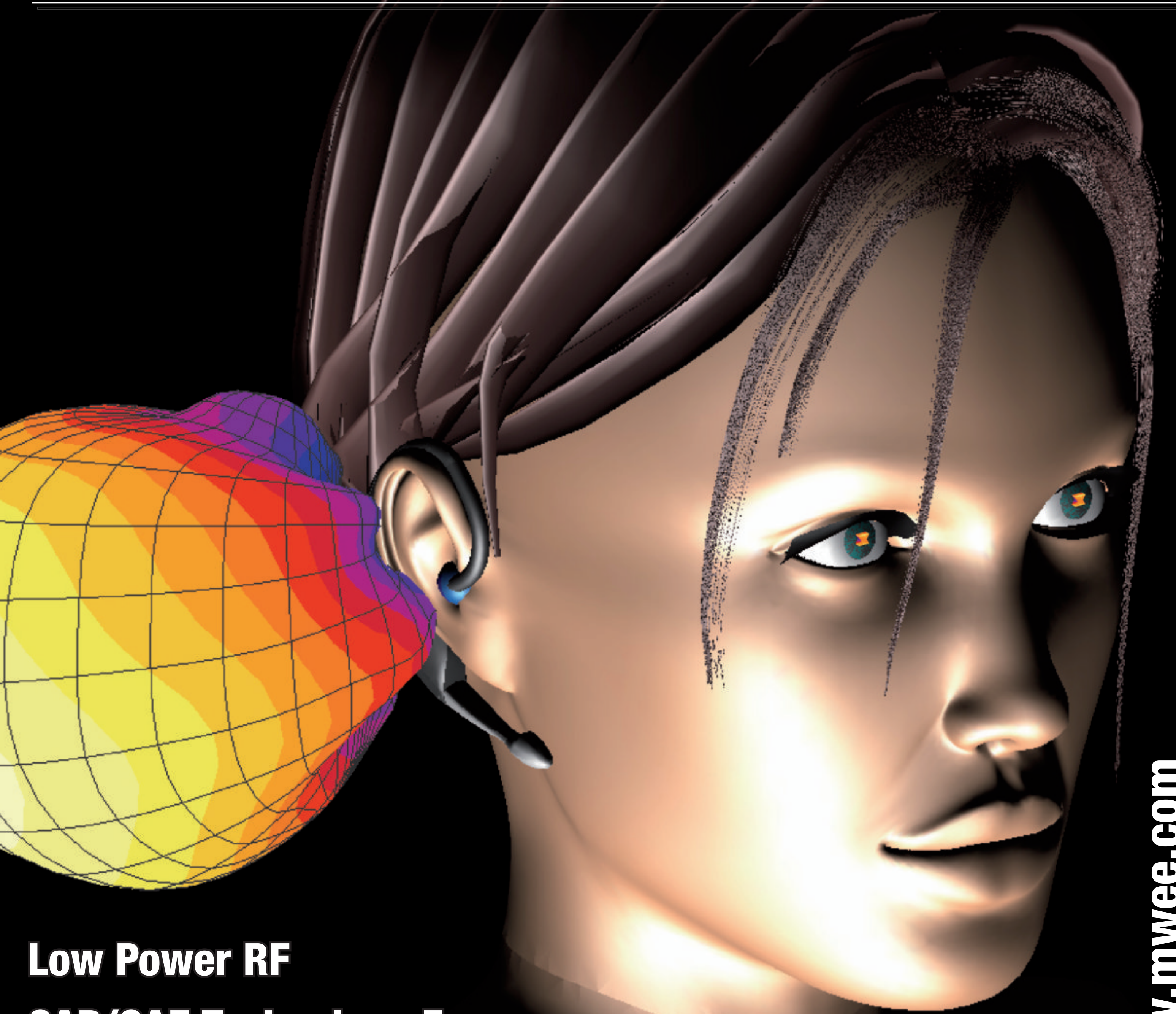
CMP
United Business Media

June 2006

MICROWAVE ENGINEERING EUROPE



Low Power RF

CAD/CAE Technology Focus

Virtual Prototyping Considering Different Usage Patterns

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Virtual prototyping considering different usage patterns

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Virtual prototyping of wireless devices has become feasible with the latest advances in electromagnetic analysis. Some of the major manufacturers have begun to apply the virtual prototype methodology by parameterizing electronic components, PCB layouts, materials, antennas and feeding configurations. We investigated whether virtual evaluations can accurately assess how different usage patterns affect the transceiver performance. All simulations and evaluations were performed with SEMCAD X, an advanced FDTD/FIT platform utilizing hardware acceleration and including many novel features. The excellent correspondence between measurement and simulation results demonstrates the great potential of applying TCAD for the virtual prototyping of wireless devices under different usage patterns and conditions early in the design/development process.

I. Introduction

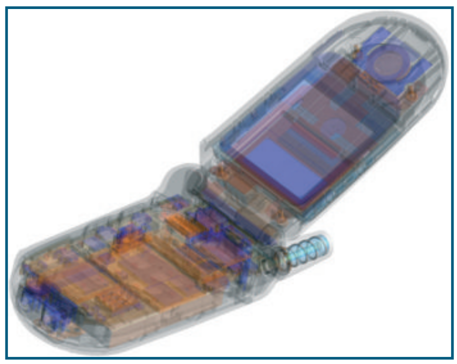
Electromagnetic (EM) tools became an essential component of the design process when they demonstrated reliable and efficient analysis and synthesis capabilities for evaluating real complex commercial transmitters [1]. Today, manufacturers have started to apply these tools for virtual prototyping. Most advanced tools can effectively import and modify devices consisting of different and numerous (thousands) components within a few seconds. Simulations of these devices with resolutions of less than 0.1 mm can now be completed within 10 - 30 minutes. The next step is to provide an extensible platform for analyzing and synthesizing the device performance under different usage patterns and conditions. This paper explores the possibilities and limitations for conducting an extended analysis using a commercial multi-band mobile phone.

II. Methods

a) Mobile phone device

A quad-band (GSM850/900, DCS, PCS) V180 clamshell phone manufactured by Motorola Inc. was used for this study. Highly detailed .IGES CAD files describing the geometry of the phone were directly imported into SEMCAD X (Figure 1).

Figure 1: Full SEMCAD X CAD model of the V180 type phone.



b) Numerical method

The TCAD platform SEMCAD X Eiger [2], combining the advantages of FDTD and FIT, was used to perform the simulations. Its solid modeling environment is based on the ACIS® R16 modeling toolkit and allows the generation of complex 3-D objects as well as the import and smooth handling of whole CAD datasets (>> 10'000 parts) in various formats. The postprocessing engine enables an extraction of time and frequency domain data from the near- and far-fields. In addition, the combined platforms SEMCAD X and DASY4 allow a direct comparison of numerical and experimental data within the same environment. 3-D full wave EM FDTD, ADI-FDTD, conformal FDTD kernels as well as coupled EM-Thermal solvers are available. In addition, support for novel FDTD hardware acceleration enables speeds (about 400 MCells/s) more than ten times faster than regular P4 desktop PCs.

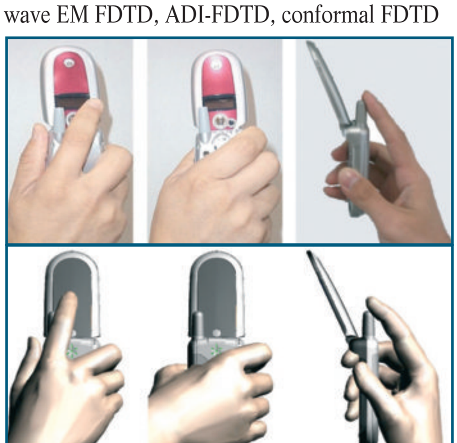


Figure 2: Real hand positions describing the detuning (upper row) and their CAD representations (lower row) for the simulations: H1 (left), H2 (middle), H3 (right).

c) Measurement technique

The measurements were conducted with the near-field scanning system DASY4, which is the fourth generation of the system described in [3]. The scanner was equipped with the latest probes providing the required isotropy, sensitivity and spatial resolution. Far-field measurements were carried out at Motorola Singapore.

III. Numerical modeling

a) Representation of the device structure

The CAD data describing the phone contained more than 1'000 subparts. The antenna was a multi-band stretched helix type. While the model was imported into SEMCAD X, the most significant parts were identified and used for harmonic and broadband simulations to determine relevant gridding parameters and to verify excitation modes and materials. The complexity of the model was then increased by adding the remaining parts according to their RF significance.

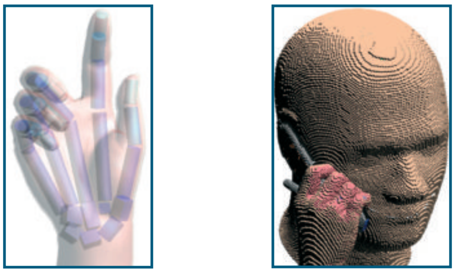
b) Numerical phantom modeling

The SAM head phantom was used as the head load in the simulations. The three hand positions describing the detuning are shown in Figure 2. Homogeneous hand models were generated using Poser® and exported as .3DS CAD files. Further modifications based on anatomical data [4] were made in SEMCAD X, such that the final hand models consisted of skin, muscle and significant finger and wrist bone tissues (Figure 3).

c) Simulation parameters

All metallic parts were modeled as PEC, and the remaining phone parts were represented using 5 different dielectric materials. A minimum grid step of 120 µm was used to resolve the model in significant areas (helix, feed, multilayered PCB). The maximum grid step was limited to about 1 mm in the remaining areas (total 7.8 million cells, MCells). The hand and head phantom models (total 15 and 19

Figure 3: Non-homogeneous CAD hand model (left) and discretized representation of phone, head and hand (right).



MCells) were resolved using a maximum grid of 2.2 mm. The discretized phone, SAM head and H2 setup are shown in Figure 3.

IV. Results

a) Freespace near-field comparison

Freespace near-field measurements were performed using DASY4 to validate the simulation results.

E- and H-Field scans were made on either side of the phone in planes 5 mm below the phone and 5mm above the keypad. Figure 4

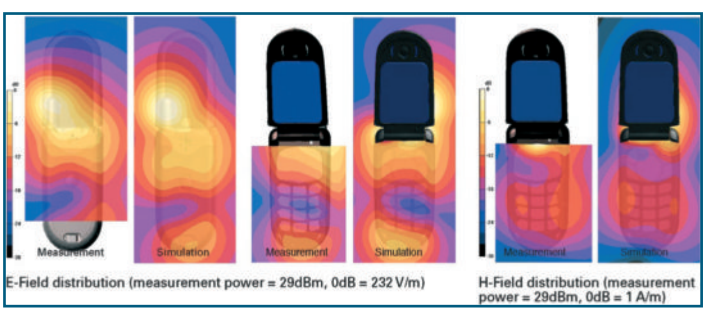


Figure 4: Freespace E- and H-field comparison between simulation and measurement.

shows the comparison between measured and simulated data for E- and H-Field distributions. Good to excellent agreement was obtained for the near-field comparisons.

b) Far-field comparison

The manufacturer performed far-field measurements such that the radiation performance [5] in terms of efficiency, TRP and radiation pattern could be compared between measurement and simulation for freespace and against the head testing. Table 1 shows a comparison of the measured and simulated radiation efficiency and TRP. Figure 5 shows a 3D comparison of the

Load	η_{total} (%)		TRP (dBm)	
	meas	sim	meas	sim
phone	71.3	62.6	27.83	26.99
phone+SAM	33.3	34.9	24.52	24.46

Table 1: Comparison of measured and simulated performance at 1880 MHz.

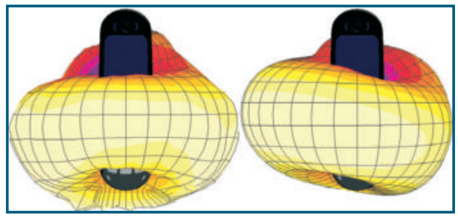


Figure 5: Simulated (right) and measured (left) radiation pattern of the V180 phone: 3D freespace comparison.

measured and simulated radiation pattern.

c) Radiation performance parameters

Simulations for head-only and head+hand setups were also run to investigate efficiency and detuning issues for the antennas. A simple matching circuit was designed to match the freespace antenna impedance to 50 Ohm at 1880 MHz to illustrate the detuning effect of the head and hands on the antenna impedance. Figure 6 shows the S11(f) for the phone with different loads. Although the antenna was fairly resistant to detuning for the head-only setup, severe detuning for all 3 head+hand setups was observed. H1 and H3 hands were characterized by more severe detuning due to the close proximity of the index finger to the antenna.

V. Computational requirements

SEMCAD X currently offers the most advanced computational solutions by employing high performance Yee-FDTD, C-FDTD, ADI-FDTD and hardware accelerated FDTD solvers. To compare the performance of all different configurations, the Freespace, SAM and SAM+H1 structures were run as benchmark simulations. The software based solvers calculated the addressed configurations on a typical P4 3.4 GHz desktop PC in about 2 hours, whereas, the hardware accelerated solutions aXware and ClusterInABox [6] performed simulations more than 10 times faster than typical desktop PCs. Simulations of detailed CAD derived mobile phone structures applying grid resolutions as low as 120 µm and with a total grid size of about 8 million cells can be performed in approximately 10 minutes. SEMCAD X is 10 to 50 times faster than any other currently available tool.

VI. Conclusions

This study demonstrates that virtual prototyping for RF performance is not limited to only the components, PCB layout, materials, antennas and feeding configurations of a device. Evaluations can be extended to assess the effect of different usage patterns on the transceiver performance. The evaluation was conducted with SEMCAD X based on an advanced FDTD/FIT platform utilizing hardware accelerations and including many novel features. The excellent correspondence between measurement and simulation results demonstrates the great potential for further developing an extensible and reliable TCAD platform for the virtual prototyping of wireless devices under different usage patterns early in the design/development process.

VII. Acknowledgments

This study was generously supported by the Swiss Commission for Technology and Innovation (CTI) and assisted by the Foundation for Research on Information Technologies in Society (IT'IS), Switzerland.

VIII. References

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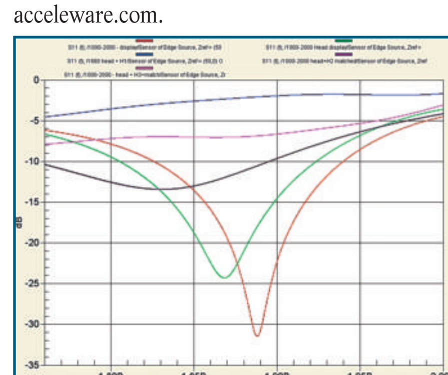


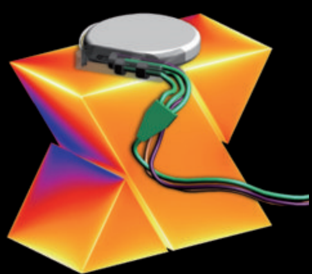
Figure 6: S11 for free-space (red), phone-head (green), phone-head-H1 (blue), p-h-H2 (magenta), p-h-H3 (pink): a matched 50 Ohm impedance is used as reference impedance.

Mission Statement

Schmid & Partner Engineering AG (SPEAG) is the leading developer and manufacturer of the most reliable and efficient experimental and numerical tools for the electromagnetic near- and far-fields (free space and various media). Our proven technology, application expertise, and worldwide support serve a wide array of markets around the world, including the telecommunications, medical device and automotive industries.

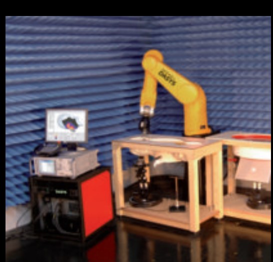
SPEAG has a strategic research alliance with the Foundation for Research on Information Technologies in Society (IT'IS) and the Laboratories of the Swiss Federal Institute of Technology (ETH) in Zurich, both leading research institutions and competence centers. Our joint research efforts enable this consortium to maintain its pacemaker role in its core business and activities.

It is SPEAG's mission to continuously develop, manufacture and sell the world's premier and most reliable systems to evaluate, design and optimize electronic equipment for maximum RF efficiency and safety/compliance and minimal EMC/EMI problems.



SEMCAD X – Full-Wave EM Simulation Platform

SEMCAD first revolutionized EM simulation techniques by enabling the simulation of CAD based complex transmitters (over 1000 parts). SEMCAD X is now the first EM tool to offer virtual prototyping (assess the effects of component, layout, material changes on communication performance, signal integrity and EMC/EMI). The cutting-edge software package is user-friendly, efficient, accurate, versatile and 10 – 50 times more powerful than all currently available tools.



DASY5 – Dosimetric Assessment System (5th Generation)

DASY2 was the first dosimetric near-field scanner. DASY4 is the fastest and most accurate scanner for compliance testing of transmitters, fully compatible with all standards, and used worldwide. DASY5 will be the ultimate in efficiency and versatility. Optimized performance for various applications including, fast compliance testing of transmitters, safety evaluations of active implants with RF links or implants in the MR environment and general near-field evaluations from ELF to 100 GHz.

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iSAR is a breakthrough in dosimetric near-field analysis. The only device to fully and reliably (<0.5dB) characterize the RF performance of transmitters within less than 3s under fully loaded testing conditions. Optimized for informed go/no-go decisions on the manufacturing line. Effective R&D tool to analyze and optimize any kind of handheld, body-mounted or implanted RF device.

EASY4 – Stand-Alone Monitoring System

EASY4 can simultaneously monitor up to 4 probes (compatible with all of our electric field, magnetic field and temperature probes). Flexible and remote control is possible through any computer via an Ethernet link (e.g., LabView, Macros, etc.). EASY4 should be applied whenever high precision measurements (anechoic chambers, open test sites, EMC laboratories, etc), in-house exposure evaluations and more are required.

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