MODELING, SIMULATION AND DESIGN

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Effective CAD: a Dilemma of Models!

a panel session at the 1996 IEEE MTT-S International Microwave Symposium/Exhibition, San Francisco, CA, June 19, 1996

Time:	12:15 - 1:35 pm
Location:	Moscone Convention Center
Sponsor:	MTT-1 Computer-Aided Design
Organizer:	John W. Bandler, OSA, Canada
Panelists:	Fritz Arndt, Univ. Bremen, Germany John Bandler, OSA, Canada Mike Golio, Motorola, USA Anthony M. Pavio, Motorola, USA Roberto Sorrentino, Univ. Perugia, Italy Chris Snowden, University of Leeds, UK

Abstract

Device and circuit modeling methodologies aimed at low cost design and manufacture are addressed, including automated performance-, and yield-driven design optimization of microwave and millimeter-wave circuits with accurate EM simulations invoked within the optimization loop. Concepts such as

the Hybrid Mode Matching/Circuit Theory approach,

the classical Adjoint Network Method,

the Feasible Adjoint Sensitivity Technique,

Hybrid Visualization-aided EM Modeling,

and the recent Space Mapping technique

promise to accelerate design optimization exploiting EM/physical simulators. As a result, CAD and modeling of engineering devices, circuits and systems will reach a level of precision and computational efficiency previously undreamed of. These concepts are founded on empirical engineering modeling, circuit theory and field theory, which embody expert knowledge accumulated over many years.

Issues

why is electromagnetic optimization necessary?

a dilemma: physical, physics-based or circuit modeling?

is statistical device modeling necessary?

tradeoffs: cut and try, visualization and user-friendliness

the eternal issue: classical or numerical design methodologies

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Modeling, Simulation and Design

$$Ax = b$$

simulation

(1) given A and x find b

easy

(2) forward problem:

given A and b find x

more difficult

optimization

(3) design problem:

given b and specs on x find some of A

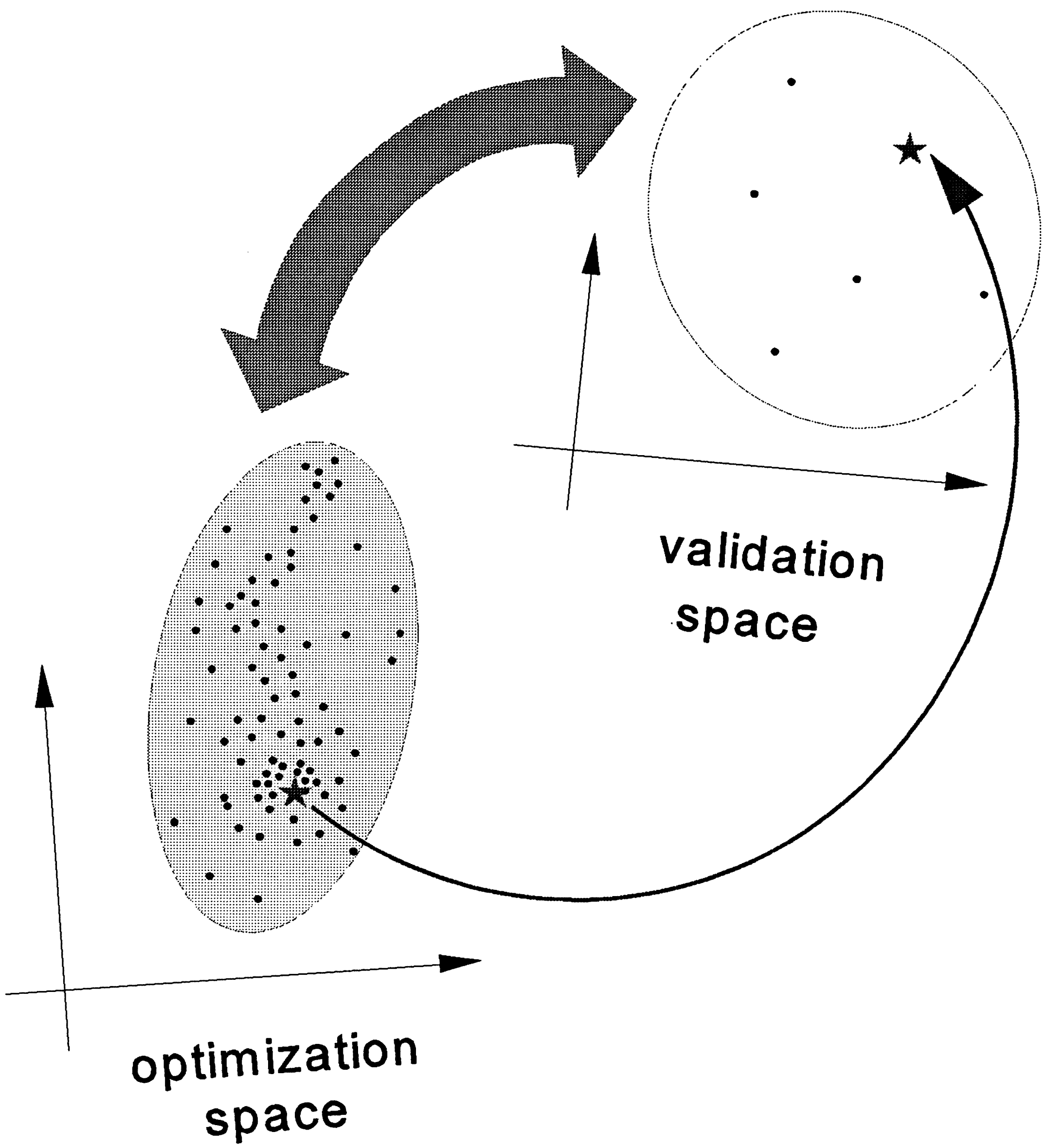
difficult

(4) inverse problem:

given x and b find A

very difficult

Space Mapping™
(Bandler et al., 1994)



FAST - The Feasible Adjoint Sensitivity Technique

performs adjoint sensitivities

retains most of the efficiency and accuracy of the EAST (exact adjoint sensitivity technique)

accommodates the simplicity of the conventional perturbation method, which we name PAST (perturbation approximate sensitivity technique)

directly applicable to both the node/port formulation and the state variable formulation

suitable for implementation within the framework of general purpose software

extends to the computation of Jacobians for high speed HB simulation

the features of FAST and its Jacobian extensions are illustrated by a mixer example and a frequency doubler example

Gradient Analysis Using FAST

the harmonic balance equation (split real-imaginary)

$$F(\boldsymbol{\phi}, V) = \mathbf{0}$$

the output voltage is computed as

$$V_{out} = e^T V$$

an approximate sensitivity of the output voltage is

$$\partial V_{out} / \partial \phi \approx -\hat{V}^T F(\boldsymbol{\phi} + \Delta\boldsymbol{\phi}, V_{solution}) / \Delta\phi$$

adjoint voltages $\hat{V}$ are obtained from solving the linear system

$$J^T \hat{V} = e$$

where J is the Jacobian matrix at the solution

Comparison of FAST with PAST

consider 10 design variables in a nonlinear circuit

PAST analysis

the circuit has to be perturbed 10 times
10 nonlinear circuits have to be solved

FAST analysis

the circuit has to be perturbed 10 times
no additional nonlinear circuits have to be solved
only 10 errors need to be evaluated

the best possible situation for PAST is that all 10 simulations use the same Jacobian and all converge in one iteration

FAST always requires less computation than that of the best possible situation of PAST since error evaluation takes a fraction of the time needed for simulation

FAST is more accurate than PAST

Comparison of FAST with EAST

EAST

commonly accepted as the most powerful tool
a need to keep track of variable locations
expensive to implement

FAST

no need to keep track of variable locations
only the output port has to be identified
implementable in general CAD programs