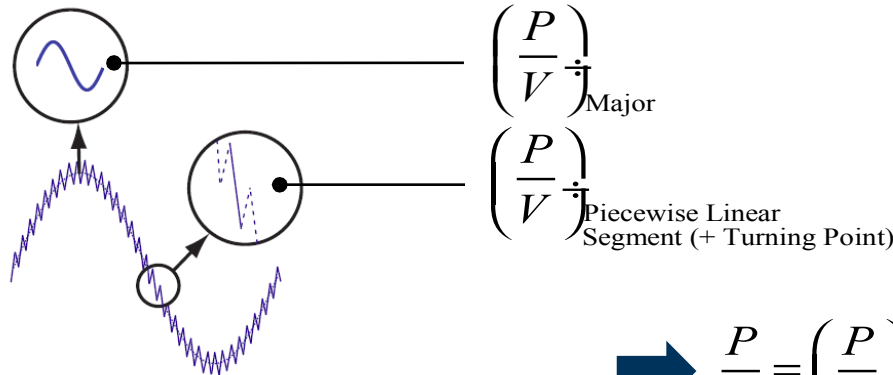
# Hybrid Loss Modeling (1)

## Idea



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

## Implementation



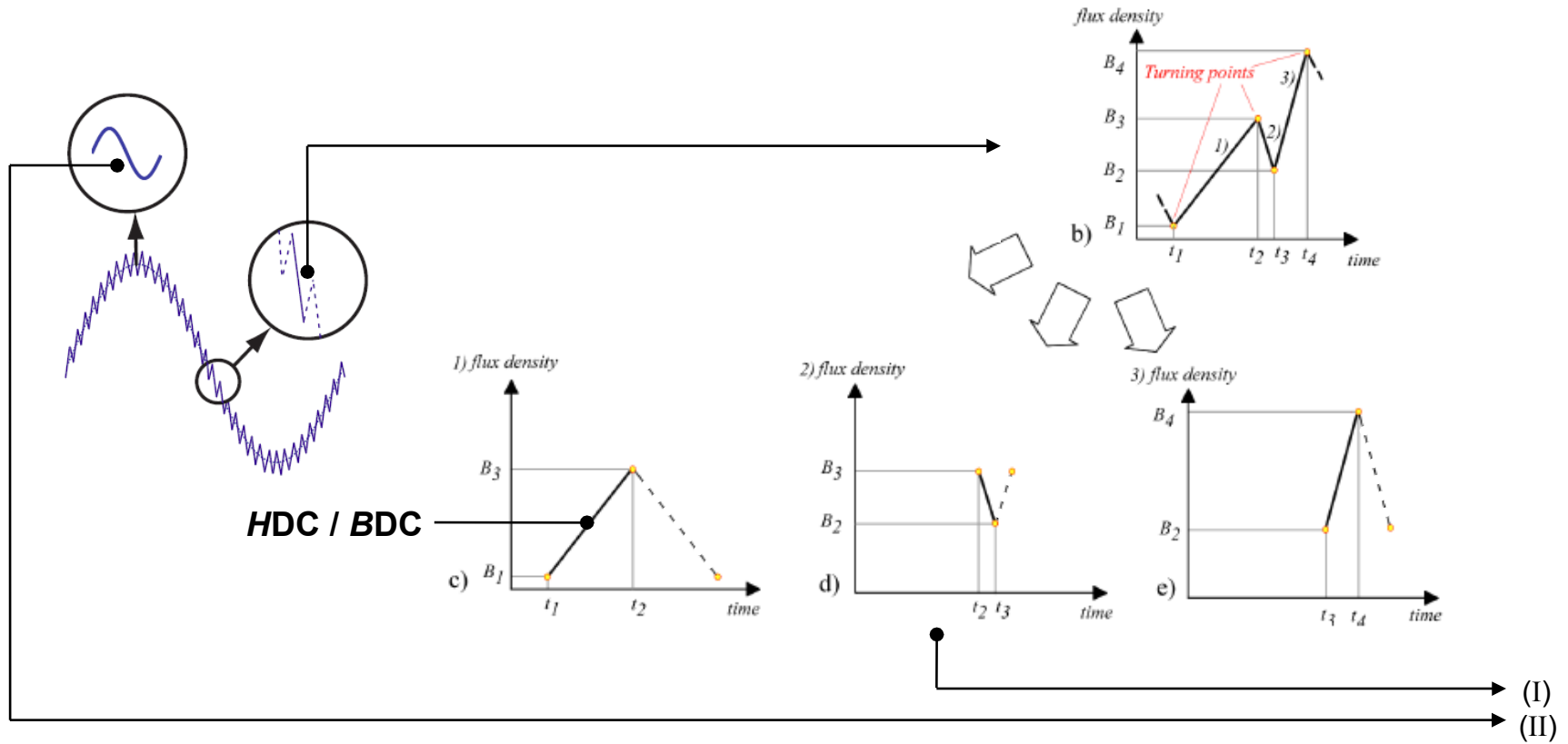
$$\left(\frac{P}{V}\right)_{\text{Major}}$$

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

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).

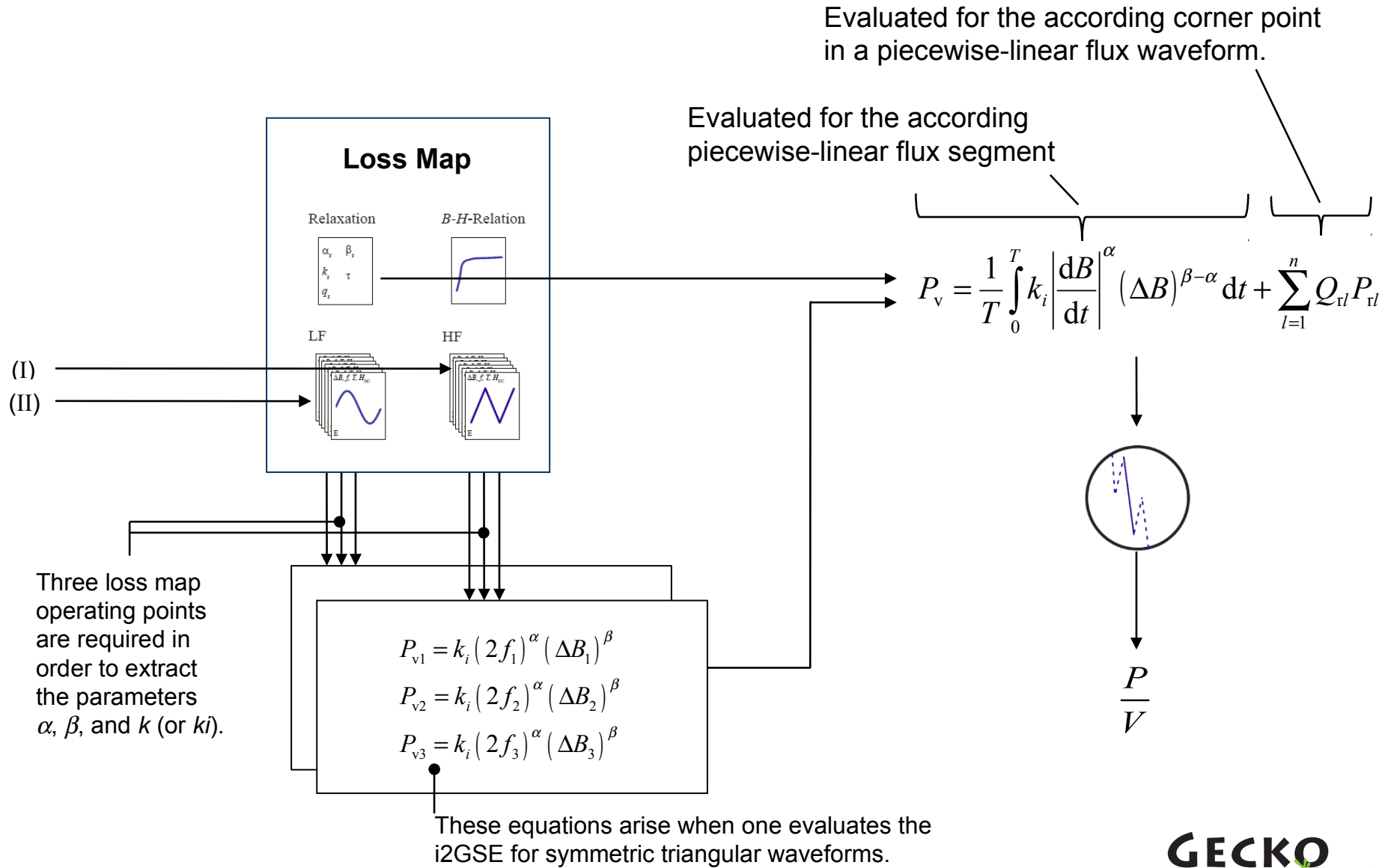
$$\Rightarrow \frac{P}{V} = \left(\frac{P}{V}\right)_{\text{Major}} + \sum \left(\frac{P}{V}\right)_{\text{Piecewise Linear Segment (+ Turning Point)}}$$

# Hybrid Loss Modeling (2)

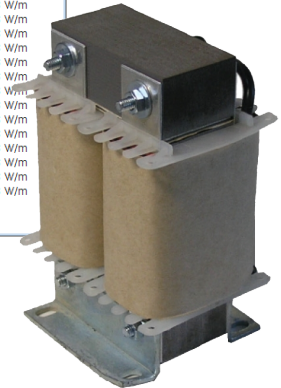
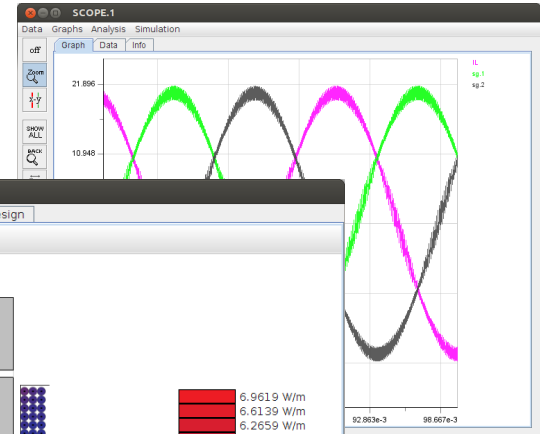
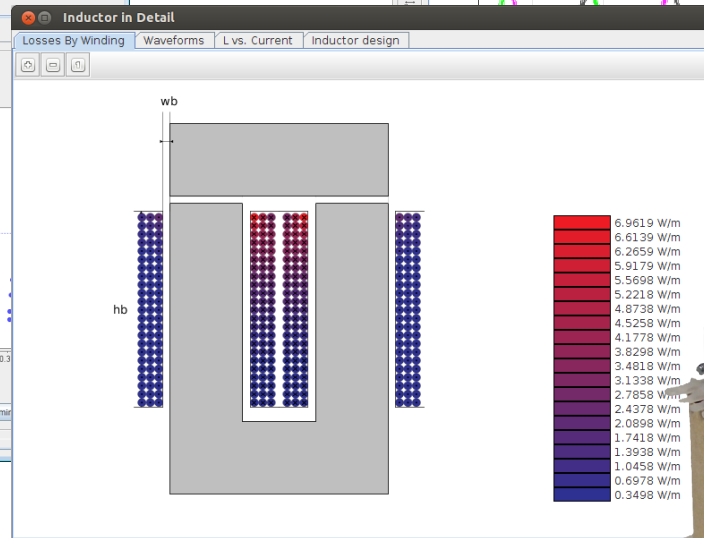
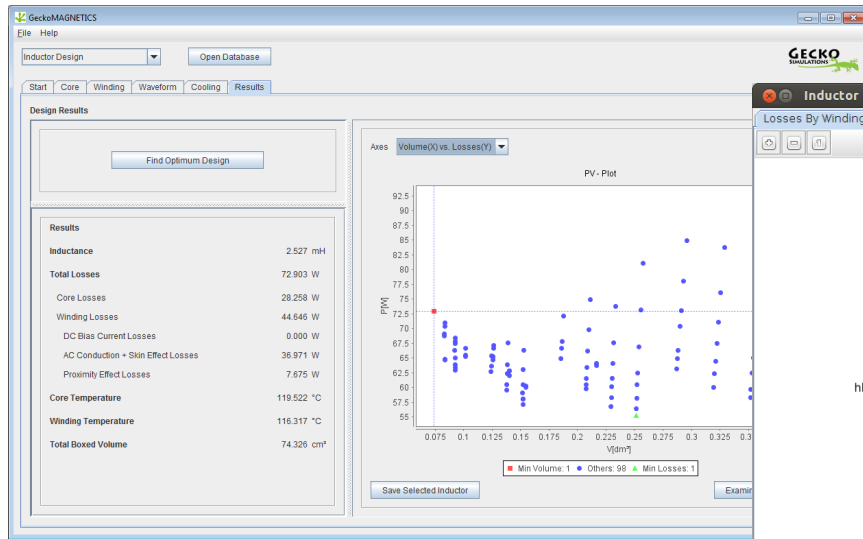




# Hybrid Loss Modeling (3)



# GeckoMAGNETICS



# GeckoMAGNETICS Database

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The screenshot shows the GeckoDB application window. The title bar reads "GeckoDB". The menu bar includes "File" and "About". The main window has several tabs: "Magnetic (Core) Materials", "Conductor Materials", "Core Shapes", "Core Dimensions", "Winding Shapes", and "Winding Dimensions". The "Magnetic (Core) Materials" tab is active, displaying a list of materials on the left and a detailed view of the selected material, "N27+ (EPCOS)", on the right.

**Magnetic (Core) Materials List:**

- 3C81+ (Ferroxcube)
- 3C94+ (Ferroxcube)
- 3E27+ (Ferroxcube)
- 3F3+ (Ferroxcube)
- M165-35S (grain-oriented steel)+ (-)
- Micrometals -14 (Micrometals)
- Micrometals -18 (Micrometals)
- Micrometals -26 (Micrometals)
- Micrometals -30 (Micrometals)
- Micrometals -34 (Micrometals)
- Micrometals -40 (Micrometals)
- Micrometals -52 (Micrometals)
- N27+ (EPCOS)**
- N30+ (EPCOS)
- N87+ (EPCOS)
- T35+ (EPCOS)
- test (test)

**Magnetic Component Core Material: N27+ (EPCOS)**

**Name:** N27+

**Manufacturer:** EPCOS

**Initial relative permeability:**  $\mu_{r,i} =$  2000.0

**Maximum (saturation) flux density:**  $B_{max} =$  0.4 T

**Type:** Ferrite

**Lamination factor:** 1.0

**Buttons:** Other parameters, Datasheet, Initial B-H Characteristics, Loss Database, Dynamic B-H Characteristics, Relaxation Parameters,  $\mu$ -H Characteristics, Steinmetz Parameters, Modify, New, Delete, Discard Changes, Save Changes.

# GeckoMAGNETICS

## Core Tab

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GeckoMAGNETICS

File Help

Inductor Design

Start Core Winding Waveform Cooling Results

**Core Specifications**

Core type:

Height of one Half (h):	<input type="text" value="2.7"/>	mm	<input checked="" type="checkbox"/>
Diameter(Width/Length) (d):	<input type="text" value="9.3"/>	mm	<input checked="" type="checkbox"/>
Inner Width(Diameter) (wi):	<input type="text" value="7.5"/>	mm	<input checked="" type="checkbox"/>
Outer Mid-leg Diameter (dm):	<input type="text" value="3.9"/>	mm	<input checked="" type="checkbox"/>
Inner Mid-leg Diameter (di):	<input type="text" value="2"/>	mm	<input checked="" type="checkbox"/>
Length (l):	<input type="text" value="2.1"/>	mm	<input checked="" type="checkbox"/>
Air Gap Size (gap):	<input type="text" value="0.2"/>	mm	<input checked="" type="checkbox"/>
Window Height (hw):	<input type="text" value="1.8"/>	mm	<input checked="" type="checkbox"/>
Number of stacked cores / sheets:	<input type="text" value="1"/>		<input checked="" type="checkbox"/>

Core Material

- Ferrite
  - Ferroxcube
    - 3C81+
    - 3C94+
    - 3E27+
    - 3F3+
- EPCOS
- Steel
- Iron Powder
- powder core

GECKO SIMULATIONS

# GeckoMAGNETICS

## Winding Tab

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File Help

Inductor Design

Start Core **Winding** Waveform Cooling Results

**Winding Type**

- Foil
- Litz Round
- Solid Rectangular
- Solid Round**

**Winding Material**

- Al85-Cu15
- Aluminium
- Annealed Copper
- Copper (drawn wire)**
- Copper (pure)
- Silver

**customized**

Predefined Windings

**Bobbin Parameters** Fixed

Bobbin Gap (wb):  mm

Bobbin Height (hb):  mm

**Winding Parameters** Fixed

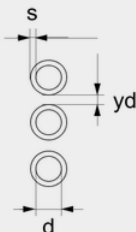
Nr. of Turns:

Conductor Diameter (d):  mm

Isolation Thickness (s):  mm

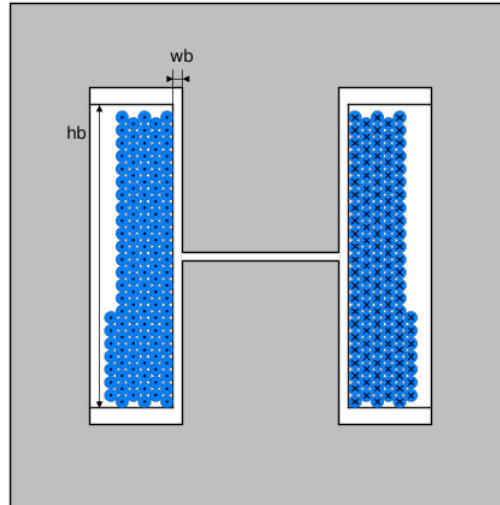
Wire Spacing (yd):  mm

**Winding Figure**



**Winding Pattern**

- square
- hexagonal
- continuous
- distributed
- concentrated
- top
- bottom
- split windings



# GeckoMAGNETICS

## Waveform: Link to GeckoCIRCUITS

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File Help

Inductor Design

Start Core Winding **Waveform** Cooling Results

### Waveform Specifications

Flux Waveform:

Maximum Expected Current:  A

Inductor Label in GeckoCIRCUITS:

Inductor Voltage Name in GeckoCIRCUITS:

Inductor Current Name in GeckoCIRCUITS:

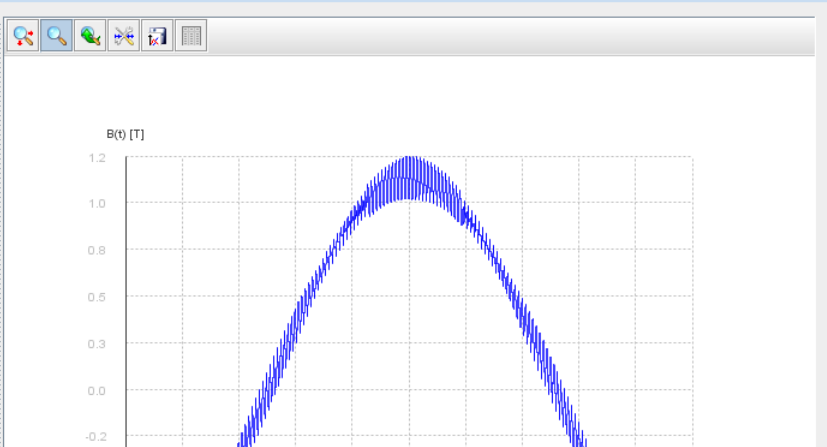
Simulation Step Width [dt]:  s

Simulation Time [t\_SIM]:  s

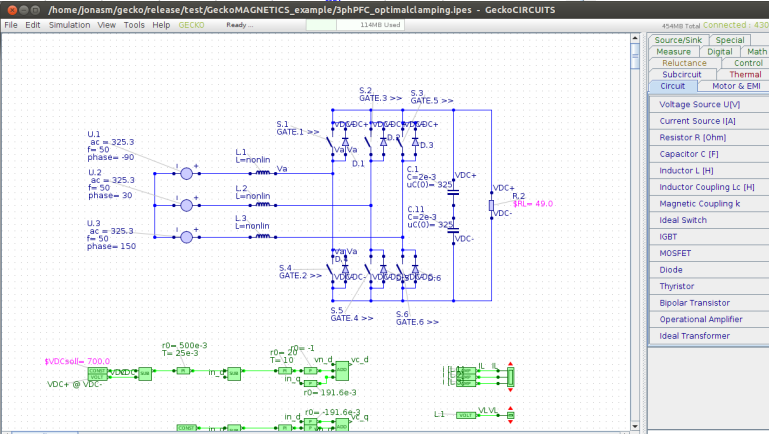
Fundamental Waveform Frequency:  Hz

Current Waveform Shape:

Maximum Occurring Frequency:  Hz



**GeckoCIRCUITS**  11488 Used



43488 Total Connected: 43035

- Source/Sink | Special
- Measure | Digital | Math
- Reluctance | Control
- Subcircuit | Thermal
- Circuit | Motor & EMI
- Voltage Source U[V]
- Current Source I[A]
- Resistor R [Ohm]
- Capacitor C [F]
- Inductor L [H]
- Magnetic Coupling k
- Ideal Switch
- IGBT
- MOSFET
- Diode
- Thyristor
- Bipolar Transistor
- Operational Amplifier
- Ideal Transformer

# GeckoMAGNETICS

## Cooling Tab

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File Help

Inductor Design

Start Core Winding Waveform **Cooling** Results

**Cooling Concept**  
Forced Convection

Ambient temperature: 25 °C

**Orientation (Gravity Direction)** Side Definition  
Top-Down

**Air Flow**  
Direction: Front-Back  
Speed: 3 m/s

**Convection Sides**

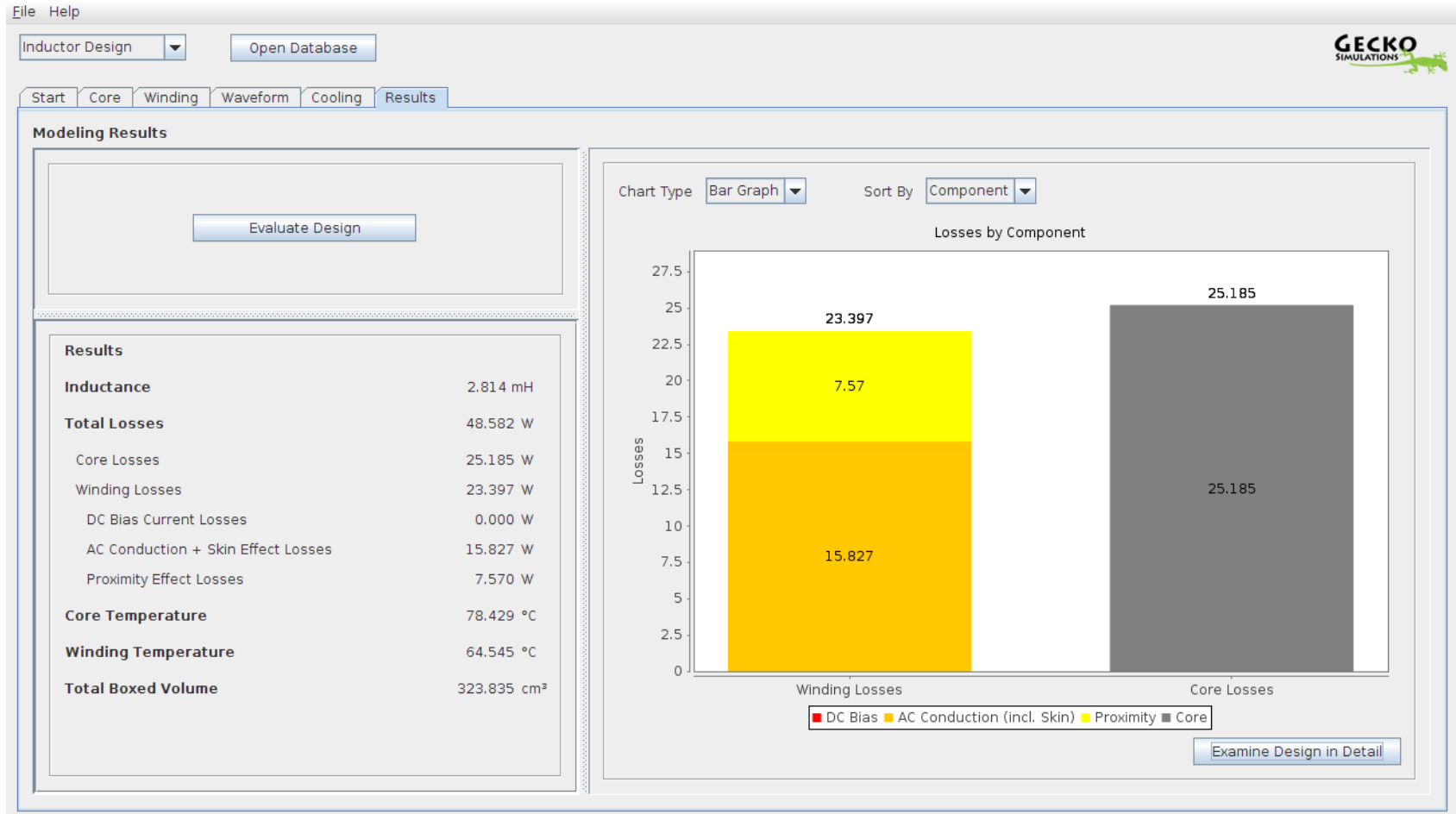
- front
- back
- left
- right
- top
- bottom

The diagram illustrates a cooling tab configuration. The main cross-section shows a central gap of width  $w_m$  between two vertical sections of width  $w_i$  each, all within a total width  $w$ . The height of the top section is  $h_w$  and the bottom section is  $h$ . A gap of height  $gap$  is shown between the two sections. Below this, a side view shows a tab of length  $l$  and width  $w$ . To the right, two diagrams show air flow directions: the top one shows air flowing into the page ( $\otimes$ ) and gravity acting downwards ( $\downarrow$ ); the bottom one shows air flowing out of the page ( $\otimes$ ) and gravity acting upwards ( $\uparrow$ ).

# GeckoMAGNETICS

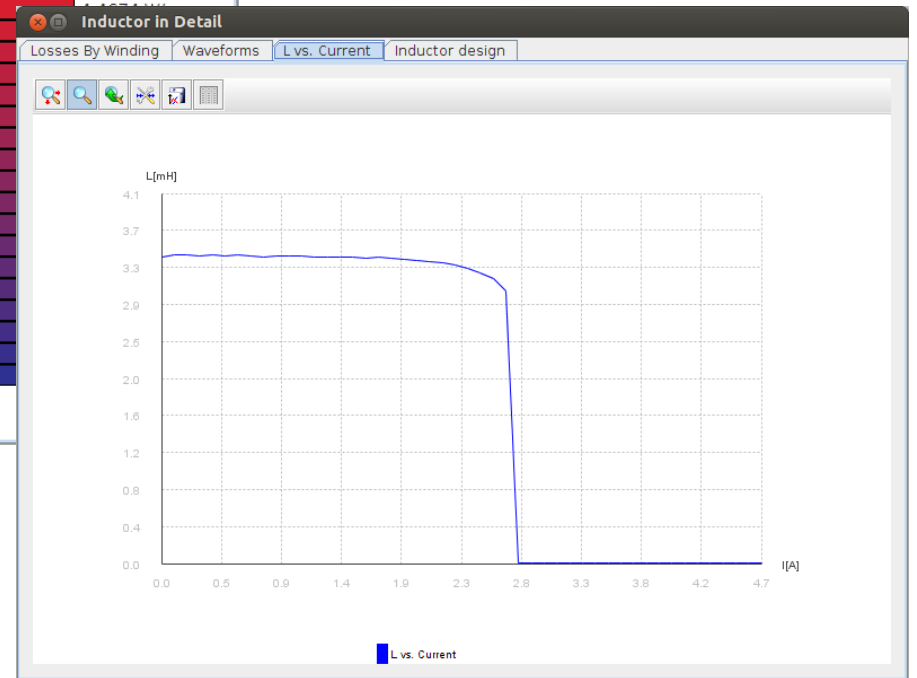
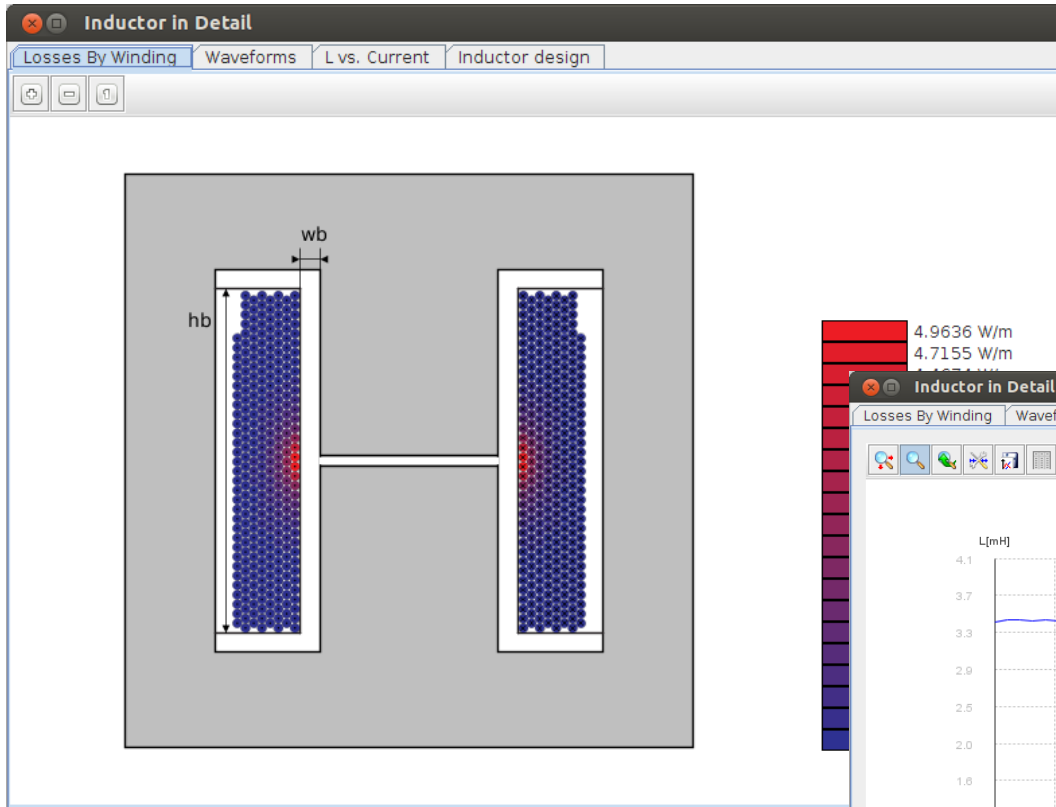
## Results Tab (1)

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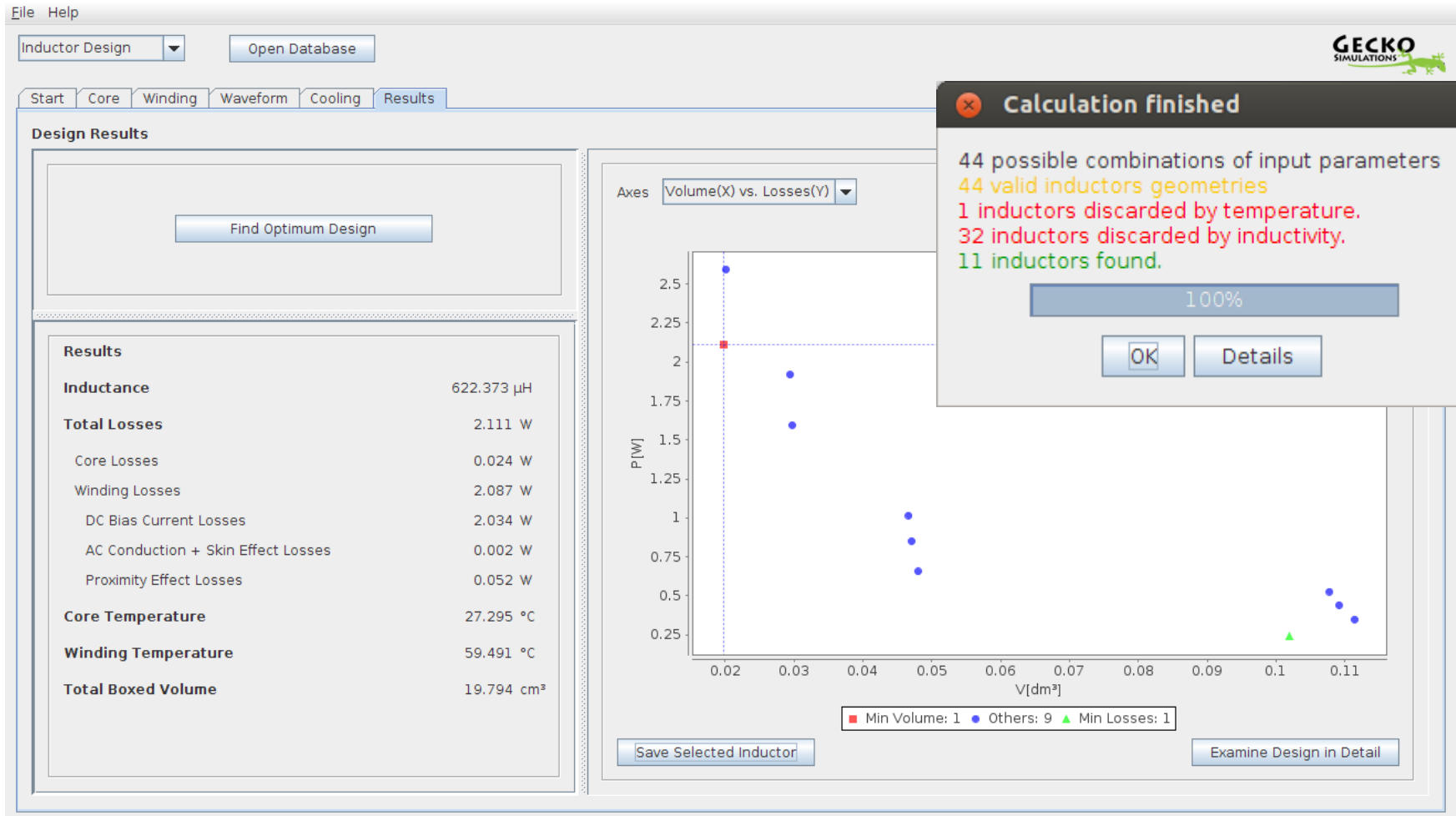
# GeckoMAGNETICS Results Tab (2)



# GeckoMAGNETICS

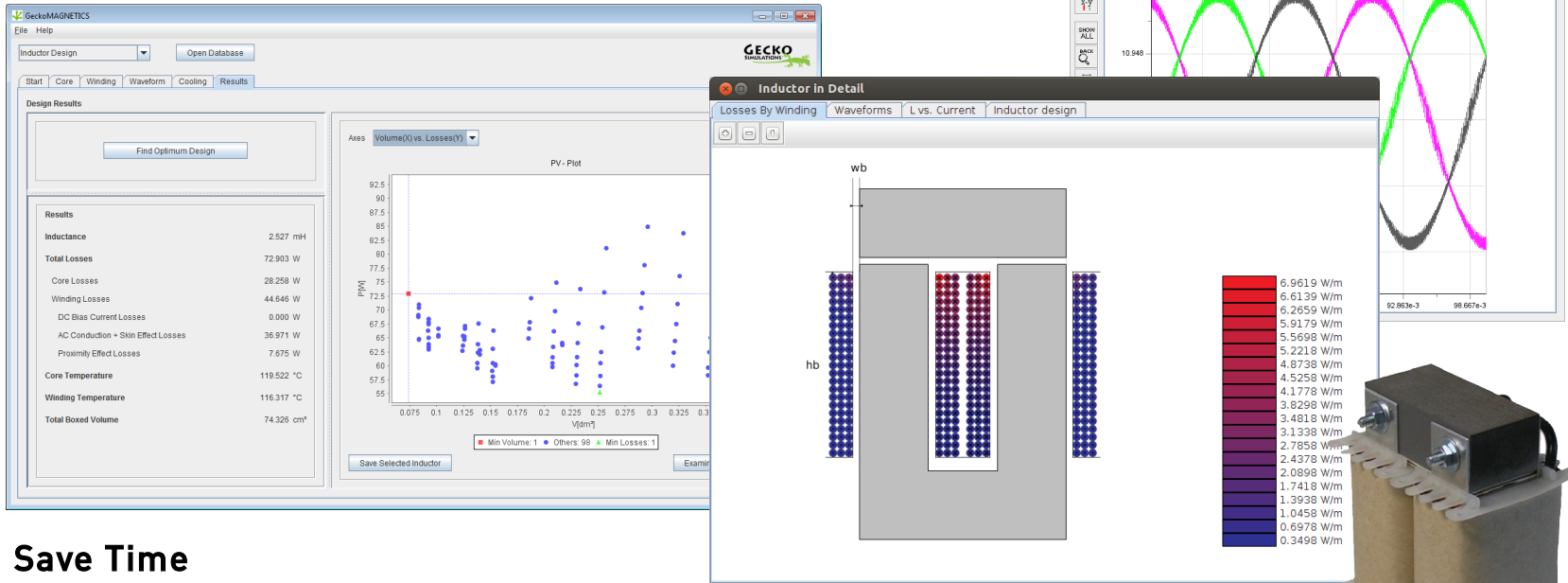
## Design Mode

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THANK YOU !!!

## GeckoMAGNETICS



### 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, ...