Automotive Link Segment Analysis for 10SPE

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TE Connectivity
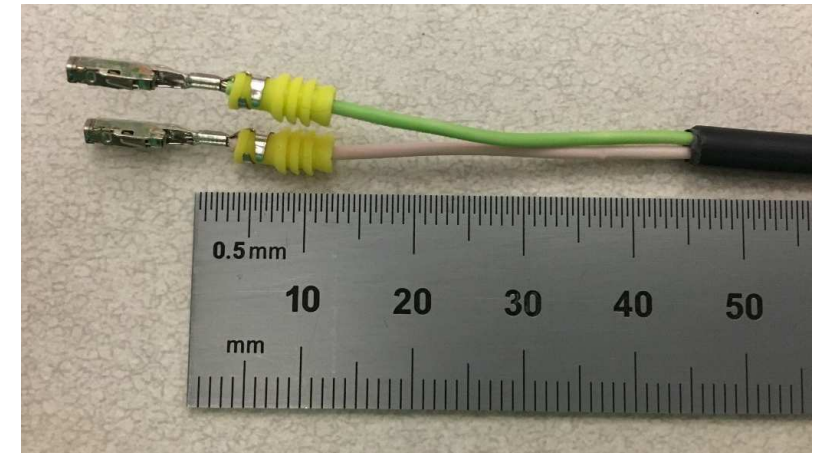
August 30, 2017

4mm Pitch, Single wire seal Connector Testing

Work continued from previous contributions

http://www.ieee802.org/3/cg/public/Mar2017/DiBiaso
_Bergner_01a_0314.pdf

http://www.ieee802.org/3/cg/public/July2017/DiBiaso
_Bergner_01a_0717.pdf

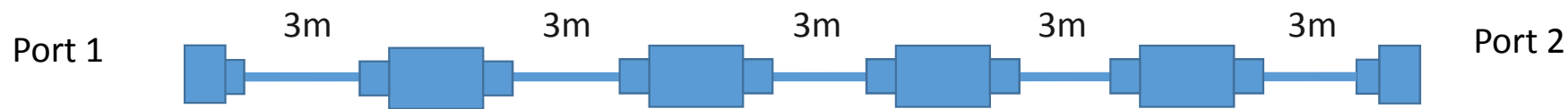**Untwist length for each inline connector**

110mm

45mm ← → ← 45mm

20mm

- Termination requires 45mm jacket strip length on each side of the connector to insert 1 terminal at a time into the connector body

4mm Pitch, Single wire seal Connector (Link Segment Testing)

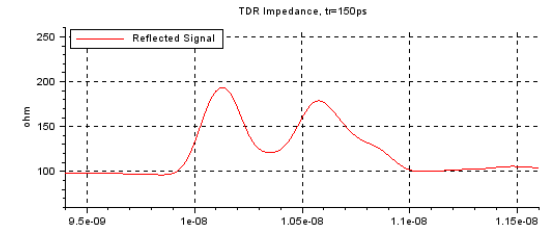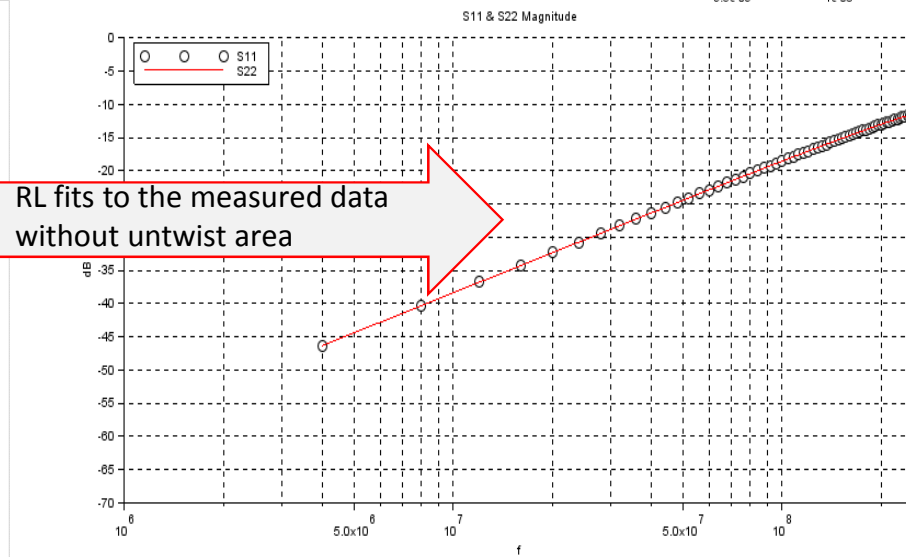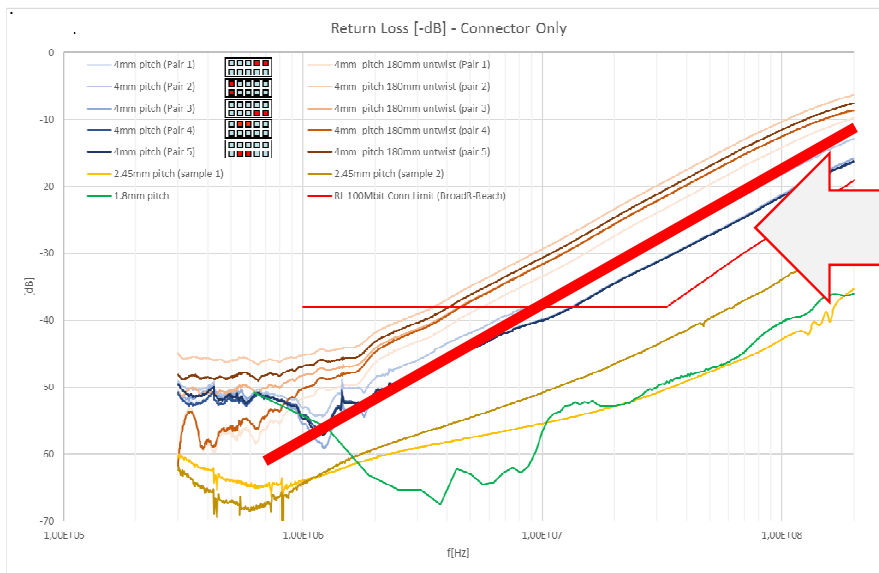Port 1   3m   3m   3m   3m   3m   Port 2

- 5x3m link segments with 45mm untwist at each termination
- Cut each cable to 3m
- Strip outer jacket to 45mm

Is this the worst case link segment for 10SPE (Short Reach)??

# Simulations to Determine Worst Case Link Segment

Transmission Line Model – 4mm Inline Connector

Return Loss [-dB] - Connector Only

- 4mm pitch (Pair 1)
- 4mm pitch (Pair 2)
- 4mm pitch (Pair 3)
- 4mm pitch (Pair 4)
- 4mm pitch (Pair 5)
- 2.45mm pitch (sample 1)
- 1.8mm pitch
- 4mm pitch 180mm untwist (Pair 1)
- 4mm pitch 180mm untwist (Pair 2)
- 4mm pitch 180mm untwist (pair 3)
- 4mm pitch 180mm untwist (pair 4)
- 4mm pitch 180mm untwist (pair 5)
- 2.45mm pitch (sample 2)
- RL 100Mbit Conn limit (BroadR-Reach)

RL fits to the measured data without untwist area

S11 & S22 Magnitude

TDR Impedance, tr=150ps

TDR profile

Parameter model (5 concatenated waveguides):

4mm Inliner	wire & crimp left	spring body left	pin	spring body rigth	wire & crimp right	Total length (mm)
Zw (Ohm)	210	85	190	85	210	
vp (m/s)	2,54E+08	2,10E+08	2,20E+08	2,10E+08	2,54E+08	
len (m)	0,03	0,008	0,004	0,008	0,03	80
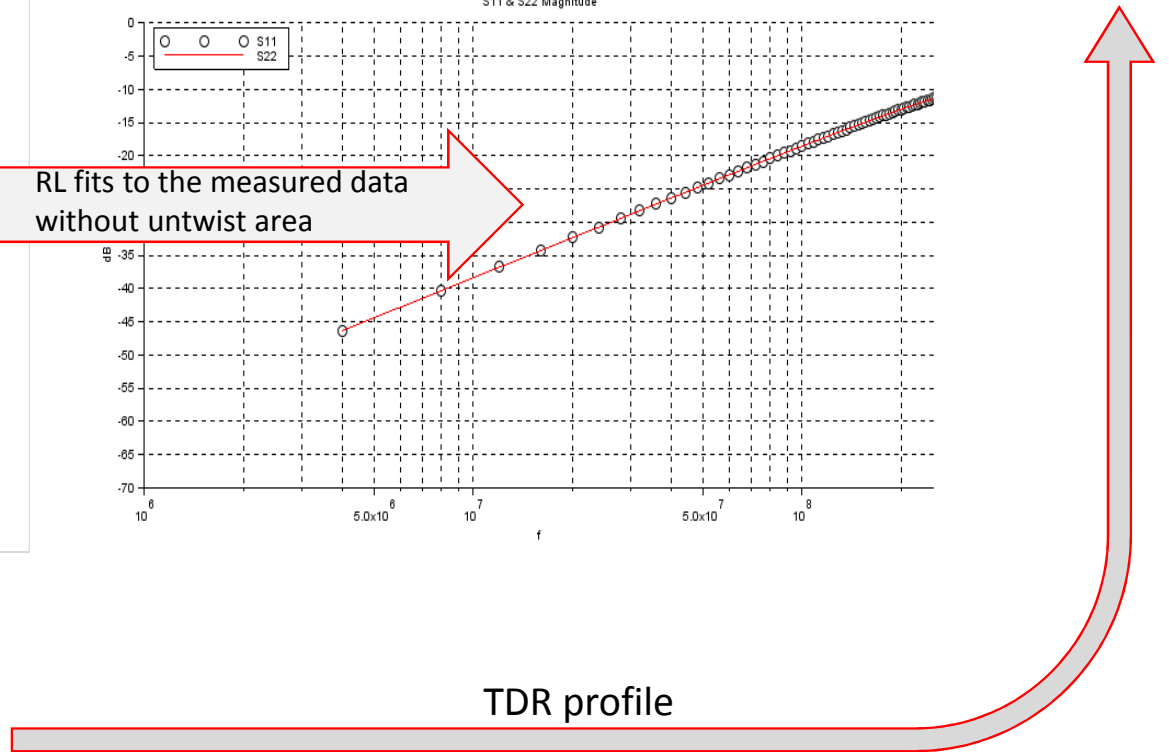
Transmission Line Model – 4mm Header (Mated MDI Connector)

S11 & S22 Magnitude

TDR Impedance, tr=35ps
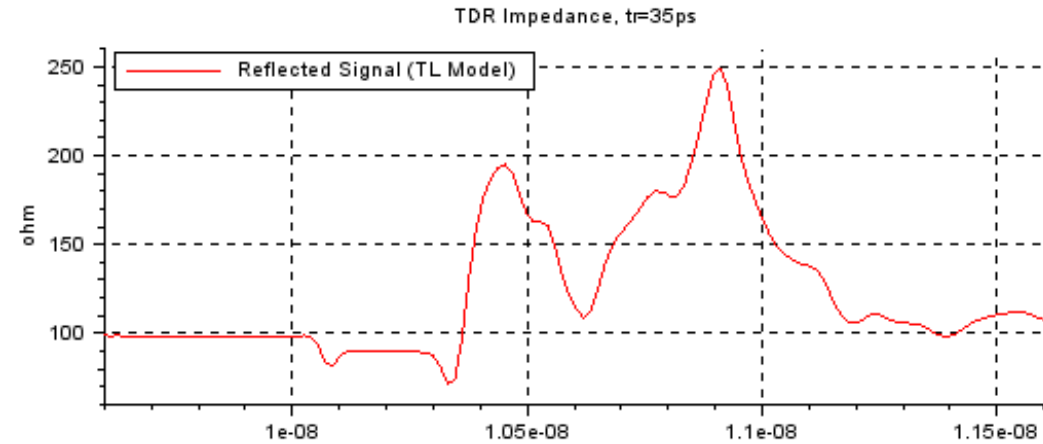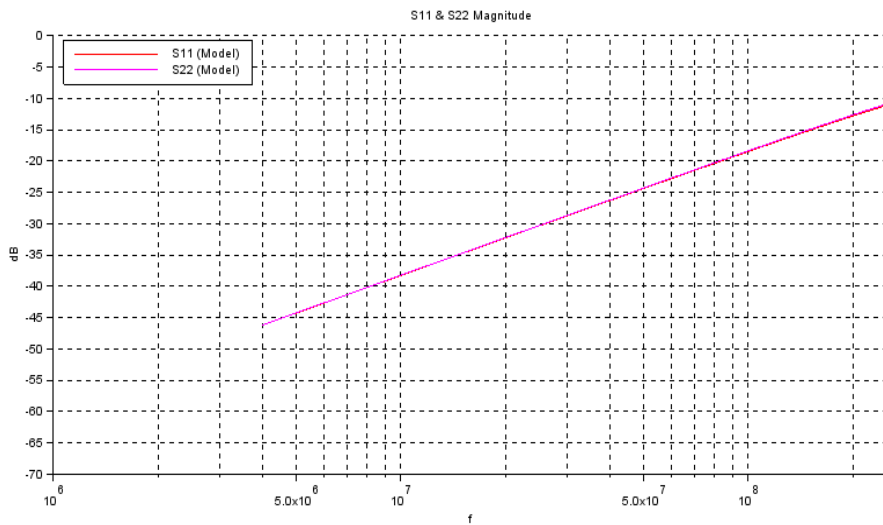
SMA+FR4+Solder Lands

TDR profile
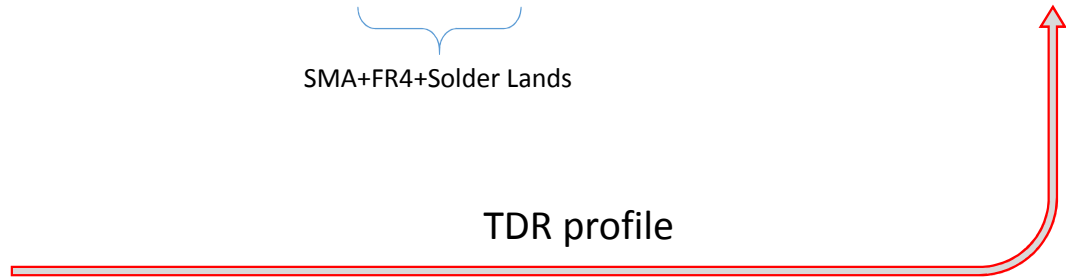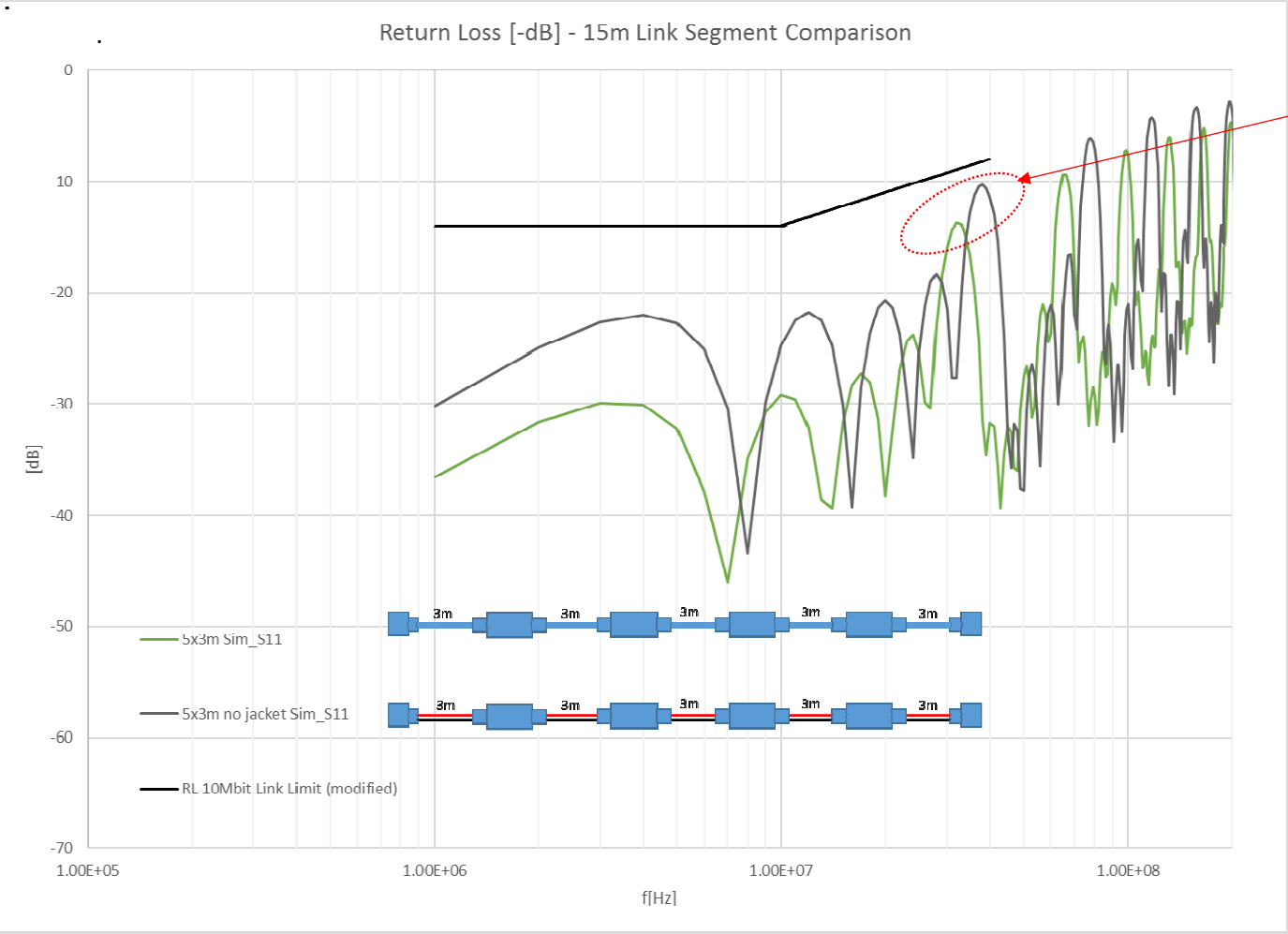
Parameter model (5 concatenated waveguides):

4mm Header (left side is PCB)	header leads	pin in housing	pin	spring body rigth	wire & crimp right	Total length (mm)
Zw	230	150	190	85	210	
vp	2,47E+08	2,10E+08	2,20E+08	2,10E+08	2,54E+08	
len	0,015	0,005	0,004	0,008	0,03	62

Worst Case Link Segment Comparison

5x3m causes worst case impedance mismatch in 10SPE Frequency Band of interest (< 40MHz)

Longer length segments cause the first peak to move to the left

Less segments of identical length causes the magnitude of the peaks to be lower

Other Simulated Parameters:
- 45mm jacket stripping length
- 2x0.35mm², 95 Ohm, FlexRay type Cable with jacket
- 20 degrees C
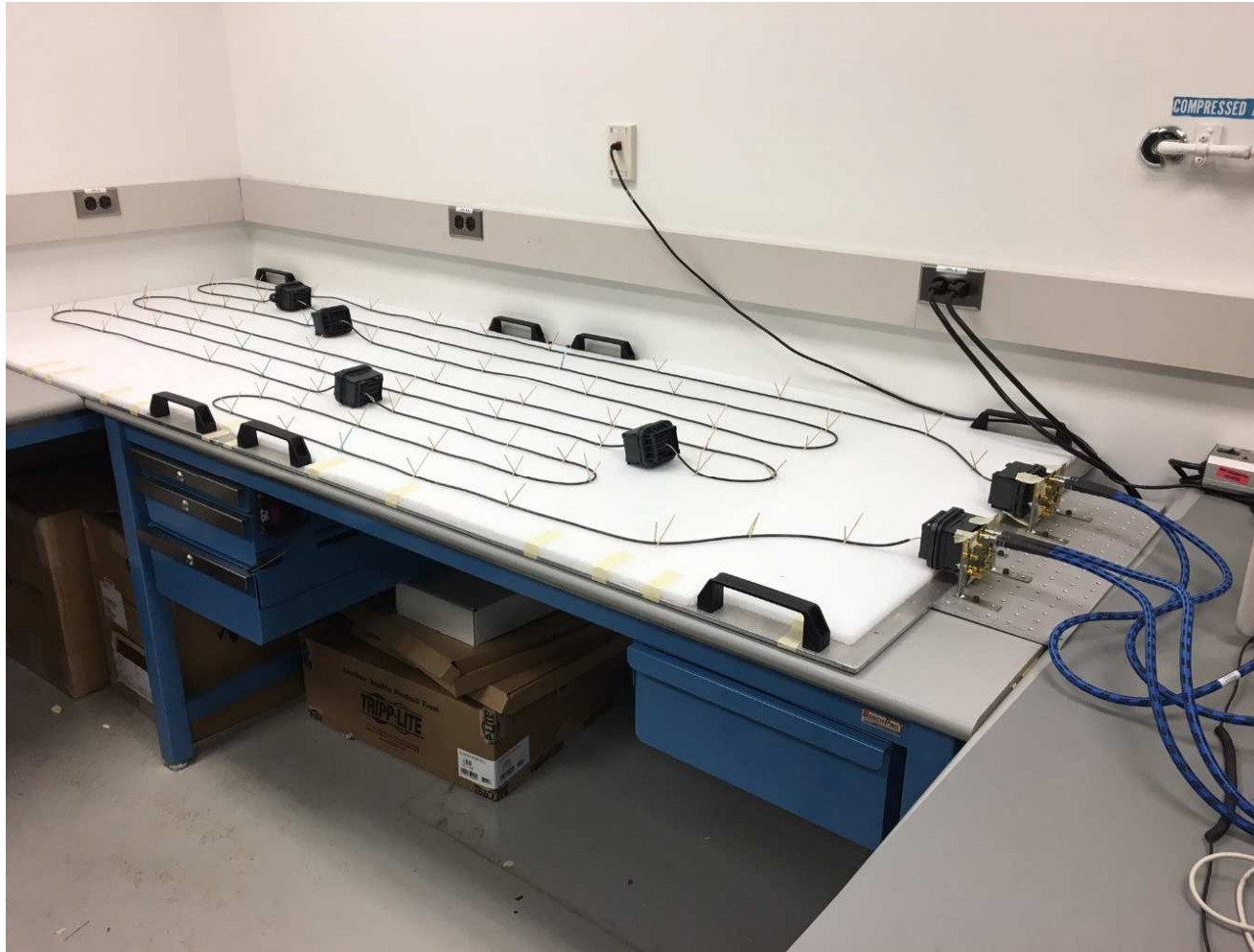
Jacketed vs. Unjacketed Cable Comparison

Return Loss [-dB] - 15m Link Segment Comparison

Worst case cable (lower attenuation due to construction **without** jacket,
- 2x0.35mm², 90 Ohm,
- 20 degrees C

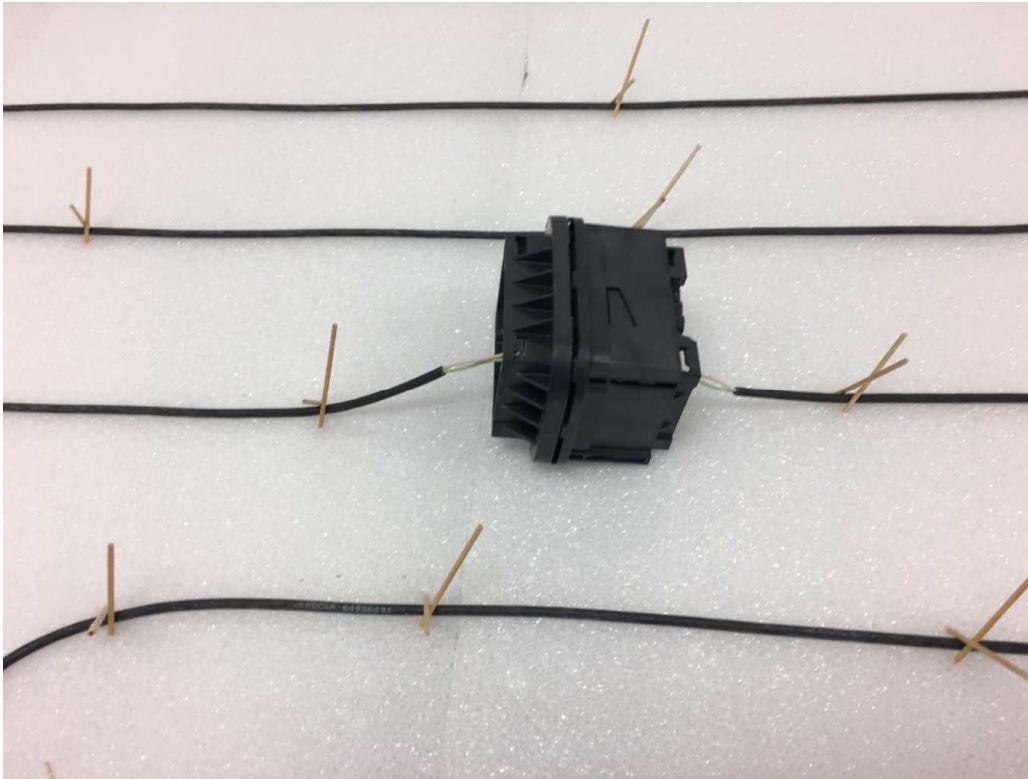# 5x3m Link Segment Measurements

5x3m Link Segment

Testing Parameters:
- 35mm^2 FlexRay type Cable with 45mm jacket striping length
- 4mm single wire seal connectors
- ~20 degrees C
- 10mm Styrofoam to keep UTP above GND Plane
- Distance of the meanders > 30mm
- Renormalization of the CM impedance (25Ω → 200Ω)
- Toothpicks to keep cable flat against Styrofoam.

5x3m Link Segment

110mm total untwist length for each inline connector
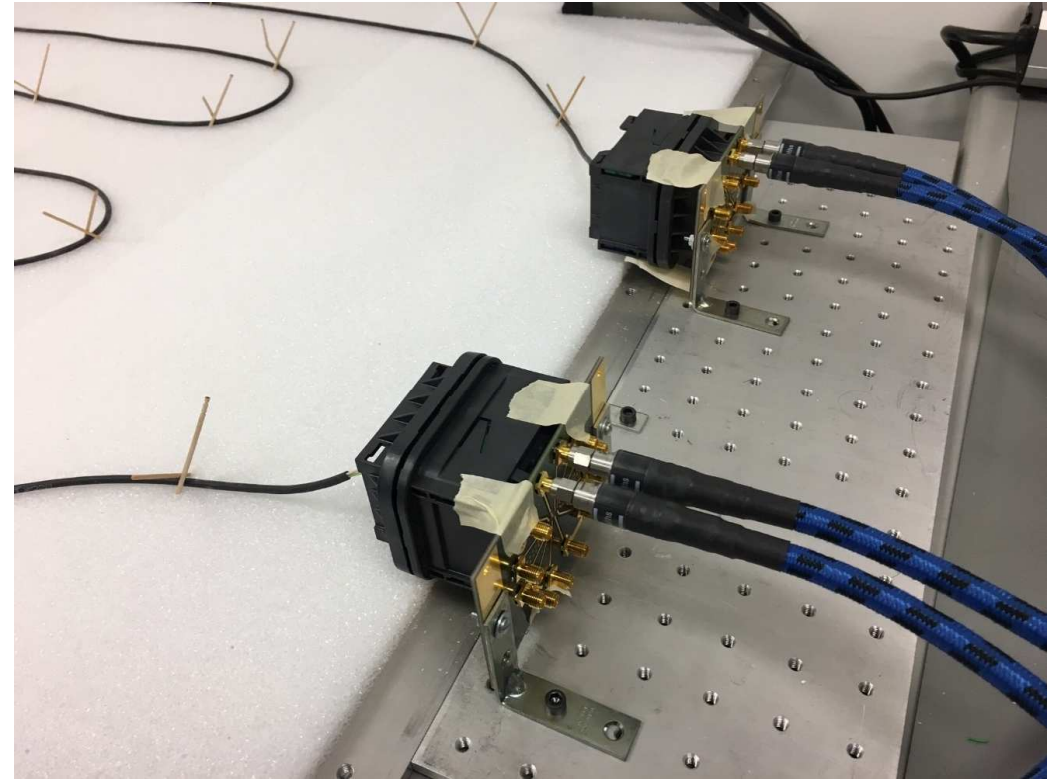
Terminated wires soldered directly to PCB for SMA connections to the VNA cables

Return Loss 5x3m Link Segment
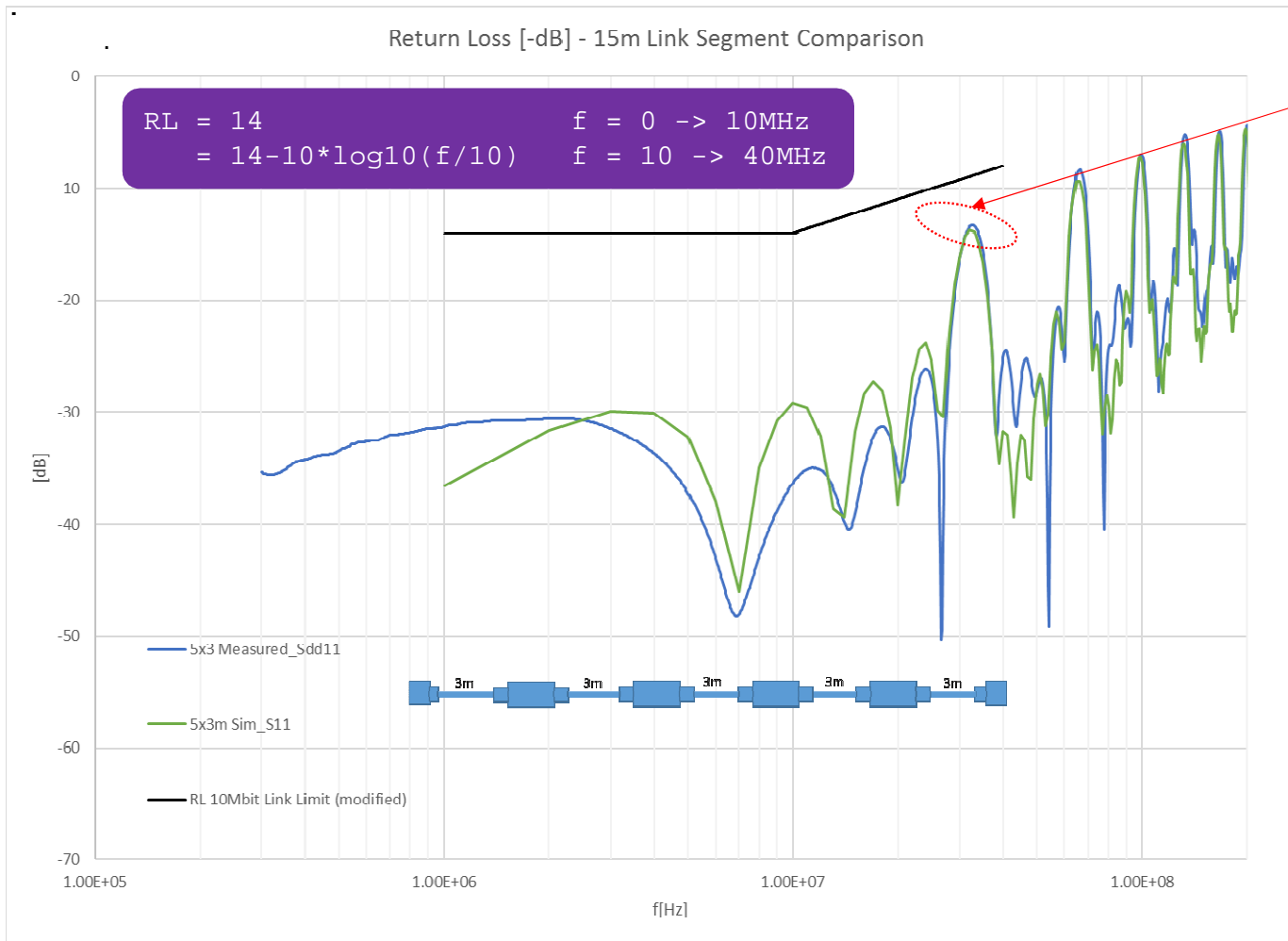
Measured data matches very well with simulations

Proposed Return Loss Limits from:

http://www.ieee802.org/3/cg/public/adhoc/kaindl_matheus_3cg_01_0817.pdf

– and –

8/2/2017 Email from Oisin Ocuanachain to reflector [802.3_10SPE] Comment on 'Automotive Link Segment for 10SPE' presentation

Insertion Loss - 5x3m Link Segment

Insertion Loss [-dB] - 15m Link Segment Comparison

$$IL = 0.2+0.004*f+0.8*SQRT(f)+0.07*(1/SQRT(f))$$
$$for\ f = 1 \rightarrow 40MHz$$

5x3 Measured_Sdd21

5x3m Sim_S21

IL 100Mbit Link Limit

IL 10Mbit Link Limit (original)

Measured data matches very well with simulations

Proposed Insertion Loss Limits from:

http://www.ieee802.org/3/cg/public/adhoc/kaindl_matheus_3cg_01_0817.pdf

Keep 100Mbit Link Limit but just lower to 40MHz

Reflected Mode Conversion - 5x3m Link Segment

LCL [-dB] - 15m Link Segment with 4 Inlines - Reflected Mode Conversion

Legend:
- 4mm pitch Sdc11
- 4mm pitch Sdc22
- Mode Conversion 100Mbit Link Limit
- Mode Conversion 10Mbit Link Limit (modified)

$$MC = 30 \qquad\qquad f = 0 \; -> \; 20MHz$$
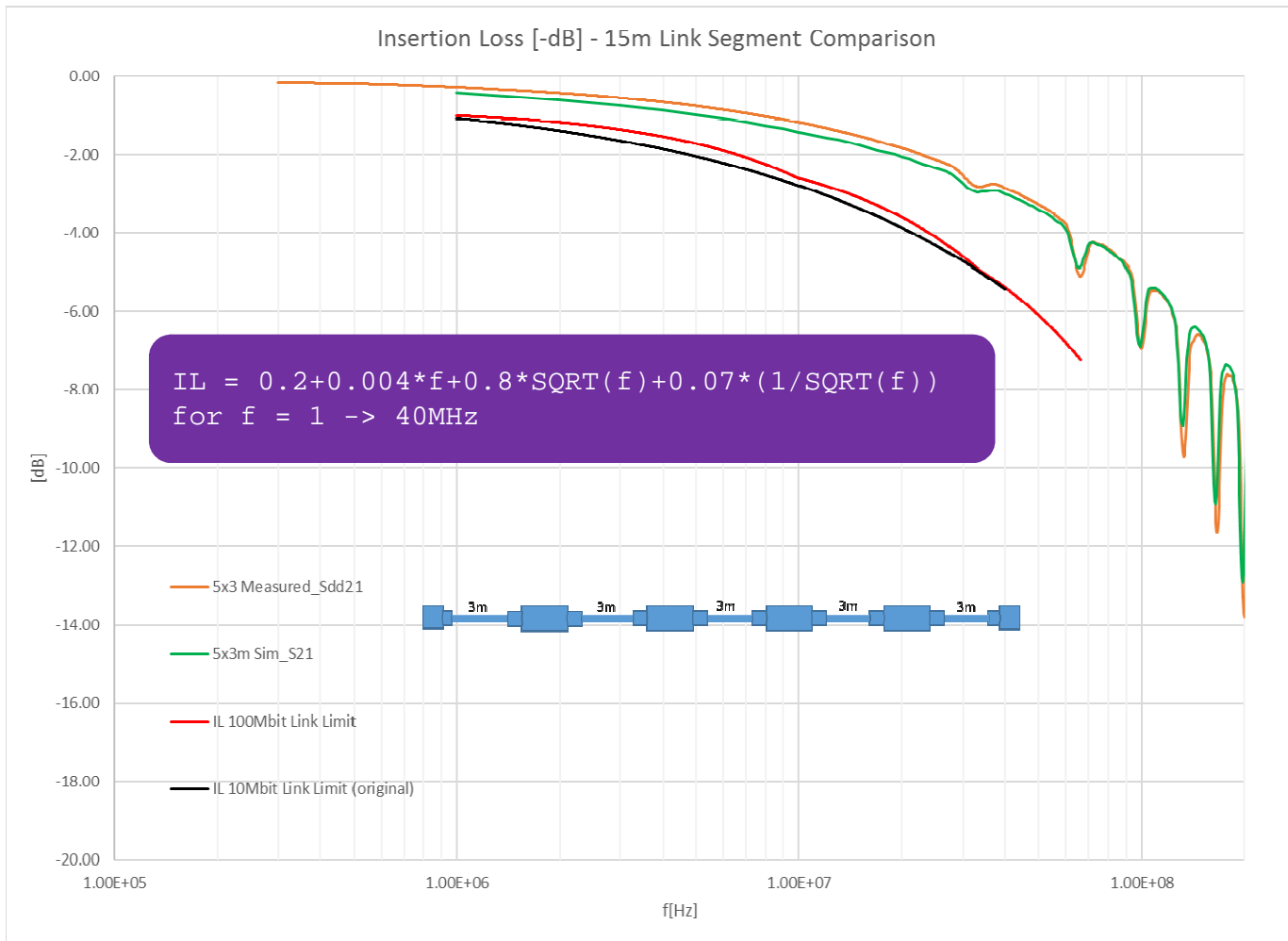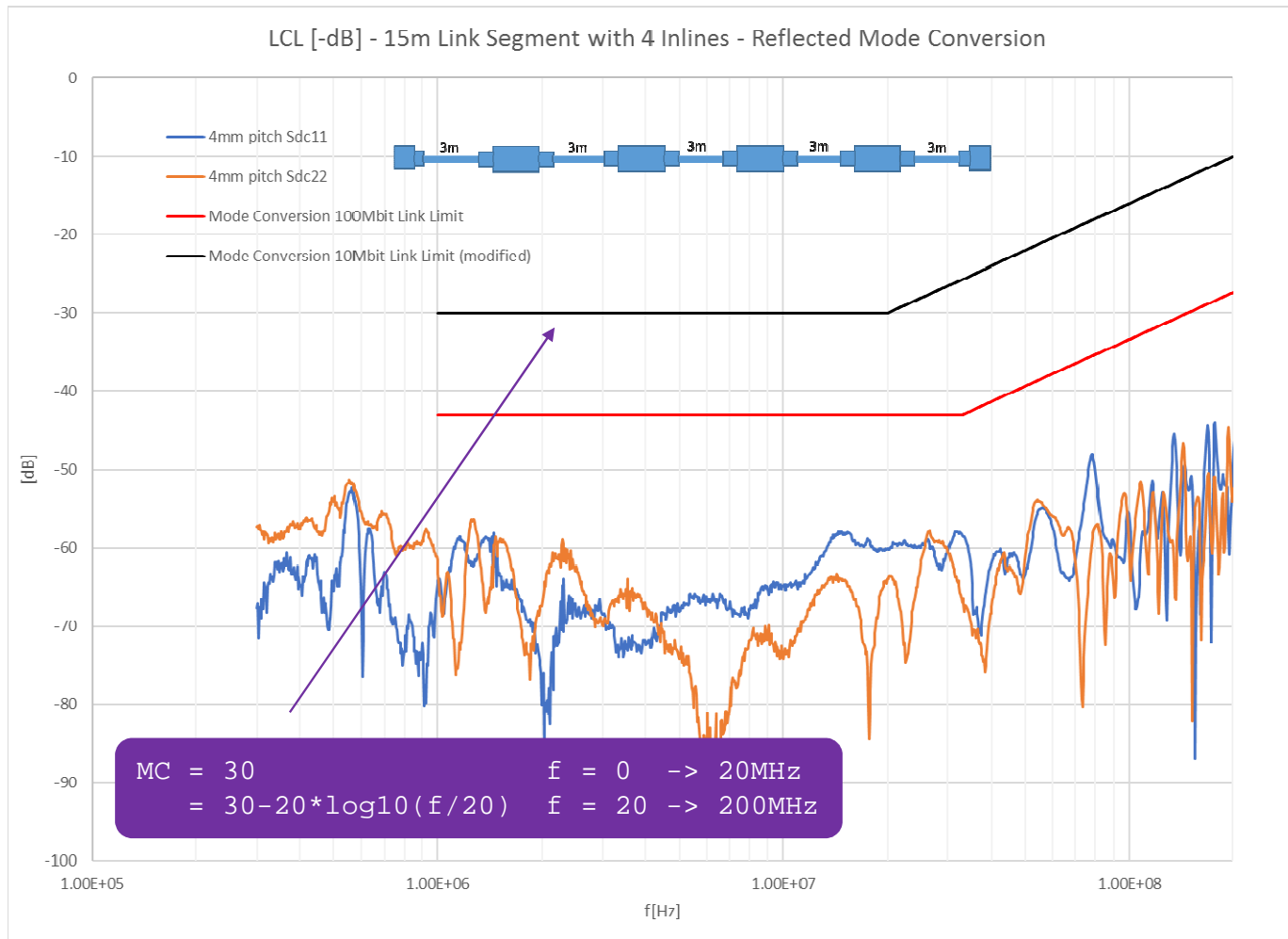$$= 30-20*log10(f/20) \quad f = 20 \; -> \; 200MHz$$

Proposed Mode Conversion Limit from:

http://www.ieee802.org/3/cg/public/adhoc/kaindl_matheus_3cg_01_0817.pdf

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Transmitted Mode Conversion - 5x3m Link Segment

LCTL [-dB] - 15m Link Segment with 4 Inlines - Transmitted Mode Conversion

Legend:
- 4mm pitch Sdc12
- 4mm pitch Sdc21
- Mode Conversion 100Mbit Link Limit
- Mode Conversion 10Mbit Link Limit (modified)

MC = 30   f = 0 -> 20MHz
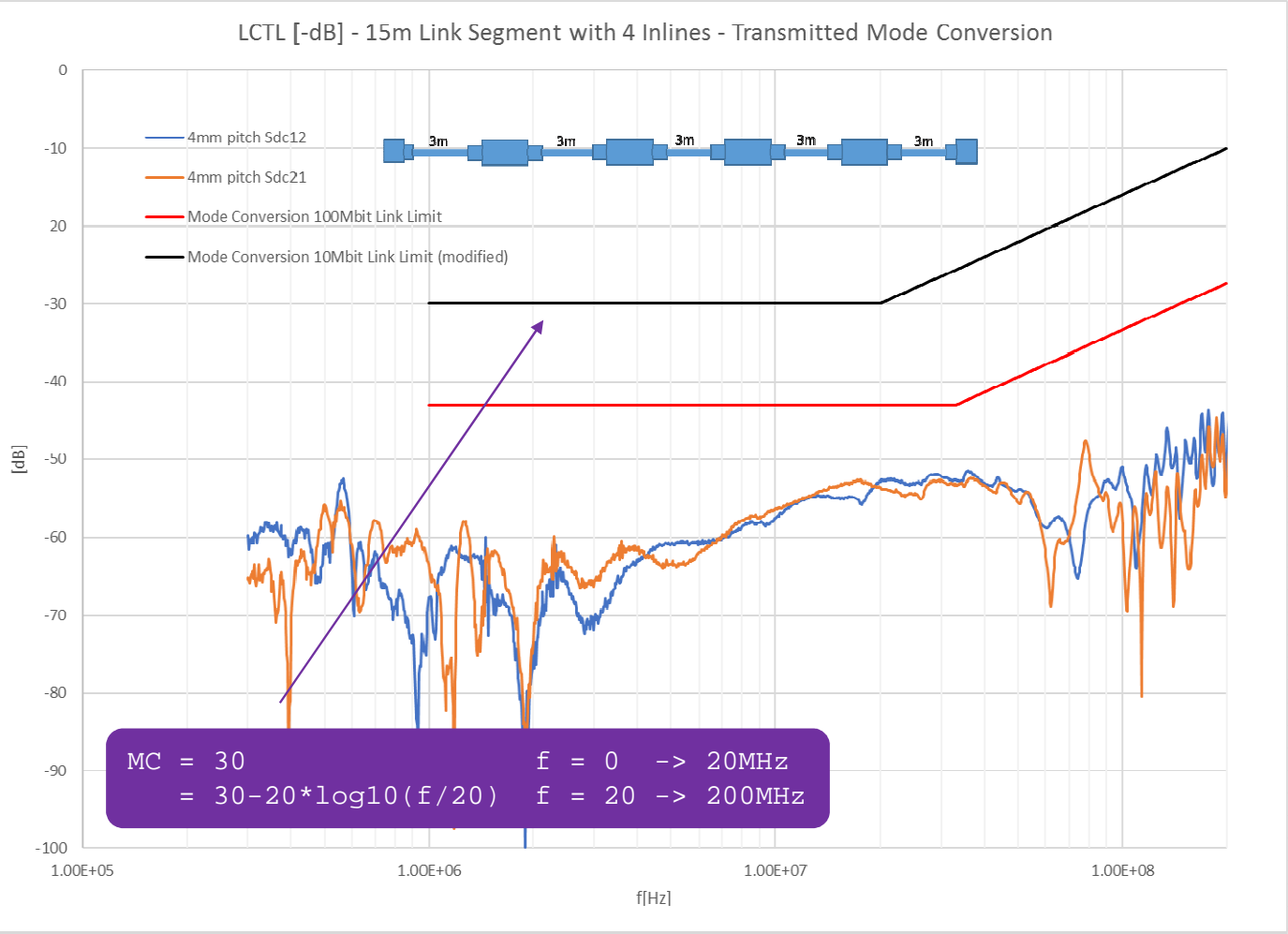   = 30-20*log10(f/20) f = 20 -> 200MHz

Proposed Mode Conversion Limit from:

http://www.ieee802.org/3/cg/public/adhoc/kaindl_matheus_3cg_01_0817.pdf

– and –

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Worst Case Connector Cross Mode Conversion

LCTL [-dB] - 15m Link Segment with 4 Inlines - Transmitted Mode Conversion

Legend:
- 4mm pitch Sdc12
- 4mm pitch Sdc21
- Conn. Only Mode Conversion (Worst Case)
- Mode Conversion 100Mbit Link Limit
- Mode Conversion 10Mbit Link Limit (modified)

MC = 30   f = 0 -> 20MHz
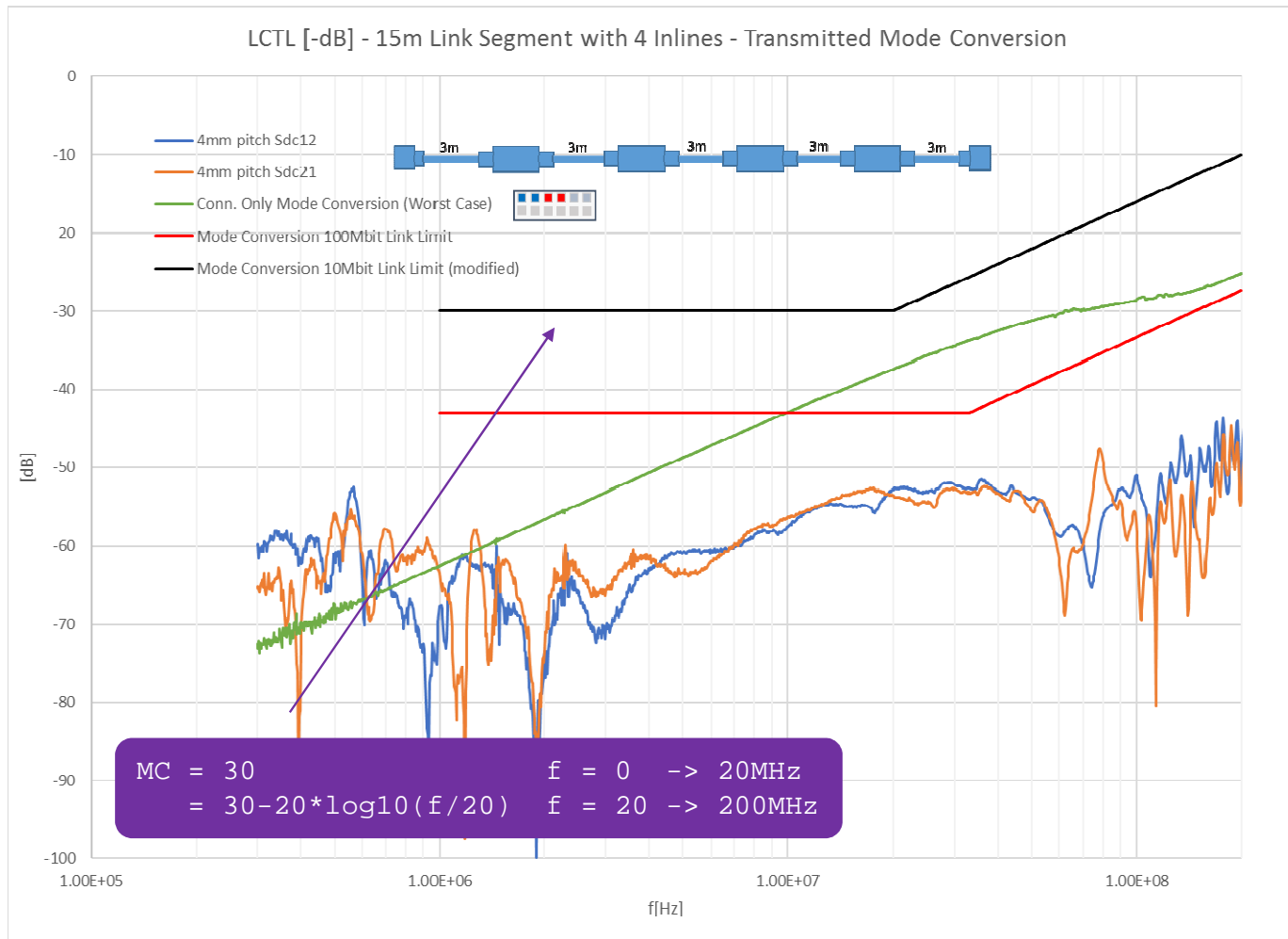   = 30-20*log10(f/20) f = 20 -> 200MHz

Proposed Mode Conversion Limit from:

http://www.ieee802.org/3/cg/public/adhoc/kaindl_matheus_3cg_01_0817.pdf

– and –

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Conclusions

- 4mm pitch connectors used for CAN and FlexRay applications can also be used for 10SPE
- Such connectors were not designed for RF applications and are not being used for 100Base-T1
- Worst case link segment was found by simulation (5x3m, 4 inlines)
- Simulations shown to correlate to measurement results
- Previously proposed link segment limits align well to test results
- Some margin is assumed for temperature and component tolerances

Conclusion – Proposed Link Limits

```
Return Loss (f)      > 14 dB                        for f  (1MHz  -> 10MHz)
                     > 14 - 10*log10(f/10) dB       for f  (10MHz -> 40MHz)
```
Same as previously proposed

```
Insertion Loss (f) < 1.0 + 1.6*(f-1)/9   dB        for f (1MHz  -> 10MHz)
                   < 2.6 + 2.3*(f-10)/23 dB        for f (10MHz -> 33MHz)
                   < 4.9 + 2.3*(f-33)/33 dB        for f (33MHz -> 40MHz)
```
Same as 802.3bw but limited to 40MHz

```
Mode Conversion Loss (f) > 30 dB                   for f (1MHz  -> 33MHz)
                         > 30-20*log10(f/20) dB  for f (33MHz -> 200MHz)
```
Same as previously proposed

Thank You!!