SDU

The Faculty of Engineering

POPULAR SCIENTIFIC ABSTRACT

Daniel Lyngby Commerou

Determining Coupling Paths for Radiated Emission Caused by Common Mode Emission by Help of Near-field Scanning and Numerical Methods

Time to market, product development cost and final product cost are factors greatly impacted by failing legally mandatory electromagnetic compatibility tests. Electromagnetic interference in power converters usually stems from the indispensable switching stage, making it unavoidable. Engineers tend to over-design to avoid failing late in the development process, increasing the unit price. This thesis investigates the possibility of implementing simulation early in the product development phase to identify the coupling path from the source to the measurement antenna. First, **Study I** provided a method to reduce the modelling complexity of a flyback transformer by introducing a hybrid simulation and an equivalent model. The study successfully obtained an equivalent near-field of the transformer compared to measurements in the frequency range of 80 MHz to 600 MHz. Study I focused on the common-mode equivalent of the transformer, as common-mode currents have a large contribution to radiated emissions from attached cables. Thereafter, **study II** investigated the use of simulation to identify and visualize the coupling path to the attached cables. The study used a method based on the reciprocity theorem, which has been emonstrated effective in digital electronics for visualization. Study II was a full simulation study and a proof of concept for using the method in power electronics. The study showed that visualization was useful for identifying the dominant radiating cable at two frequencies of interest. Some R&D departments do not have the funds, expertise or time to co-develop a simulation model. Therefore, this thesis also investigated the possibility of identifying and visualising the coupling path by near-field scanning or measurements. **Study III** utilized a near-field scan of a power electronic DC-DC converter to visualize the coupling path to the attached cables. This was done by performing a coupling near-field scan (CNFS), a novel method of giving a value for the spatial contribution in the scan area to the attached cable. A vector network analyzer (VNA) was used to perform the coupling measurement, and the results were compared to radiated emission measurements. A regular, absolute near-field scan (ANFS) was also obtained. CNFS and ANFS were obtained for the Hx, Hy and Ez components. A correlation was shown between CNFS with high values combined with a high value of ANFS to high radiated emissions. Dominant radiator was also identified by CNFS and confirmed by radiated emission. **Study IV** expanded on the novel concept of CNFS from Study III. The study introduces a tool to qualitatively evaluate a combined CNFS and ANFS called

calculated coupling (CC). The CC represents a normalized CNFS matrix multiplied by the ANFS matrix element by element and yields a visual representation of the areas of a device under test that could pose a problem for radiated emissions from attached cables. A quantitative analysis method was introduced based on CC by performing field plot addition (FPA), obtaining a single value of the CC at a frequency point. The trend along the frequency obtained by FPA indicates frequency peaks in radiated emission. In a case study, a board layout was modified based on visual information provided by the CC, and actions were taken to reduce the CC. The two layouts were compared in terms of CC, FPA and radiated emission. **Study V** aimed to provide a black-box model of a power drive system for radiated emission evaluation from 20 MHz to 300 MHz. The power drive system was characterized by obtaining VNA measurements, including the attached cables, of the complete radiated emission setup. The coupling between the drive system and a measurement antenna was also measured. In post-processing, the S-parameters were created as a black box with couplings, and the motor characterization was modelled as a circuit model. The direct VNA measurement was compared to the black-box model and circuit-based model for radiated emission. The three were aligned within 2 dB over most of the frequency range but up to 10 dB at 60 MHz