A PARADIGM SHIFT IN MICROWAVE CAE

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Introduction

commercial CAE systems for high-speed, wireless and microwave circuits and systems are no longer regarded as complete without a variety of design automation capabilities

computer-integrated manufacturing, including CAD, CAM, information management and decision support systems will be a reality facing the design engineer in the next century

History

by tradition, general purpose EM simulation has been directed at the analysis and validation of proposed designs obtained by circuit simulators

on the other hand, circuit based simulators have had automatic optimization capabilities for decades, e.g., Touchstone

with fast, robust, commercial EM simulators increasingly available, microwave engineers are pushing the frontiers beyond traditional uses of EM simulators

the new thrust is to integrate EM simulations directly into the linear/nonlinear circuit design process in a manner transparent to the designer

Vision of the Future

CAE in the future is expected to be physically and electromagnetically based, to include electrical, mechanical and thermal effects

future developments must integrate CAE tools concurrently linking geometry, layout, physical, EM and process simulations, with performance, yield, cost, system specifications, manufacturability and testability in a manner transparent to the designer

automatic EM optimization of arbitrary geometrical shapes will be a cornerstone of future CAE

The State of the Art in CEM

there have been extraordinary recent advances in computational electromagnetics (CEM) for simulation, modeling, design and validation

advances include novel theoretic concepts

- Space Mapping
- the adjoint network method
- reduced-order modeling
- fast frequency sweeps
- mixed electromagnetic/circuit simulation

some of these techniques are already available in commercial software, e.g., fast frequency sweeps in HFSS

Driving Forces

the industrial drive for shortened time to market and reduced product costs further demands more efficient and accurate design methodology

the use of EM-based models and simulation tools is emerging as essential in the design cycle of high-frequency circuits and systems

recent advances in microwave CAD technology, the availability of powerful PCs, workstations and massively parallel systems, suggest the feasibility of interfacing EM simulations into CAD systems for direct application of powerful optimizers

Applications of EM-Based Design

high-speed VLSI interconnects, chip design, package design, design of multichip modules, printed circuit boards and backplanes

low cost, high-performance, microwave and millimeter wave components for system applications such as in radar, and secure communications: filters, multiplexers, antennas, waveguides, MMICs

The CAE Environment of the Future

future CAE environments must be useful for system requirements down as well as component up design methodologies

the CAE environment must allow rapid prototyping and design of products and the study of tradeoffs between various design approaches

the result will be in systems meeting performance requirements at the lowest possible cost

the future CAE environment will address yield-driven and cost-driven optimization (statistical design centering, design with tolerances, etc.) methodologies crucial not only for massively manufactured circuits but also for improving the probability of first-pass success in designs for small volume production

EM-Based Optimization Features of the Future

robust, efficient *S*-parameter based EM optimization will be standard

optimization capabilities relevant to packaged component/circuit design (coupling effects between the circuit and the enclosure)

concurrent optimization with multiple EM simulators and active devices

optimization of distributed local EM field quantities such as field distributions, current distributions, radiation patterns, etc., in addition to *S* parameters

yield-driven EM-based design methodologies

efficient EM design with tolerances

use of supercomputers, massively parallel and heterogeneous workstations for EM optimization

efficient use of data bases, multidimensional approximations and automated table look-up

visualization for EM design optimization problems

neural network approaches to EM-based design

EM-Based Optimization Features of the Future (cont'd)

implementable EM adjoint parameter sensitivity computations

automatic parameterization of 2D and 3D geometries

parameterized geometrical model primitives

scalable models for optimization

Space Mapping optimization

quasi-global modeling of EM simulated subcircuits and devices

techniques for numerical, geometrical and EM decomposition

optimization strategies for complex and irregular shapes

active device physical/EM simulation and optimization

exploitation of meshing, simulation accuracy and simulation speed

efficient techniques for inverse EM problems

EM-Based Optimization Features of the Future (cont'd)

mixed analytical, empirical and numerical EM simulation and optimization

mixed EM/circuit simulation