Getting Started - Design of a Flyback Transformer

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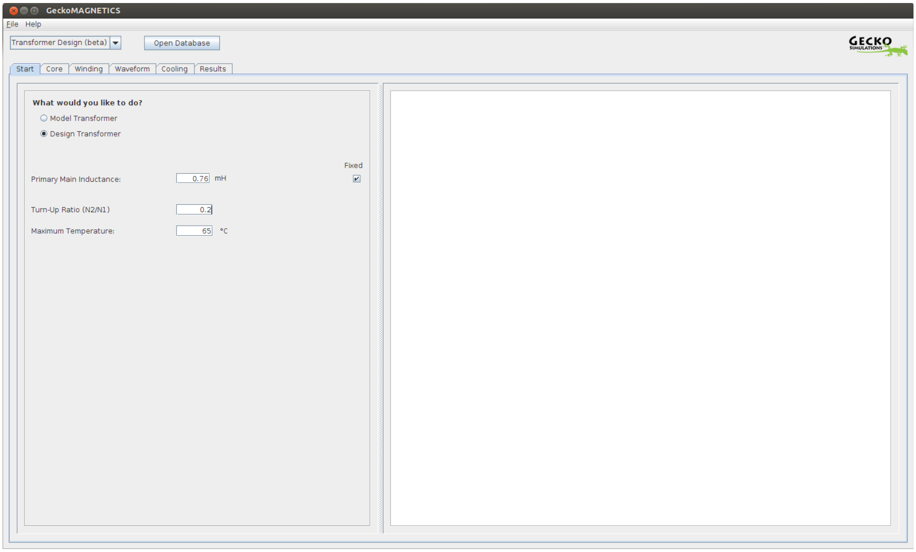
GeckoMAGNETICS is a tool that enables fast, accurate and user-friendly modelling and pareto-optimal design of inductive power components.

On the example of a flyback type DC/DC converter, this tutorial shows how flyback transformers can be pareto-optimally designed. The output of the tool is a so-called pareto-front from which the user can select loss and/or volumetric optimized designs, according to his needs. This tutorial gives insight into the transformer design mode of 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.

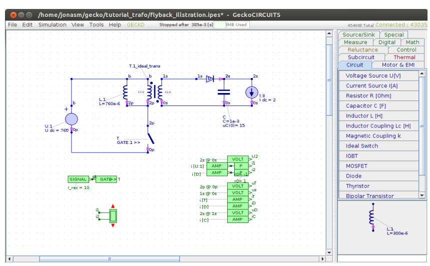


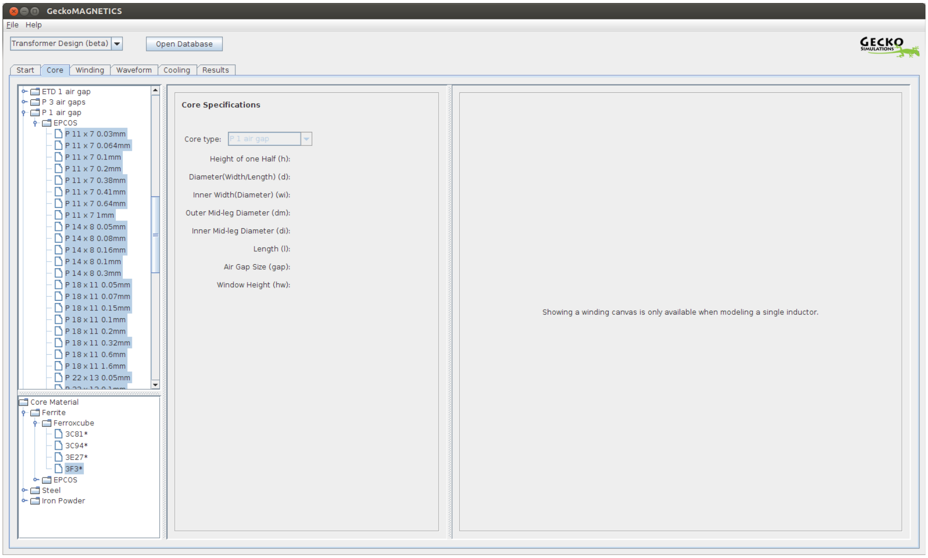
After starting GeckoMAGNETICS, the tab "Start" is active, as is illustrated in the figure above.

In this tutorial, we would like to find the optimum design of a flyback transformer for a flyback type DC/DC converter as shown on the right; **accordingly, please choose first "Transformer Design" in the drop down box at top left and then the "Design Transformer"** option.

Now, the primary main inductance, the turn-up ratio and the maximum allowed hot spot temperature can be selected in the "Start" tab. Often, a minimum main inductance has to be guaranteed in order to limit the magnetizing current. Here, a range can be defined by unselecting the according "fixed" parameter. However, in case of a flyback transformer the inductance value determines the operating condition/point. Accordingly, the flyback transformer has to be designed for a specific inductance value.

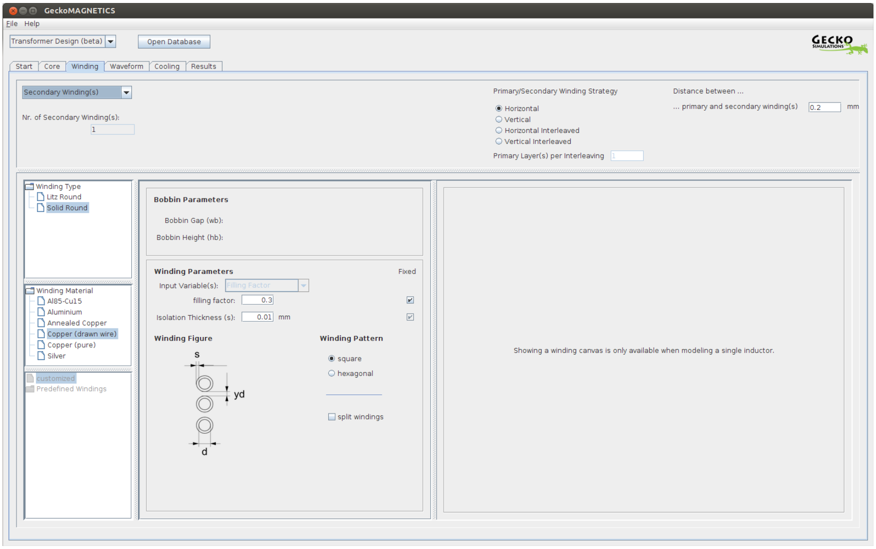
In the example at hand, please choose a primary main inductance of **0.76 mH**, a turn-up ratio of **0.2** and a maximum temperature of **65 °C**.





As already described in the tutorial „Design of an Inductor for a Buck Converter“, a typical design approach is to preselect the core shape. In the example, we go for pot cores; however, since we do not know the needed size yet, we simply choose ***all* EPCOS “P 1 air gaps”** cores from the database. A multiple selection is done by pressing SHIFT to choose a range, or by pressing CTRL to add a core to the previously made selection.

Different materials can be selected; the tool then searches for the best possible material. Here, we select just one material, the Ferroxcube material “**3F3+**”.



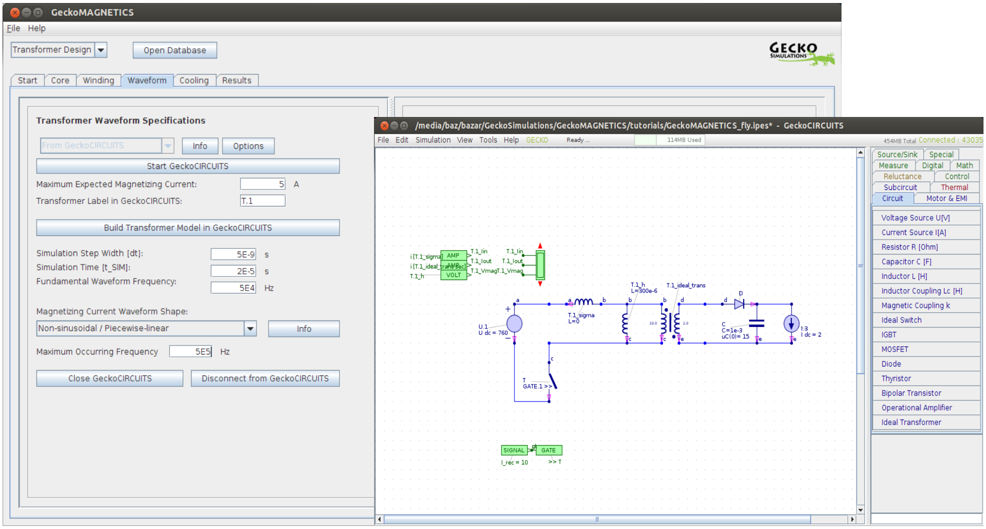
In a next step, we define the winding design space. The user can select a filling factor that allows the tool picking the according wire diameter. The winding window is split into two equally sized sections, one for the primary winding and one for the secondary winding. A splitting into two sections of same size is usually a good choice since the total current that is flowing in the winding window is the same for both windings (i.e. $N_1 I_1 = N_2 I_2$). A filling factor of e.g. 0.5 means that the according winding fills 50% of its winding window share. This means if e.g. a filling factor of 0.4 is selected for the primary as well as for the secondary winding, the winding window is filled with a total filling factor of 40%.

First, the **primary winding** type is selected; in this example we choose "**Solid Round**", "**Copper (drawn wire)**", and a filling factor of **0.3**.

At top left of the GeckoMAGNETICS window is a drop down menu which allows to go to the "**Secondary Winding(s)**" specifications. We choose again "**Solid Round**", "**Copper (drawn wire)**", and a filling factor of **0.3**.

Furthermore, we choose "**Horizontal**" as the "Primary/Secondary Winding Strategy" and a "Distance between primary and secondary winding(s)" of **0.2 mm**.

The "Primary/Secondary Winding Strategy" determines how the winding window is divided into two sections, with or without interleaving.

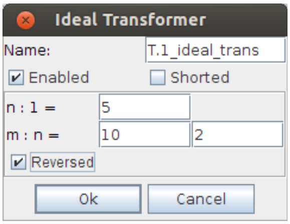


Unlike in inductor mode, in transformer mode the waveforms are always simulated in GeckoCIRCUITS. This is because of the increased complexity of the transformer mode. For instance, the circuit that is connected to the secondary side of the transformer strongly influences the currents in the transformer. GeckoMAGNETICS linked with Gecko-CIRCUIT gives the user full flexibility to define the input and output according to his needs. Also, standard voltage / current shapes can easily be generated in Gecko-CIRCUITS.

In the tab “Waveform”, press the button “Start GeckoCIRCUITS”. After Gecko-CIRCUITS is started, open the model “**GeckoMAGNETICS_fly.ipes**”.

The transformer as well as its current and voltage labels have to follow a certain pattern. The easiest way to achieve this is to let GeckoMAGNETICS build the transformer model. Press “**Build Transformer Model in GeckoCIRCUITS**” and a transformer equivalent circuit, an input voltage source, an output resistance, and a scope with properly defined labels are built in GeckoCIRCUITS. The transformer consists of a leakage inductance, a magnetizing inductance and an ideal transformer.

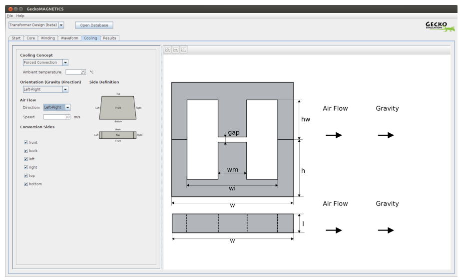
The voltage source as well as the load resistance are not needed for this example and should therefore **be deleted**. The transformer itself can be connected into the pre-built circuit as shown in the figure above. The secondary side of the ideal transformer has to be reversed such that it matches the output circuit. For this purpose, please double-click the isolation transformer block and select "Reversed", as shown in the figure below.



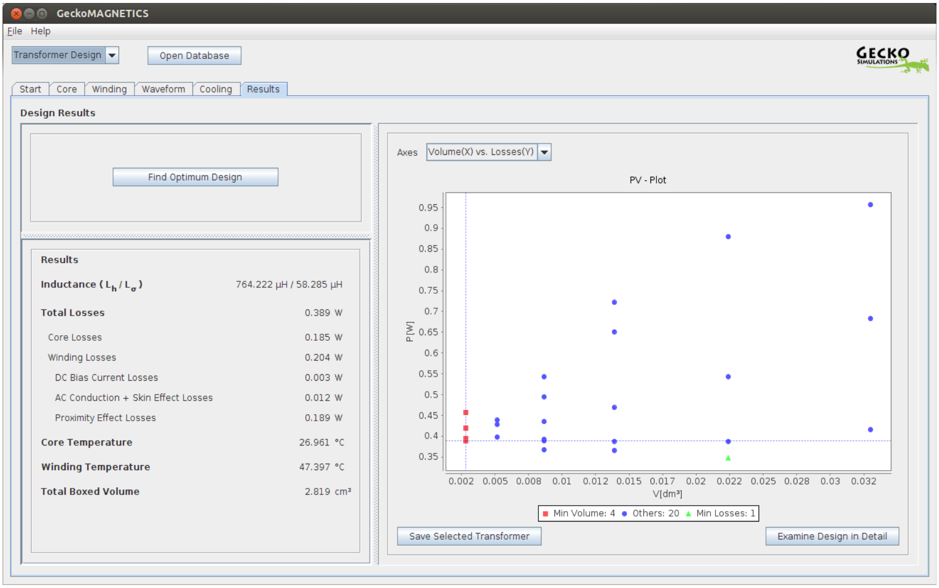
If we look at the component values in GeckoCIRCUITS, we see that they are not updated yet. This will happen automatically during the optimization procedure. Another important thing to note is that, in design mode, the leakage inductance is not taken into consideration, i.e. the leakage inductance is not updated in GeckoCIRCUITS. In design mode, the leakage inductance is set constantly to zero. This allows a faster and easier design for which this parasitic effect is neglected. However, a final design can be saved and, subsequently, loaded in model mode, where then the leakage inductance is taken into consideration in Gecko-CIRCUITS.

Set in GeckoMAGNETICS the simulation step width to **5E-9 s**, the simulation time to **2E-5 s**, and the fundamental frequency to **50E3 Hz**. The magnetizing current waveform shape is "**Non-sinusoidal / Piecewise-linear**".

The maximum occurring frequency defines up to which frequency the tool is taking current harmonics into account for the winding loss calculation. A frequency that is a factor ten higher than the switching frequency is a good choice in order to take the most important harmonics into account. Thus, the maximum occurring frequency is set to **5E5 Hz**.



In the tab "Cooling", the thermal boundary conditions can be defined. **Please select "Forced Convection" with air speed of 10 m/s; the air flow direction and orientation are set to "Left-Right".**

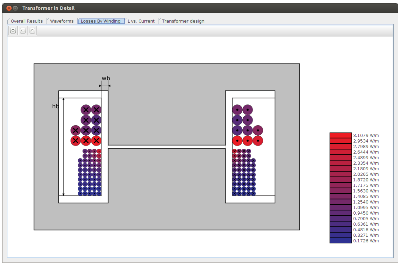


Now, all required information for a proper inductor design is defined and GeckoMAGNETICS can search for an optimized design.

Please press the button "**Find Optimum Design**" in the "Results" tab and wait until the calculation is finished.

In the graph "PV – Plot", all calculated designs are visualized in an "inductor power loss" vs. "inductor volume" graph (i.e. a pareto-plot). Depending on whether the aim of the optimization is more on reducing the volume or the losses, one would select a different design.

By holding the mouse on top of a design in the PV - Plot, a blue tooltip appears. The tooltip gives more detailed information about a specific inductor. Furthermore, by double-clicking on a design, more information shows up. For instance, the losses per winding, as shown in the figure below, are displayed. The increased losses due to the air gap stray field are clearly evident.



This tutorial has given a step-by-step introduction to the tool GeckoMAGNETICS. It has been demonstrated how a pareto-optimal flyback transformer can be designed.

A particular focus was put on how to couple GeckoMAGNETICS with the Gecko-CIRCUITS power electronics simulator.

This tutorial example gives the reader a good starting point to GeckoMAGNETICS. Generally, the tool is designed to be as self-explanatory as possible. Nevertheless, if anything is unclear, or you would like to have a feature which is not available at the moment, please do not hesitate to contact us. Please also consider visiting our bug reporting platform

www.bugs.gecko-simulations.org

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