Ferrochip Design Studio:
A New Design Tool for Integrated Magnetics

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Introduction

One of the many benefits of integrated magnetics is the ability to optimise the component for a particular specification due to the many degrees of freedom. However, with this benefit comes increased complexity in design.

The Ferrochip Design Studio has been designed to be a user friendly software package to aid in the design, optimisation and fabrication of integrated magnetics.

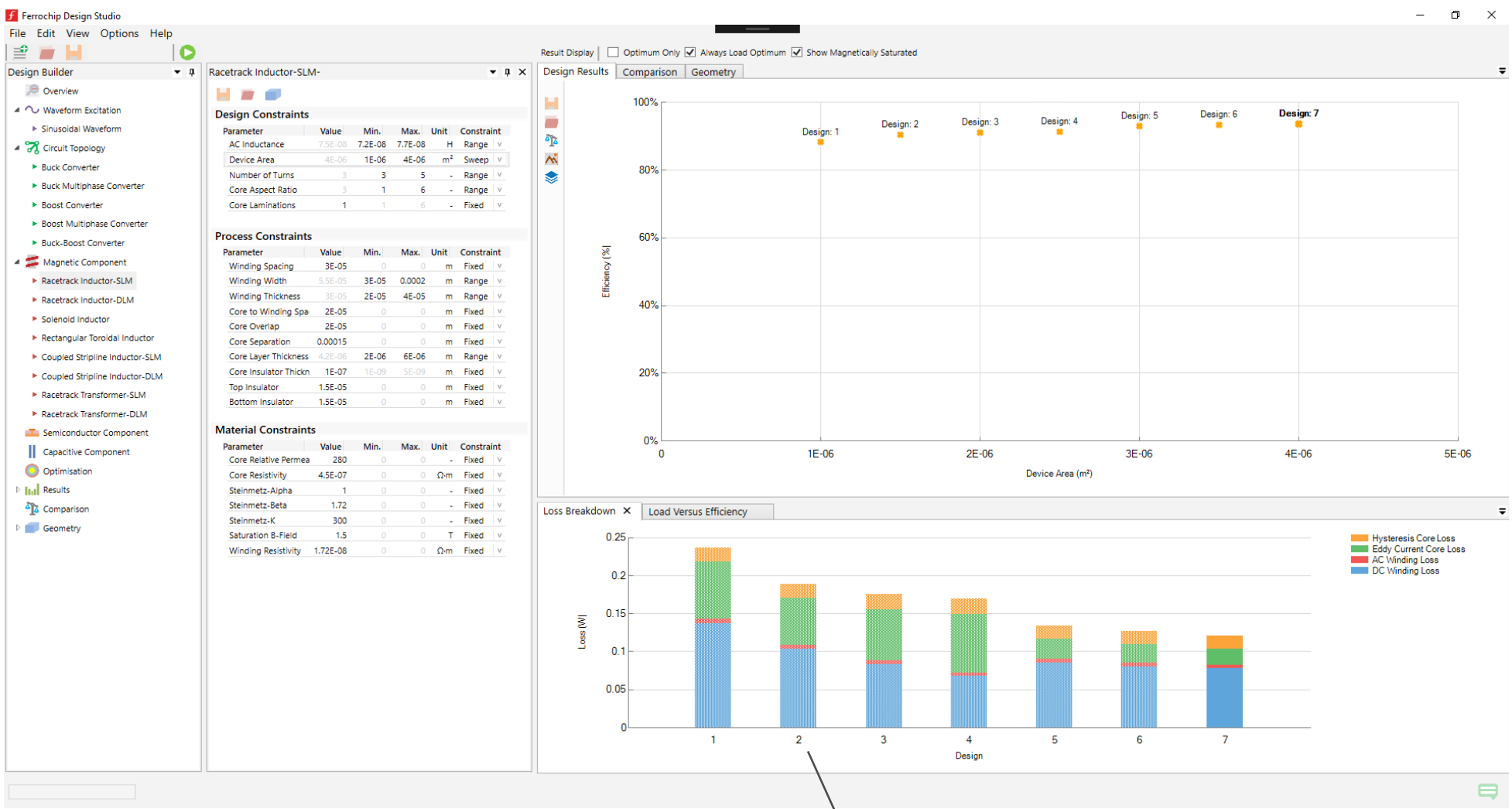
It currently allows accurate modelling of magnetic components while also automatically generating Spice models and GDSII layout files.

The studio allows users to generate optimised designs with ease while also providing the detail required by experts.

Intuitive User Interface	Magnetic Modelling Circuit Modelling Semiconductors* Capacitors*	Maximum Efficiency Minimum Area Maximum Inductance Minimum DCR	Accurate Loss Models Loss Breakdown Load vs. Efficiency Process Parameters	Industry Standard GDSII Advanced Spice Models

*Planned

An Intuitive User Interface



Easily compare optimised designs

Currently Available Components

Magnetics

Solenoid Inductor

Rectangular Toroidal Inductor

Racetrack Inductor
Single Layer Metal
Double Layer Metal

Coupled Solenoid Inductor

Coupled Stripline Inductor
Single Layer Metal
Double Layer Metal

Racetrack Transformers
Single Layer Metal
Double Layer Metal

Circuits

Buck Converter
Single Phase
Multiphase

Boost Converter
Single Phase
Multiphase

Buck-Boost
Single Phase

Sinusoidal Excitation

Optimisation Objectives

Maximise Full Load Efficiency

Maximise Inductance

Minimise DC Resistance

Minimise Footprint Area

Design Study - Coupled Cyclic Cascade Multiphase Inductors

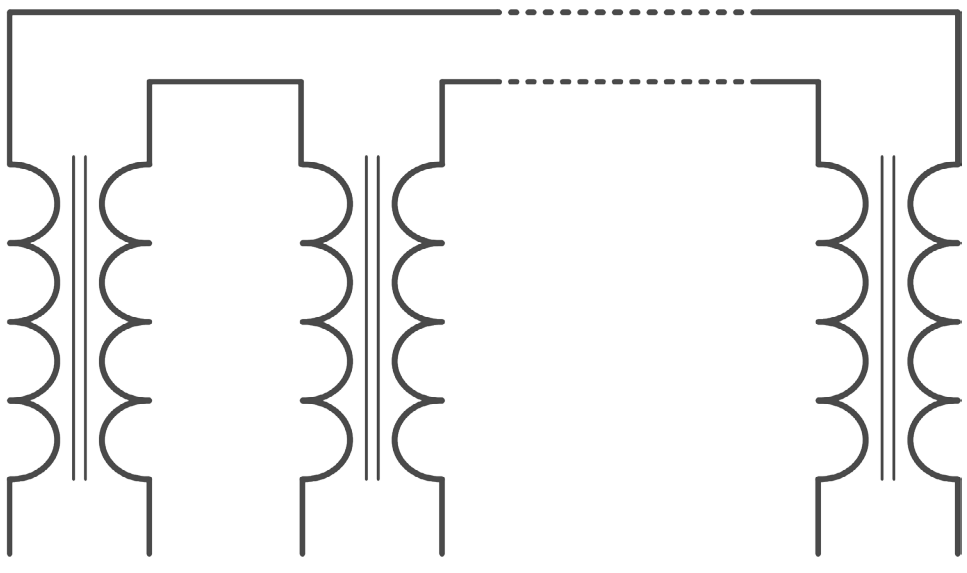
The Design Studio is used to investigate the performance of two coupled structures for use in a multiphase buck converter which would be suitable for a microprocessor load. Two phase ripple current ratios($\Delta I_{p\text{-}p}/I_{dc}$) are investigated; 30% and 50%.

Circuit Specification

Frequency:	100 MHz
Input Voltage:	1.8 V
Output Voltage:	1 V
DC Current:	8 A

Coupled Inductors

Stripline - Single Layer Metal
Solenoid - Interleaved

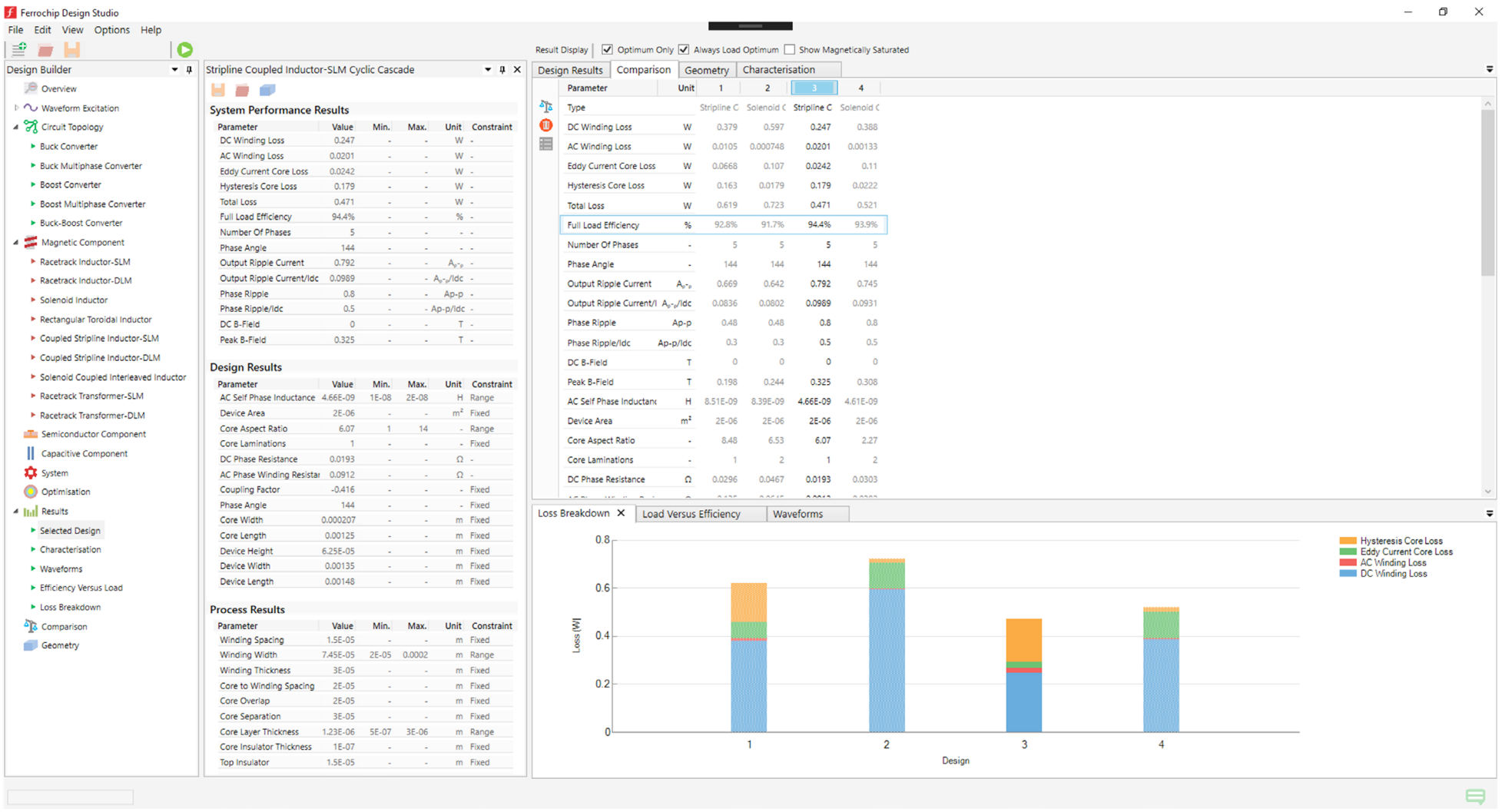


N-Phase cyclic cascade coupled Inductor

To enable a fair comparison of designs the stripline coupled inductor has a fixed winding thickness of 30 µm and a single core lamination. For the solenoid type the winding thickness is set to 15 µm (i.e. 30 µm/2) and has two core laminations.

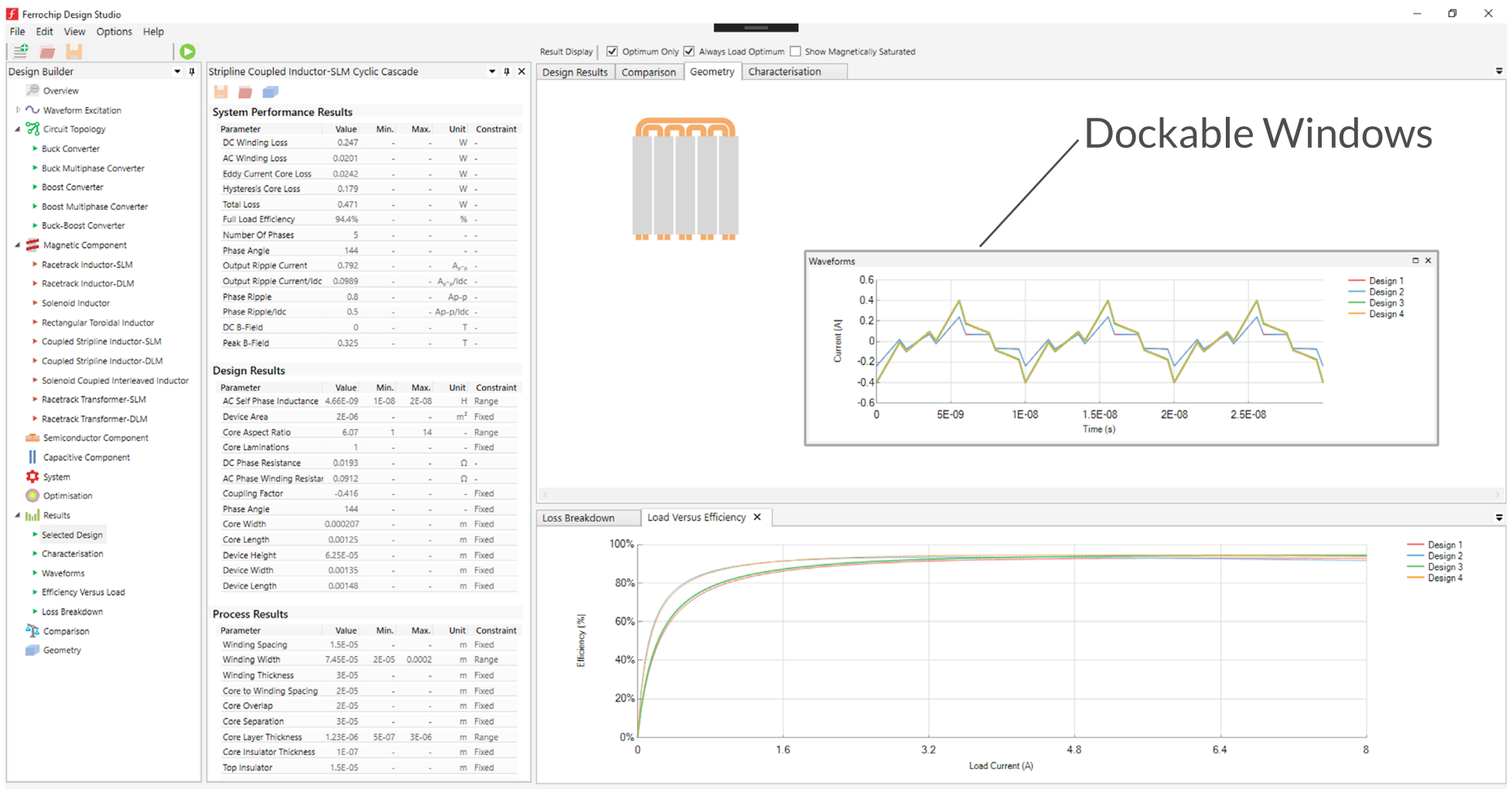
A number of design parameters are optimised for full load efficiency such as winding width, the number of phases, core aspect ratio and core layer thickness within a fixed area of 2 mm^2.

For this specification the optimum number of phases for all design cases is 5.



Loss Breakdown and Comparison

The results show that for both phase ripple ratios investigated the coupled stripline inductor offers the highest full load efficiency.
That is 92.8% and 94.4% for 30% and 50% phase ripple current ratios respectively.



Geometry, Waveforms and Load vs. Efficiency

For load currents below approximately 3 A, the solenoid coupled inductor has a higher efficiency due to lower AC losses. It is interesting to note that core layer thickness for the solenoid is greater than the skin depth (2 µm) in order to reduce DC resistance. This results in a sharper inductance roll off compared to the stripline structure.

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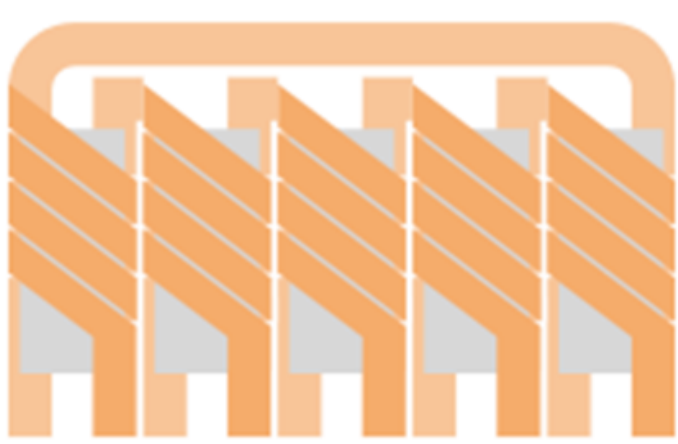
Optimum Designs for a 50% Phase Ripple Current Ratio

Stripline SLM

Efficiency: 94.4 %
Phase DCR: 19.3 mΩ
Inductance: 4.66 nH
Coupling: -0.416
Area: 2 mm^2

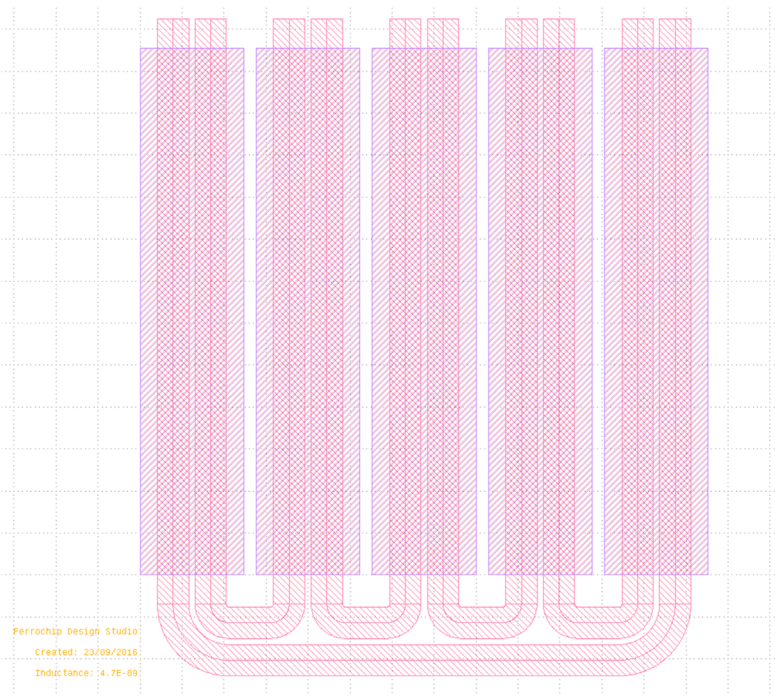
Solenoid - Interleaved

Efficiency: 93.9 %
Phase DCR: 30.3 mΩ
Inductance: 4.61 nH
Coupling: -0.409
Area: 2 mm^2

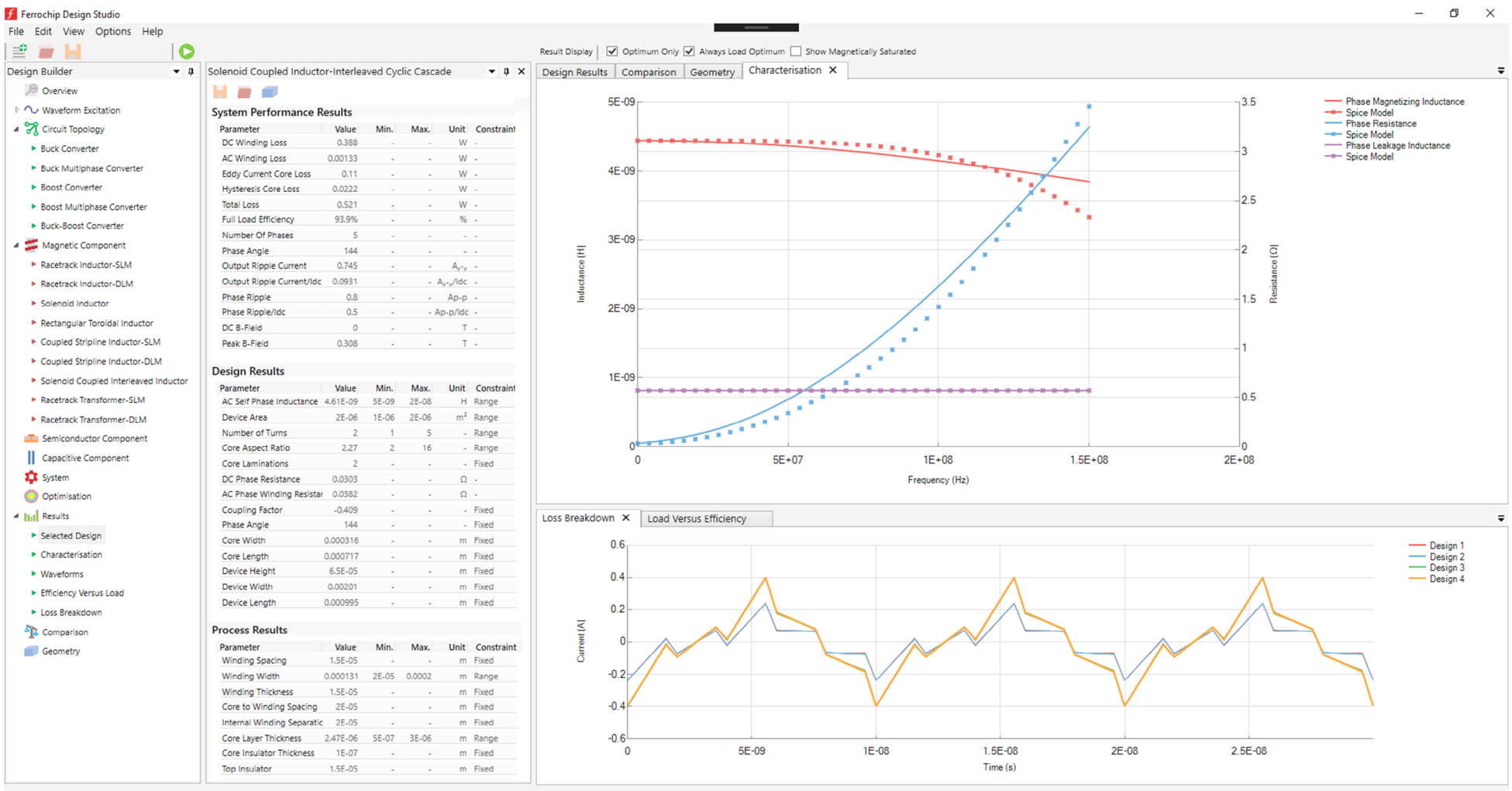


GDSII Layout Files

Layout files automatically generated for export to 3rd party layout tools



Spice Model Curve Fitting



Frequency independent Spice model automatically curve fitted.

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Conclusions

A brief outline of a new Design Studio for the optimisation of integrated magnetics is presented. It has been used to optimise a 1.8 V to 1 V multiphase buck converter using coupled inductors arranged in a cyclic cascade configuration.

The results of this study show that for high load currents, coupled stripline inductors offers the highest full load efficiencies compared to coupled interleaved solenoid inductors due their lower DC resistance for a fixed phase ripple current ratio.

The number of degrees of freedom allowed in the design of integrated magnetics mean that the component can be optimised for particular load conditions to achieve maximum performance.

Future Work

It is envisaged that the Design Studio will eventually provide a complete platform for the optimisation and validation of integrated systems incorporating magnetics.

Links to 3rd party software packages is seen as a key piece of future work and plans are in place to incorporate semiconductor and capacitor models into the Design Studio. This coupled with a scripting interface will allow smooth integration into already established design flows.

Ferrochip Design Studio - Beta

A 1-month trial version with limited models is now available to users. Please contact us for more information.

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