Reduced Twisted Pair Gigabit Ethernet SG Channel Definitions Ad Hoc Report

Victoria, BC, Canada
May 2013

Ad hoc – co-chairs
Chris DiMinico –
MC Communications
Mehmet Tazebay –
Broadcom

Channel Definitions Ad Hoc

- Ad Hoc charted to develop channel definitions
- Initial meeting IEEE Interim May 2012
- Communications via RTPGE reflector
- Follow-on conference calls
  - June 14, 2012, November 1, 2012, December 13, 2012, January 10, 2013, May 2, 2013, May 9, 2013

Minutes - Channel definitions ad hoc minutes

Minutes– May 2, 2013

May 2 Agenda

- Reviewed IEEE patent
- Review : RTPGE Link segment definitions decision process (diminico_3bp_02_0313.pdf) Orlando, Florida, March 2013
- Review: UNH testing update – Curtis Donahue, Dave Estes
- Review: Channel Measurement Results RTPGE – Return Loss & Insertion Loss Bert Bergner / Jens Wülfing - TE Connectivity
- Review: Update to (diminico_02_0313_rtpge.pdf)

Summary: Focused discussion on channel insertion loss and return loss with consideration for consensus proposal to be completed May 9 ad hoc.

Minutes - Channel definitions ad hoc minutes

Minutes– May 9, 2013

May 9 Agenda

•Review: Channel performance contribution from -Todd Herman CommScope

•Review: UNH testing update – Curtis Donahue, Dave Estes

•Review: Channel definition insertion Loss and return loss consensus – C DiMinico

•Update Industrial Cabling standardization – Bob Lounsbury, Rockwell Automation

•Summary:

–Observation in UNH testing update that balance of link with connectors better than link with cable and no connectors.

–Ad hoc consensus to utilize insertion model from Channel Performance contribution – Todd Herman and Channel definition insertion Loss and return loss consensus – Chris DiMinico, MC Communications

– Ad hoc consensus to utilize TIA return loss model staring with Category 6A cable and Category 6A connectors in channel definition insertion loss and return loss consensus – Chris DiMinico, MC Communications

–Observation: RL measurement contributions presented with better RL performance than Todd's proposed limits. RL critical parameter and final limits need to be carefully considered with phy performance.

RTPGE Channel definitions ad hoc insertion loss and return loss consensus

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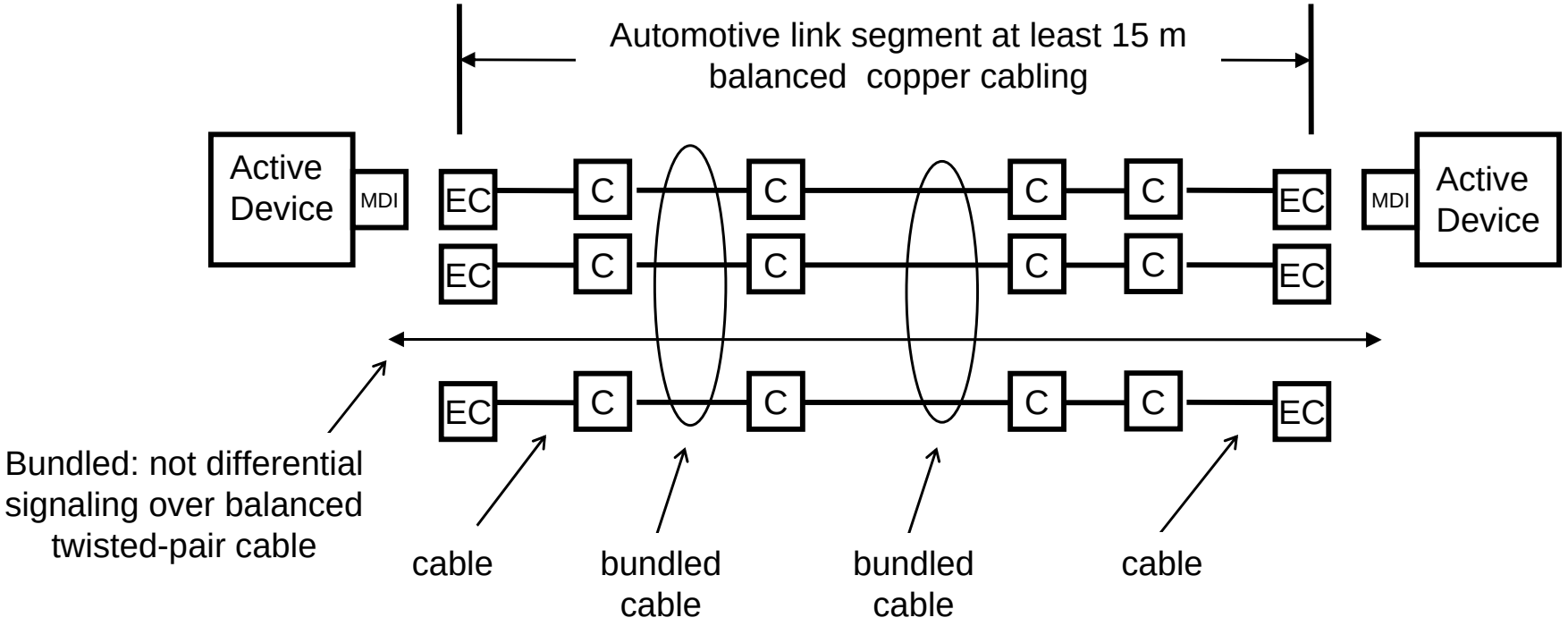
Summary

- Insertion loss and return loss proposal developed from
  - diminico_02_0313_rtpge.pdf
  - Channel performance ad hoc contribution from - Todd Herman CommScope

Automotive link segment



The IEEE 802.3 nomenclature is bracketed to identify relationship to the IEEE 802.3 definitions.

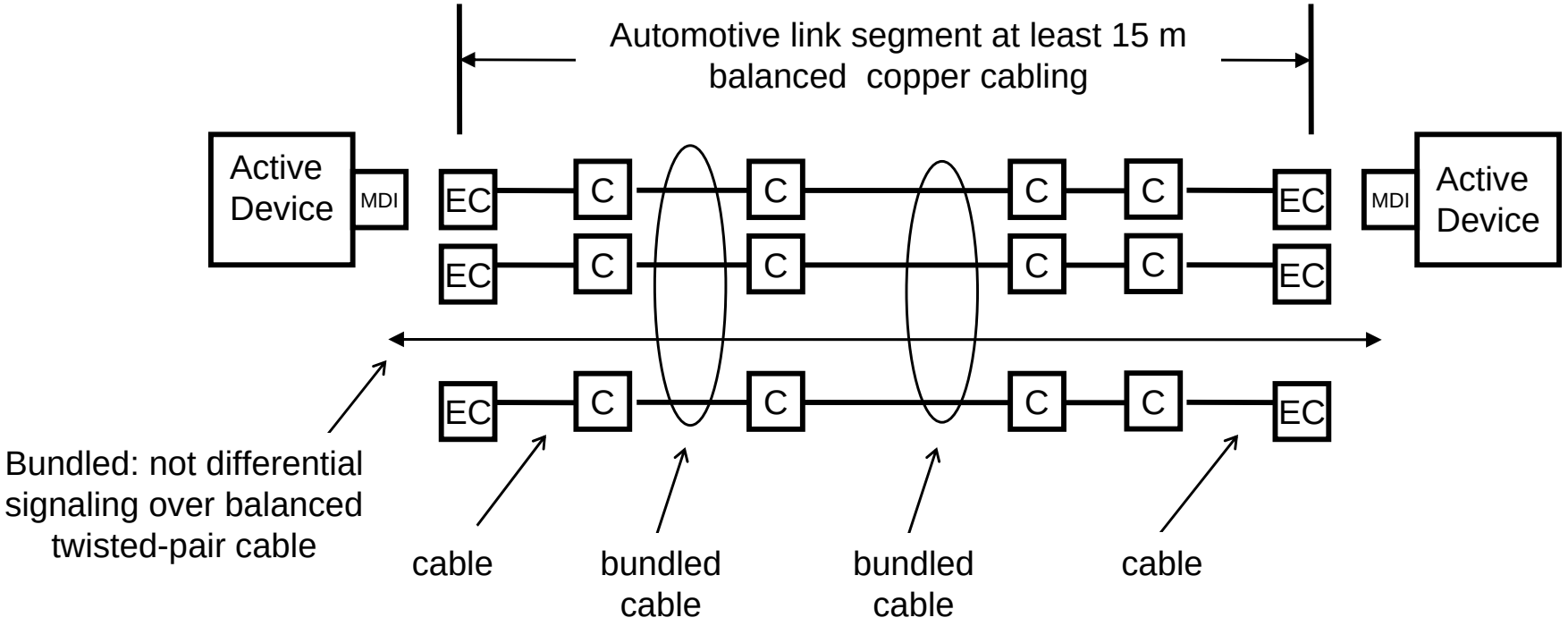
Length objective [EC] to [EC] at least15 m
Number of inline connectors [C] = 4

C = inline connector

EC = connection to equipment

MDI = Active electronics connector [Medium dependent interface (MDI)]

Link segment transmission parameters



Link segment transmission and coupling parameters

- *Insertion loss*, return loss
- NEXT, FEXT, multiple disturber crosstalk
- Alien Crosstalk
- Balance

Cable insertion loss dB @ 500 MHz

AWG	Diameter (in)	Diameter (mm)	dB/m at 500 MHz solid	dB/m at 500 MHz stranded	dB/15m stranded	dB/40m stranded
22	0.025346	0.643795	0.40	0.48	7.25	19.35
23	0.022571	0.573314	0.45	0.54	8.15	21.72
24	0.020100	0.510549	0.51	0.61	9.15	24.39
25	0.017900	0.454655	0.57	0.68	10.27	27.39
26	0.015940	0.404881	0.64	0.77	11.54	30.76
27	0.014195	0.360555	0.72	0.86	12.95	34.54
28	0.012641	0.321083	0.81	0.97	14.55	38.79
29	0.011257	0.285931	0.91	1.09	16.33	43.56
30	0.010025	0.254628	1.02	1.22	18.34	48.91
31	0.008927	0.226752	1.14	1.37	20.60	54.93
32	0.007950	0.201928	1.28	1.54	23.13	61.68

- IL(f)
- Reference IL (dB/100m) =1.82*SQRT(f)+0.0091*f+0.25/SQRT(f)
- Reference IL (dB/m) = 0.01*(1.82*SQRT(f)+0.0091*f+0.25/SQRT(f))
- 20% increase for stranded (dB/m) = 1.2*(0.01*(1.82*SQRT(f)+0.0091*f+0.25/SQRT(f)))
- 12% increase per gauge (dB/m) = 1.12*(0.01*(1.82*SQRT(f)+0.0091*f+0.25/SQRT(f)))

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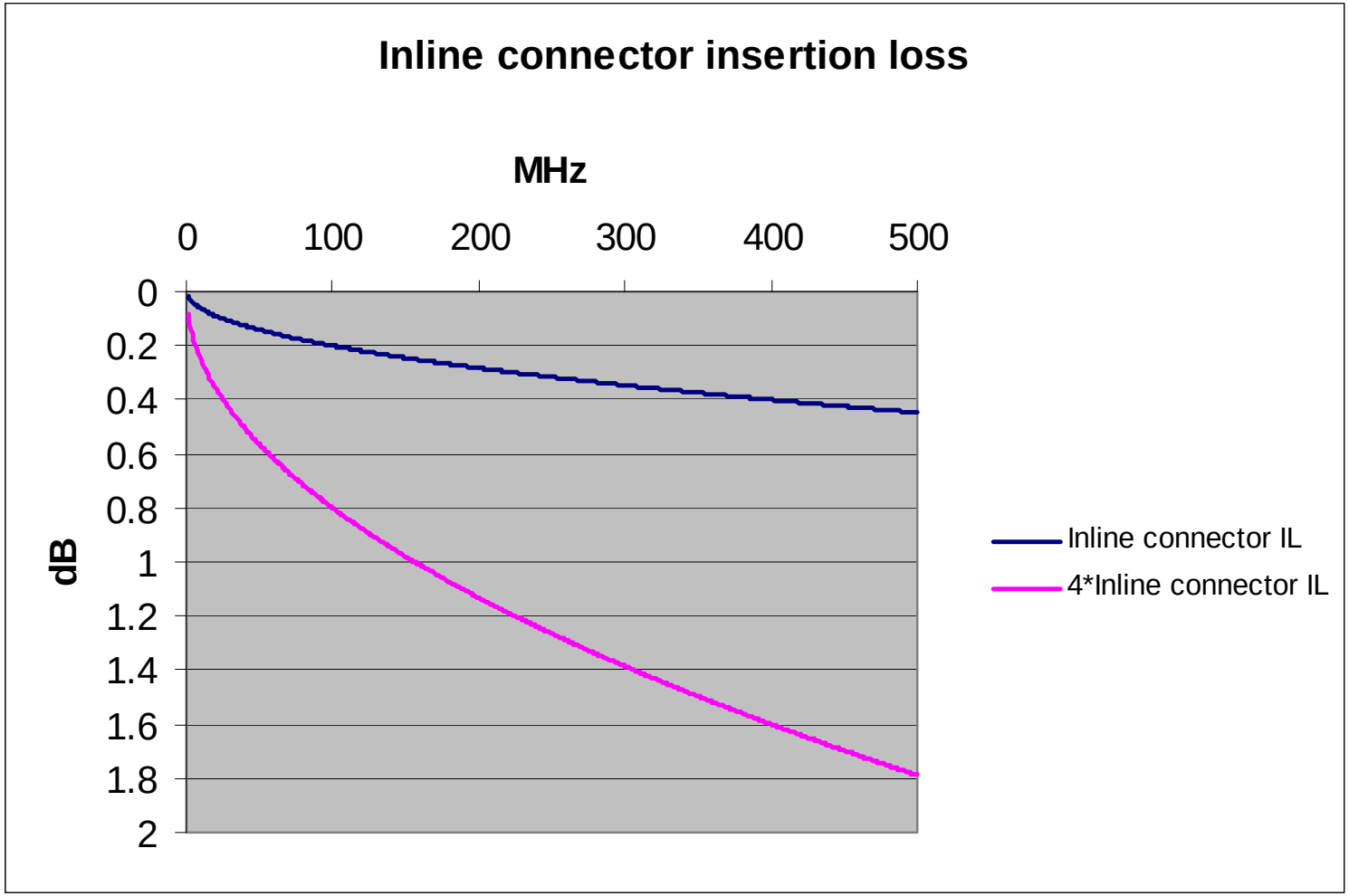
Inline connector insertion loss

- Inline connector IL(f) = x*sqrt(f)
- x=0.02*sqrt(f)



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ANSI/TIA/EIA-568-C.2 – Cable insertion Loss

Temperature correction

•The maximum insertion loss for UTP horizontal cables shall be adjusted at elevated temperatures using a factor of 0.4 % increase per °C from 20 °C to 40 °C and 0.6% increase per °C for temperatures from 40 °C to 60 °C.

•The maximum insertion loss for ScTP horizontal cables shall be adjusted at elevated temperatures using a factor of 0.2% increase per °C from 20 °C to 60 °C.

Source: diminico_02_0313_rtpge.pdf

Channel Performance Formulation Proposal -Todd Herman CommScope

equations for insertion loss of 1-pair ethernet channel

For 20 degrees C and AWG 23

$$IL := \left(1.2 \cdot \frac{L}{100}\right) \cdot \left(1.82 \cdot \sqrt{f} + .0091 \cdot f + \frac{.25}{\sqrt{f}}\right) + B \cdot .02 \cdot \sqrt{f}$$

Inline connector IL

where

B := number of connectors

f := frequency_MHz

L .. length_m

20% increase for stranded

Category 6A reference (23 AWG)

For any temperature above 20 degrees C and for any conductor size

$$IL := [1 + .004 \cdot (T - 20)] \cdot \left(1.2 \cdot \frac{L}{100}\right) \cdot \left[\frac{1.82}{92^{\frac{(23-n)}{39}}} \cdot \sqrt{f} + .0091 \cdot f + \frac{.25}{\sqrt{f}}\right] + B \cdot .02 \cdot \sqrt{f}$$

~12% increase for each gauge reduction

where

T := Temperature in degrees_C

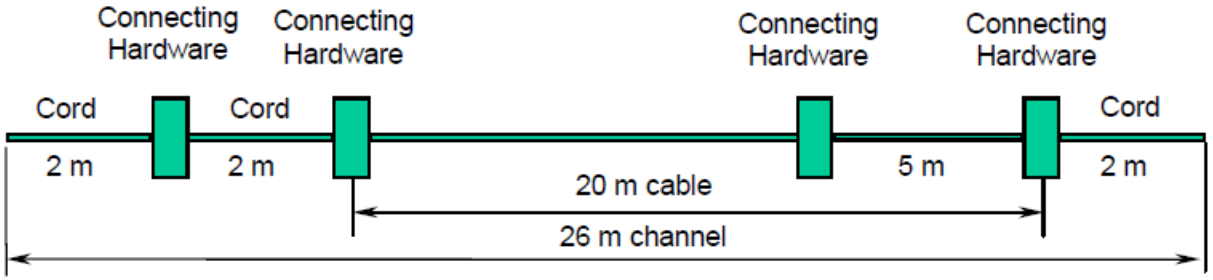
n := conductor_size_in_AWG

insertion loss adjusted using a factor of 0.4 % increase per °C from 20 °C to 125 °C

Link segment return loss

- **Use ANSI/TIA-568-C.2 Annex I (informative) - Development of channel and component return loss limits as basis for RTPGE link segment RL limits.**
- **Use Category 6A cable and connector return losses as basis for return loss limit modeling of automotive link segment…example below…**

Modeling configuration example



Category 6A Channel Return Loss

Category 6A	$1 \le f < 10$ $10 \le f < 40$ $40 \le f < 398.1$ $398.1 \le f \le 500$	19 $24\text{-}5\log(f)$ $32\text{-}10\log(f)$ 6

Automotive operating environment

Lifetime Requirements and Testing of ECUs

Active Operation: Typical Temperature-Load Distribution (ambient)

$T_{I,ECU}$ = ECU inner air temperature	Typ. load (Passenger Car)	
	Vehicle body, bulkhead, extension close to the engine	
-40°C..10° C	6.0 %	480 h
10°C...45° C	20.0 %	1600 h
45°C...60° C	33.0 %	2640 h
60°C...70° C	18.0 %	1440 h
70°C...80° C	9.0 %	720 h
...85° C	3.0 %	240 h
...90° C	2.0 %	160 h
...95° C	1.7 %	136 h
...100° C	1.5 %	120 h
...105° C	1.4 %	112 h
...110° C	1.3 %	104 h
...115° C	1.2 %	96 h
...120° C	1.0 %	80 h
...125° C	0.9 %	72 h
Total	**100%**	**8000 h**

http://grouper.ieee.org/groups/802/3/RTPGE/public/july12/hoganmuller_01a_0712.pdf

Summary

- **Use insertion loss closed form equations slide 8 for link segment insertion losses**
- **Use ANSI/TIA-568-C.2 Annex I (informative) - Development of channel and component return loss limits as basis for RTPGE link segment RL limits.**
- **Use Category 6A cable and connector return losses as basis for return loss limit modeling for automotive link segment**