About Models, Designers and Simulators

A short view back

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About Models, Designers and Simulators

- In the 60th integrated circuits have been build by a few elements only, see Siemens TA111
- Circuit design tools were simply: paper, pencil, slide rule
- Used equations were simple, applied from discrete circuit techniques
- Missing calculation accuracy was compensated by designers experience

TA111, the first commercial Siemens IC included 3 npn and 5 resistors only
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- Serious problem appeared soon: error correction became extremely expensive, compared to discrete technique
- Changing a resistance value needed at least on mask
- Way out: breadboard technique
- Special transistor arrays have been made and used for circuit optimization, before realizing the circuit in silicon

Circuit board (left) and circuit (right) of the oscillator in the Siemens dial tone IC S359
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- Breadboard technique was used extensively at least until the end of the 80th

Circuit board of the reference circuit SV84 (left) and the car stereo decoder TDA4340 (right)

- However, the first simulator programs like SPICE were available in the 70th. Additional, proprietary programs were used too. At Siemens, e.g. the program NETANY for ECL circuit simulation was developed around 1975
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- Why the breadboard survived so long?
- In the industry we had several reasons:
  1. Simulation procedure was circumstancely
  2. Computer performance was low, simulator speed too
  3. Circuit simulation result was in doubt, because of inaccurate models
  4. Insufficient results did not made management willing to invest for measurement and model parameter extraction
- But with increasing operation frequency, it became impossible to predict the dynamic circuit behavior because of wire parasitics
- Additional, the circuits became more complex, increasing the need for new circuit design methods

First modeling measurement setup at Siemens WIS TI 522 for discrete devices, build by G. Donig in 1981/82, for DC and AC measurements vs. temperature
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Ian Getreu pointed out the CAD advantages in 1976 (Modeling the Bipolar Transistor, p.1):

“Although the computer is often thought of only in terms of a cheap and fast breadboard (or dry lab), computer aided design enables the circuit designer to do things which are not possible with other techniques. Using the computer, he can

1. observe waveforms without loading the circuit
2. predict the performance of an IC at high frequencies, without the parasitics a breadboard introduces
3. use ideal devices selectively, to isolate the effect of various device parameters on the circuit performance
4. open a feedback loop without disturbing the DC levels
5. do noise, sensitivity, worstcase and statistical analysis”
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- One of the first successful simulation examples at Siemens was the design of the bandgap reference for the tone dial IS S369.
- Netlist input was realized on a Siemens terminal 9750, which was connected to a Siemens BS2000 mainframe computer.
- Result: sufficient agreement between measurement and simulation and ICC reduction from 2 mA to 0.1 mA.

S369 bandgap reference circuit (left) and the IC on the application board (right)
Nowadays, the circuit simulation is faced with new challenges

1. Increasing operating frequencies demand better RF device models
2. Increasing circuit complexity demands the exact collaboration of the different circuit blocks, a Top Level Design is mandatory.
3. Increasing operating frequency, demands taking into account effects of bond wires circuit boards and packages, leading to the so called Chip and Package Co-Design
4. For all these challenges, we need new design methods, design tools and new models and new extraction methods
Summarizing, we may say: During the past twenty years, the device modeling became more and more important for circuit design. No designer will be able to develop an IC successful without accurate models and design kits. We, as model engineers, have to recreate this insight continuously, because one principle is everlasting:

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