
Reduced Twisted Pair Gigabit Ethernet Link Segment Characteristics

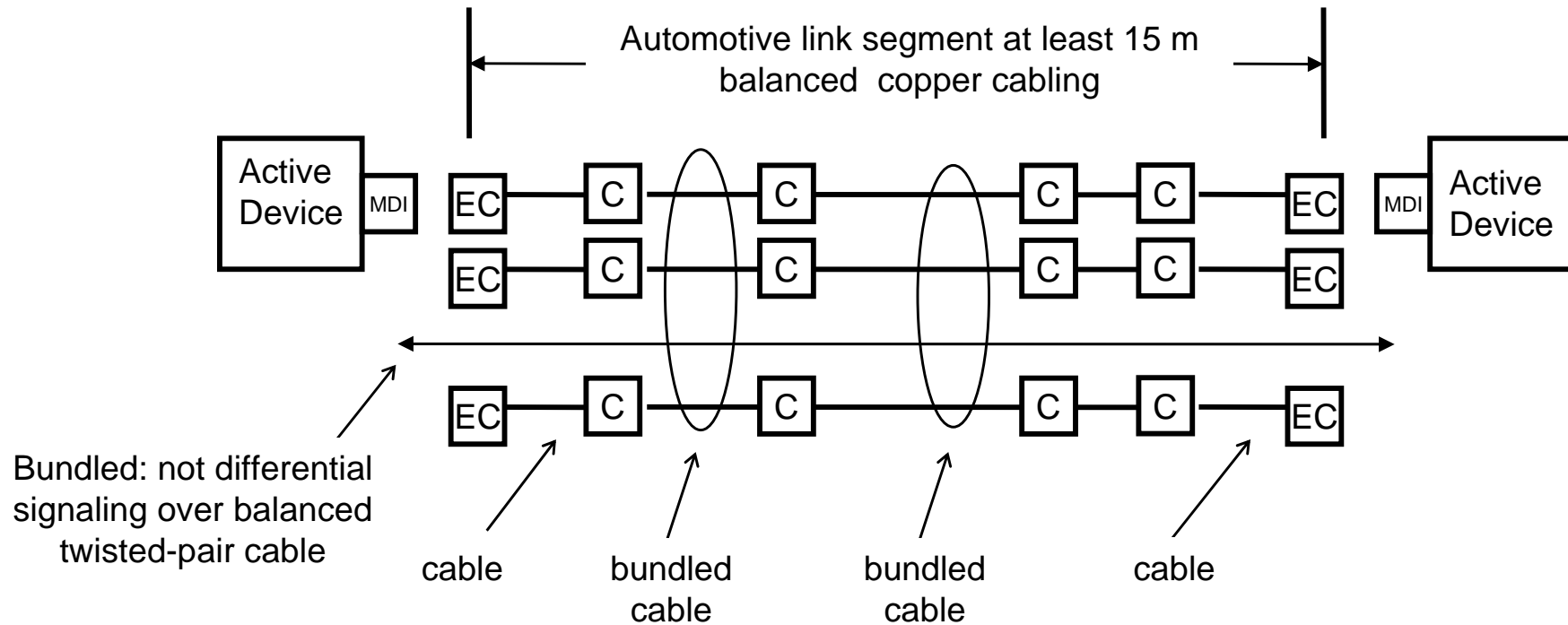
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Discussion

- **Identification of link segment insertion losses for target topologies (15m and 40m) derived from cable and inline connector insertion losses**
 - **Inclusion of gauge and temperature dependencies**
- **Link segment insertion losses required for PHY considerations.**

Automotive link segment

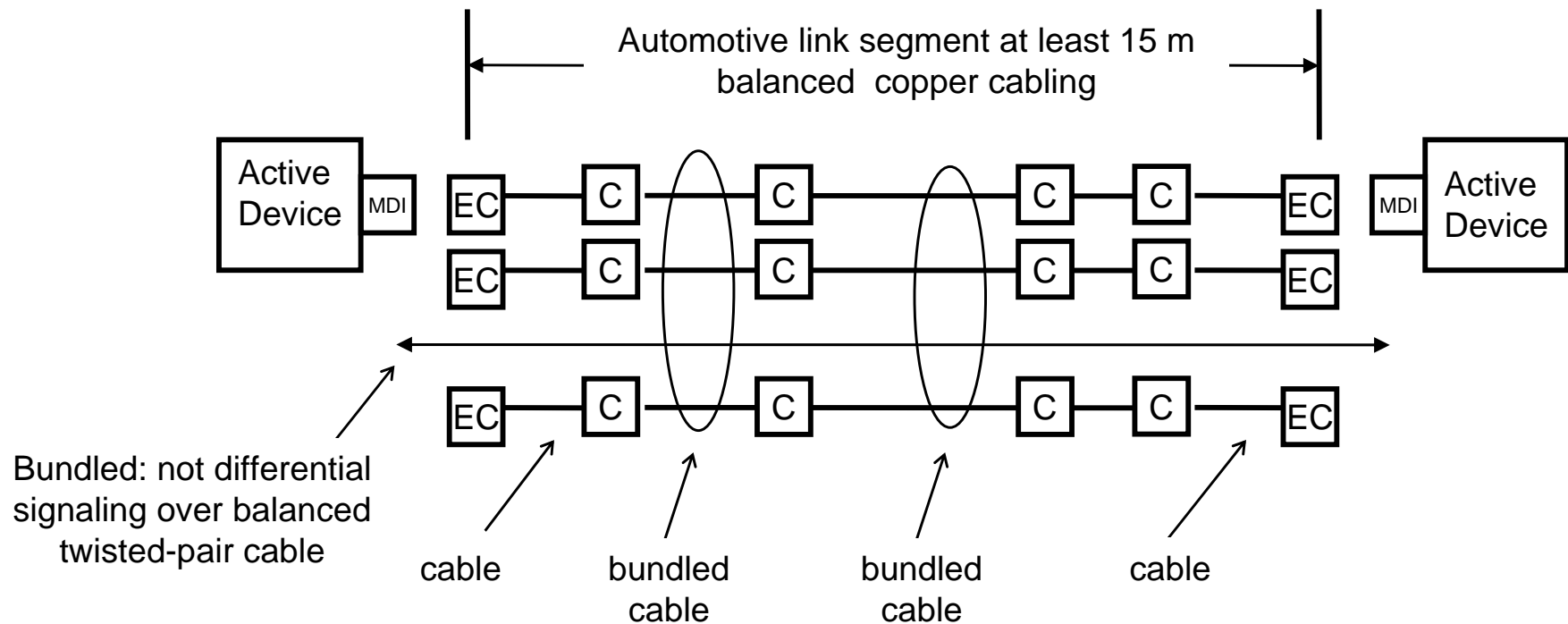


The IEEE 802.3 nomenclature is bracketed to identify relationship to the IEEE 802.3 definitions.

Length objective [EC] to [EC] at least 15 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

**commercially available specified to 500 MHz*

***~12% increase per gauge*

****20% increase for stranded*

*Reference IL = 1.82 * SQRT(f) + 0.0091 * f + 0.25 / SQRT(f)*

Usage of 26 and 27 stranded reported by survey respondents

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.

UTP temperature correction to 60 °C

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	0.488	0.59	8.78	23.40
23	0.022571	0.573314	0.547	0.66	9.85	26.28
24	0.020100	0.510549	0.615	0.74	11.07	29.51
25	0.017900	0.454655	0.690	0.83	12.43	33.13
26	0.015940	0.404881	0.775	0.93	13.95	37.21
27	0.014195	0.360555	0.870	1.04	15.67	41.78
28	0.012641	0.321083	0.977	1.17	17.59	46.92
29	0.011257	0.285931	1.098	1.32	19.76	52.69
30	0.010025	0.254628	1.233	1.48	22.19	59.16
31	0.008927	0.226752	1.384	1.66	24.91	66.44
32	0.007950	0.201928	1.554	1.87	27.98	74.61

UTP	deg C	Correction factors	dB/m corrected to 60 deg C	dB/m 20 deg C
0.40%	20 to 40	0.080	0.489	0.453
0.60%	40 to 60	0.120	0.547	

ScTP temperature correction to 60 °C

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	0.435	0.52	7.83	20.89
23	0.022571	0.573314	0.489	0.59	8.80	23.46
24	0.020100	0.510549	0.549	0.66	9.88	26.35
25	0.017900	0.454655	0.616	0.74	11.09	29.58
26	0.015940	0.404881	0.692	0.83	12.46	33.22
27	0.014195	0.360555	0.777	0.93	13.99	37.31
28	0.012641	0.321083	0.873	1.05	15.71	41.89
29	0.011257	0.285931	0.980	1.18	17.64	47.04
30	0.010025	0.254628	1.101	1.32	19.81	52.83
31	0.008927	0.226752	1.236	1.48	22.24	59.32
32	0.007950	0.201928	1.388	1.67	24.98	66.61

ScTP	deg C	Correction factor	dB/m Corrected to 60 deg C	dB/m 20 deg C
0.20%	20 to 60	0.080	0.489	0.453

Automotive operating environment

Lifetime Requirements and Testing of ECUs

Active Operation: Typical Temperature-Load Distribution (ambient)

T _{1,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

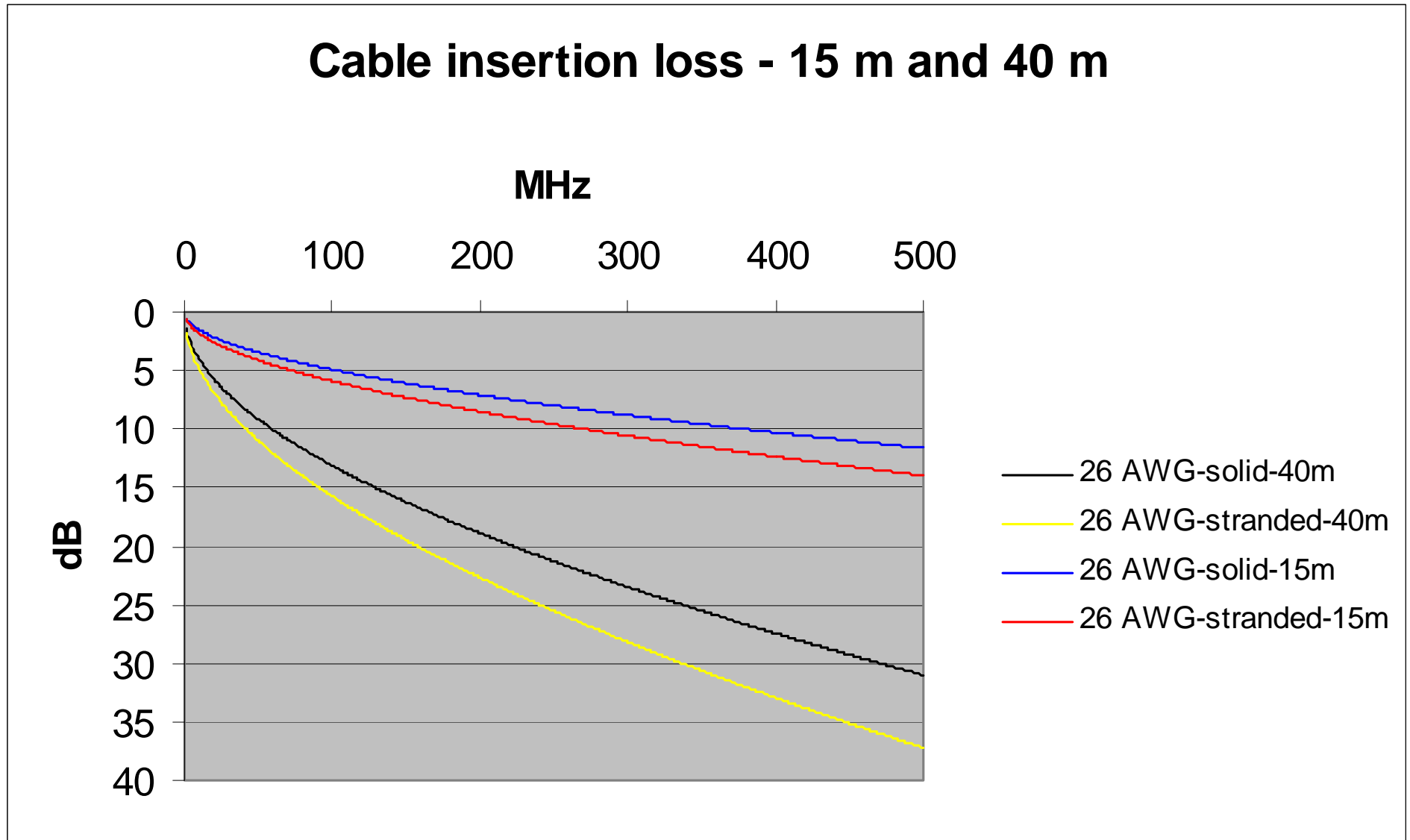


Non-PVC - Temperature correction to 125 °C

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	0.488	0.59	8.78	23.41
23	0.022571	0.573314	0.548	0.66	9.86	26.29
24	0.020100	0.510549	0.615	0.74	11.07	29.52
25	0.017900	0.454655	0.691	0.83	12.43	33.15
26	0.015940	0.404881	0.775	0.93	13.96	37.22
27	0.014195	0.360555	0.871	1.04	15.67	41.80
28	0.012641	0.321083	0.978	1.17	17.60	46.93
29	0.011257	0.285931	1.098	1.32	19.76	52.70
30	0.010025	0.254628	1.233	1.48	22.19	59.18
31	0.008927	0.226752	1.385	1.66	24.92	66.46
32	0.007950	0.201928	1.555	1.87	27.99	74.63

Non-PVC	deg C	Correction factor	dB/m Corrected to 60 deg C	dB/m 20 deg C
0.20%	20 to 125	0.210	0.548	0.453

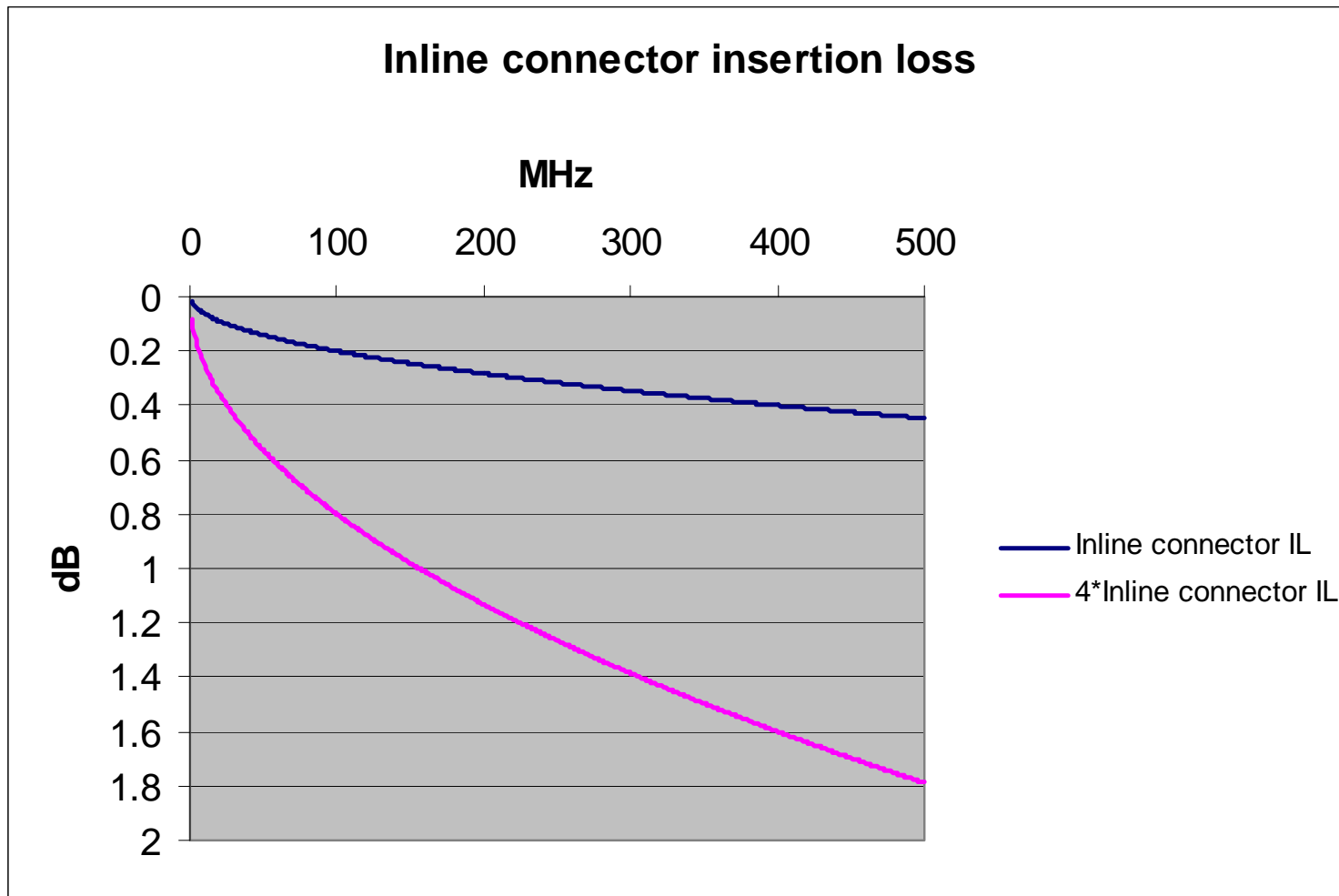
Cable insertion loss – 15 m and 40 m



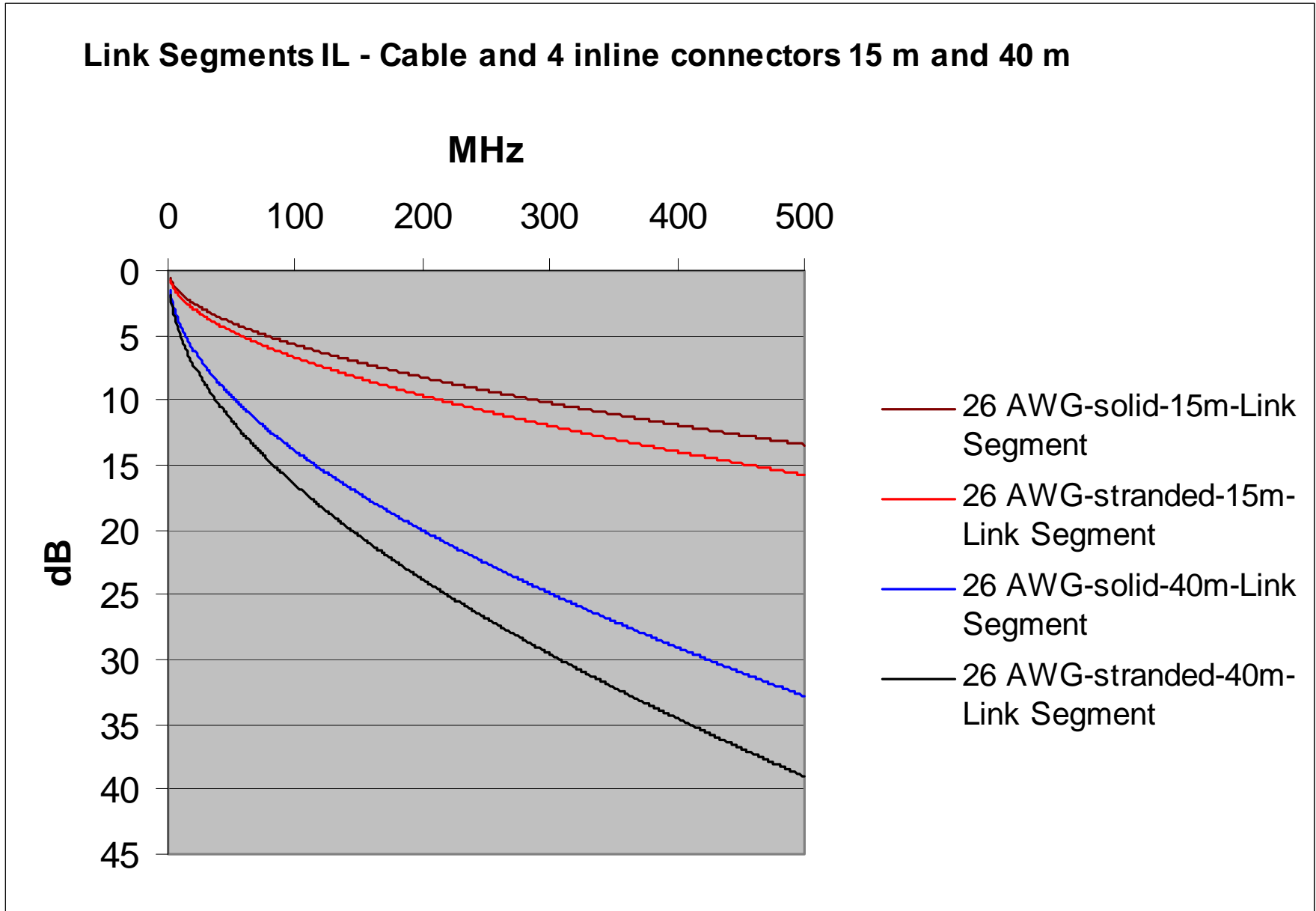
Insertion loss adjusted using a factor of 0.2% increase per °C from 20 °C to 125 °C

Inline connector insertion loss

- Inline connector $IL(f) = x \cdot \sqrt{f}$
- $x = 0.02 \cdot \sqrt{f}$



Link Segments – insertion loss



Cable insertion loss adjusted using a factor of 0.2% increase per °C from 20 °C to 125 °C

Summary

- Insertion losses for link segments of 15 m and 40 m derived from 32 AWG to 22 AWG solid and stranded cables scaled from reference loss. Insertion loss adjusted for temperature.

- Cable Reference IL =

- $1.82 * \text{SQRT}(f) + 0.0091 * f + 0.25 / \text{SQRT}(f)$ at 20 °C

- Inline connectors insertion loss modeled as $0.02 * \text{sqrt}(f)$

- Link segment insertion losses required for PHY considerations.