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**Xiaomin Duan**

**Extension of the Contour Integral Method  
for the Electrical Design of Planar  
Structures in Digital Systems**

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Phone: 0049/2407/9596-0 • Telefax: 0049/2407/9596-9

Internet: [www.shaker.de](http://www.shaker.de) • e-mail: [info@shaker.de](mailto:info@shaker.de)

## **Summary**

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In response to the rapid advance of semiconductor technologies, the demand for dedicated electronic design automation tools has been increasingly high. This thesis focuses on the efficient and accurate modeling of planar structures and power planes in digital systems by the extension of a fast two-dimensional (2D) numerical technique, the contour integral method (CIM).

The advantage of CIM rests on its capability to handle arbitrary shape planar structures and to generate field information efficiently. However, when dealing with power planes with a large number of cylindrical vias, its efficiency drops drastically due to the numerical modeling of via boundaries. To overcome this drawback, CIM is extended here using analytical solutions for circular ports to expedite the computation. Expressions are derived for isotropic modes as well as for anisotropic modes that concerns the accuracy of CIM when applying to dense via arrays at high frequencies.

Although CIM is restricted to 2D problems, the fact that it represents a closed planar region surrounded by microwave ports allows it to be easily networked with other models. Hence, CIM is further extended by combinations with other efficient approaches including equivalent circuits, method of moments, and the physics-based via model to account for the effects of decoupling capacitors, radiation losses, and multilayer substrates, respectively.

The validation and evaluation of the method and its extensions are thoroughly addressed by a variety of application examples. A selection of power/ground plane pair configurations is analyzed to assess the efficiency and applicability to complex shapes. Simulations of multiplayer printed circuit boards are then presented and the results concerning all respects of electrical designs, which covers the signal integrity, the power integrity, and radiated emissions, are demonstrated. Application to dense via arrays will follow and the resolution of potential passivity problems is discussed. The overall efficiency and accuracy of the extended method are solid and it can be expected to produce comparable results 100 times faster than general-purposed full-wave solvers.