The Introduction to EDT (TestKompress)

High Test Quality & Low Test Cost

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Park sung-chul
Contents

- Today’s DFT Challenge
- Comparison Factors of TestKompress
- Comparing Techniques
  - ATPG
  - EDT
  - LBIST
- How TestKompress works
- Recommendations & Summary
Design Trends, Test Challenges

- **Smaller DSM devices**
  - New types of defects
  - Requires at-speed testing

- **Growing gate counts**
  - Exploding test set sizes
  - Requires test set compression

- **Complex SoC architectures**
  - Diverse test methods
  - Requires integrated test products
DFT Reduces Test Cost

- DFT reduces test set sizes
  - Reduces ATE memory requirements
  - Reduces test time
  - Minimizes or eliminates tester reloads
  - Improves tester throughput
- DFT offers high quality and reduced cost
Quality -- The Reason You Test!

Factors to Consider Compression Methods

- Support for all fault models
  - Ease of obtaining high stuck-at coverage
  - Support of IDDQ testing
  - Support of at-speed testing
  - Extendable to future fault models
- Support for all pattern types
  - Sequential patterns
- Testing of all logic
- Diagnostics
Compression

Factors to Consider Compression Methods

- *Compression results* are what you’re after
- *Compression factors*
  - Test time
  - Test data volume
  - Compatibility with existing ATE
  - Scalability of approach
Comparison Factors Summary

High Quality

Ease of Adoption

An *Ideal Solution* would look like this!

Test Data Compression

Test Time Compression

Minimal Design Intrusion
ATPG Comparison Factors

- High Quality
- Test Data Compression
- Test Time Compression
- Ease of Adoption
- Minimal Design Intrusion
LBIST Comparison Factors

- High Quality
- Ease of Adoption
- Test Data Compression
- Test Time Compression
- Minimal Design Intrusion
EDT Comparison Factors

- High Quality
- Test Data Compression
- Test Time Compression
- Ease of Adoption
- Minimal Design Intrusion
EDT Compared to Standard ATPG

- Shorter scan chains
- Up to 100x:
  - Less cycles
  - Less test data
  - Shorter test time
- Up to 100x less tester memory
  - Less expensive tester
  - Higher throughput
  - Improved quality with lower cost
EDT Architecture

Compressed stimuli

ATE

Compacted responses
EDT Test Pattern Generation Process

1. Target faults
2. Generate test cube: 1-5%
3. Compressed stimuli: \( \approx 1-5\% \)
4. Random fill: \( \approx 99-95\% \)
5. Compact response
EDT Stimuli Compression

\[ e + f + j + l = 0 \]
\[ c + d + e + j + k = 0 \]
\[ d + e + f + g + k = 1 \]
\[ c + g + l = 1 \]
\[ b + c + e + f + g + i + m + p = 0 \]
\[ a + b + c + g + h + i + n + o = 0 \]
\[ a + b + d + h + i + j + k + o = 1 \]
\[ a + b + e + i + n = 1 \]
\[ a + c + f + m + n + r + t = 1 \]
\[ a + b + d + f + h + i + k + l + m + o + s + v = 1 \]
Compression Factors: Encoding Capacity

How many care bits are in a test cube?

- 500K scan cells
- 2% test cube fill rate
- 10M gates
- 10,000 care bits
EDT Encoding Capacity

How Scalable is it?

- EDT decompressor is highly scalable with minimal overhead.
Per pattern programmable scan selection
Unique Compaction Features

Handling of X states

- Programmable scan selection eliminates impact of X states
- No X bounding logic required
Unique Compaction Features

Zero Aliasing

- Programmable scan selection eliminates aliasing
- Fault coverage computed on compactor outputs
EDT Example

#Gates: 2.1M
#SCs: 181K
Decompressor: 64 bits
Max Specified: 1242
#X Sources: 556
Area: 1.31%
Coverage: 98.79%

Test Cycles = \frac{1600 \times 11292}{2238 \times (76 + 4)} = 100X
TestKompress™
Defines the Standard for Low Cost Scan Test

- Improves manufacturing test floor throughput
  - Shortens scan test time
- Increases current ATE value
  - Eliminates memory upgrades
  - Extends ATE life
- Reduces capital expenditures
  - Fewer new ATE
  - Less expensive ATE
- Easily adopted and completely synergistic with FastScan
TestKompress: Already a Winning Product

26th Annual Product of the Year Awards
TestKompress
Similar flow to ATPG

- Fits easily into all standard design flows
  - Vast majority of FastScan users and all current TestKompress users use Synopsys’ synthesis
  - Very similar flow; simple migration from ATPG to EDT
- Reuses FastScan’s proven
  - Libraries
  - Dofiles (+ TestKompress commands)
  - Output vector formats
  - Diagnostic capabilities
TestKompress in Production at Infineon

- Five designs taped out in 2002
  - Automotive, wireless communication, data communication
  - 1.3M - 2.8M gates
- Extensively validated versus ATPG (bypass)
  - Effective compression
  - Test effectiveness/quality
- Currently testing “extreme” compression ratios (>50X)
- Usage is expanding in 2003
## Comparison Factors of EDT

<table>
<thead>
<tr>
<th>Requirement</th>
<th>EDT Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support all fault models</td>
<td>High</td>
</tr>
<tr>
<td>Extends to other faults</td>
<td>High</td>
</tr>
<tr>
<td>Support at-speed test</td>
<td>High</td>
</tr>
<tr>
<td>Support all pattern types</td>
<td>High</td>
</tr>
<tr>
<td>Test all logic</td>
<td>High</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>Similar to ATPG</td>
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### Quality

- **Flow**: Relatively easy
- **Ease of adoption**: Easy for ATPG users
- **Expertise level**: Low
- **Functional intrusion**: Low
- **Area overhead**: 4-5% (for scan) 0.2-3% for EDT
- **Performance Impact**: Low
- **Test time**: 20X-100X+
- **Test data volume**: 20X-100X+
- **Pattern efficiency**: High
- **Compatible with ATE**: Yes
- **Scalability of approach**: Highly Scalable
EDT Summary

- EDT is a natural extension to ATPG
  - Easy to learn and implement (similar flow to ATPG)
  - Obtains high quality tests with dramatic compression

- EDT supports
  - Reduction of test data volume and time
  - All fault models
  - All pattern types
  - X-handling without functional logic modification

- EDT is highly scalable

- TestKompress is a proven commercial EDT solution
All Methods Compared

- EDT
- High Quality
- ATPG
- Ease of Adoption
- Test Data Compression
- Minimal Design Intrusion
- Test Time Compression
- LBIST
## Comparison Summary

<table>
<thead>
<tr>
<th></th>
<th>ATPG</th>
<th>EDT</th>
<th>LBIST</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test Quality</strong></td>
<td>High, supports all fault models</td>
<td>Same as ATPG</td>
<td>High test quality hard to achieve without ATPG top-up or test points.</td>
</tr>
<tr>
<td><strong>Compression</strong></td>
<td>Baseline. New techniques continue to improve results.</td>
<td>20X-100X+ of test time and data volume vs. best ATPG results.</td>
<td>Test time not reduced. Test data can be as low as 0 vectors.</td>
</tr>
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# Recommendations

<table>
<thead>
<tr>
<th>When to Use</th>
<th>EDT</th>
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<tr>
<td>Design Style or Size</td>
<td>When ATPG cannot compress test data and run time enough.</td>
</tr>
<tr>
<td>Typical Applications</td>
<td>Any devices not requiring self-test.</td>
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</tbody>
</table>