DELTA-L+ FOR ELECTRICAL CHARACTERIZATION

Intel Corporation
Data Center Platform Application Engineering

July 2016
Reference Number: 334684-001
Revision Number: 0.5

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Purpose

- Material characterization is a critical step in PCB ecosystem enabling
  - Need to have a robust yet accurate method for the industry
  - Available industry methods have limitations in efficiency and accuracy

- Delta-L+ can provide:
  - accurate de-embedding with full S parameter extraction
  - material extraction capability
  - allow for flexibility/capability of HVM Monitoring by smaller coupon

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PCB Characterization Process

Accurate Characterization /Material Selection

Quality Control

Material Selection

Production Board Samples

High Volume Manufacture Production

Material Selection	Production Board Samples	High Volume Manufacture Production
Intel (requirement)	ODM/OEM	PCB Manufacturer
Testing House	PCB Manufacturer	
ODM/OEM	Testing House	
Material Vendor		
PCB Manufacturer		

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What's New in Delta-L+ compared to Delta-L 2.0?

- Three-category approach to address the need of PCB characterization at different stages
- Major enhancements from Delta-L 2.0:
  - Three-length (3L) method to self-check and ensure the accuracy of the de-embedding results
  - One-length (1L) method for HVM monitoring
- Future enhancements (Working In Progress):
  - Dk/Df extraction methodology
  - Surface roughness characterization methodology

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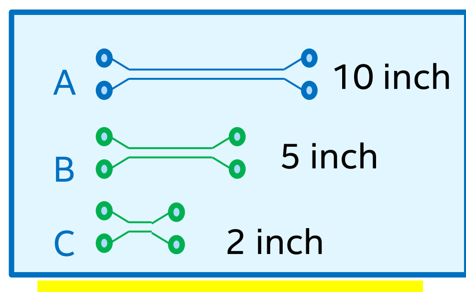
Delta-L+ Metrology



Note: Actual length may vary

Choose coupons with different length combinations at different stages of PCB Characterization

3L

A 10 inch
B 5 inch
C 2 inch

Best accuracy

Most suitable for:
Material Characterization
DK/DF Extraction, Insertion Loss & Surface Roughness characterization

2L

A 10 inch
B 5 inch

Cost effective

Most suitable for:
Board Quality Validation
Insertion loss & Impedance validation

1L

A 10 inch

Small Coupon

Most suitable for:
HVM Monitoring
Insertion loss and impedance variation, by one-length approach

Typically <5 Boards — Material Selection → Typically 5-30 Boards — Board Sampling → Sample size varies — HVM Monitoring → Board Sampling

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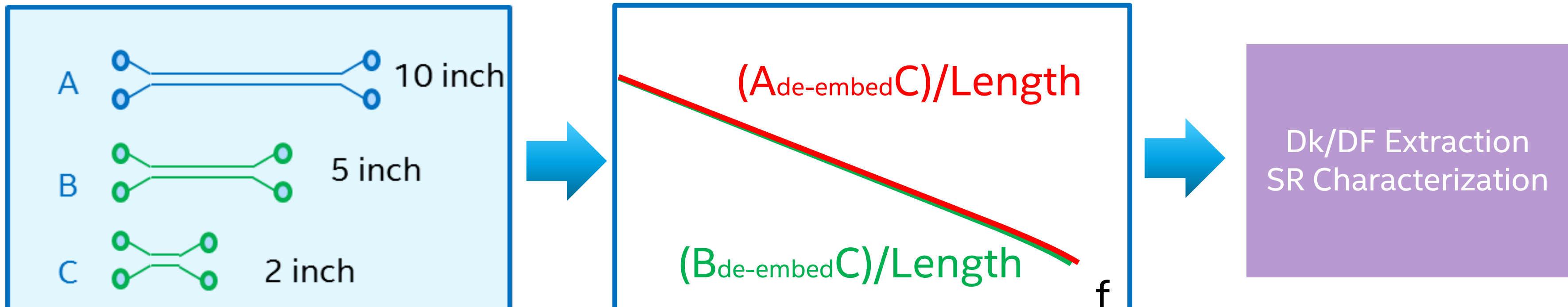
Delta-L+ (3L) Three-Line Method



3L method

1. A de-embedded by C using 2X-thru de-embedding
2. B de-embedded by C using 2X-thru de-embedding
3. dB/in comparison of (A-C) and (B-C)
4. Dk/Df extraction

Note: Other de-embedding method, such as TRL, can be implemented as well

This is an important step to validate the de-embedded results.

Criteria: < 5% (TBD) error @ up to the highest frequency of interest

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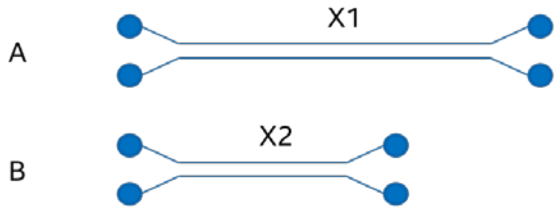
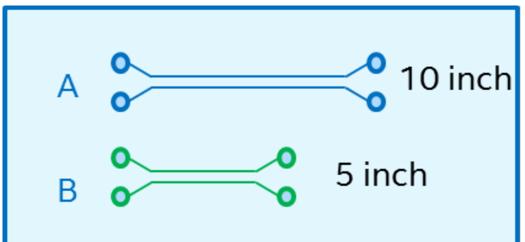
Delta-L+ (2L)

Two-Line Method

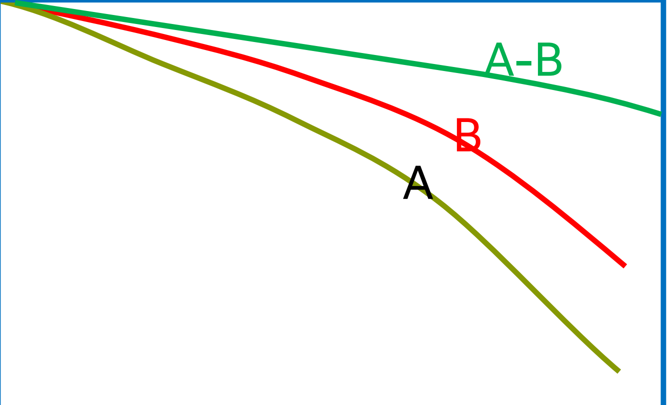
Delta-L Methodology





- Direct through measurement for insertion loss.
  - Insertion of structure A: IL(A) -- X1 inches + vias
  - Insertion of structure B: IL (B) -- X2 inches + vias
  - dB/inch loss = (IL(A) – IL(B)) / (X1-X2)
  - X2 cannot be too short, and X1-X2 better to bigger than 3~4".
  - **Recommendation:** The routing length of X1 is twice of X2
- No full SOLT or TRL calibration needed; compatible to TRL calibration or AFR.
- VNA or TDR/TDT measurement
  - If TDT/TDT measured is performed, it needs to be converted to S parameter first.

Category 2 (two-line)
Direct A – B subtraction using Delta-L 2.0



Reference: ***Delta-L Methodology for Electrical Characterization, Rev. 330223-001***
http://www.intel.com/content/www/us/en/processors/xeon/delta-l-methodology-for-electrical-characterization-guide.html

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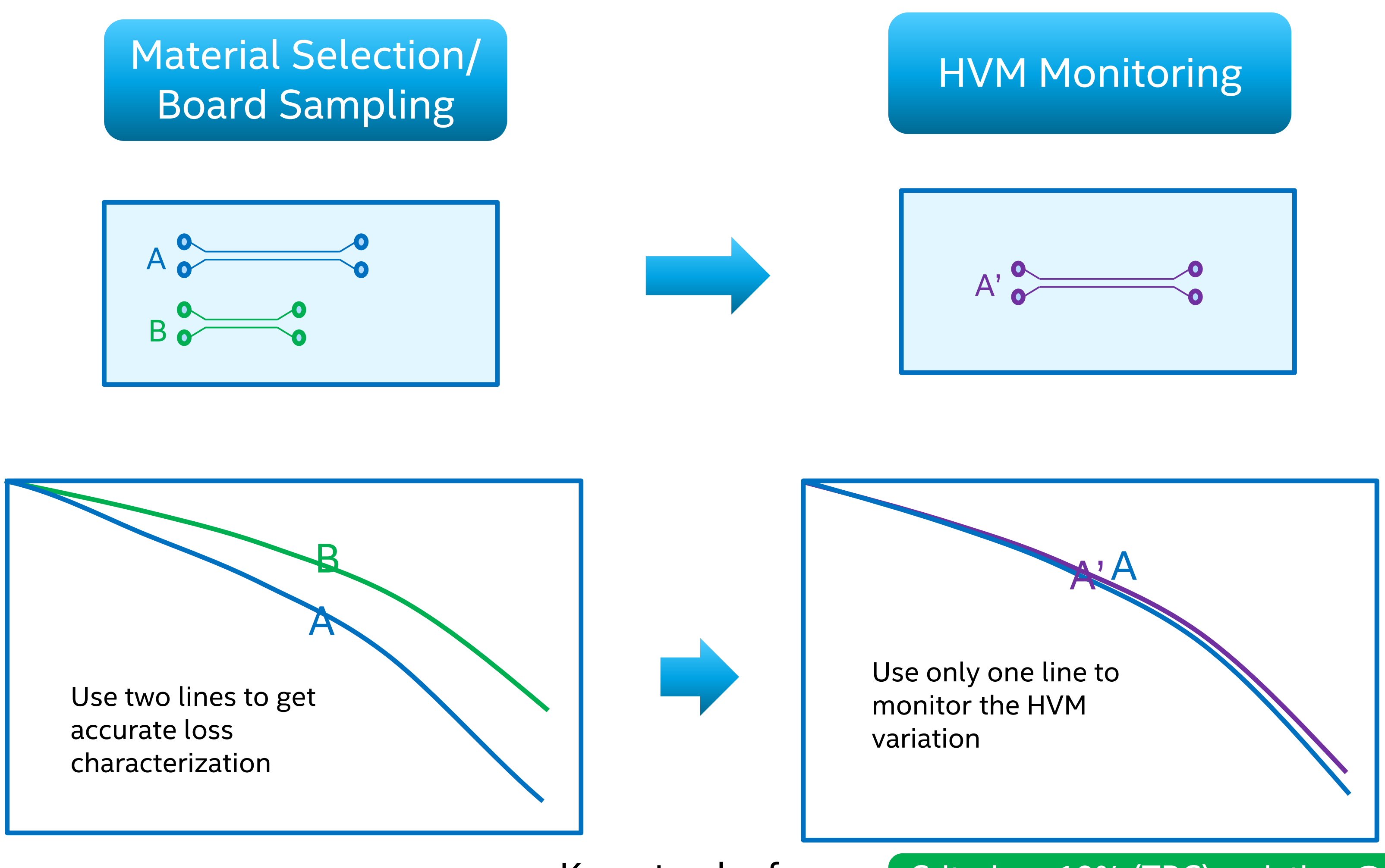
Delta-L+ (1L) One-Line Method



Keep track of performance of "A"

Criteria: < 10% (TBC) variation @ Nyquist frequency for at least x samples

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Delta-L+ Usage Model

Category	Primary Usage	Note
1L A — 10 inch	PCB house, HVM monitoring	Lowest cost solution, TDR/TDT or VNA is ok
2L A — 10 inch B — 5 inch	PCB House (optional) OxM seeking low cost “de-embedding”	This is Delta-L 2.0, TDR/TDR or VNA is ok, VNA is preferred
3L A — 10 inch B — 5 inch C — 2 inch	Material vendor OxMs **Any measurement capability verification**	VNA preferred. Prefer rigorous de-embedding (AFR, SFD, TRL, etc.)

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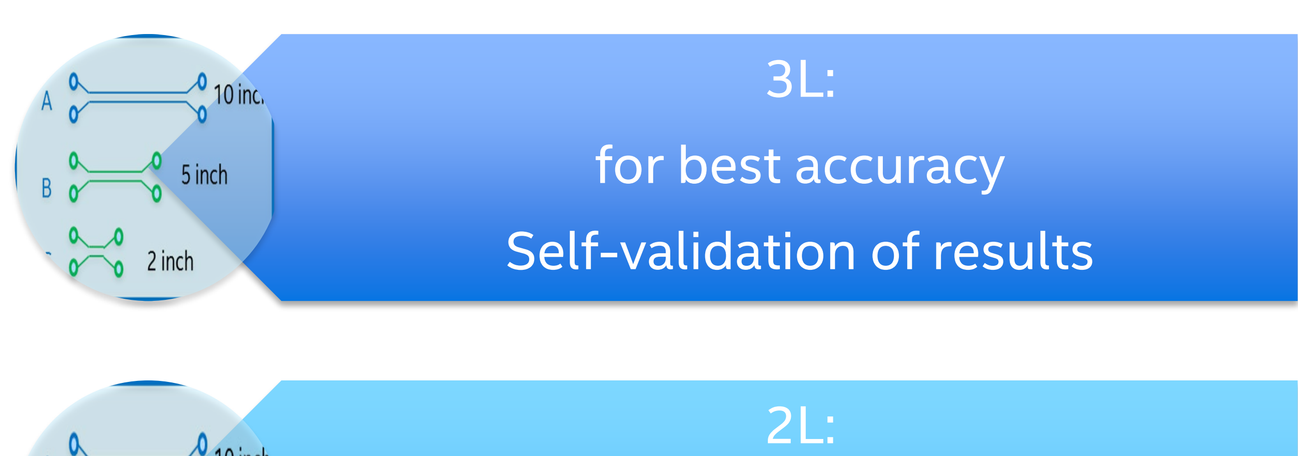
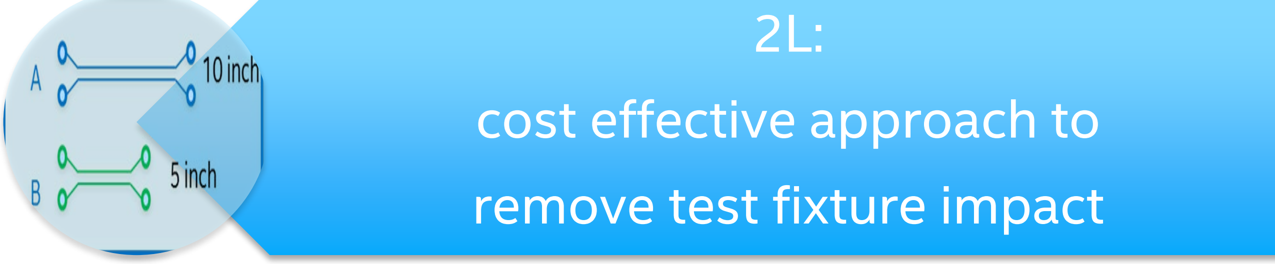
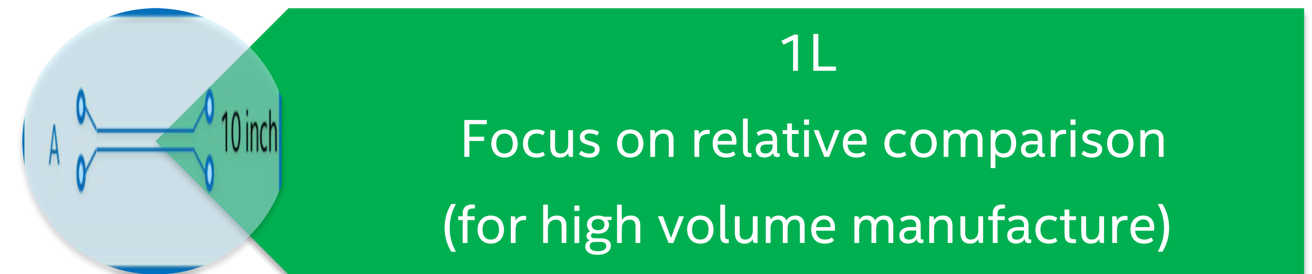
Summary







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