AI/ML-Based Near-field to Far-field mapping for mm-wave ICs in EMC modelling

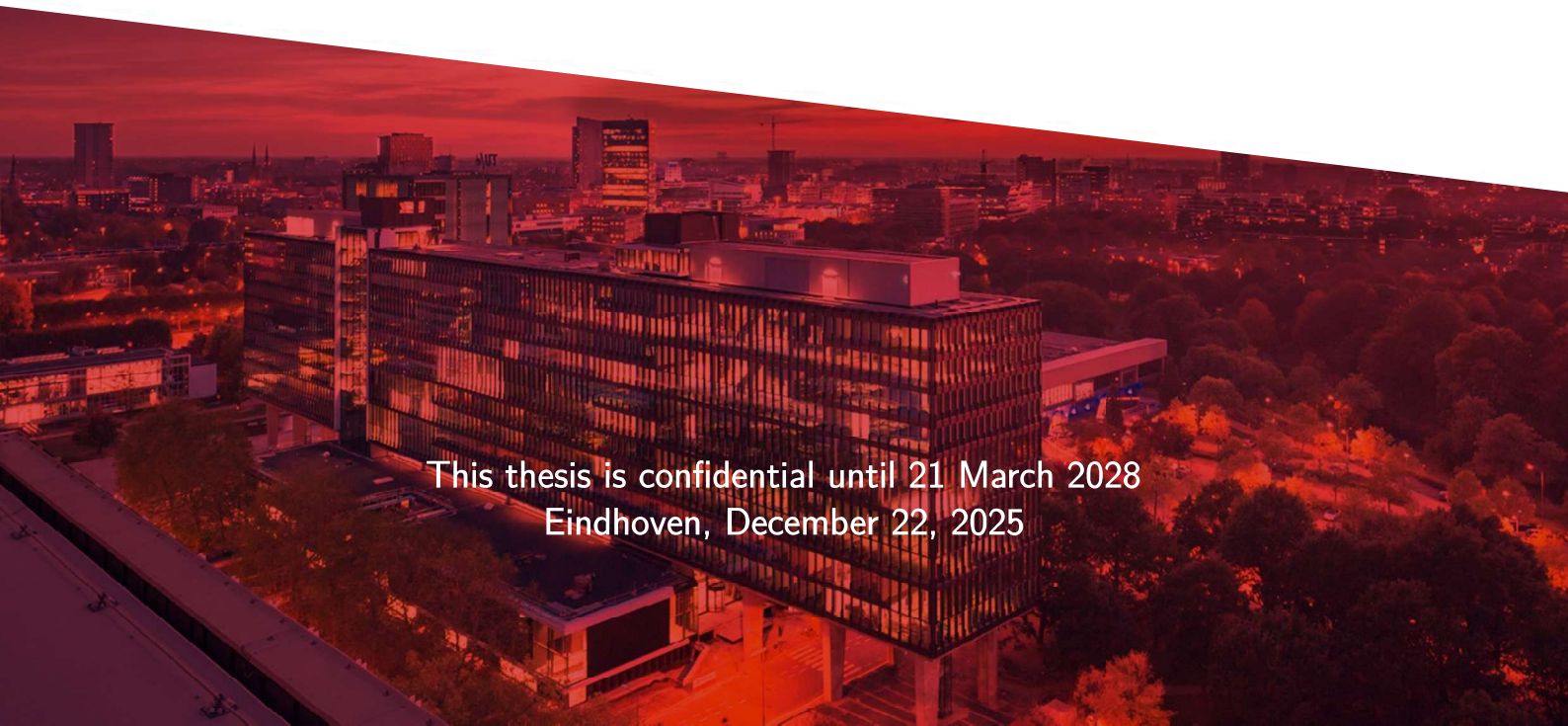
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This thesis is confidential until 21 March 2028
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The research and design described in this thesis has been carried out in accordance with the TU/e Code of Scientific Conduct

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Executive Summary

Millimeter-wave (mm-wave) technologies are central to modern automotive electronic systems, enabling high-resolution radar sensing and ultra-wideband communication for advanced driver assistance systems. The increasing integration density of compact integrated circuits (ICs) and package-level designs at these frequencies introduces significant challenges related to unintended electromagnetic radiation and electromagnetic interference. Localized radiating structures within ICs, packages, and interconnects can couple to surrounding system-level components, leading to elevated emissions and potential non-compliance with regulatory requirements.

In practice, electromagnetic characterization at the IC level is often limited to near-field (NF) measurements or simulations, whereas compliance assessment and system-level impact are governed by far-field (FF) radiation. This creates a critical need to transform NF observations into corresponding FF radiation characteristics. However, conventional NF-to-FF transformation methods rely on dense spatial sampling and computationally intensive post-processing, making them difficult to integrate into fast, iterative design workflows. This limitation motivates the development of more efficient, data-driven approaches for NF-to-FF prediction.

This thesis presents a data-driven framework for predicting far-field radiation directly from near-field measurements. The NF-to-FF transformation is formulated as a supervised learning problem, supported by a fully automated simulation workflow that generates consistent NF and FF data across a parameterized design space. This dataset enables training and systematic evaluation of multiple neural network architectures for both rapid one-dimensional radiation prediction and full two-dimensional far-field reconstruction. The results demonstrate accurate capture of key radiation features and strong generalization to previously unseen designs. By replacing repeated full-wave simulations with learned surrogate models, the proposed approach significantly reduces computational effort, enabling faster and more scalable electromagnetic analysis for iterative design workflows.

From an industrial perspective, this work supports NXP in identifying and mitigating radiation issues in mm-wave integrated circuits more efficiently by enabling faster detection of potential emission sources and facilitating streamlined compliance with regulatory requirements. More broadly, the methodology contributes to the development of scalable, data-driven tools for electromagnetic modeling, supporting advancements in high-frequency wireless systems for automotive and communication applications. Overall, this thesis demonstrates the potential of combining physics-based simulation data with machine learning to enable efficient and scalable electromagnetic design workflows.

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