Focus on CAD

Integration enhances design and test

One of the recurrent themes in the area of microwave CAD today is the increased integration of different types of software module into a common framework, often combining products from different vendors, a trend which is set accelerate in Europe as the EC's EDGE programme unfolds (see article on page 23). Two of its participants, Barnard Microsystems and Jansen Microwave, have already made early announcements of increased co-operation with other vendors with their most recent software upgrades, and Barnard's WaveMaker has also added microwave fibre optic capability. Optimization Systems Associates (OSA) has been one of the pioneers of integrating third party modules into its simulator, having for some time incorporated a port to Sonnet's em 3D planar simulator within its OSA/hope framework (see CAD focus in the May 1995 issue of Microwave Engineering Europe): it has now described a similar tie-in with the Hewlett-Packard HFSS full 3D electromagnetic simulator. Test software, too, is finally becoming more integrated with the design suites, a trend illustrated by the recent announcement of an interface between MMICAD for Windows from Optotek of Canada and vector network analyzers from the test equipment manufacturer Anritsu Wiltron.

3D EM

Optimization Systems Associates will present for the first time at the 1996 MTT Microwave Symposium in San Francisco next month a description of its automated Space Mapping technique for optimizing 3D structures, which can include an interface to HFSS. The Space Mapping (SM) strategy requires the implementation of two nested loops, the iterative process of updating the mapping and setting up the next electromagnetic (EM) simulation, and the parameter extraction process, where the two responses, empirical (coarse) and EM model, are aligned. The flow chart in figure 1 shows how this process has been automated. The two iterative loops involve two different sets of variables: the outer level automates a generic SM loop, incorporating the Broyden update, and updates the parameters of the electromagnetic model based on the latest mapping. The inner loop is set up according to the specific pair of models used, and the Datapipe technique is utilized within this loop to connect the external EM simulator to the optimization environment. In the parameter extraction performed in the inner loop, the coarse optimization model parameters are variables, while parameters of the electromagnetic model are held constant. The use of Datapipe allows the nested optimization loops to be carried out as separate processes, while maintaining a functional link between them, since the next increment to the electromagnetic parameters is a function of the parameter extraction results.

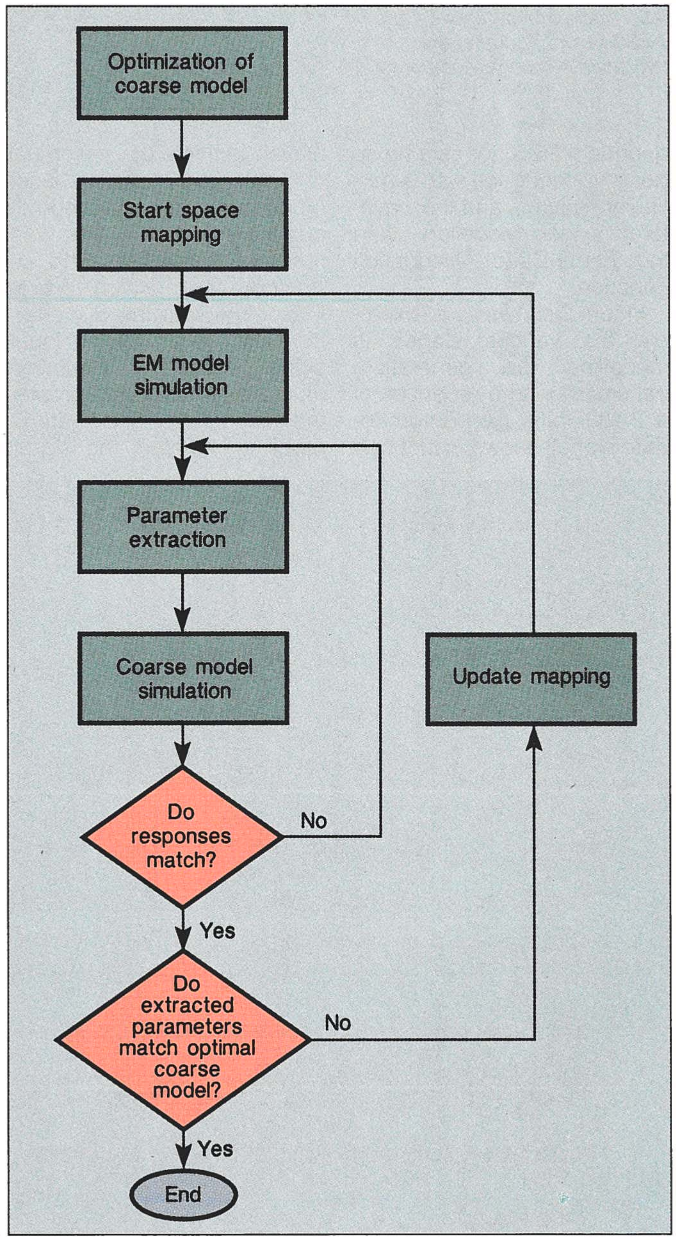
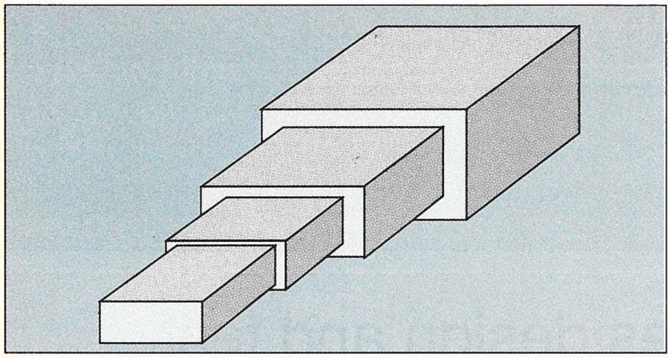


Figure 1: Flow chart of Optimization Systems Associates' "Automated Aggressive" Space Mapping strategy.

Transformer

OSA has applied the automated SM optimization technique to a two-section waveguide transformer as shown in figure 2(a). The heights and lengths of the waveguide sections provide the variables for the simulation, giving a total of four variables for the two-section transformer. The structure was parameterized using OSA's "Geometry Capture" process, and HFSS was embedded into the optimization loop.

Figure 2(b) shows the VSWR response of the transformer



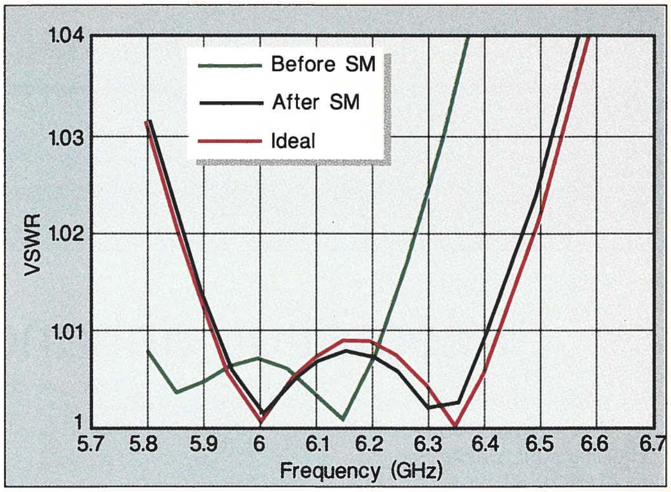


Figure 2: (a) Two section waveguide transformer used by OSA for comparison of electromagnetic simulation techniques - above - and (b) its VSWR response simulated by HFSS before and after the application of 10 space mapping optimization iterations, compared with the ideal response - right.

when simulated by HFSS alone and when HFSS is included in the SM loop: ten iterations were required to achieve this result. The "ideal" response is also shown.

Bi-directional

In its recent upgrade to version 4.3, WaveMaker from Barnard Microsystems has added Optotek's MMICAD to the list of simulators for which it provides bi-directional processing and generation of text-based netlists. Previously available for SuperCompact, Touchstone and LINMIC formats. Additional structures are supported which can be used in the AMPSA MultiMatch amplifier and oscillator circuit synthesis software. MultiMatch can synthesize the circuit topology and generate a netlist from a specification, from which WaveMaker can then create a circuit layout. The new version also features an extended "Model" option, which can extract parameters for the Gummel-Poon bipolar transistor model from a set of dc measurements combined with multi-bias S-parameter measurements. This complements the existing TriQuint Own Model parameter extractor, and the support for bias-dependent TOM and Gummel-Poon models in Touchstone-compatible netlists.

Fibre optic

A further addition is the ability to simulate a microwave fibre optic link as part of the "Design" option. The digital signal is initially specified in terms of a Pseudo Random Bit Sequence (PRBS), or as a hexadecimal sequence with a particular risetime, and the waveform is then modelled using the Fermi-Dirac Distribution Function.

Figure 3 shows as an example the various stages in modelling the generation, transmission and reception of a 2.488Gbit/s Non-Return-to-Zero signal, shown in plot 1. A netlist defines the electrical characteristics of the laser diode package, including microstrip lines, bond wires, chip resistors, capacitors and inductors, from which WaveMaker predicts the S_{21} characteristics seen by the input signal. The linear simulation must be performed at greater than 3.5 times the bit rate in order to maintain the signal integrity: in practice the response is simulated to approximately six times the bit rate. The voltage waveform is converted by Fast Fourier Transform (FFT) into the frequency domain, convolved with the package response, then transformed by inverse FFT to give the predicted time domain current waveform into the laser diode, as shown in plot 2.

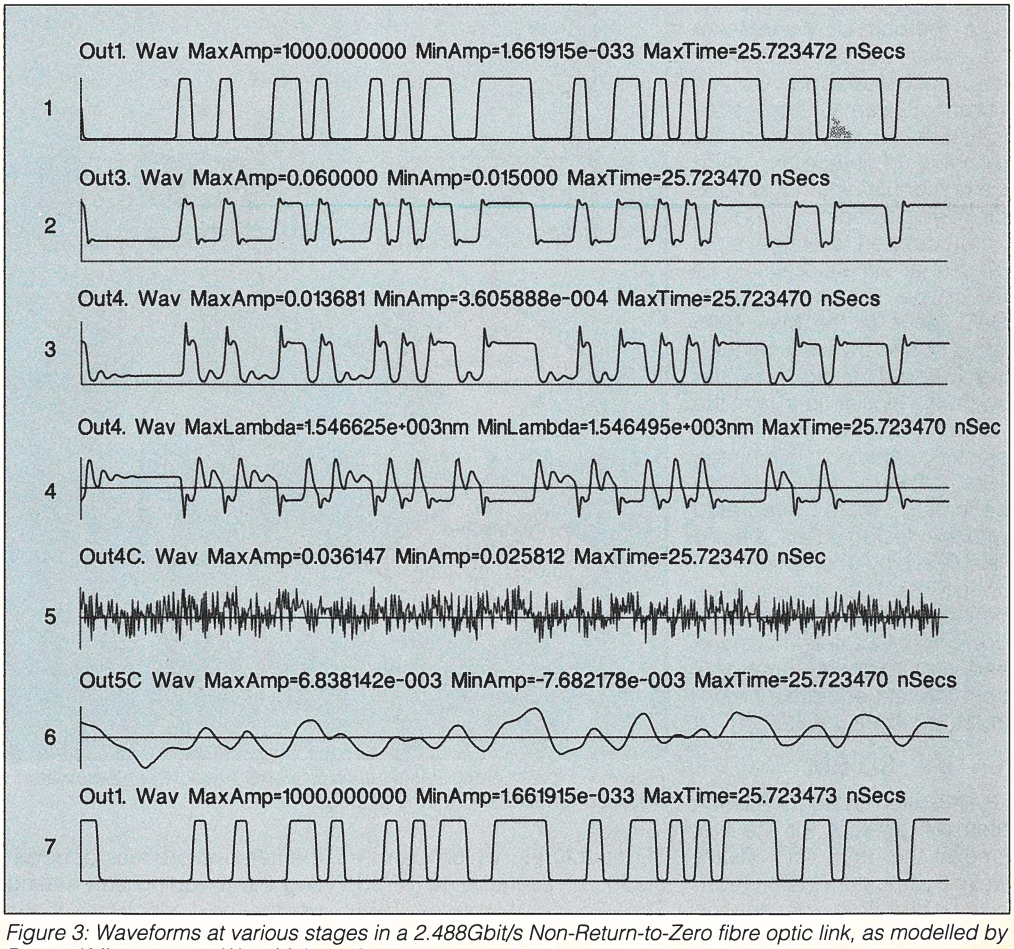


Figure 3: Waveforms at various stages in a 2.488Gbit/s Non-Return-to-Zero fibre optic link, as modelled by Barnard Microsystems WaveMaker 4.3.

Plot 3 shows the optical power, and plot 4 the wavelength, output from the distributed feedback laser diode, for which the optical response is predicted from its physical parameters. The time samples correspond to those of the incident current waveform. The transmission of the signal through a 100km length of optical fibre, with a chromatic dispersion of 18ps/nm per km of fibre, is then modelled using standard FFT and convolution techniques. At the receiver, a PIN photodiode connected to a transimpedance amplifier, the noise added to the signal is simulated by adding a noise generator with a physically realistic flat spectral response, to achieve the signal shown in plot 5.

This is then filtered through a fourth-order low pass Thomson-Bessel filter, with a flat group delay and a cutoff frequency at 0.75 times the bit rate (plot 6).

Finally, a Fourier Transform Correlator is used to determine the delay to add to the original waveform (plot 7) to align the two waveforms in time and work out the number of bit errors in the received bitstream.

The fibre optic simulation capability thus allows the effects of changing parameters in the laser diode or the package components to be simulated, and the bit error rate to be optimized.

Interface

Version 4.0 of LINMIC+/N, from Jansen Microwave, incorporates among its new features a mouse and menu-driven graphics interface, based on Motif, which was developed as part of its activities under EGIP, the ESPRIT project which was the predecessor of EDGE. The interface is expected to form the basis of compatibility with other software which will be developed under EDGE: already netlists are interchangeable with WaveMaker (see above), and S-parameters can be exported in Touchstone format. The new interface provides a unified 2.5D layout-orientated front end access to the LINMIC+/N network simulator, along with its module libraries, and to the SPFMIC+ 2.5D electromagnetic simulator. It transforms the inputs into the earlier netlist format, at which level interchange between the software modules takes place: the numerical data is still available in a pop-up window and can be edited directly as before.

Models

The layout-orientated component library includes models for both MIC and MMIC structures. Simple components have analytical models while more complex ones are based on lookup tables or can be modelled in the EM simulator. The nonlinear harmonic balance simulator can handle structures with up to 6 dielectric layers and two levels of metallization. Up to 40 ports per component, and 40 external ports per circuit, are permitted. Port connectivity is automated, and geometric and electromagnetic compatibility checking is included. Optimization capability includes sensitivity analysis. Simultaneous DC and RF modelling of GaAs FETs and Schottky diodes is provided, and broadband device modelling accuracy can be monitored using the parameter extraction process. Two independent 2.5D EM simulators are included, utilizing spectral domain techniques for the analysis of both microstrip and coplanar waveguide structures. There are no limitations on either dielectric constant or frequency values. LINMIC+/N 4.0 operates on HP9000/700 series, Sun SparcStations, VAXstation 3000 series and IBM RISC RS/6000 workstations.

Gain compression

The MMICAD gain compression module for Anritsu Wiltron network analyzers interfaces directly with the 360 and 37000 series of VNAs, allowing S-parameter acquisition either in real-time or via disk storage. A range of device and amplifier characterization routines are included. The response curves which can be produced by the module include gain versus frequency as a function of input power (P_{in}), gain versus output power (P_{out}) as a function of frequency, phase difference versus P_{out} as a function of frequency, and gain compression (either 1 dB or to any user-defined ratio) versus frequency. CW measurements of gain and phase versus P_{in} and P_{out}, and P_{in} versus P_{out}, are also available, and AM to PM conversion can be derived from the phase versus P_{out} characteristic.

A power meter calibration feature, using any Hewlett-Packard or Anritsu Wiltron power meter, can be used to ensure a precise input power to the device under test, and is normally performed at a fixed power level over a swept frequency range. MMICAD works under Windows 3.1 or later, requiring a PC with an 80386 or higher processor with 4MB minimum memory.

For data write number on information card

OSA	**260**
Barnard Microsystems	**261**
Jansen Microwave	**262**
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Anritsu Wiltron	**264**

CAD goes up to system level

With the complex combination of digital functions and analogue RF technology found in state of the art communications systems, CAD vendors are turning their attention to analyzing and simulating the complete systems, rather than combining the results of separate RF and digital simulations which may not be fully independent. Both Compact Software and HP-Eesof have systems-level CAD packages, but have taken rather different approaches to the problem.

End-to-end

Microwave Success from Compact Software provides combined nonlinear analogue-digital system analysis capability, with support for modulation schemes including AM, FM, PM, MPSK, π/4DQPSK and GMSK, and covering both TDMA and CDMA access techniques. The systems approach facilitates the prediction of how changes in individual component parameters will affect end-to-end system performance. Features available include bit error rate (BER) analysis, multipath Rayleigh channel modelling, and intermodulation and budget analysis. Time-domain (waveform) and frequency-domain (spectrum) output formats are available, as are eye diagram and constellation plots. Figure 1 shows an example of the various output formats for a typical wireless system. The available set of digital functions, which are commonly performed by digital signal processing (DSP) components, includes random and periodic binary data sources, digital filters, adaptive equalizers, modulators and demodulators, and Viterbi decoders. Designs are entered graphically using the Serenade Schematic Editor. The system model created within Microwave Success can be refined using manufacturers' data, results from other Compact simulators such as Microwave Explorer, and experimental results. Once a final design is achieved, Serenade Layout can be used to generate a final layout, with feedback into the schematic.

Mixed signal

HP-Eesof's systems simulation capability is centred on its Series IV Communications Design Suite (CDS) and OmniSys software, which offers the means to design relatively complex systems by allowing simpler, more abstracted, definitions of elements than are used in circuit level or EM/physics simulations. Mixed signal capability, including the simulation of DSP components, is included to allow the simulation of a complete wireless communications channel, and allows trade-offs to be made between components in the RF and IF stages,