Actual Cable Data update

Insertion loss, return loss, charcteristic impedance at worst case condition, propagation delay
Coupling attenuation at different ageing conditions
Screening attenuation at different ageing conditions

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Motivation – Actual Cable Data

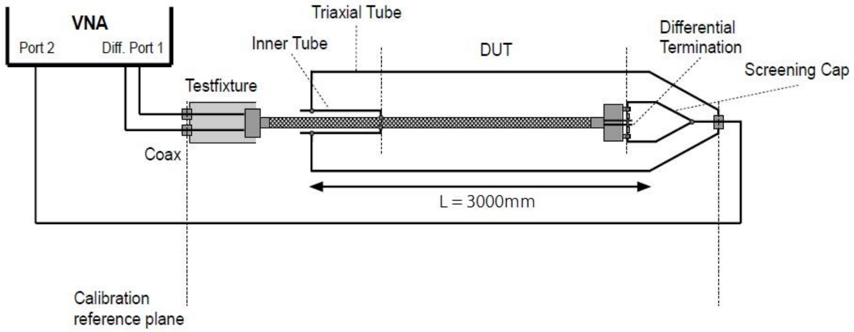
- Update about development progress of different cable types
- Requests for additional cable parameter data
- Review of actual limit recommendation and new proposal

Tested cables

- Shielded twisted pair (STP) $0.14mm^2$ AWG 26 specified up 5.5 GHz
- Shielded twisted pair (STP) $0.22mm^2$ AWG 24 specified up to 4.5 GHz PROTOTYPE!
- Cable length 3.5m (coupling and screening attenuation)
- Cable length 10m (all other measurements)
- **All cables are bulk cables no extra inliner or connector!**

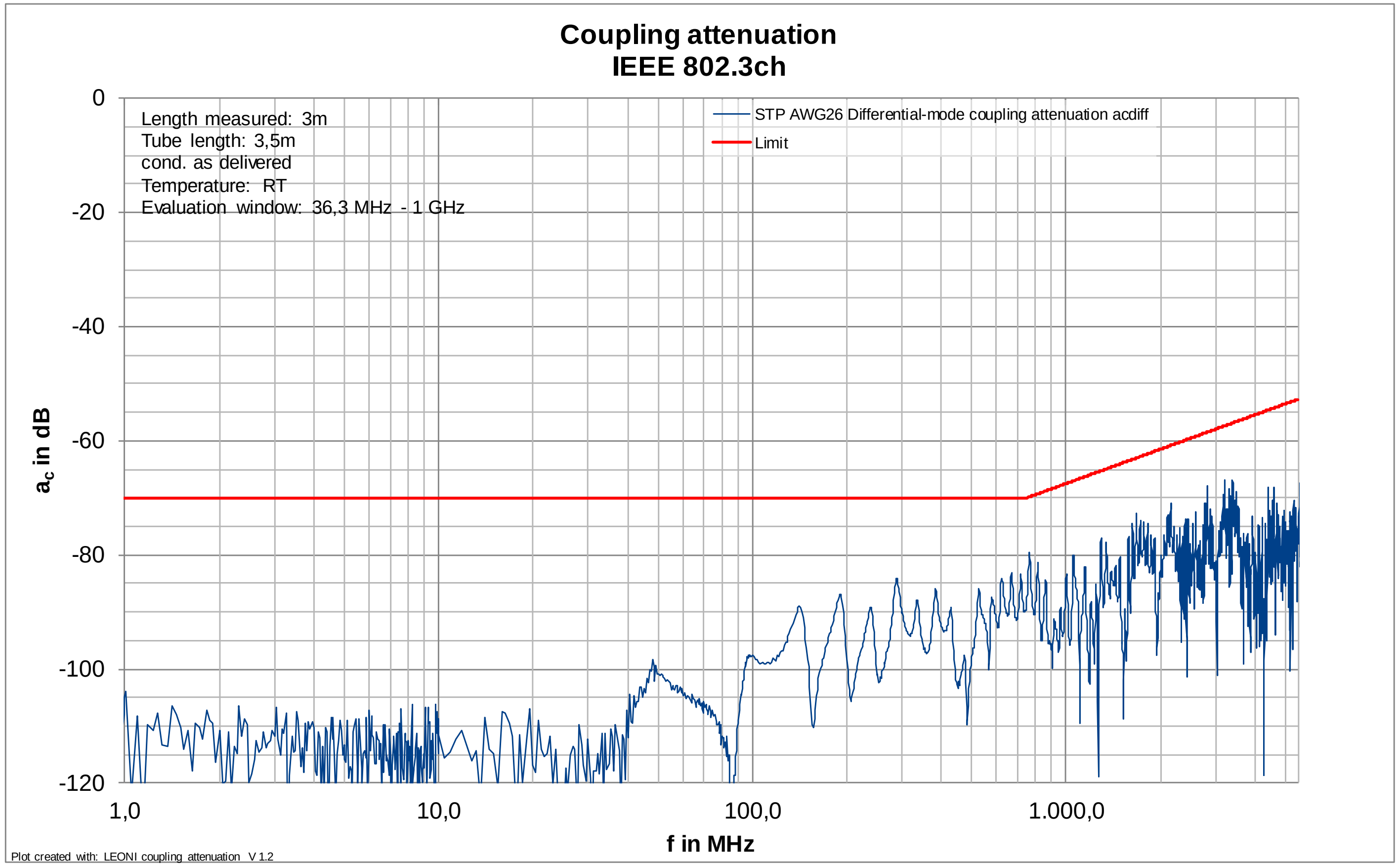
Test setup (Coupling attenuation)

- A standard 4-port vector network analyzer from 1 MHz to 8 GHz was used
- The tests were performed at room temperature (RT, 23°C) before and after ageing (240h/130°C)
- The length of each cable is 3.5m (3.0m inside tube)
- The 3m Rosenberger Bedea measurement tube (triaxial method) was used



- The measured cables are bulk cable <u>without</u> any inliner or connector

Coupling attenuation data AWG 26



Condition as delivered (new) at room temperature

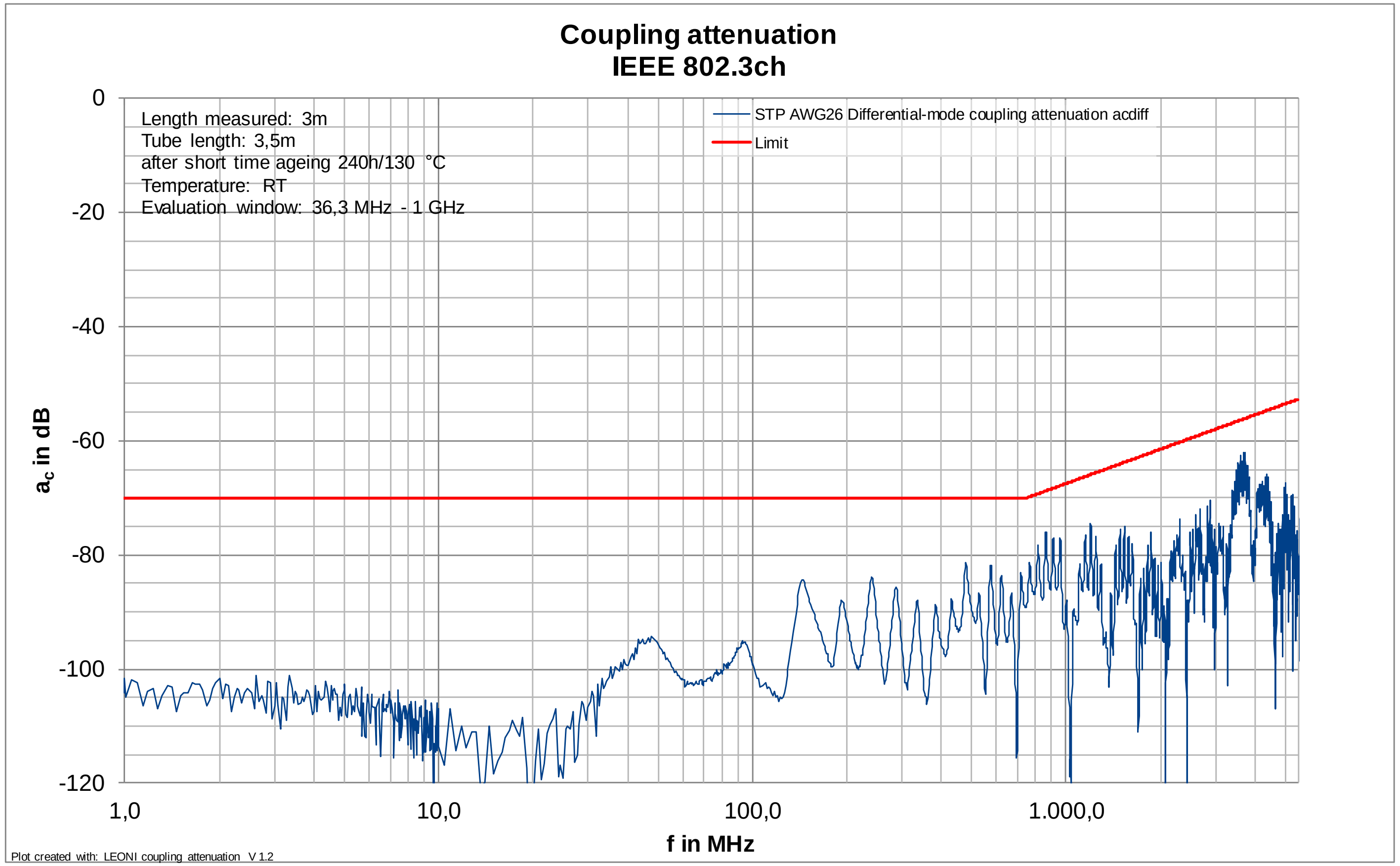
No limit violation

Limit: * mueller_3ch_02a_0518.pdf

$$\begin{pmatrix} 70 & 30 \le f < 750 \\ 50 - 20\log(f/7500) & 750 \le f \le 5500 \end{pmatrix} dB$$

$30 \le f \le 5500$ frequency f in MHz

Coupling attenuation data AWG 26



Condition: after short time ageing (240h/130°C) at room temperature

No limit violation

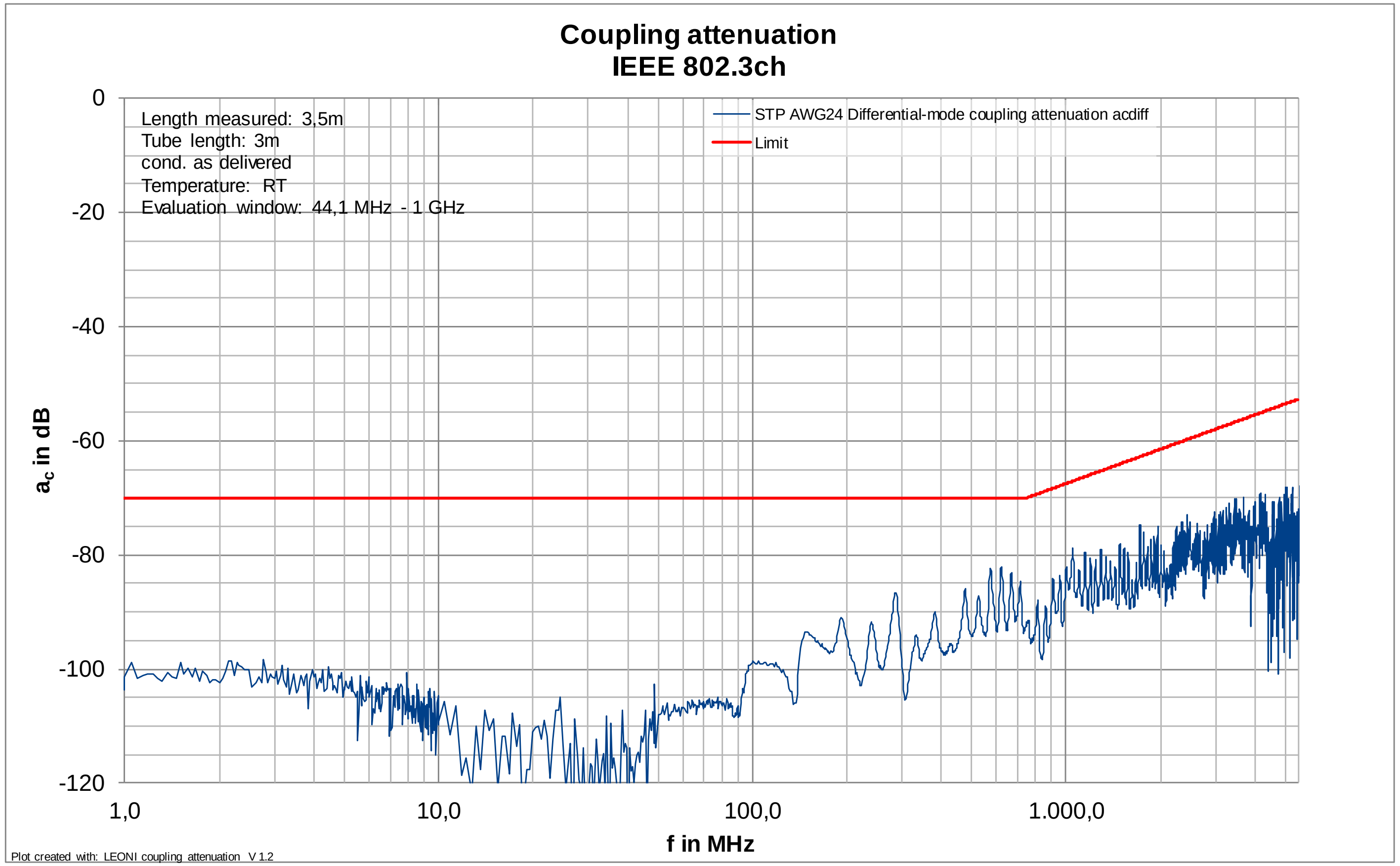
Limit: * mueller_3ch_02a_0518.pdf

$$\begin{pmatrix} 70 & 30 \le f < 750 \\ 50 - 20\log(f/7500) & 750 \le f \le 5500 \end{pmatrix} dB$$

$30 \le f \le 5500$ frequency f in MHz

So significant change of coupling attenuation for this cable type after ageing.

Coupling attenuation data AWG 24



Condition as delivered (new) at room temperature

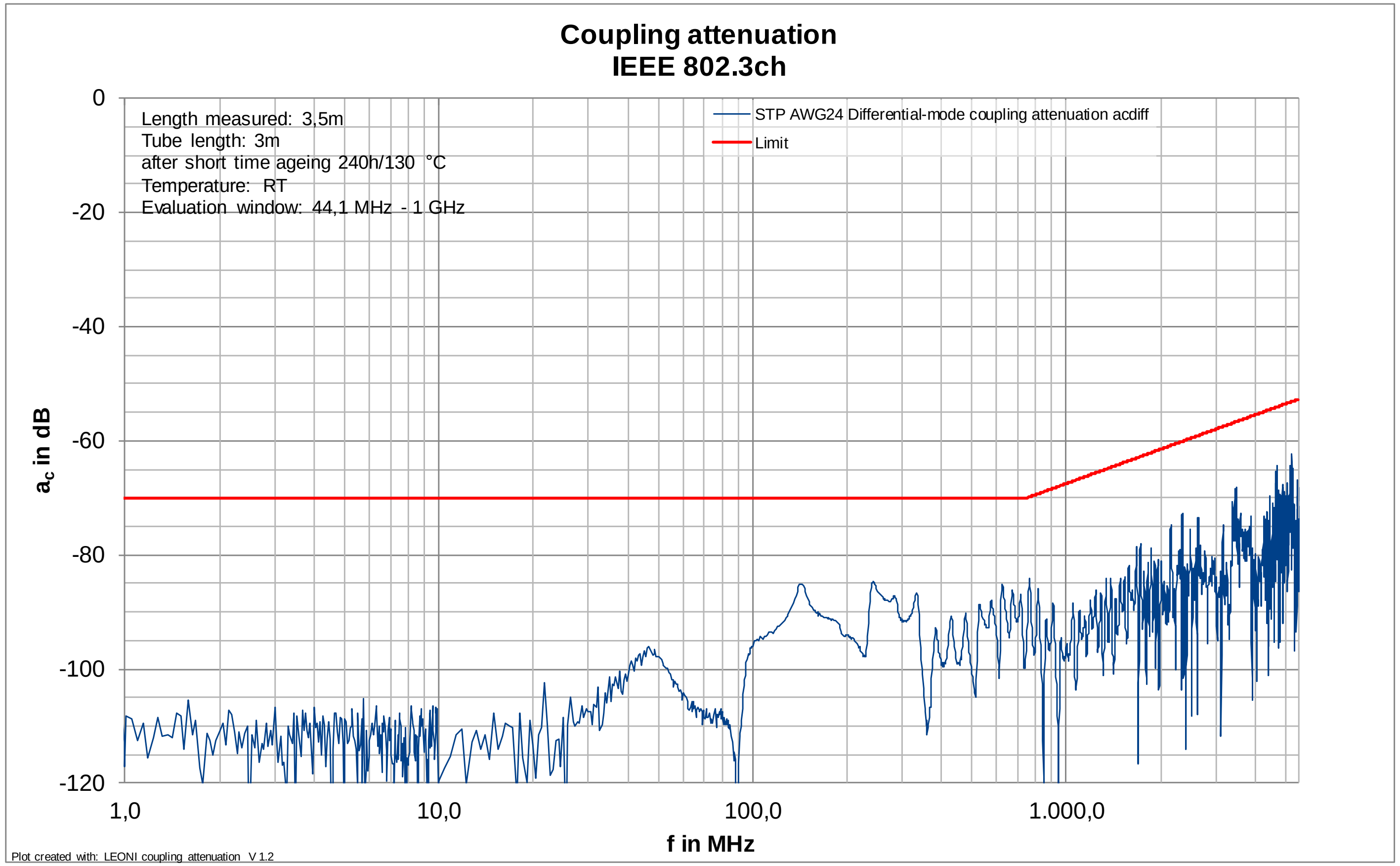
No limit violation

Limit: * mueller_3ch_02a_0518.pdf

$$\begin{pmatrix} 70 & 30 \le f < 750 \\ 50 - 20\log(f/7500) & 750 \le f \le 5500 \end{pmatrix} dB$$

$30 \le f \le 5500$ frequency f in MHz

Coupling attenuation data AWG 24



Condition: after short time ageing (240h/130°C) at room temperature

No limit violation

Limit: * mueller_3ch_02a_0518.pdf

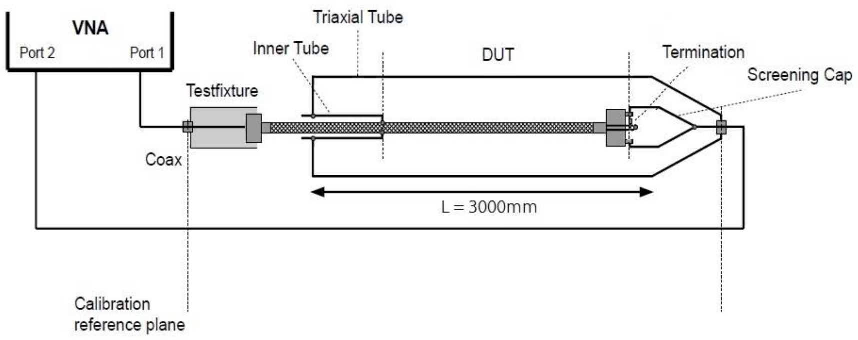
$$\begin{pmatrix} 70 & 30 \leq f < 750 \\ 50 - 20\log(f/7500) & 750 \leq f \leq 5500 \end{pmatrix} dB$$

$30 \leq f \leq 5500$ frequency f in MHz

So significant change of coupling attenuation for this cable type after ageing.

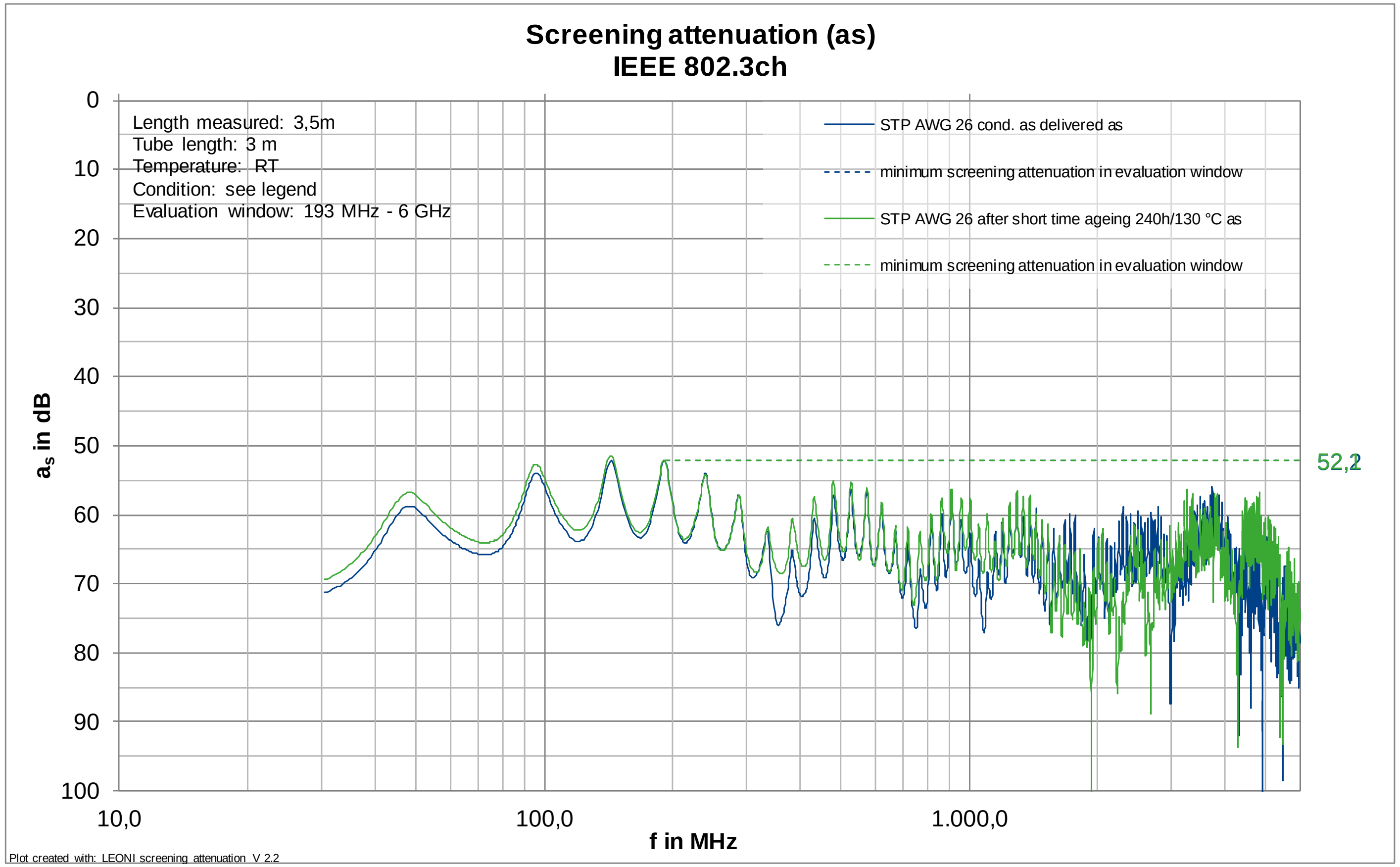
Test setup (Screening attenuation)

- A standard 4-port vector network analyzer from 1 MHz to 8 GHz was used
- The tests were performed at room temperature (RT, 23°C) before and after ageing (240h/130°C)
- The length of each cable is 3.5m (3m inside tube)
- The 3m Rosenberger Bedea measurement tube (triaxial method) was used (cable treated quasi-coaxial)



- The measured cables are bulk cable <u>without</u> any inliner or connector

Screening attenuation data AWG 26

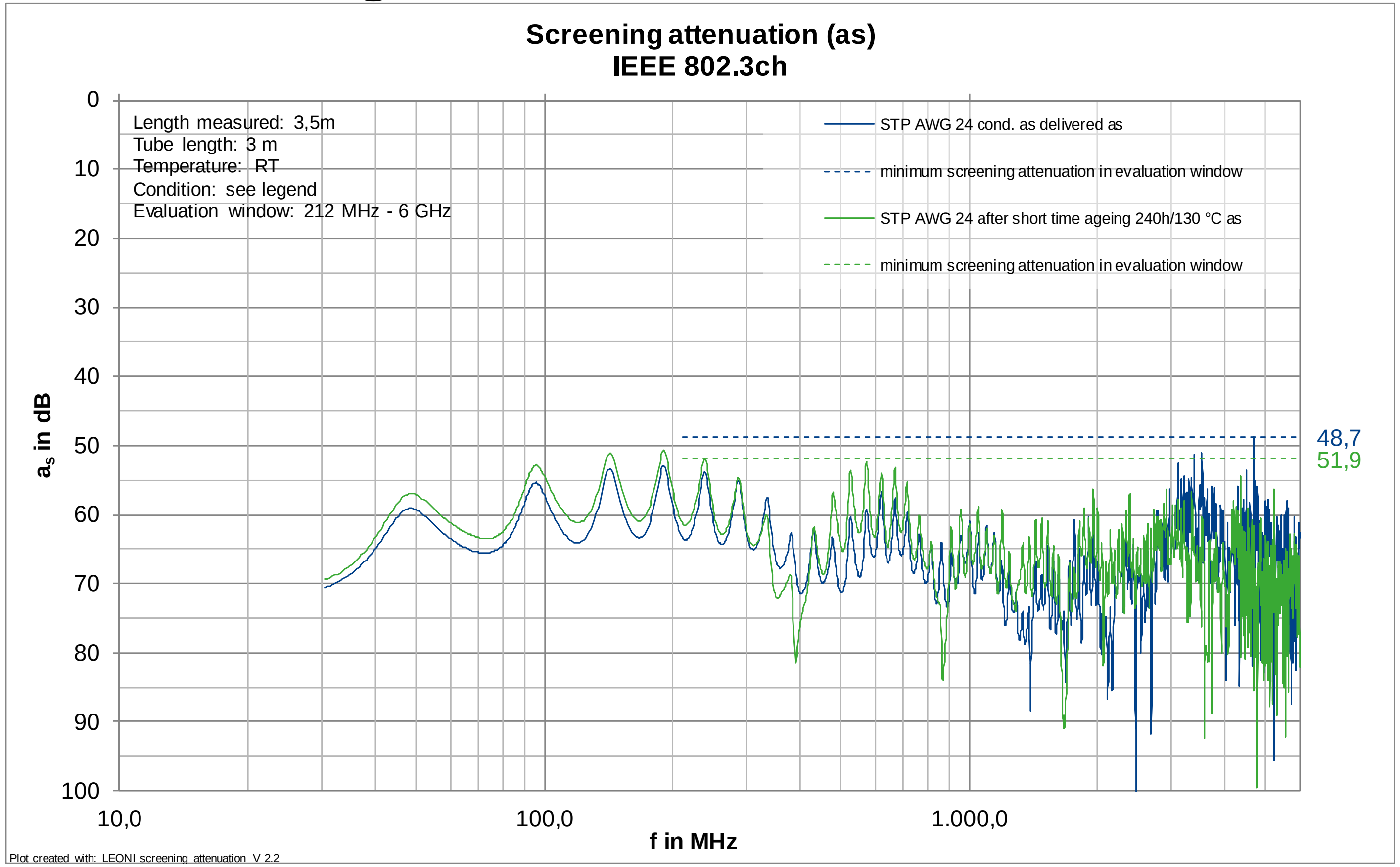


Condition as delivered and after short time ageing (240h/130°C) at room temperature.

Minimum requirement of 45 dB met

(*DenBesten_3ch_03_311018.pdf)

Screening attenuation data AWG 24



Condition as delivered and after short time ageing (240h/130°C) at room temperature.

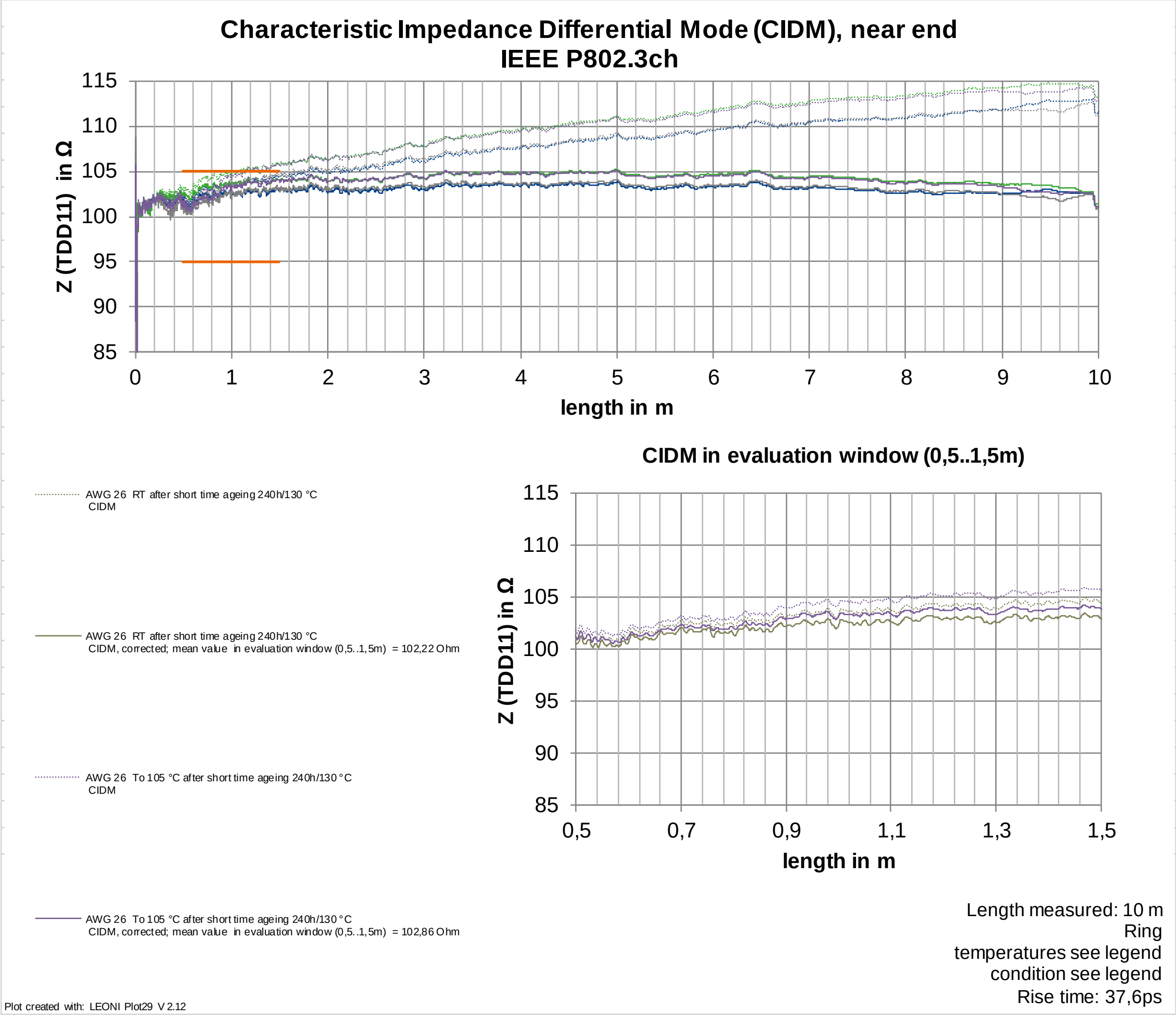
Minimum requirement of 45 dB met

(*DenBesten_3ch_03_311018.pdf)

Test setup (IL, RL, impedance, propagation delay)

- A standard 4-port vector network analyzer from 1 MHz to 20 GHz was used.
- The tests were performed at room temperature (RT, 23°C) and at 105°C at climatic chamber before and after ageing (240h/130°C).
- The measured length of each cable is 10m and the results for IL were calculated for 11m and 15m respectively in the diagrams and compared to current insertion loss limit.
- The measured cables are bulk cable <u>without</u> any inliner or connector.
- Only the worst case condition after ageing (240h/130°C) is displayed in the diagrams for a better overview (insertion loss and return loss). Worst case situation evaluated in presentation *vernickel_3ch_01b_0918 during last face to face meeting in September.

Characteristic impedance data for AWG 26



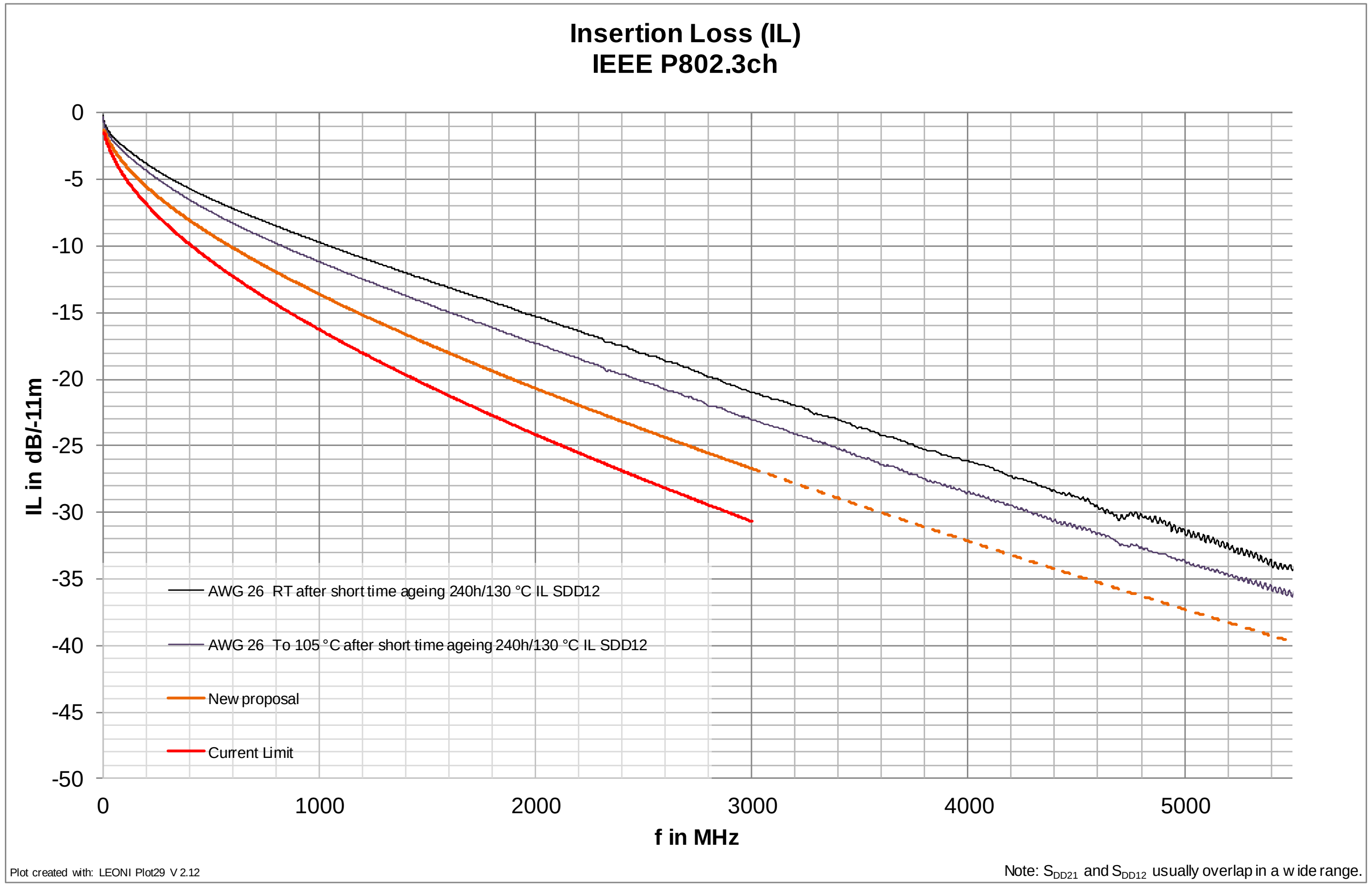
Impedance now more optimized compared to previous presentation.

The TDR was calibrated using an E-Cal-Kit. Then, a pair of airlines with Z_(DM_Airline)=100Ω was measured. The measured sample impedance is corrected using the measured airline impedance using

$$Z_{Sample} = Z_{meas} \cdot \frac{Z_{DM_{Airline}}}{Z_{Airline_{meas}}}$$

The impedance values are attenuation corrected using a method similar to Open Alliance TC 2, Annex B or Open Alliance TC9, Annex B

Insertion loss data for 11m AWG 26



Current Limit: *DiBiaso_3ch_01_0718.pdf

$ILdBf \leq 0.002*f+0.45*\sqrt{f}+1/\sqrt{f}$

Calculated for 11m

Worst case after ageing displayed only.
(see presentation vernickel_3ch_01b_0918.pdf)

No limit violation of actual limit.

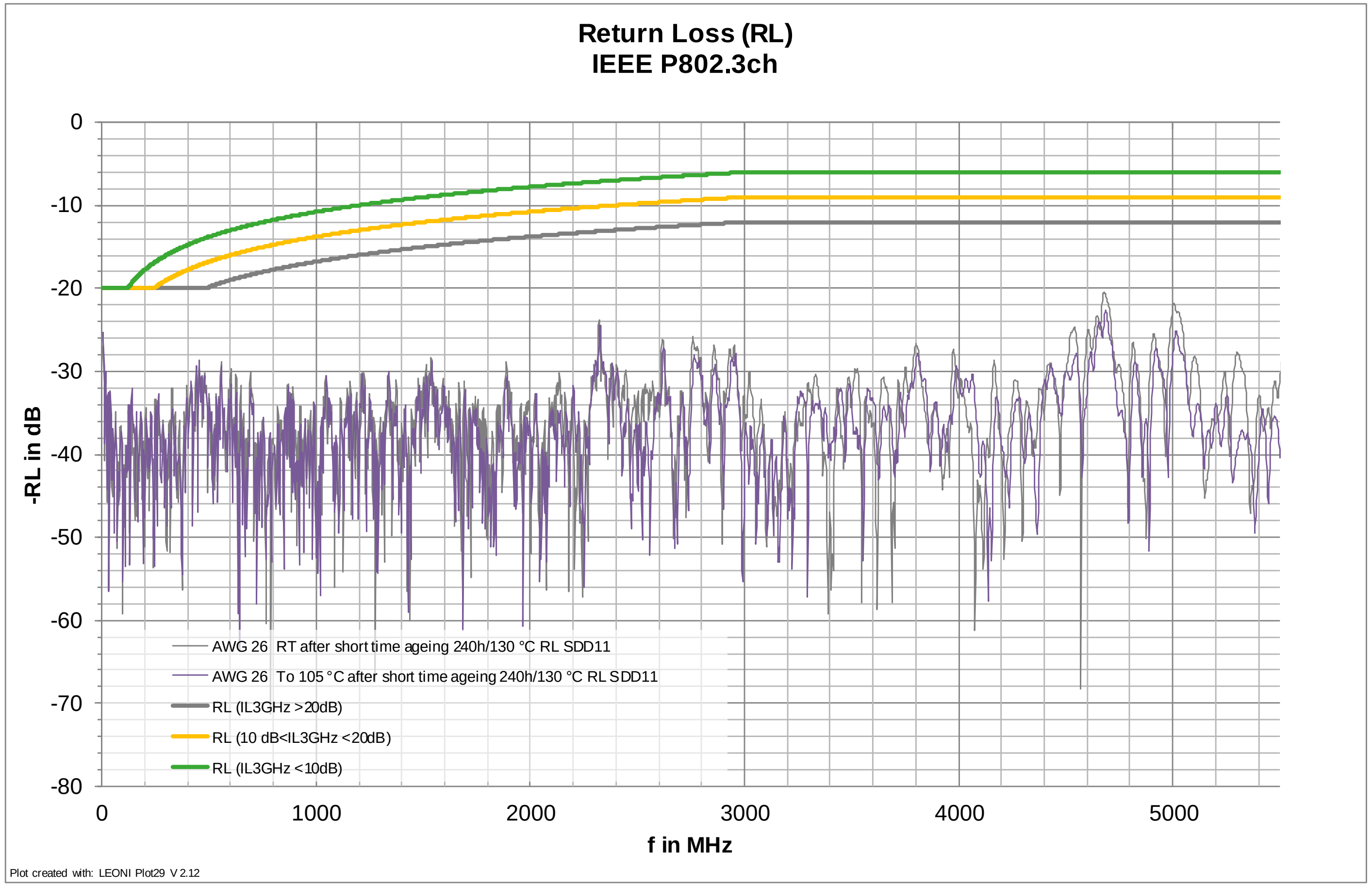
New proposal for a stronger limit:

$ILdBf \leq 0.0025*f+0.35*\sqrt{f}+1/\sqrt{f}$

f is the frequency in MHz: 5 ≤ 5500

This limit would allow 4dB (@ 3 GHz) margin for connectors/inliner, measurement uncertainty and production variations for the worst case after ageing at 105°C.

Return loss data AWG 26



No limit violation

Gated measurement:

- Influence of measurement adapter compensated
- Pure cable data

RL Limit: * Farjad_3ch_01b_0118.pdf

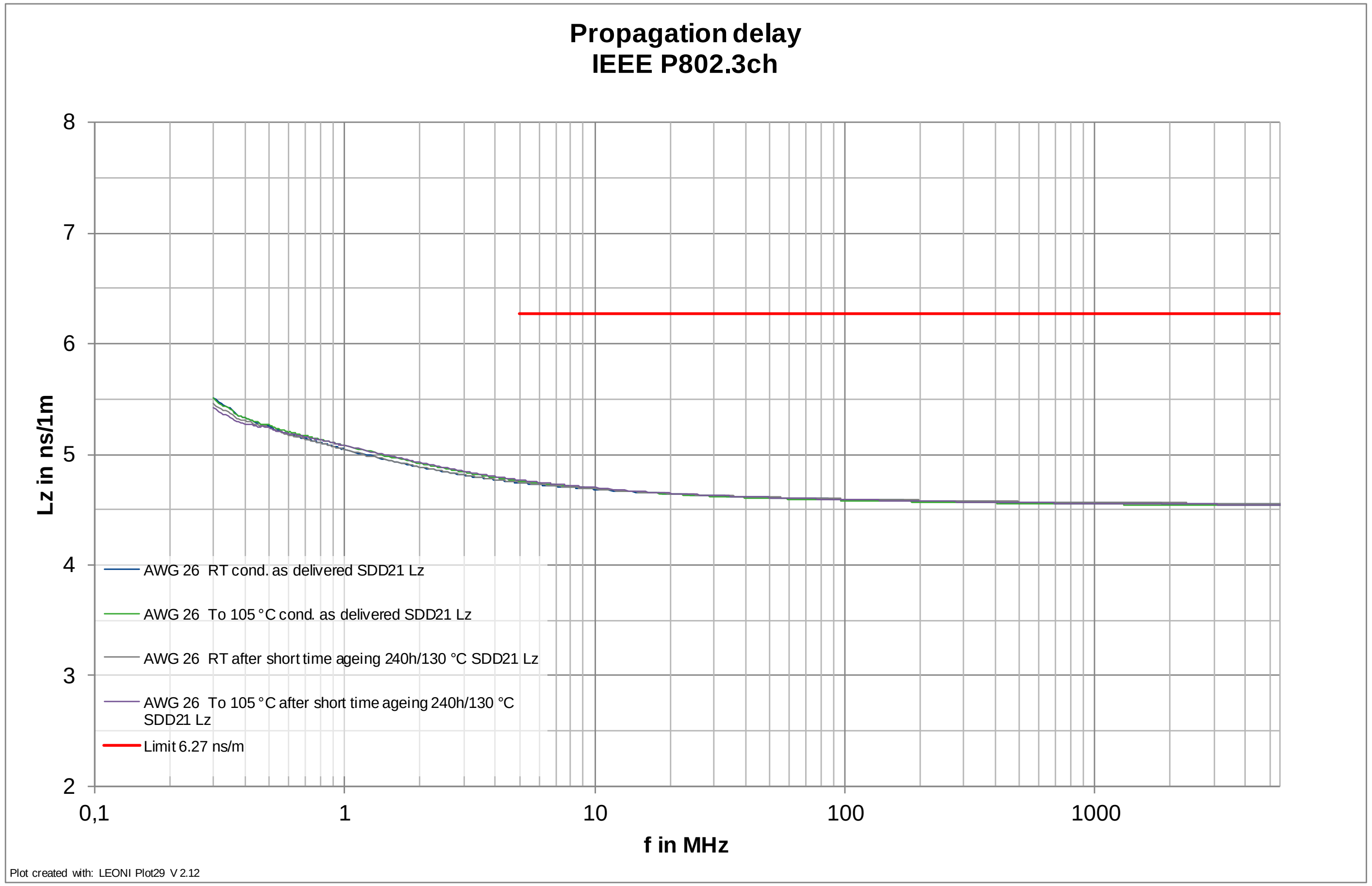
- IL_{3GHz} > 20dB → N=0
- 10dB< IL_{3GHz} < 20dB → N=1
- IL_{3GHz} < 10dB → N=2

$$\text{Return.Loss(dB)} \le \begin{cases} 20\text{dB} & 5 \le f < 500/2^N \\ 12-3N - 10\log(f/3000) & 500/2^N \le f < 3000 \\ 12-3N & 3000 \le f < 5500 \end{cases}$$

(*f* in MHz)

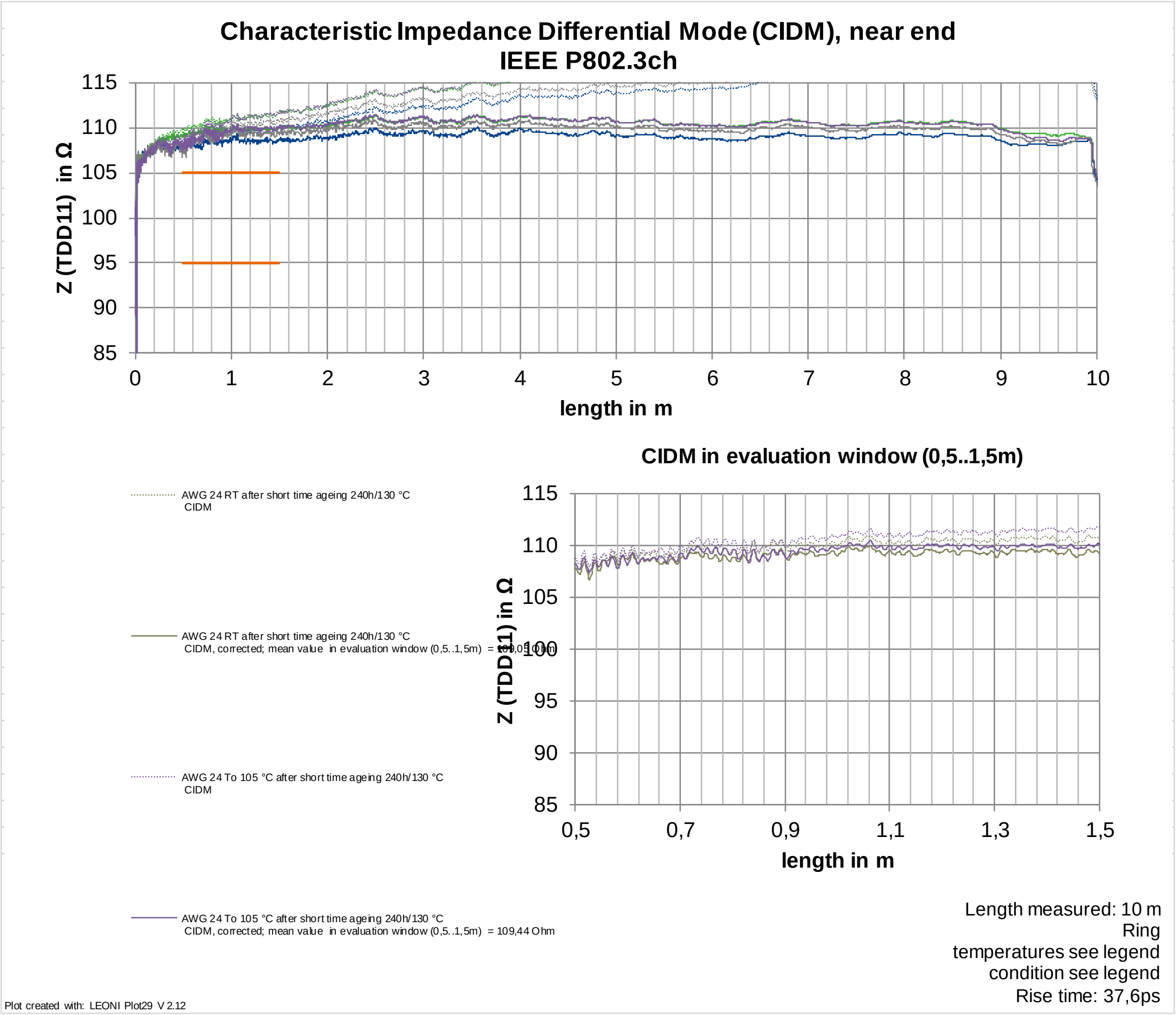
Contributions from :
Garret den Besten
Bert Bergner
James Withey
Masood Shariff

Propagation delay data AWG 26



Propagation delay always better than the required 6,27 ns/m in all conditions.

Characteristic impedance data for AWG 24



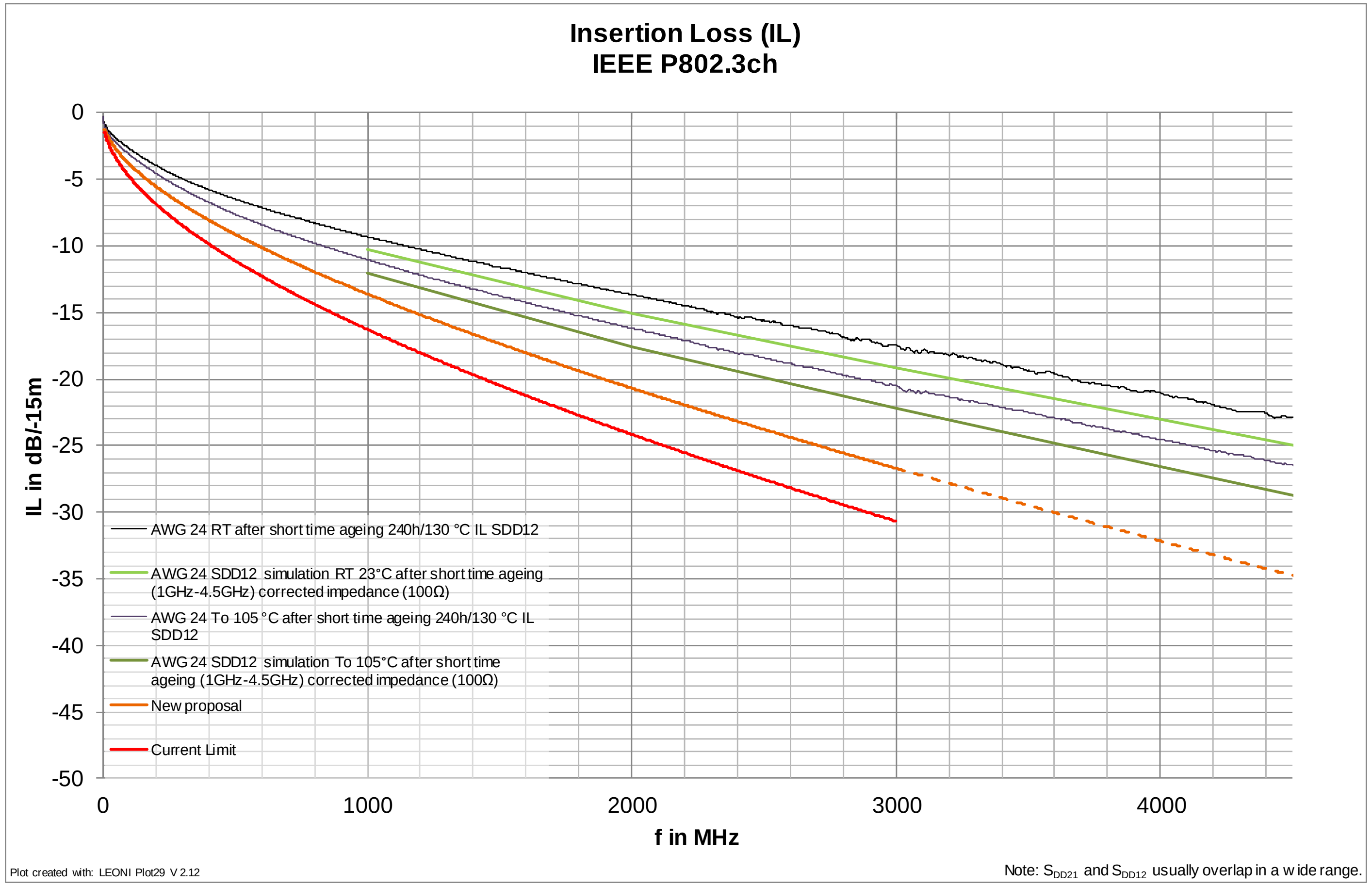
Impedance of AWG 24 PROTOTYPE needs more improvement which will lead to an increase of insertion loss (simulation data added to the insertion loss diagram).

The TDR was calibrated using an E-Cal-Kit. Then, a pair of airlines with Z_(DM_Airline)=100Ω was measured. The measured sample impedance is corrected using the measured airline impedance using

$$Z_{Sample} = Z_{meas} \cdot \frac{Z_{DM_{Airline}}}{Z_{Airline_{meas}}}$$

The impedance values are attenuation corrected using a method similar to Open Alliance TC 2, Annex B or Open Alliance TC9, Annex B

Insertion loss data for 15m AWG 24 PROTOTYPE



Current Limit: *DiBiaso_3ch_01_0718.pdf

$ILdBf \leq 0.002*f+0.45*\sqrt{f}+1/\sqrt{f}$

Calculated for 15m

Worst case after ageing displayed only.
(see presentation vernickel_3ch_01b_0918.pdf)

No limit violation of actual limit.

The improvement of the impedance will lead to an increase of approx. 1.5 dB @ 3 GHz acc. to simulation data.

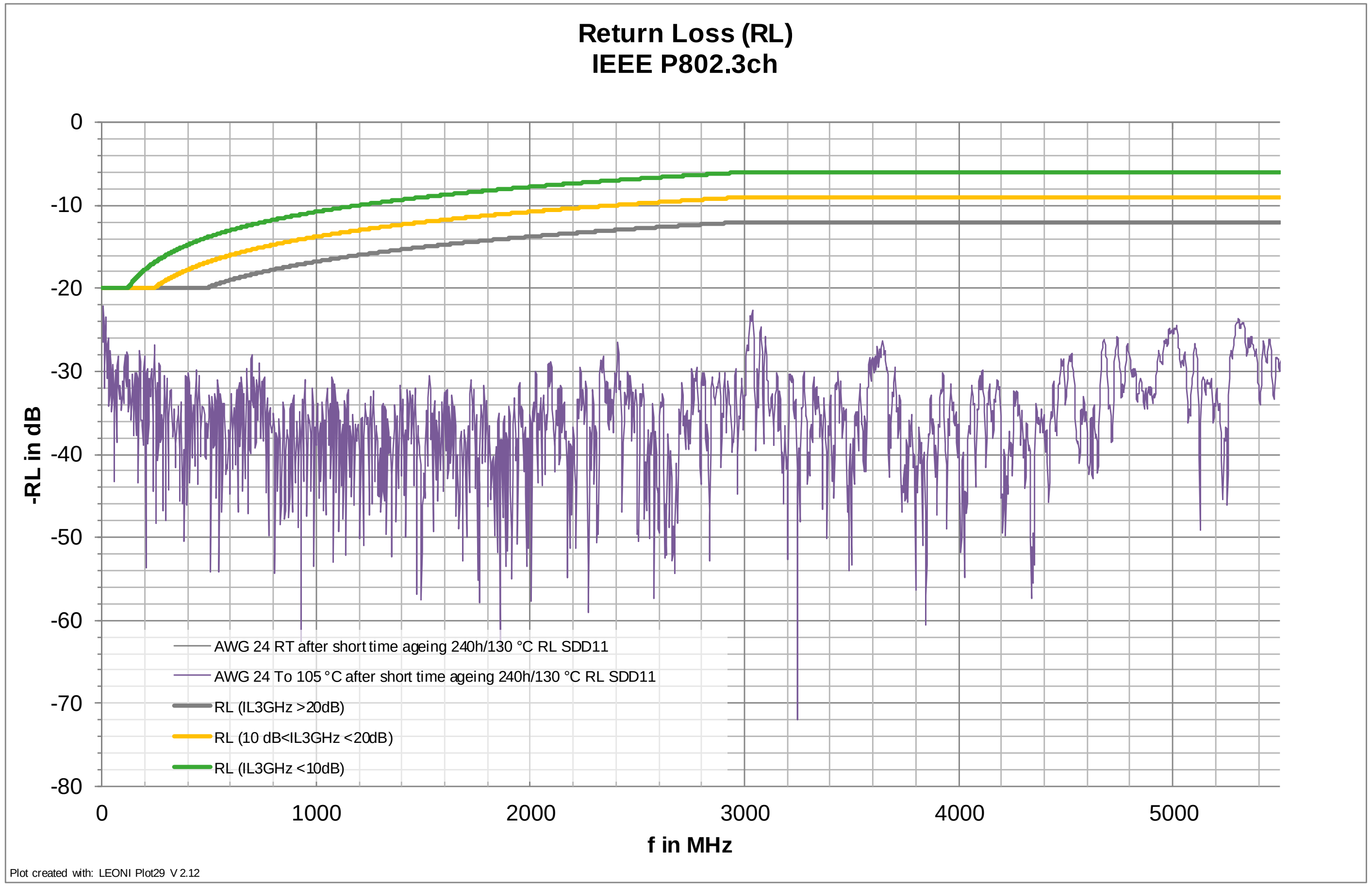
New proposal for a stronger limit:

$ILdBf \leq 0.0025*f+0.35*\sqrt{f}+1/\sqrt{f}$

f is the frequency in MHz: 5 ≤ 4500

This limit would allow 5.5dB (@ 3 GHz) margin for connectors/inliner, measurement uncertainty and production variations for the worst case after ageing at 105°C.

Return loss data AWG 24



No limit violation

Gated measurement:

- Influence of measurement adapter compensated
- Pure cable data

RL Limit: * Farjad_3ch_01b_0118.pdf

- IL_{3GHz} > 20dB → N=0
- 10dB< IL_{3GHz} < 20dB → N=1
- IL_{3GHz} < 10dB → N=2

$$\text{Return.Loss(dB)} \le \begin{cases} 20\text{dB} & 5 \le f < 500/2^N \\ 12-3N - 10\log(f/3000) & 500/2^N \le f < 3000 \\ 12-3N & 3000 \le f < 5500 \end{cases}$$

(*f in MHz*)

Contributions from :
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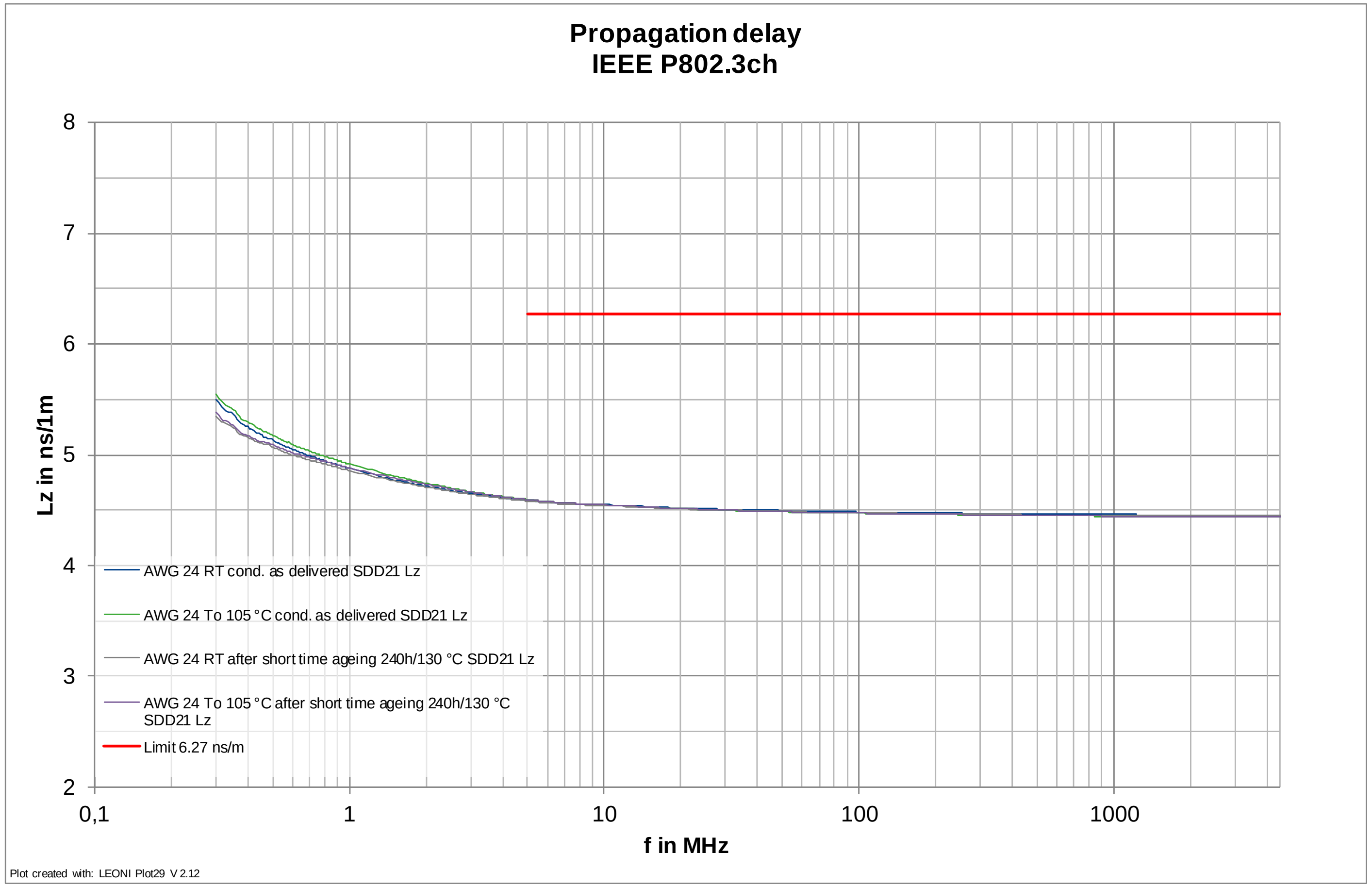
Bert Bergner
James Withey
Masood Shariff

Propagation delay data AWG 24



Propagation delay always better than the required 6,27 ns/m in all conditions.

Conclusions

- Proposal (* mueller_3ch_02a_0518.pdf) for coupling attenuation is acceptable for both cable types.

- A screening attenuation limit of 45dB is acceptable for both cable types.

- Propagation delay within requirements in all conditions.

- For 15m and 11m link length no limit violation for current limit with both cable types.

Conclusions

- Actual cable data would allow a stronger limit for insertion loss.

New proposal for new insertion loss limit:

$$ILdBf \leq \mathbf{0.0025*}f\mathbf{+0.35*\surd}f\mathbf{+1/\surd}f$$

f is the frequency in MHz: 5 ≤ 5500 (4500 AWG24)

Future discussion

- It is highly recommend to use also STP cable for 2.5 GB/s:
- discussions about the use of STP cables also for 1 GB/s, due to EMI problems with unshielded cables in critical installation positions
- it is very difficult to connect a cable just with conductive foil to a connector so a normal braiding is required/recommended
- Relative cost difference might not be significant enough to justify the development of a complete new connector and/or cable type.

Proposal:

For 2.5GB/s use the same limit as for 5 and 10 GB/s but different frequency range. Proposal 1 GHz for insertion and return loss.

Thank you !!!