On the example of a three-phase boost PFC, this application note shows how to design laminated sheet inductors using GeckoMAGNETICS. If you are new to using GeckoMAGNETICS, we recommend going through the tutorials "Design of an Inductor for a Buck Converter" and "Model Inductive Components" before continuing.

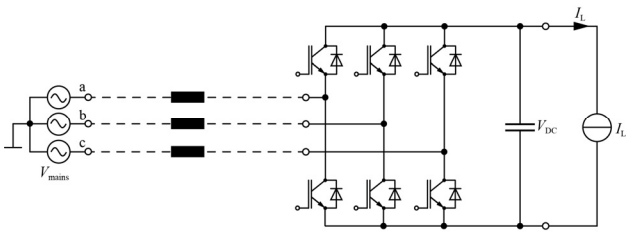
The example design is a boost inductor for a three-phase boost PFC. The converter schematic and specifications, are shown in the figure below. To limit the current ripple below 4 A, a boost inductance of 2.53 mH has to be achieved.

To begin, go to the GeckoMAGNETICS "Start" tab, select design mode and specify a nominal inductance of **2.53 mH**, a minimum inductance of **80 %**, and a maximum temperature of **120 °C**.

For the inductor core, we use UI sheets made of grain-oriented steel (M165-35S, lam. thickness 0.35 mm). The design space has to be specified in the tab "Core". **Therefore, select sheets with sizes between UI 39 and UI 90 of the DIN41302 series and select the material M165-35S.**

Notice that in contrast to the tutorial "Design of an Inductor for a Buck Converter", sheets are selected here rather than entire cores. A core is produced by stacking several sheets together, and accordingly, the number of sheets in the stack has to be specified. This is done via the parameter "Number of stacked cores / sheets". To find the optimum number of stacked sheets per core, define the range here as "**60 to 100 by 10**". The software tool then evaluates cores with 60, 70, 80, 90, and 100 stacked sheets.

Parameter	*Value*
Input voltage AC V_{mains}	230 V
Mains frequency f_{mains}	50 Hz
DC Voltage V_{DC}	650 V
Load Current I_L	15.4 A
Switching frequency f_{sw}	8 kHz



Furthermore, we also want GeckoMAGNETICS to find the optimal air gap size. Thus, define the range for it as **"1.0 to 3.0 by 0.25 mm"**.

In the next step, the design space in the "Winding" tab has to be defined. In this example, please choose "**Solid Round**" and fix the **filling factor at 0.3**. The windings should be distributed on both core legs. Hence, enable the **"Split Windings"** option.

Choose **"LF Sinusoidal + HF Triangular"** in the "Waveform" tab. This allows you to specify a pre-defined waveform that consists of a low frequency (LF) sinusoidal and a high frequency (HF) triangular component. The default type of calculation performed on these waveforms is the "Fast Approximation", meaning that the losses of the HF and LF waveforms are computed independently. In this calculation mode, the effect of DC pre-magnetization on the core losses is neglected. As a result, the designs are evaluated much faster, but with reduced accuracy.

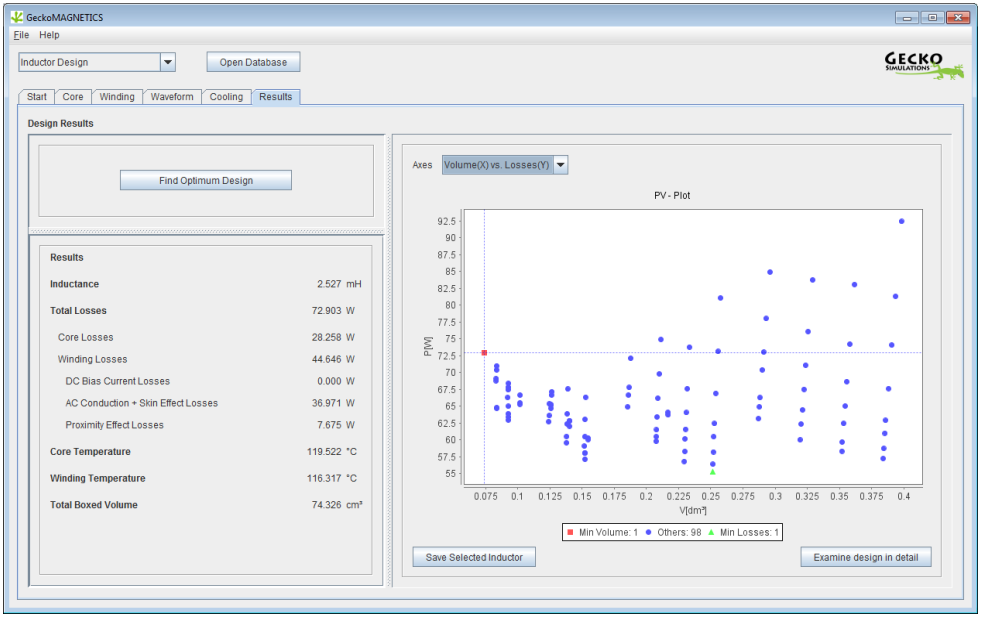
To proceed, select the following options: "Fast Approximation", HF Frequency 8 kHz, HF Voltage Time Area 0.01 Vs, Duty-Cycle 0.5, LF Frequency 50 Hz, and a LF Peak Current of 21.8 A. The voltage time area and the LF peak current were calculated beforehand for this example.

Alternatively, you have the option to select "From GeckoCIRCUITS" or "Exact Calculation" to increase the modeling accuracy. The link to GeckoCIRCUITS allows the direct application of simulated current and voltage waveforms in GeckoMAGNETICS.

In the tab "Cooling", please choose "Forced Convection" with an air speed of 5 m/s; set the air flow direction and orientation to "Left-Right".

After pressing "Find Optimum Design" in the "Results" tab, a graph as shown in the screenshot below summarizes the design results. In the graph "PV – Plot", all calculated designs are visualized in an "inductor power loss" vs. "inductor volume" graph (i.e. a pareto-plot). The designs with minimal losses (green) and with minimal volume (red) are highlighted. Depending on whether the aim of the optimization is more on reducing the volume or the losses, one would select a different design.

The user can save a single inductor design via the button "Save Selected Inductor". Later, this file can be loaded and used in the GeckoMAGNETICS modeling mode.
This is useful for a subsequent more accurate inductor model, which is combined with the circuit simulator GeckoCIRCUITS.



Contact Information / Feedback

Dr. Jonas Mühlethaler

Gecko-Simulations AG
Physikstrasse 3
CH-8092 Zürich, Switzerland

Phone +41-44-632 6576
Fax +41-44-632 1212

www.gecko-simulations.com
jonas.muehlethaler@gecko-simulations.com

Document version: August 2013