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LAYOUT OPTIMIZATION OF POWER MODULES USING A SEQUENTIALLY COUPLED APPROACH

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Abstract
Nowadays, the design of Power Modules (PM) is shared between multidisciplinary teams of designers using various modelling tools. Consequently, optimizing the layout of PM is a long process with high risk of errors.

In this paper, a sequentially coupled approach is proposed to optimize this process. This integrated method is based on coupling physical models and applying an optimization process. It is illustrated through the example of the layout of a half-bridge Mosfet power module exposed to electric and thermal constraints. So, physical models and software components have been developed, in order to define the multidisciplinary design process and then to perform the layout optimization using the NLPQL algorithm.

It is shown that, the proposed approach allows automatic data exchange between physical models and optimal configurations are proposed with reduced design time and risk. Therefore, this integrated approach shows a great improvement in the design of PM and multidisciplinary products.
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Key Words: Multidisciplinary Design, Multi-Physical Coupling, Layout Optimization, Power Modules

1. INTRODUCTION

Power modules are widely used in many domains such as automotive and aircraft applications. In the design of such multidisciplinary products, layout must be optimized because it acts on both electrical and thermal performance. Layout consists in connecting semi-conductors (transistors and diodes also called chips), to external pins by using Direct Bonded Copper (DBC) tracks and wire bondings [1]. These connecting elements have electrical resistances, inductances and capacitances that can have parasitic effects on the power module. The layout has a strong effect on these parasitic elements. Thus, keeping parasitic effects low is a major requirement in order to reduce electric power losses, over-voltages and poor current balance during switching phases [2]. Long distances between chips improve the thermal dissipation of power modules, since heat spreads more easily. However, the effect of parasitic parameters increases due to the longer commutation path. Consequently, thermal dissipation contrasts with electrical performance when dealing with layout design [3]. Coupling between electric, thermal and geometric modelling is therefore necessary for optimizing power module layouts.

Today, designers are constrained to use different modelling tools in the multidisciplinary design process of power modules: mechanical design, computing parasitic elements, electrical design and finite element analysis. Exchange of data between the different modelling tools is necessary for optimizing the layout of power modules. In the classical design method, The method of defining software components for automation of data exchange could be ameliorated to improve the process of optimization.

By its contribution in reducing the time of the design cycle and improving the design quality, the presented approach is effective and shows a significant importance in engineering design of multidisciplinary products.

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