Graph Theory Approach for Automatic Test Board Parameter Extraction in Multisite IC Testing

Abraham Steenhoek*, Praise Farayola*, Isaac Bruce*, Degang Chen*, Shravan Chaganti†, Abalhassan Sheikh†, Srivaths Ravi†

* Iowa State University, Ames, IA USA

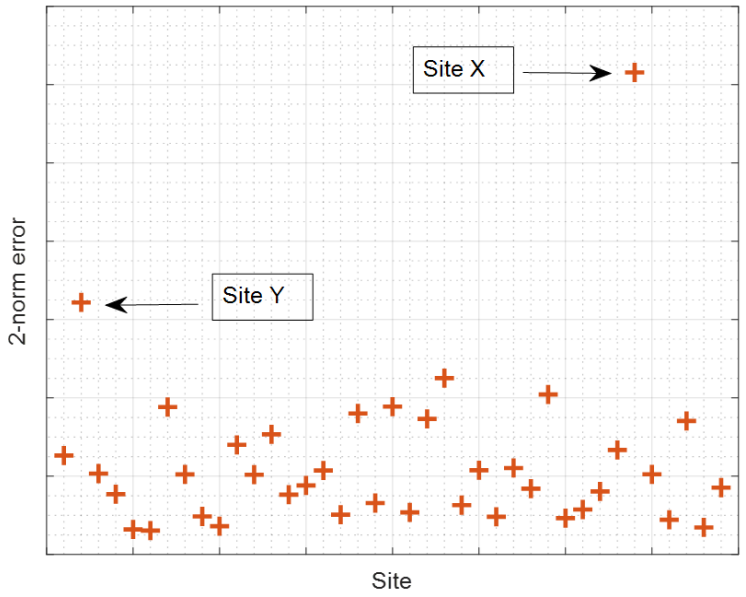
† Texas Instruments Inc.

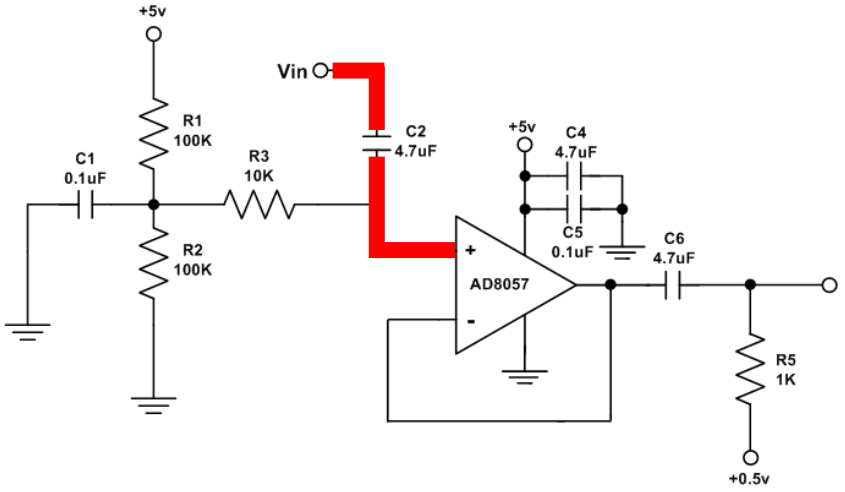
Motivation

- Multisite Testing is proven to save cost and testing time
- Site-to-site (s2s) variation in Multisite testers directly impacts yield loss
- Analysis from test wafers
  - Proven to find some issue sites
  - WBD, CC, QQ algorithms
  - **Cannot detect root causes with only die data**
- Board Parameter (BP) Analysis
  - Adds level of pre-fabrication verification in ATE development
  - Arduous manual process – requires automation
  - **Root causes for s2s variations come from hardware variations**

NEED BP Extraction Method that…

- Can extract board parameters **relevant to s2s variations**
- Is an **automated** end-to-end solution

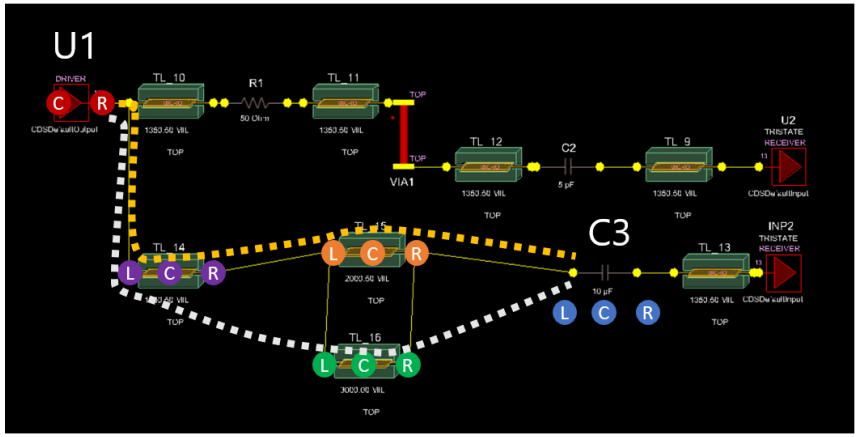




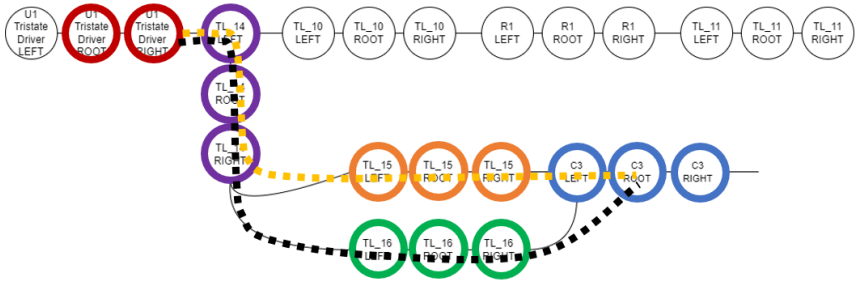
Method

- The “topology” of a testing circuit can be represented as a graph with nodes and edges
  - Topology: physical layout of PCB
  - Nodes: PCB components, traces, vias, etc.
    - Nodes contain metadata (e.g. etch length)
  - Edges: component connections
- **General** – Graph theory is agnostic to Probe Cards and CAD tools
- **Flexible** – Graph traversals can analyze wide array of relevant parameter related to PCB topology
  - Path U1 → C3 is found with a traversal
- **Automated** – Graph API can be run on any set of topology data files
- Multi-path edge case
  - Depth-first search

Topology of sample test circuit

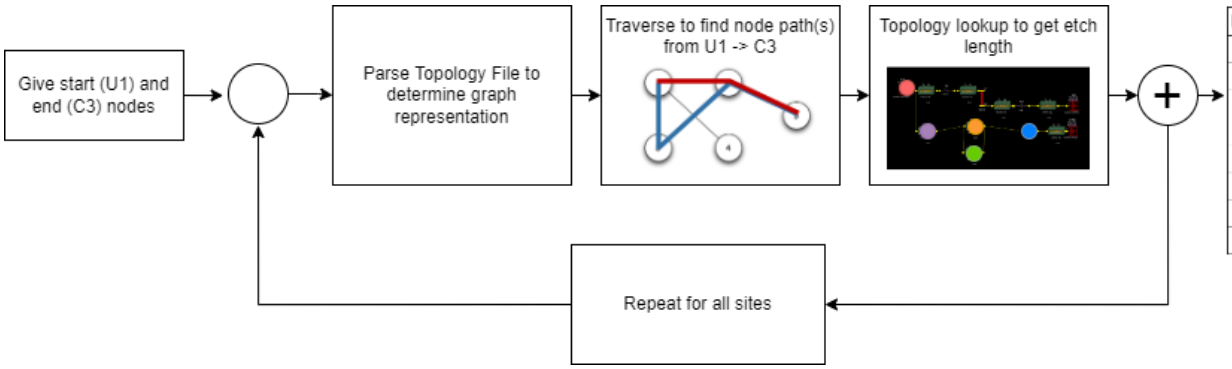


Graph representation of topology



Results

Etch Length Extractor Flow Diagram & Results



Etch Len, path 1 (mm)	Etch Len, path 2 (mm)	Site (#)
4409.941		1
7755.13		2
4608.838	4608.496	3
5736.229		4
4608.305		5
3617.021	3617.124	6
4647.202	4647.305	7
5372.46	5372.118	8

- Etch Length Extractor (ELE) tool applies our approach on real MST designs
- Etch lengths found with ELE match measurements found with manual processes
- **Flexible** – Extracts any parameter related to path between two components
- **Detected root causes** – Board parameters from the ELE motivated hardware revisions on future TI MST designs
- **Automated end-to-end solution** – ELE can be scripted to extract parameters from every site on a MST design automatically

Discussion

Summary

- Graph traversal applications opened access to BP's that previously couldn't be obtained
- Automation made extraction feasible and enhanced datasets for WBD, CC, QQ algorithms

Future Work

- Expand graph method to represent **entire site as a single node graph**
  - Graphs are currently limited to groups of discrete components
- **Standardize** graph representation to work for any CAD tool
- Use BP's to **enrich simulation models**