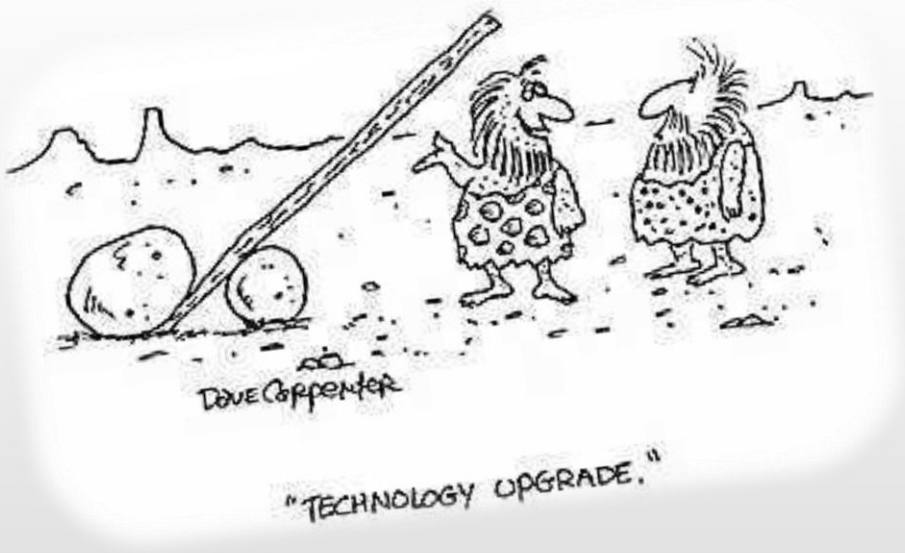



# Update of DkDf Algebraic Model

IEEE March 2012 Plenary - Waikoloa Village, HI

Beth Kochuparambil - Cisco Systems, Inc.

Joel Goergen - Cisco Systems, Inc.

# Background

- Model first shown in Kochuparambil_01_1111
  - Filling a gap – allows us to talk the same “language”
  - Great for initial channel loss discussions!
- Model is made public: http://www.ieee802.org/3/bj/public/tools.html
- No secret sauce
  - All equations used in the model are given in reference document
  - Also in public Tools folder; link above

# Updated to Version 2.03

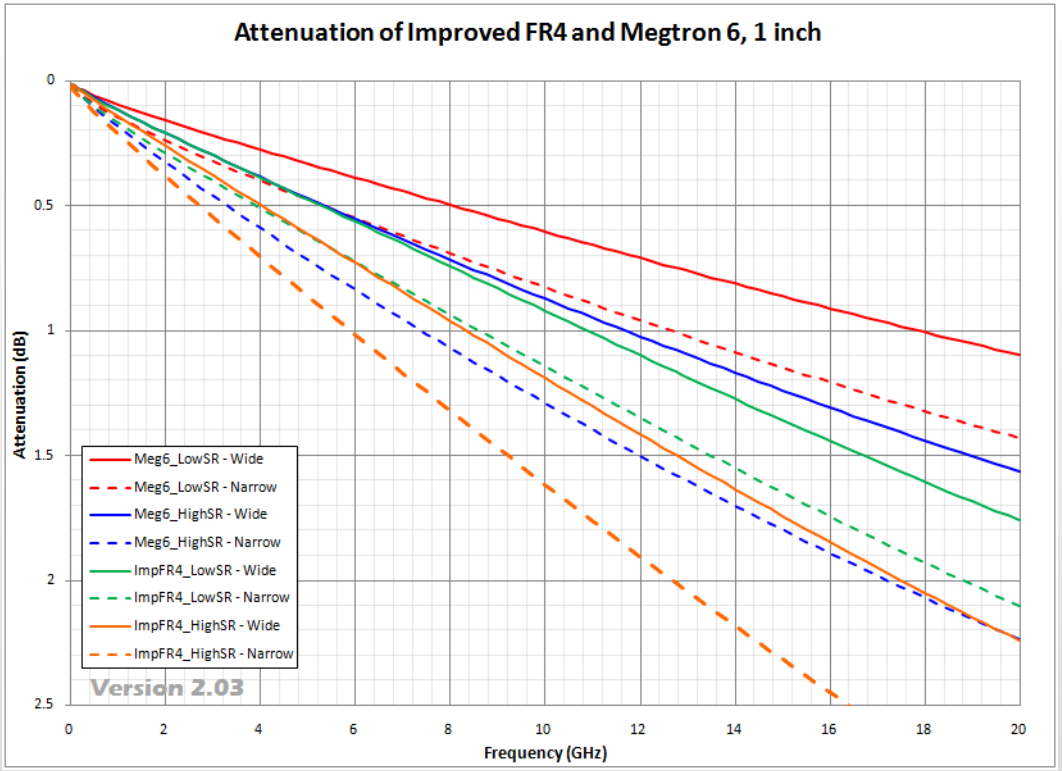
- Thank you for all feedback; more is welcome!
- Version 2.03 is now available online

Changes from Version 2.02

- Rearrangement of “Backplane w/ 2 connectors, 1 material” GUI due to confusion
- Correction of linecard SR equations
  - Backplane equation was incorrect since its addition
  - Linecard eq’n error (v2.02) → changed to match reference

# Updated to Version 2.03

- Note that these changes did NOT change the loss parameters accepted in the January motion



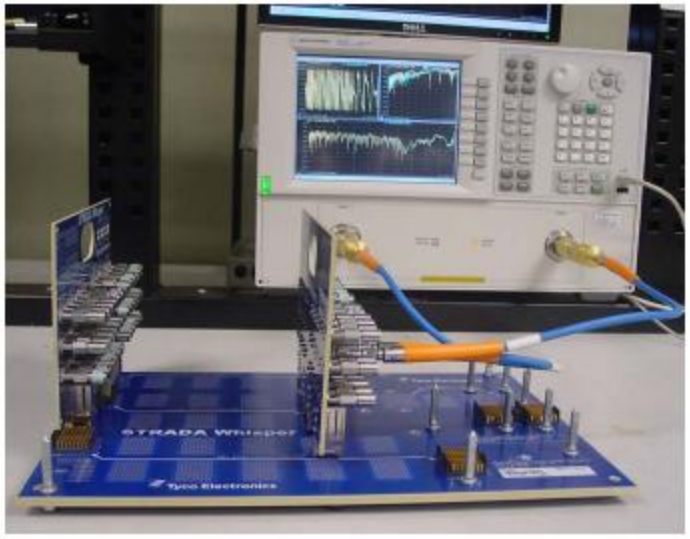

| Attenuation* (dB/in) at: | 1 GHz | 6.5 GHz | 7 GHz | 12.89 GHz | 14 GHz |
|---|---|---|---|---|---|
| Meg6_LowSR – Wide | 0.0951 | 0.4159 | 0.4433 | 0.7562 | 0.8127 |
| Meg6_LowSR – Narrow | 0.1466 | 0.5849 | 0.6205 | 1.0152 | 1.0847 |
| Meg6_HighSR – Wide | 0.1175 | 0.5960 | 0.6367 | 1.0891 | 1.1688 |
| Meg6_HighSR – Narrow | 0.1856 | 0.8971 | 0.9557 | 1.5924 | 1.7020 |
| ImpFR4_LowSR – Wide | 0.1202 | 0.6096 | 0.6541 | 1.1772 | 1.2734 |
| ImpFR4_LowSR – Narrow | 0.1717 | 0.7794 | 0.8323 | 1.4410 | 1.5512 |
| ImpFR4_HighSR – Wide | 0.1427 | 0.7904 | 0.8484 | 1.5158 | 1.6367 |
| ImpFR4_HighSR – Narrow | 0.2106 | 1.0930 | 1.1692 | 2.0283 | 2.1813 |

*Model entries can be found in backup slides

**Validations unchanged from version change can be found in backup slides

# Tool Validation (updated to v2.03)

## TE Connectivity - 802.3bj submitted channel



**DAUGHTER CARD**
- Board Material = Megtron6 VLP
- Trace length = 5"
- Trace geometry = Stripline
- Trace width = 6 mils
- Differential trace spacing = 9 mils
- PCB thickness = 110mils, 14 layers
- Counterbored vias, 1 – 6mil stub
- Test Points = 2.4mm (included in data)

**BACKPLANE**
- Board Material = Megtron6 HVLP
- Trace length = 17"
- Trace geometry = Stripline
- Trace width = 8 mils
- Differential trace spacing = 13 mils
- PCB thickness = 200 mils, 20 layers
- Counterbored vias, 1 – 6mil stub

Snapshot from shanbhag_02_0511

- w and L given.
- t was assumed as ½ oz Cu
- b assumed to be calculated by
  $b = [(t_{Total} – 0.6*N_{lyrs})/(N_{lyrs}-1)] *2 + 0.6$

| Backplane/Trace Material | | |
|---|---|---|
| Length (inch) | | 17 |
| Trace Width (mil) | | 8 |
| Cu Thickness (mil) | | 0.6 |
| Diel. Thickness (mil) | | 20.389 |
| Freq | Dk | Df |
| 1.00E+08 | 3.67 | 0.0039 |
| 1.00E+09 | 3.65 | 0.004 |
| 2.00E+09 | 3.59 | 0.0043 |
| 5.00E+09 | 3.576 | 0.0049 |
| 1.00E+10 | 3.3494 | 0.0055 |
| 2.00E+10 | 3 | 0.0065 |
| Low Roughness | 20 | 6.0E-07 |

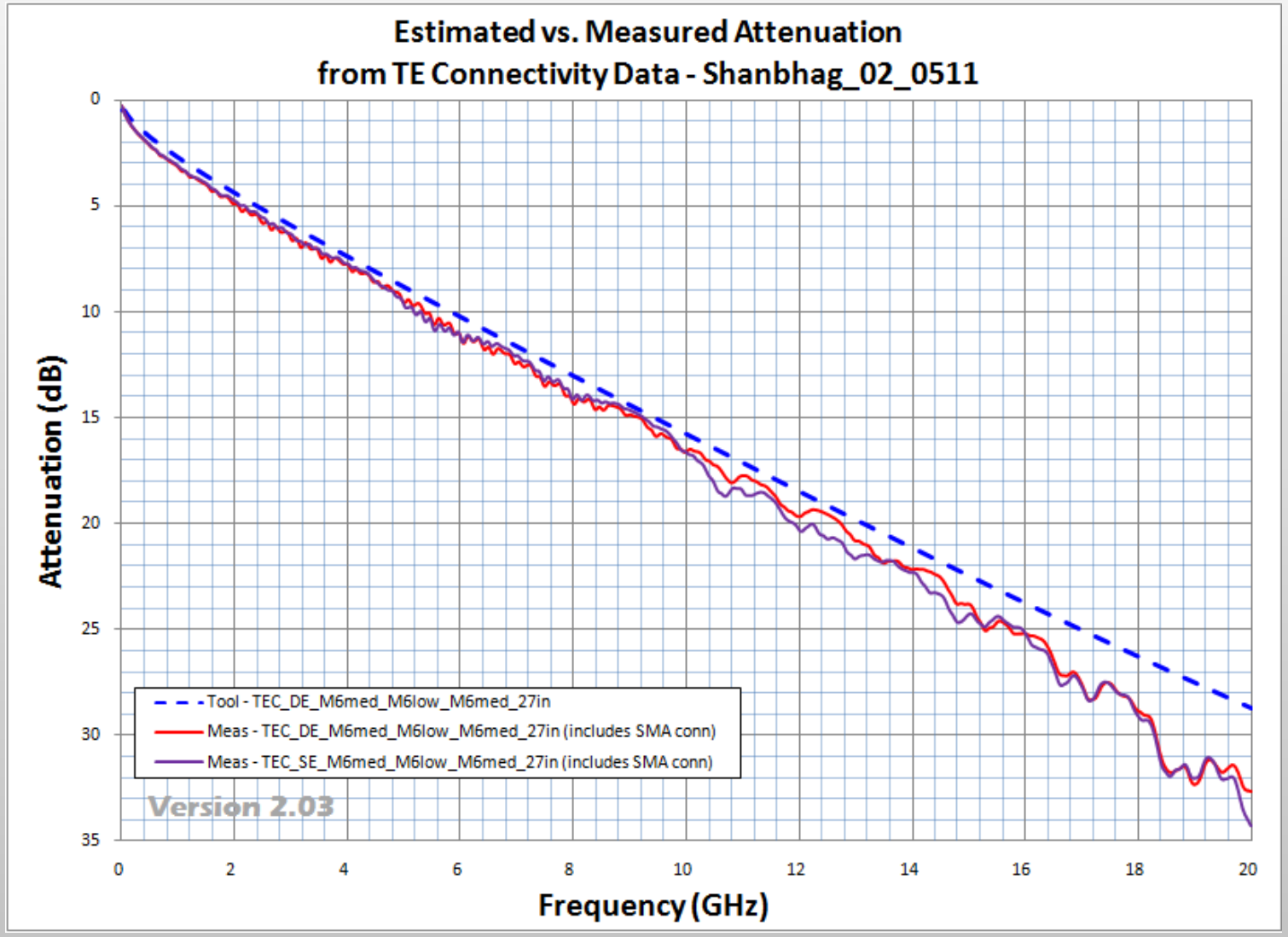
23dB loss at 12.75G - 1.21dB loss at 1

| Linecard A Material | | |
|---|---|---|
| Length (inch) | | 5 |
| Trace Width (mil) | | 6 |
| Cu Thickness (mil) | | 0.6 |
| Diel. Thickness (mil) | | 16.231 |
| Freq | Dk | Df |
| 1.00E+08 | 3.67 | 0.0039 |
| 1.00E+09 | 3.65 | 0.004 |
| 2.00E+09 | 3.59 | 0.0043 |
| 5.00E+09 | 3.576 | 0.0049 |
| 1.00E+10 | 3.3494 | 0.0055 |
| 2.00E+10 | 3 | 0.0065 |
| Medium Roughness | 31 | 6.0E-07 |

| Linecard B Material | | |
|---|---|---|
| Length (inch) | | 5 |
| Trace Width (mil) | | 6 |
| Cu Thickness (mil) | | 0.6 |
| Diel. Thickness (mil) | | 16.231 |
| Freq | Dk | Df |
| 1.00E+08 | 3.67 | 0.0039 |
| 1.00E+09 | 3.65 | 0.004 |
| 2.00E+09 | 3.59 | 0.0043 |
| 5.00E+09 | 3.576 | 0.0049 |
| 1.00E+10 | 3.3494 | 0.0055 |
| 2.00E+10 | 3 | 0.0065 |
| Medium Roughness | 31 | 6.0E-07 |

# Tool Validation (updated to v2.03)

## TE Connectivity - 802.3bj submitted channel

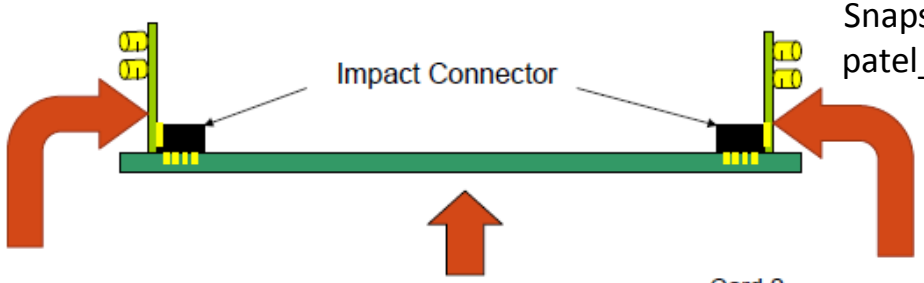



- Test channel is 27in total (5” + 17” + 5”) length
- Single-ended and differential measurements shown
- Remember measurements include the 2 launches (including SMA conn. and vias)

# Tool Validation

## IBM Corporation - 802.3bj submitted channel

**1 Meter Backplane Channel Construction:**




Snapshot from patel_02_0911

Card 1
- Length =5.1 Inches
- 1 oz copper
- VLP copper Foil"
- Meg 6
- 110 mil thick,
- 5.7/9.3/5.7 mils,
- Via stub ~ 10mil
- 14 layers
- 100 ohm +/-10%

Backplane
- Length = 29 Inches
- 1 oz copper
- HVLP copper Foil"
- Meg 6
- 250 mil thick,
- 7.0/9.0/7.0 mils,
- Via stub ~ 10mil
- 26 layers
- 100 ohm +/-10%

Card 2
- Length =5.1 Inches
- 1 oz copper
- VLP copper Foil"
- Meg 6
- 110 mil thick,
- 5.7/9.3/5.7 mils,
- Via stub ~ 10mil
- 14 layers
- 100 ohm +/-10%

- w and L given.
- t was assumed as 1.2mil (1 oz Cu)
- b assumed to be calculated by
  $b = [(t_{Total} - 1.2*N_{lyrs})/(N_{lyrs}-1)] *2 + 1.2$

| Backplane/Trace Material | | |
|---|---|---|
| Length (inch) | | 29 |
| Trace Width (mil) | | 7 |
| Cu Thickness (mil) | | 1.2 |
| Diel. Thickness (mil) | | 18.704 |
| Freq | Dk | Df |
| 1.00E+08 | 3.67 | 0.0039 |
| 1.00E+09 | 3.65 | 0.004 |
| 2.00E+09 | 3.59 | 0.0043 |
| 5.00E+09 | 3.576 | 0.0049 |
| 1.00E+10 | 3.3494 | 0.0055 |
| 2.00E+10 | 3 | 0.0065 |
| Low Roughness | 20 | 6.0E-07 |

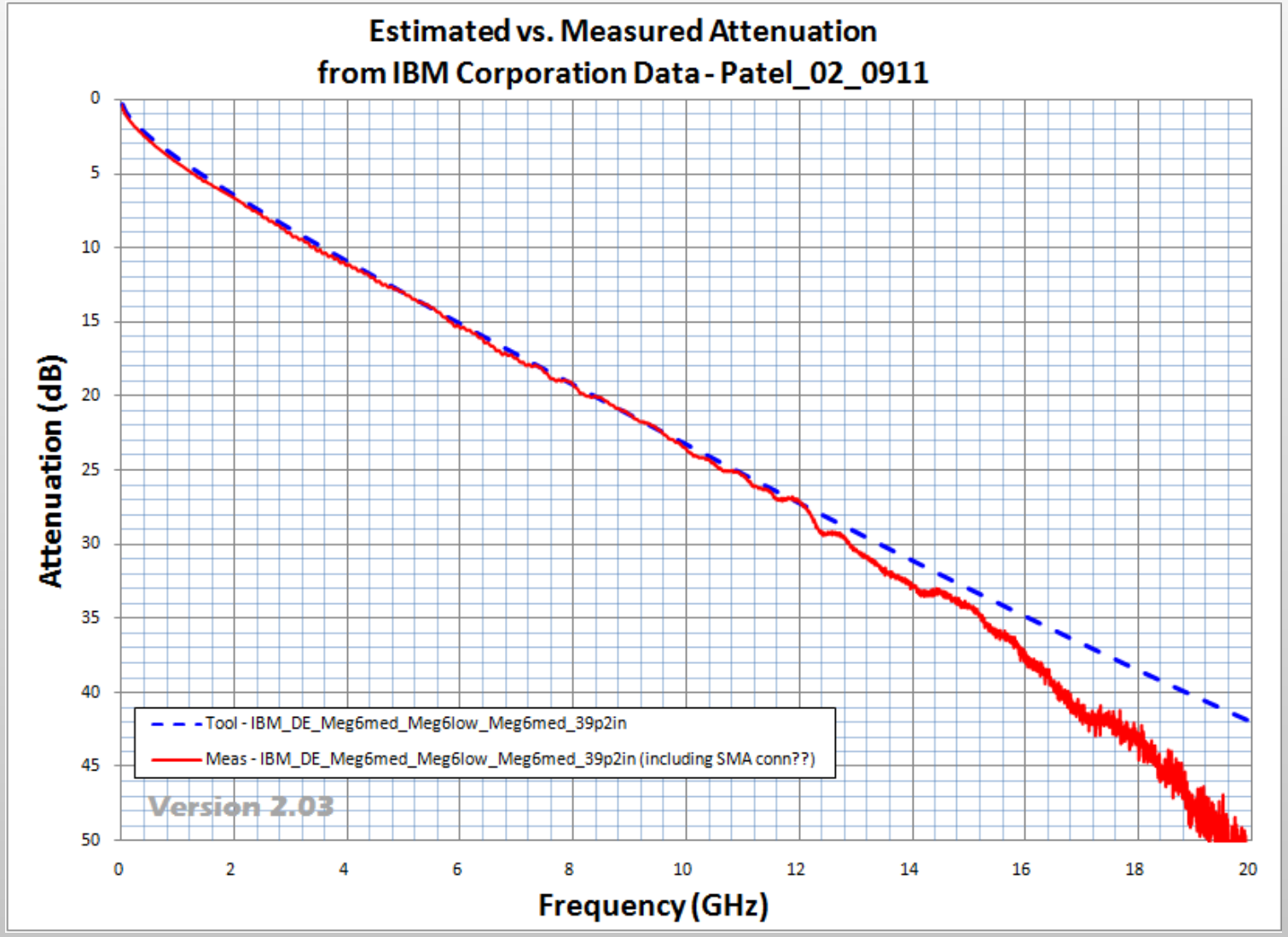
23dB loss at 12.75G - 1.21dB loss at 1

| Linecard A Material | | |
|---|---|---|
| Length (inch) | | 5.1 |
| Trace Width (mil) | | 5.7 |
| Cu Thickness (mil) | | 1.2 |
| Diel. Thickness (mil) | | 15.54 |
| Freq | Dk | Df |
| 1.00E+08 | 3.67 | 0.0039 |
| 1.00E+09 | 3.65 | 0.004 |
| 2.00E+09 | 3.59 | 0.0043 |
| 5.00E+09 | 3.576 | 0.0049 |
| 1.00E+10 | 3.3494 | 0.0055 |
| 2.00E+10 | 3 | 0.0065 |
| Medium Roughness | 31 | 6.0E-07 |

| Linecard B Material | | |
|---|---|---|
| Length (inch) | | 5.1 |
| Trace Width (mil) | | 5.7 |
| Cu Thickness (mil) | | 1.2 |
| Diel. Thickness (mil) | | 15.54 |
| Freq | Dk | Df |
| 1.00E+08 | 3.67 | 0.0039 |
| 1.00E+09 | 3.65 | 0.004 |
| 2.00E+09 | 3.59 | 0.0043 |
| 5.00E+09 | 3.576 | 0.0049 |
| 1.00E+10 | 3.3494 | 0.0055 |
| 2.00E+10 | 3 | 0.0065 |
| Medium Roughness | 31 | 6.0E-07 |

# Tool Validation

## IBM Corporation - 802.3bj submitted channel




- Test channel is 39.2in total (5.1” + 29” + 5.1”) length
- Differential measurement shown
- Do not know if measurement include the 2 SMA launches

# Tool Validation

## Emerson - 802.3bj submitted channel

- BACKPLANE
  - C4440 Rev.B (8406883e61b)
  - Nelco 4000-13SI, 22 Layer, 227 mil
- DAUGHTER CARD
  - Test-F140 ((6306855G)
  - FR408, 16 Layer, 100mil
  - Trace length ~ 6.2 inch
  - Normal, High and Low Impedance
  - Typical ATCA board topology
  - ZDplus Backplane connector
  - SMA Lunch for TP1 and TP4
  - Receiver AC Capacitors

Snapshots from meier_01_1011

### Longest Link

- Channel Length
  - Tx Daughter Card ~ 6.2 inch
  - Backplane ~ 10.5 inch
  - Rx Daughter Card ~ 6.2 inch

### Shortest Link

- Channel Length
  - Tx Daughter Card ~ 6.2 inch
  - Backplane 2.6 to 3.0 inch
  - Rx Daughter Card ~ 6.2 inch

- L given.
- t was *assumed* as 1.2mil (1 oz Cu)
- *Assumed* Cu surface roughness to be between Med and High (both shown)

- b assumed to be calculated by: $b = [(t_{Total} - 1.2*N_{lyrs})/(N_{lyrs}-1)] *2 + 1.2$
- Board thickness → b → w (given t, b, material - above - found w that gives 50 ohms @5G)

**Note: Limited information was given;**

**Assumptions were made, so don't expect it to be exact!**

Version 2.03 LOSS SNAPSHOT: Loss at 5GHz: 12.57 dB Loss at 12.75GHz: 28.41 dB Loss at 14GHz: 30.77 dB

| Backplane/Trace Material | |
|---|---|
| Length (inch) | 3 |
| Trace Width (mil) | 9.17 |
| Cu Thickness (mil) | 1.2 |
| Diel. Thickness (mil) | 20.305 |

| Fre | Dk | Df |
|---|---|---|
| 1.0 | 3.6 | 0.0092 |
| | 3.52 | 0.0115 |
| | 3.49 | 0.0108 |
| .09 | 3.46 | 0.011 |
| .0E+10 | 3.44 | 0.0112 |
| .00E+10 | 3.43 | 0.0114 |
| High Roughness | 65 | 6.0E-07 |

-13SI

3dB loss at 12.75G - 1.21dB loss at 1.

| Linecard A Material | |
|---|---|
| Length (inch) | 6.2 |
| Trace Width (mil) | 4.23 |
| Cu Thickness (mil) | 1.2 |
| Diel. Thickness (mil) | 11.9733 |

| Fre | Dk | Df |
|---|---|---|
| 1.0 | **3.81** | 0.01 |
| | **3.78** | **0.0112** |
| | **3.77** | **0.0116** |
| .09 | **3.75** | **0.0122** |
| .0E+10 | 3.72 | **0.012** |
| .00E+10 | 3.7 | 0.012 |
| High Roughness | 65 | 6.0E-07 |

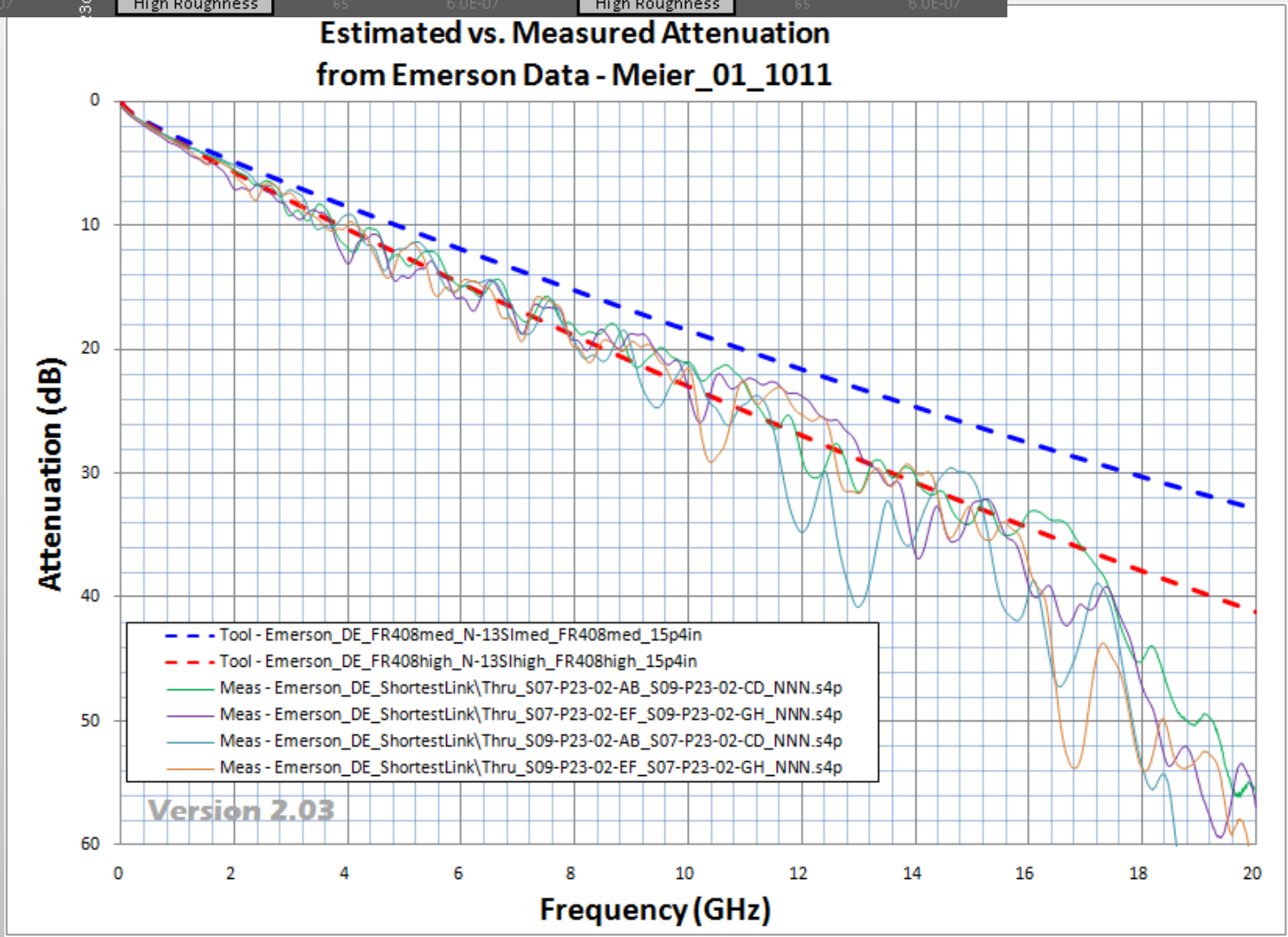
FR408

| Linecard B Material | |
|---|---|
| Length (inch) | 6.2 |
| Trace Width (mil) | 4.23 |
| Cu Thickness (mil) | 1.2 |
| Diel. Thickness (mil) | 11.9733 |

| Fr | Dk | Df |
|---|---|---|
| 1 | **3.81** | 0.01 |
| | **3.78** | **0.0112** |
| | **3.77** | **0.0116** |
| .09 | **3.75** | **0.0122** |
| .0E+10 | 3.72 | **0.012** |
| 2.00E+10 | 3.7 | 0.012 |
| High Roughness | 65 | 6.0E-07 |

FR408

Note: bolded dk/df values are from data sheet.



Version 2.03 LOSS SNAPSHOT: Loss at 5GHz: 16.23 dB Loss at 12.75GHz: 37.08 dB Loss at 14GHz: 40.2 dB

-13SI

| Backplane/Trace Material | |
|---|---|
| Length (inch) | 10.5 |
| Trace Width (mil) | 9.17 |
| Cu Thickness (mil) | 1.2 |
| Diel. Thickness (mil) | 20.305 |

| Fre | Dk | Df |
|---|---|---|
| 1.0 | 3.6 | 0.0092 |
| | 3.52 | 0.0115 |
| | 3.49 | 0.0108 |
| | 3.46 | 0.011 |
| | 3.44 | 0.0112 |
| | 3.43 | 0.0114 |
| High Roughness | 65 | 6.0E-07 |

3dB loss at 12.75G - 1.21dB loss at 1.

FR408

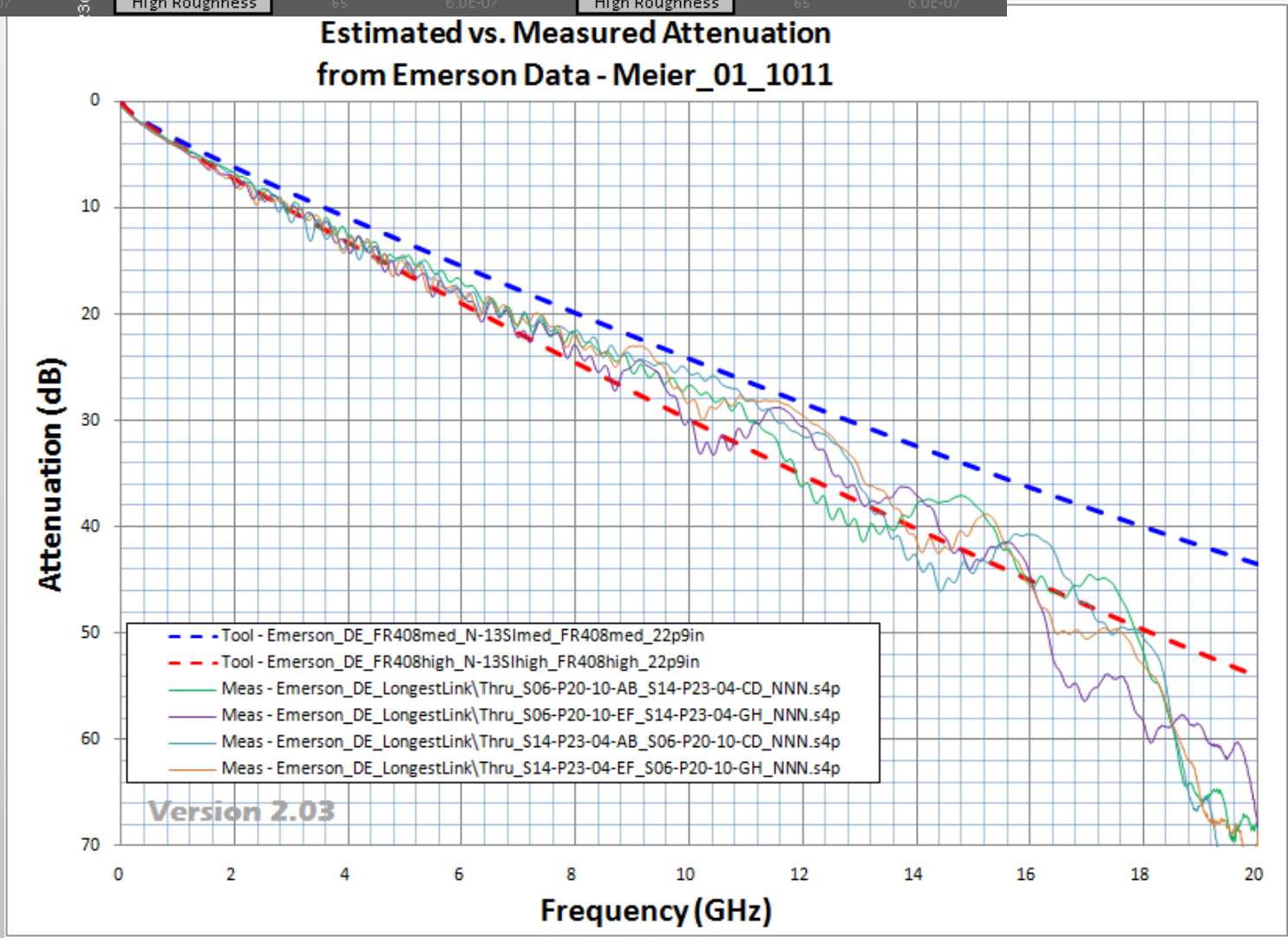
| Linecard A Material | |
|---|---|
| Length (inch) | 6.2 |
| Trace Width (mil) | 4.23 |
| Cu Thickness (mil) | 1.2 |
| Diel. Thickness (mil) | 11.9733 |

| Fre | Dk | Df |
|---|---|---|
| 1.0 | **3.81** | 0.01 |
| | **3.78** | **0.0112** |
| | **3.77** | **0.0116** |
| | **3.75** | **0.0122** |
| | 3.72 | **0.012** |
| | 3.7 | 0.012 |
| High Roughness | 65 | 6.0E-07 |

FR408

| Linecard B Material | |
|---|---|
| Length (inch) | 6.2 |
| Trace Width (mil) | 4.23 |
| Cu Thickness (mil) | 1.2 |
| Diel. Thickness (mil) | 11.9733 |

| Fr | Dk | Df |
|---|---|---|
| 1 | **3.81** | 0.01 |
| | **3.78** | **0.0112** |
| | **3.77** | **0.0116** |
| | **3.75** | **0.0122** |
| | 3.72 | **0.012** |
| | 3.7 | 0.012 |
| High Roughness | 65 | 6.0E-07 |



# Possible Advancements

- After some thought over suggested advances, we'd like to spend time looking into implementing vias and s-parameter output
- Not guaranteeing implementation

- We welcome collaboration on these topics

Happy Channel Estimating…

# THANK YOU FOR YOUR TIME!

# Backup Slides

# Model Entries used: Megtron 6

Nominal Megtron 6

| Freq | Dk | Df |
|---|---|---|
| 1.00E+08 | 3.67 | 0.0039 |
| 1.00E+09 | 3.65 | 0.004 |
| 2.00E+09 | 3.59 | 0.0043 |
| 5.00E+09 | 3.576 | 0.0049 |
| 1.00E+10 | 3.3494 | 0.0055 |
| 2.00E+10 | 3 | 0.0065 |

Low Tol. Meg6

| Freq | Dk | Df |
|---|---|---|
| 1.00E+08 | 3.61 | 0.0024 |
| 1.00E+09 | 3.59 | 0.0025 |
| 2.00E+09 | 3.53 | 0.0028 |
| 5.00E+09 | 3.516 | 0.0034 |
| 1.00E+10 | 3.2894 | 0.004 |
| 2.00E+10 | 2.94 | 0.005 |

High Tol. Meg6

| Freq | Dk | Df |
|---|---|---|
| 1.00E+08 | 3.73 | 0.0054 |
| 1.00E+09 | 3.71 | 0.0055 |
| 2.00E+09 | 3.65 | 0.0058 |
| 5.00E+09 | 3.636 | 0.0064 |
| 1.00E+10 | 3.4094 | 0.007 |
| 2.00E+10 | 3.06 | 0.008 |

- Slide 4: Approved Loss Parameters
  - Meg6_LowSR – Wide
    - High Tol. Meg6, w = 7, b = 14.74, t = 0.6, L = 1, SR = Low (20x0.6µm)
  - Meg6_LowSR –Narrow
    - High Tol. Meg6, w = 4, b = 9.23, t = 0.6, L = 1, SR = Low (20x0.6µm)
  - Meg6_HighSR – Wide
    - High Tol. Meg6, w = 7, b = 14.74, t = 0.6, L = 1, SR = High (65x0.6µm)
  - Meg6_HighSR – Narrow
    - High Tol. Meg6, w = 4, b = 9.23, t = 0.6, L = 1, SR = High (65x0.6µm)

# Model Entries used: Improved FR4

Nominal Imp. FR4

| Freq | Dk | Df |
|---|---|---|
| 1.00E+08 | 3.6 | 0.0092 |
| 1.00E+09 | 3.6 | 0.0092 |
| 2.00E+09 | 3.5 | 0.0115 |
| 5.00E+09 | 3.5 | 0.0115 |
| 1.00E+10 | 3.4 | 0.0125 |
| 2.00E+10 | 3.2 | 0.014 |

Low Tol. Imp FR4

| Freq | Dk | Df |
|---|---|---|
| 1.00E+08 | 3.54 | 0.0077 |
| 1.00E+09 | 3.54 | 0.0077 |
| 2.00E+09 | 3.44 | 0.01 |
| 5.00E+09 | 3.44 | 0.01 |
| 1.00E+10 | 3.34 | 0.011 |
| 2.00E+10 | 3.14 | 0.0125 |

High Tol. Imp FR4

| Freq | Dk | Df |
|---|---|---|
| 1.00E+08 | 3.66 | 0.0107 |
| 1.00E+09 | 3.66 | 0.0107 |
| 2.00E+09 | 3.56 | 0.013 |
| 5.00E+09 | 3.56 | 0.013 |
| 1.00E+10 | 3.46 | 0.014 |
| 2.00E+10 | 3.26 | 0.0155 |

- Slide 4: Approved Loss Parameters
  - ImpFR4_LowSR – Wide
    - High Tol. ImpFR4, w = 7, b = 14.59, t = 0.6, L = 1, SR = Low (20x0.6µm)
  - ImpFR4_LowSR –Narrow
    - High Tol. ImpFR4, w = 4, b = 9.13, t = 0.6, L = 1, SR = Low (20x0.6µm)
  - ImpFR4_HighSR – Wide
    - High Tol. ImpFR4, w = 7, b = 14.59, t = 0.6, L = 1, SR = High (65x0.6µm)
  - ImpFR4_HighSR – Narrow
    - High Tol. ImpFR4, w = 4, b = 9.13, t = 0.6, L = 1, SR = High (65x0.6µm)

# Tool Validation

(updated to v2.03, but unchanged)

## Cisco – SR Test Board

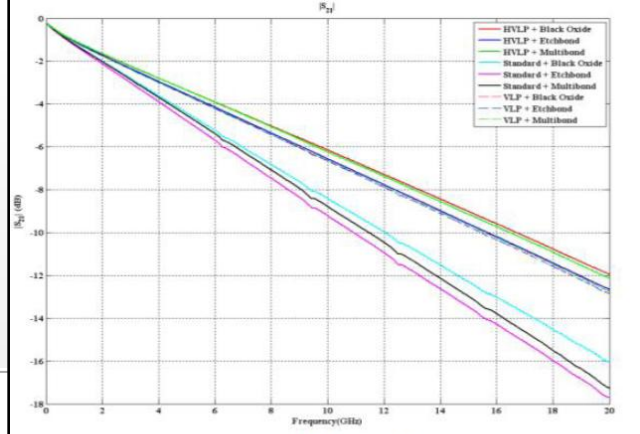
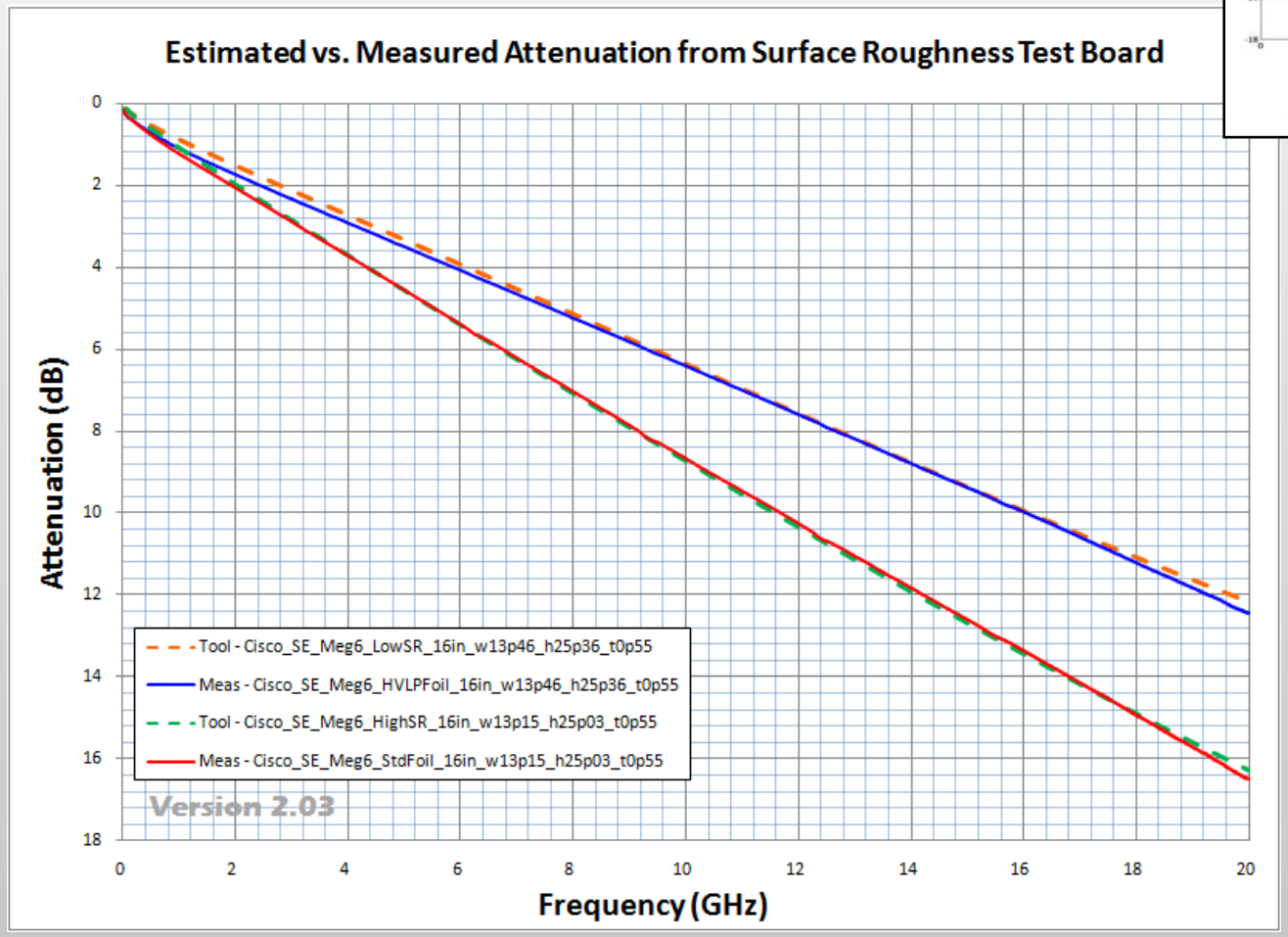



**Figure 5**
**S21 measurements for the nine test vehicles**




- Test boards are 16in length
- t, h, b, and w were taken from a cross-section measurement
- Single-ended measurement shown (data for differential not delivered to Beth)
- Graphs shown to the left are of Black Oxide process (above shows the variations due to process)

- Test boards used in surface roughness study, published in S. Hinaga, M. Koledintseva, P. Anmula, J. Drewniak, "Effect of Conductor Surface Roughness upon Measured Loss and Extracted Values of PCB Laminate Material Dissipation Factor," PCB007. Published 2010.

# Tool Validation

(updated to v2.03, but unchanged)

## Qlogic – e-mail of data given by Mike Dudek

### E-mail states

- 100 ohm differential traces
- Measurement of 6.9mil w includes the 2 launches (including SMA conn. and vias)
- w, t, and L were given
- h was not given… model was used to calculate what h should be to give 50 ohms at 5G
- No control on the surface roughness for all 3 measurements
- Only a dB/in was given, not an s-parameter

| Material | Megtron 4 | Nelco 4000-13 | Megtron 4 |
|---|---|---|---|
| Geometry | 4.5/7/4.5 | 4.5/7/4.5 | 6.9/8.6/6.9 |
| | | | |
| Freq (GHz) | Loss dB/inch | | |
| 1 | -0.173 | -0.198049 | -0.132662 |
| 6.5 | -0.564 | -0.68447 | -0.52876 |
| 7 | -0.609 | -0.720855 | -0.557981 |
| 12.89 | -1.025 | -1.071918 | -1.002522 |
| 14 | -1.190 | -1.213834 | -1.135518 |

Megtron 4

| Backplane/Trace Material | | |
|---|---|---|
| Length (inch) | | 9 |
| Trace Width (mil) | | 4.5 |
| Cu Thickness (mil) | | 0.65 |
| Diel. Thickness (mil) | | 10.34 |
| Freq | Dk | Df |
| 1.00E+08 | **3.59** | **0.005** |
| 1.00E+09 | **3.57** | **0.005** |
| 2.00E+09 | **3.56** | **0.006** |
| 5.00E+09 | 3.54 | 0.0065 |
| 1.00E+10 | **3.53** | **0.007** |
| 2.00E+10 | 3.5 | 0.008 |
| High Roughness | 65 | 6.0E-07 |

Nelco 4000-13

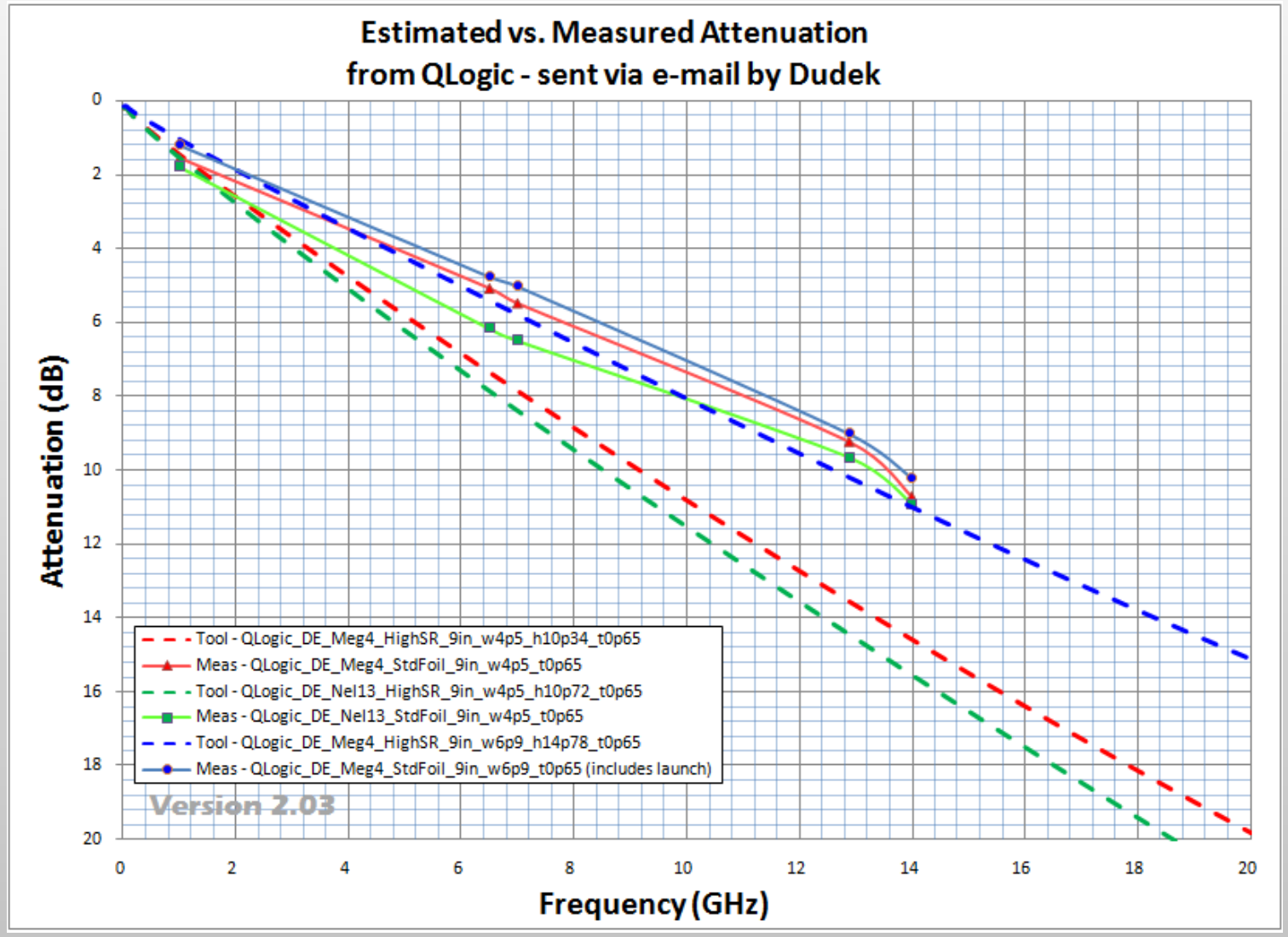
| Backplane/Trace Material | | |
|---|---|---|
| Length (inch) | | 9 |
| Trace Width (mil) | | 4.5 |
| Cu Thickness (mil) | | 0.65 |
| Diel. Thickness (mil) | | 10.6 |
| Freq | Dk | Df |
| 1.00E+08 | 3.7 | 0.0075 |
| 1.00E+09 | **3.7** | 0.0075 |
| 2.00E+09 | 3.68 | 0.008 |
| 5.00E+09 | 3.65 | 0.0085 |
| 1.00E+10 | **3.6** | **0.009** |
| 2.00E+10 | 3.55 | 0.01 |
| High Roughness | 65 | 6.0E-07 |

Material Dk/Df values determined by datasheet: Numbers that are bolded were given in datasheet… other frequencies were filled in.

# Tool Validation

(updated to v2.03, but unchanged)

## Qlogic – e-mail of data given by Mike Dudek




- "Measured" data is drawn given 5 freq points of dB/in, NOT a s-parameter
- Measurement of 6.9mil w includes the 2 launches (including SMA conn. and vias)
- Note that h was not given

# Tool Validation (using v2.02, but should not change in v2.03)

## Marvell – summary of validation by Liav Ben Artsi

Loosely Coupled Traces:

- Measurements of narrow traces of both HVLP and VLP had a good correlation to the calculated value (≤0.13dB)
- Measurements indicate that "normal" surface roughness loss may have high variance in relation to calculated loss (up to 0.3dB)

Tightly Coupled Traces:

- Measurements of narrow traces of meg6 and Nelco13SI with various surface roughness levels had a very good correlation (≤0.05dB) to the values suggested on slide 9 (which takes into account the tolerance).

| Material / construction | Trace width (before etching) | Measured loss | Calculated loss | Difference to calculated loss |
|---|---|---|---|---|
| Megtron6 HVLP (tightly coupled) | 5 | 1.04dB | 0.8dB (slide 9 indicate 1.01dB) – 0.911 for VLP | 0.204dB |
| Above is a Meg6 LowSR – Narrow: 0.03 difference from proposed parameter | | | | |
| Megtron6 Normal (tightly coupled) | 5 | 1.54dB | 1.255dB (slide 9 indicate 1.5924) | 0.19dB |
| Above is Meg6 HighSR – Narrow: 0.05 difference from proposed parameter | | | | |
| Nelco-13SI Medium surface roughness (tightly coupled) | 5 | 1.28dB | 1.297dB | 0.017dB |
| HQ FR4 – HVLP – Two width - Loosely coupled | | Can't share due to vendor Confidential note | | Calculated loss is higher by ~0.12dB |
| HQ FR4 – VLP – Two width - Loosely coupled | | Can't share due to vendor Confidential note | | Calculated loss is higher by ~0.13dB |
| HQ FR4 – Normal – Two width - Loosely coupled | | Can't share due to vendor Confidential note | | Calculated loss is higher by ~0.3 |

# Tool Validation (using v2.02, but would not change in v2.03)

## Intel– comparison to validated 3D solver (Rich Mellitz)

| setting | value | units |
|---|---|---|
| PCB: trace width sigma | 0.2625 | mils, 1 std dev |
| PCB: trace height sigma | 0.03 | mils, 1 std dev |
| PCB: dielectric height sigma | 0.11875 | mils, 1 std dev |
| PCB: er sigma | 0.05 | 1 std dev |
| PCB: Er\tanD reference frequency | 1 | GHz |
| | | |
| PKG: trace width sigma | 1.67 | um, 1 std dev |
| PKG: trace height sigma | 1.67 | um, 1 std dev |
| PKG: dielectric height sigma | 2 | um, 1 std dev |
| PKG: er sigma | 0.07 | 1 std dev |
| PKG: Er\tanD reference frequency | 5 | GHz |
| | | |
| Impedance measure frequency | 1 | GHz |
| dB/inch loss measure frequency | 5 | GHz |
| dB/inch reference impedance | lineZtarget | ohms |
| db/inch calculation (extra imap run) | disable | |
| IMAP accuracy | default | |
| Output filetype | sparam | |
| Solver IMAP/XFX | IMAP | |
| Model frequency steps linear/log | lin | |
| | | |
| Model frequency steps linear/log | lin | |
| Frequency Begin | 1.00E+08 | Hz |
| Frequency End | 20 | GHz |
| Number of Points | 2001 | |
| | | |
| min Smask on top of trace when tt>Sm | 0.3 | |

Notice 1Ghz is the reference frequency for the Djordjevic Model

Using Intel Validated Field Solver to output .s2p

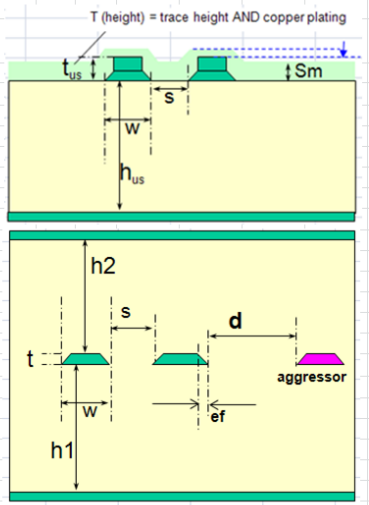
| Predicted Impedance | 50.29 |
|---|---|

| param | | nominal |
|---|---|---|
| signal mode | | se |
| stripline or microstrip | | sl |
| number of conductors | | 1 |
| dielectric above | h2 | 7.37 |
| width | w | 7 |
| dielectric below | h1 | 7.37 |
| trace thickness | t | 0.6 |
| space (edge to edge) | s | 7 |
| space (pair to pair, edge) | d | 7 |
| dielectric constant (er) | er | 3.65 |
| loss tangent | tand | 0.004 |
| stack up units | | mils |
| **roughness and filename** | | |
| Roughness model | ver | 3 |
| Sphere Radius (um) | | 0.6 |
| RMS peak width (um) | pw | 9.4 |
| RMS (hammerstad) (um) | srms | 0.815 |
| ref frequency | hz | 1.00E+09 |
| Number of Spheres | | 65 |
| solve this model tab/lcf | | tab |
| filename | | Meg6_nomtol_w7_b14.74_h |
| **Solder Mask** | | |
| solder mask dielectric | er | 3.8 |
| solder mask loss tand | tand | 0.025 |
| **etch factor and conductivity** | | |
| etch factor | | 0 |
| conductivity | ; (S/m | 5.96E+07 |

Solved Z0: 51.10 ohms; disabled\error db/inch

SOLVE

**Surface Roughness Key**
No roughness: ver 0
Packages: ver 1 Hammerstand
Package 0.32/0.35 for sl/us
Board: ver 3 Hurray
sphere radius 0.5
RMS peak width 9.4
number spheres 64/79 for sl/us
use 50 spheres for stripline RTC




AlgebraicTool v2.02

Nominal Megtron 6

| Freq | Dk | Df |
|---|---|---|
| 1.00E+08 | 3.67 | 0.0039 |
| 1.00E+09 | 3.65 | 0.004 |
| 2.00E+09 | 3.59 | 0.0043 |
| 5.00E+09 | 3.576 | 0.0049 |
| 1.00E+10 | 3.3494 | 0.0055 |
| 2.00E+10 | 3 | 0.0065 |

Intel Validated Field Solver

... withDjordjevic model at

| freq | dk | df |
|---|---|---|
| 1.00E+08 | 3.6715 | 0.00398 |
| 1.00E+09 | 3.6499 | 0.00400 |
| 2.00E+09 | 3.6436 | 0.00401 |
| 5.00E+09 | 3.6351 | 0.00402 |
| 1.00E+10 | 3.6286 | 0.00402 |
| 2.00E+10 | 3.6222 | 0.00403 |

Inputted Djordjevic model values into Algebraic Tool

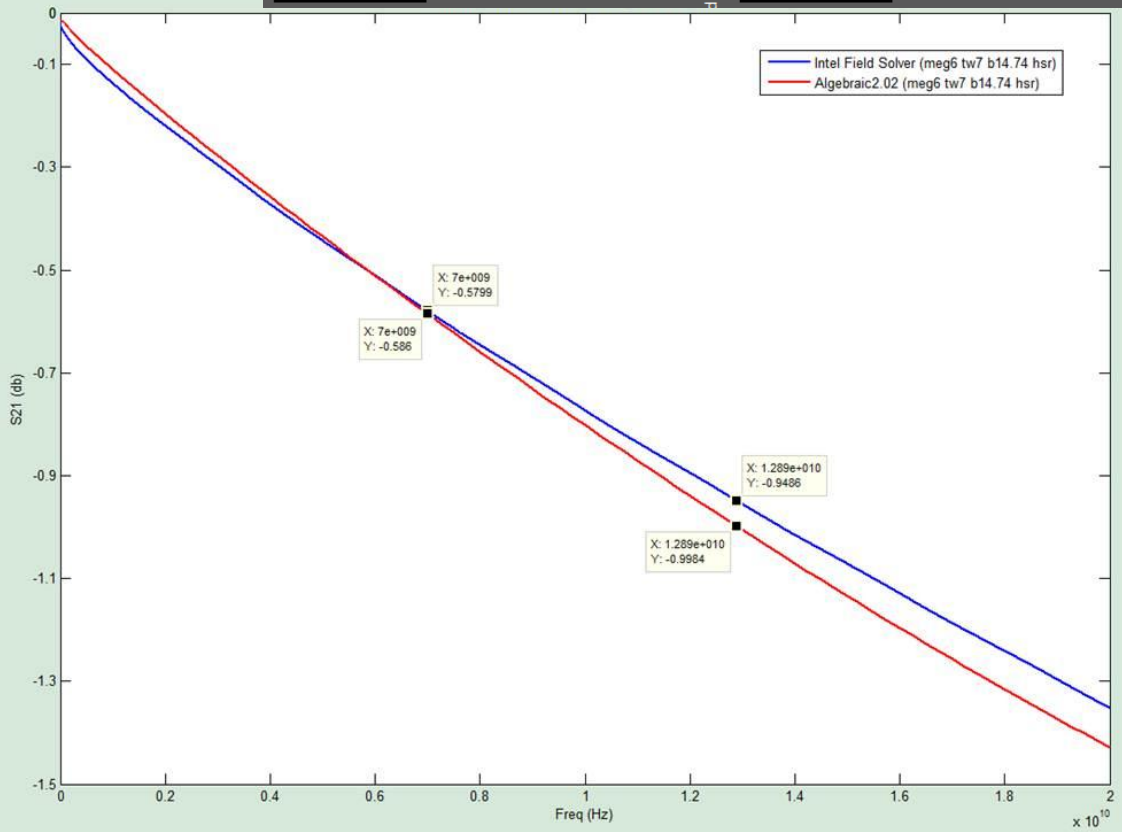
To match Algebraic 2.02 for high surface roughness (HSR) : sigma = 5.96e7, number of spheres = 65, sphere radius = 0.6

Caveat: Etch factor is set to 0.3 for Intel Validated Field Solver . For Algebraic tool, the etch factor is zero.

# Tool Validation (using v2.02, but would not change in v2.03)

## Intel– comparison to validated 3D solver (Rich Mellitz)

| Version 2.02 | LOSS SNAPSHOT: | Loss at 5GHz: | 0.42 dB | Loss at 12.75GHz: | 0.94 dB | Loss at 14GHz: | 1.01 dB |
|---|---|---|---|---|---|---|---|
| Backplane/Trace Material | | | | Linecard A Material | | Linecard B Material | |
| Length (inch) | | 1 | | Length (inch) | 0 | Length (inch) | 0 |
| Trace Width (mil) | | 7 | | Trace Width (mil) | | Trace Width (mil) | |
| Cu Thickness (mil) | | 0.6 | | Cu Thickness (mil) | | Cu Thickness (mil) | |
| Diel. Thickness (mil) | | 14.74 | | Diel. Thickness (mil) | | Diel. Thickness (mil) | |
| Freq | Dk | Df | | Freq | Dk | Freq | Dk |
| 1.00E+08 | 3.6715 | 0.00398 | | 1.00E+08 | | 1.00E+08 | |
| 1.00E+09 | 3.6499 | 0.004 | | 1.00E+09 | | 1.00E+09 | |
| 2.00E+09 | 3.6436 | 0.00401 | | 2.00E+09 | | 2.00E+09 | |
| 5.00E+09 | 3.6351 | 0.00402 | | 5.00E+09 | | 5.00E+09 | |
| 1.00E+10 | 3.6286 | 0.00403 | | 1.00E+10 | | 1.00E+10 | |
| 2.00E+10 | 3.6222 | 0.00404 | | 2.00E+10 | | 2.00E+10 | |
| High Roughness | 65 | 6.0E-07 | | | | | |




Intel comments:

- AlgebraicTool v2.02 is with 5% for dB predictions upto 13 GHz.
- AlgebraicTool v2.02 is comparable to Intel Validated Field Solver for 7GHz.
- AlgebraicTool v2.02 is a good tool to quickly estimate dB per inch loss.