Computer Aided Engineering for Integrated Circuits
- an overview

Objective: Introduction of subject matter

Outline: 1. Course description
2. Trends in microelectronics technology
3. Market trends
4. Definition of computer aided engineering
5. Hierarchy of tools
6. Simulation tools
7. Role of computer aided engineering
8. Summary
1. Course description

Tentative list of topics

1. Overview of CAE, reading assignments,
2. Formulation of circuit equations, basic elements, MNA,
3. Modeling of transistors,
4. D-C analysis, algorithms, SPICE implementation, convergence problems and solution techniques,
5. Transient analysis, solution methods, error control, SPICE implementation, guidelines/suggestions for selection of control parameters (options),
6. Circuits and packaging interconnections, signal integrity, driver/receiver (CMOS, BJT) line interaction, adjusting terminations to characteristic imp.
7. Spectral technique, AC analysis, RF circuit applications,
8. Automation of multiple runs, collection of statistics, cross-plots, parameter sweep, optimization and generation of design curves,
10. Case studies: generation of stability curves for RF power amplifiers, design curves for field programmable analog arrays - settling time, charge feed-through error.
Grading

A. Midterm written examinations (3) - 30%
B. Computer simulation assignments - 45%
C. Final examination - 25%

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2. Trends in microelectronics technology

2.1. Complexity of circuits increases
2.2. Product life time decreases
2.3. Time to market decreases
2.4. Role of computer support in design increases
3. Market trends

3.1. Military and aerospace electronics - 1960 - 1980’s

Driver:
• high reliability

3.2 Consumer electronics and communication - 1980 - 2000’s

Drivers:
• cost
• quality
• time to market
• size
• performance
Concurrent Product - Process Engineering

Form multidisciplinary team and apply principles of project management to address:

- product definition
- design
- material selection
- process development
- process control
- test.
Time from product Conceptualization to Product Availability

Traditional product development

Concurrent (winning) product development
4. Definition of computer aided engineering

Definition by description

Knowledge needed to use the computer support in integrated circuit and system design

Knowledge needed to modify/develop tools in support of design

Knowledge needed to interface various tools

Background skills required in practice:

Microelectronics, packaging

Numerical methods

Programming, system programming
5. Hierarchy of tools

Hierarchy of circuit/system representation

\[
\begin{align*}
\text{functional} & \quad \{ \text{behavioral} \} \\
\text{topological} & \quad \{ \text{logical} \} \\
\text{physical} & \quad \{ \text{symbolic} \}
\end{align*}
\]

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\begin{align*}
\text{ELECTRICAL} & \quad \text{layout} \\
\text{PHYSICAL} & \quad \text{layout verification}
\end{align*}

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6. Simulation tools

Simulation application and hierarchy

<table>
<thead>
<tr>
<th>functional</th>
<th>Conceptual verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioral or Algorithmic Level</td>
<td></td>
</tr>
<tr>
<td>Register Level</td>
<td>timing verification</td>
</tr>
<tr>
<td>Logic Gate Level</td>
<td>testability analysis</td>
</tr>
<tr>
<td>Electrical Level</td>
<td>timing verification</td>
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<tr>
<td></td>
<td>logic verification</td>
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<tr>
<td></td>
<td>fault/testability</td>
</tr>
<tr>
<td>physical</td>
<td>electrical rules check</td>
</tr>
<tr>
<td>Physical Level</td>
<td>critical path analysis</td>
</tr>
<tr>
<td></td>
<td>physical rules check</td>
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</tbody>
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Structure of A Simulator

Network description
- topology
- models
- analysis type
- output control

Input Translator (compiler)

Analyzer (Simulator Engine)

Output Processor

Transfer via files

Model data from DMBS or Layout Extractor

Files
- Plots
- Graphs
- Printouts

Files
7. Role of computer aided engineering

System design considerations

1. System specifications (product definition)
2. System architecture - evaluation via simulation
3. Partitioning (subsystem specification), packaging
4. Subsystem architecture - simulation
5. Schematic capture - simulation
6. Parallel activities

- subsystem layout, routing, simulation
- subsystem package/module design - simulation
- board design - simulation
- connector/frame design - simulation

\(\text{concurrent engineering}\)
Design Optimization

Electronic products have several performance metrics, such as:

- Cost
- Electrical performance (speed of operation)
- Reliability (related to failure rate)

These performance metrics are often in conflict, for example

- improved electrical raises the cost
- or
- cost reduction results in lower reliability.

Design should be based on Multi-Criteria Optimization (MCO)

MCO techniques are well developed and widely utilized in economics and system engineering.
8. Summary

8.1. Contemporary market requires complex and inexpensive circuits
8.2. Competition imposes “short-time-to-market” operations
8.3. Development, design, and manufacturing are main components in pricing
8.4. Design must yield product satisfying specs in a single manufacturing cycle
   - debugging hardware is prohibitively expensive and unacceptable
8.5. CAE is essential (practically the only way) to achieve good designs in short time
8.6. Circuit simulation is heavily used by engineers at all levels of design and is
   one of the most challenging in the array of CAE tools

This course will provide a knowledge, which is critical in skillful and effective
use of circuit simulators in integrated circuit and system design.