Cable comparison

Insertion loss, return loss, charcteristic impedance diff. mode at different climatic conditions

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Pittsburgh, May 24, 2018

Motivation – Cable comparison

- Providing actual cable data to the commitee from real existing cables. (no simulation data)
- Review of actual limit recommendations

Test setup

- A standard 4-port vector network analyzer from 1 MHz to 20 GHz was used
- The cable under test was connected to the VNA via LEONI fixture (no extra connector, inliner) with highly phase stable measurement cables .
- The tests were performed at room temperature (RT, 23°C), at 105°C and at

  -40°C at climatic chamber
- The measured length of each cable is 10m and the results for IL were calculated for 11m respectively for 15m in the diagrams and compared to current limit and worst case IL limit (105°C) TE proposed on 18th April AdHoc meeting
- The measured cables are bulk cable

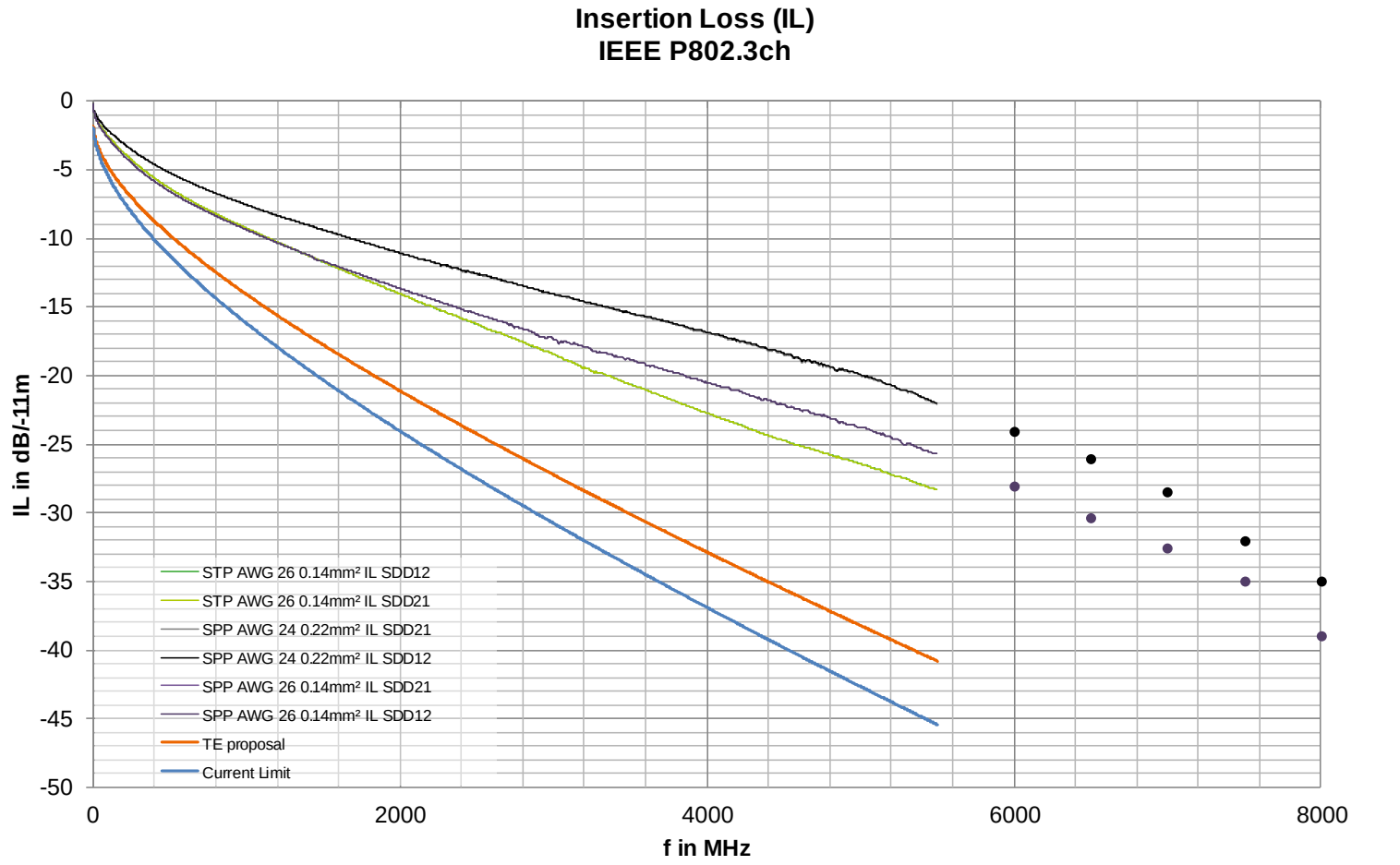
Tested cable types

- Shielded twisted pair (STP) 0.14mm² AWG 26
- Shielded parallel pair (SPP) 0.14mm² AWG 26
- Shielded parallel pair (SPP) 0.22mm² AWG 24

(keep in mind SPP is also twisted but in a different way then a STP)

Insertion loss measurements at room temperature

A future outlook



Plot created with: LEONI Plot29 V 2.12

Note: S_{DD21} and S_{DD12} usually overlap in a wide range.

Length measured: 10m
Calculated for 11m
Condition as delivered
Setup: Ring

No limit violation

SPP works good beyond 5.5 GHz (future applications)

STP specified for 5.5 GHz (physical limitation)

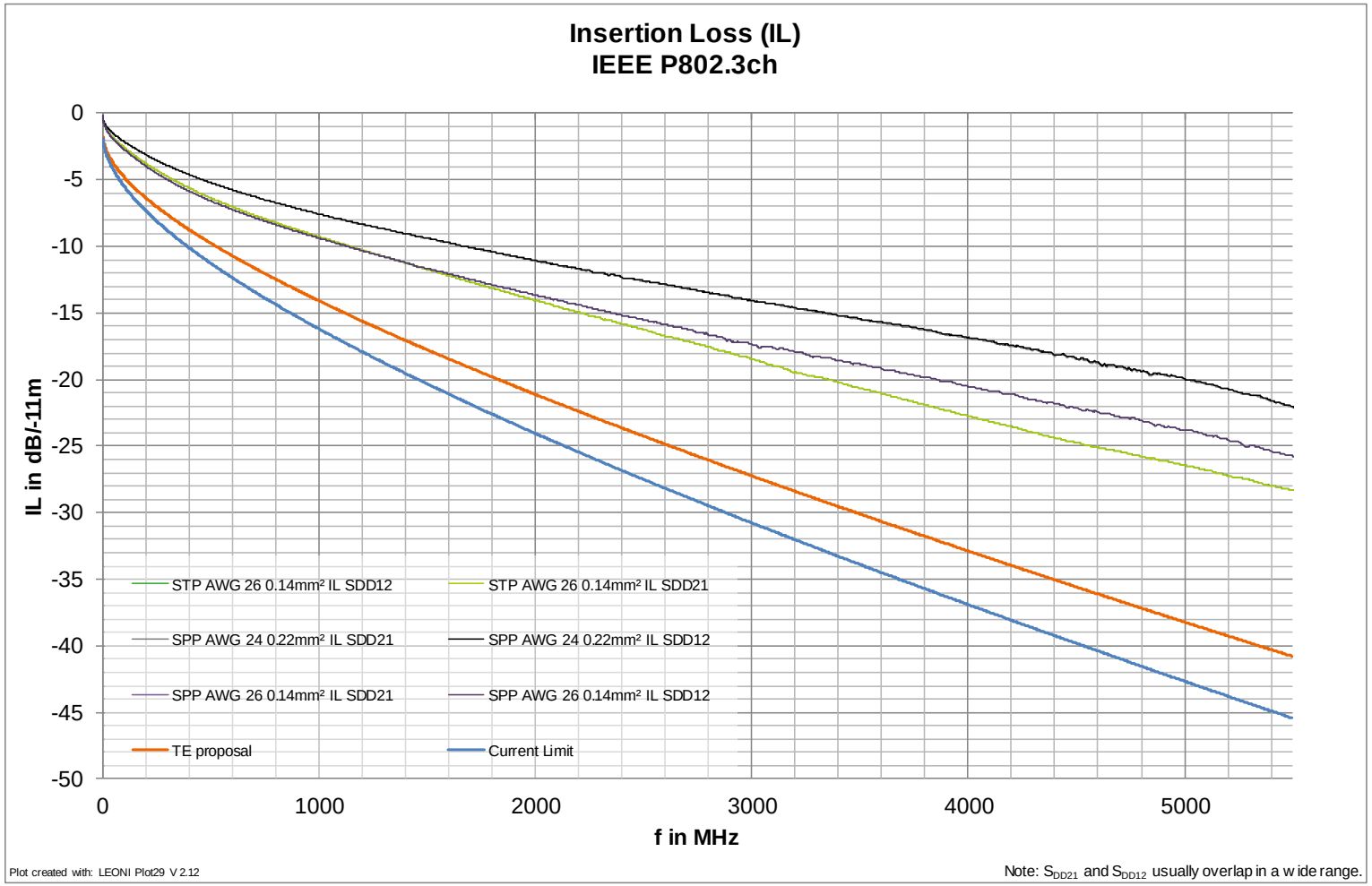
*Farjad_3ch_01b_0118.pdf
Current Limit:

$ILdBf \leq 0.0030 * f + 0.40 * \sqrt{f}$

*Bergner_DiBiaso_Mandel_3ch_01_0418.pdf:
New Limit (TE proposal):

$ILdBf \leq 0.0031 * f + 0.30 * \sqrt{f} + 1.5$

Insertion loss measurements at room temperature



Length measured: 10m
Calculated for 11m
Condition as delivered
Setup: Ring

No limit violation

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Current Limit:

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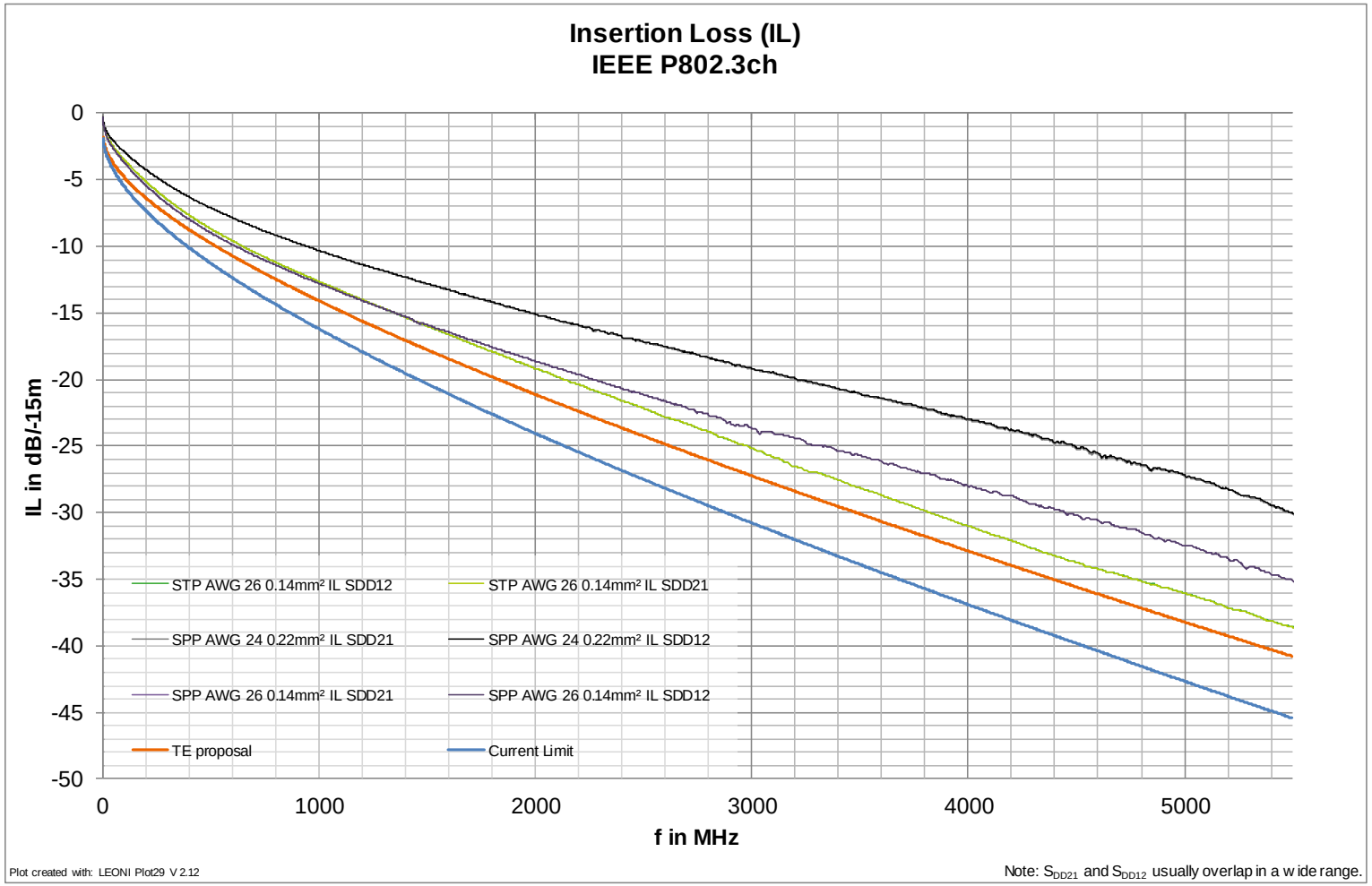
Insertion loss measurements at room temperature



Length measured: 10m
Calculated for 15m
Condition as delivered
Setup: Ring

No limit violation

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Current Limit:

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*Bergner_DiBiaso_Mandel_3ch_01_0418.pdf:
New Limit (TE proposal):

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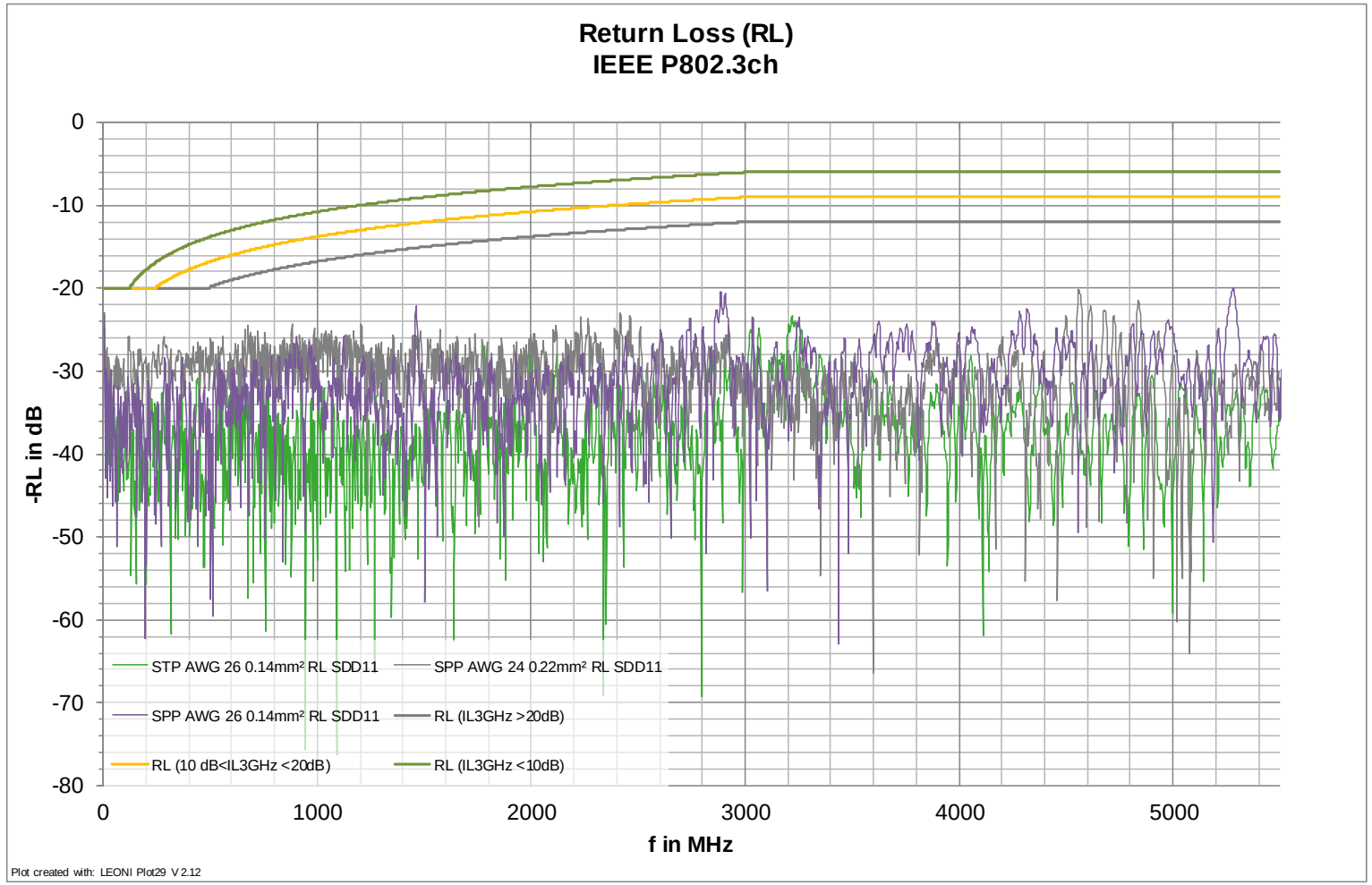
Return loss measurements at room temperature



Length measured: 10m
Condition as delivered
Setup: Ring

Gated measurement:

- Influence of measurement adapter compensated
- Pure cable data

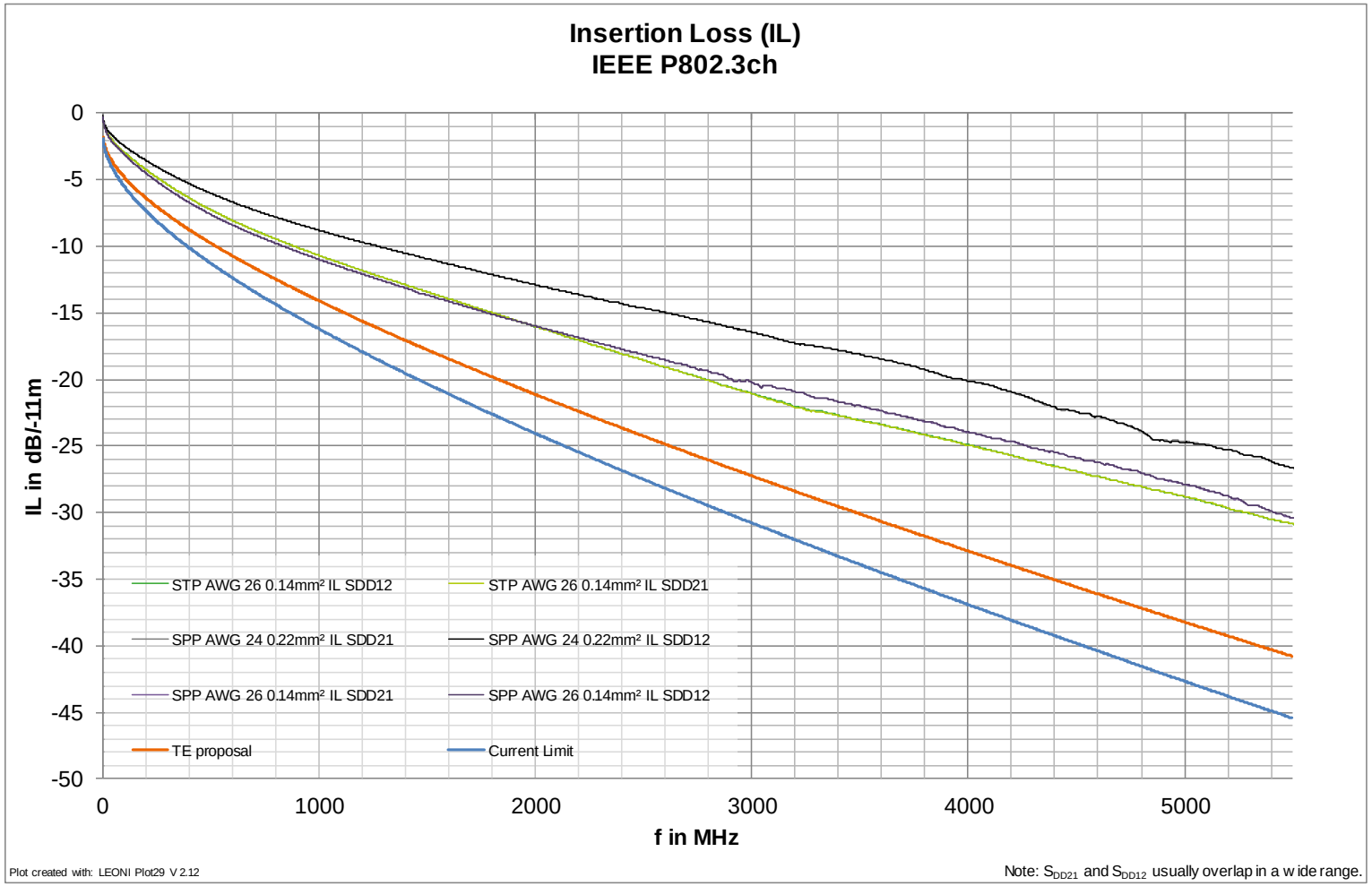
RL Limit: * Farjad_3ch_01b_0118.pdf

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

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

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

Insertion loss measurements at 105°C



Length measured: 10m
Calculated for 11m
Condition as delivered
Setup: Ring

No limit violation

*Farjad_3ch_01b_0118.pdf
Current Limit:

$ILdBf \leq 0.0030 * f + 0.40 * \sqrt{f}$

*Bergner_DiBiaso_Mandel_3ch_01_0418.pdf:
New Limit (TE proposal):

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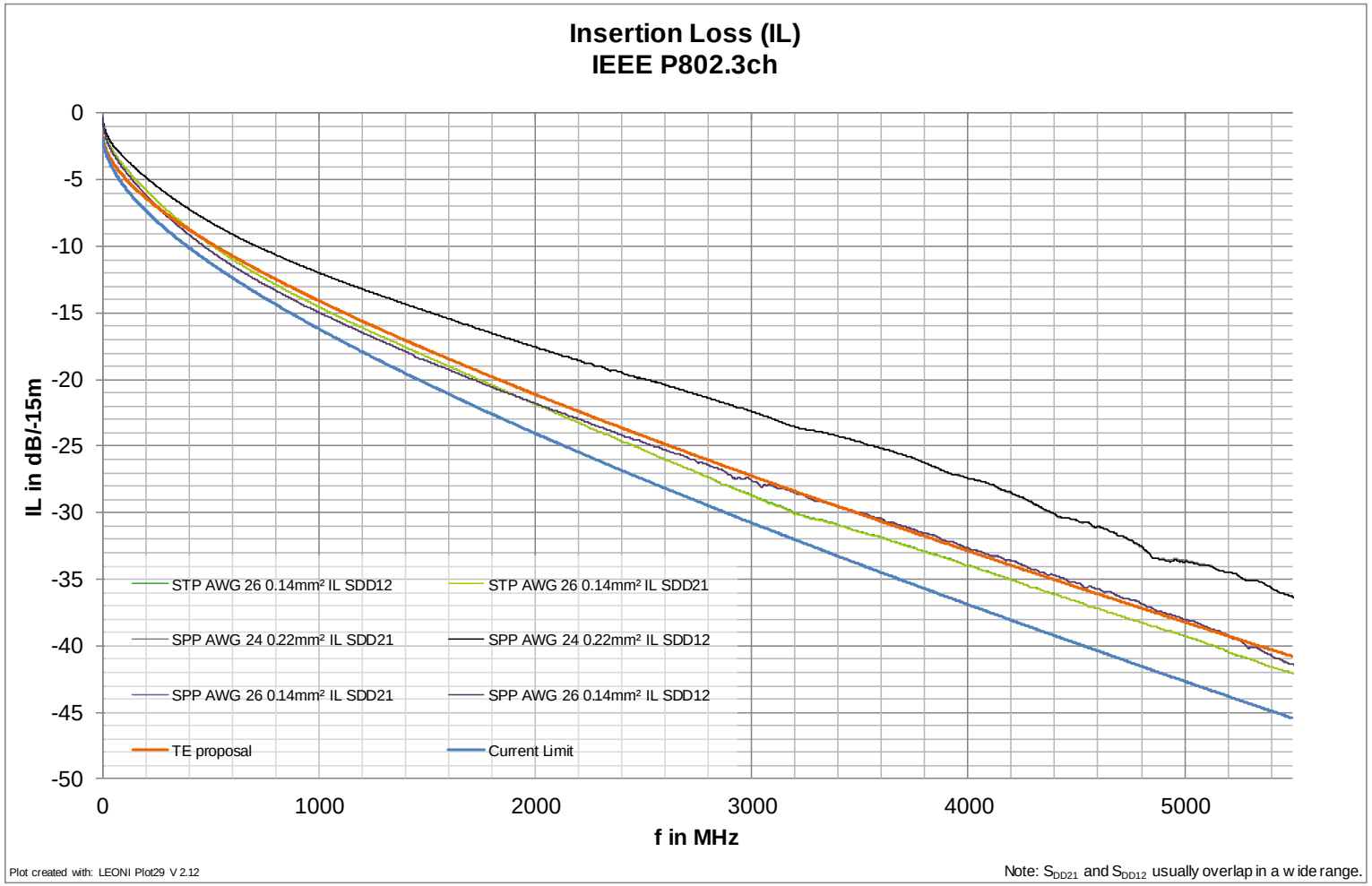
Insertion loss measurements at 105°C



Length measured: 10m
Calculated for 15m
Condition as delivered
Setup: Ring

<u>Limit violation for all AWG26</u>
with TE proposed limit

No limit violation with current limit

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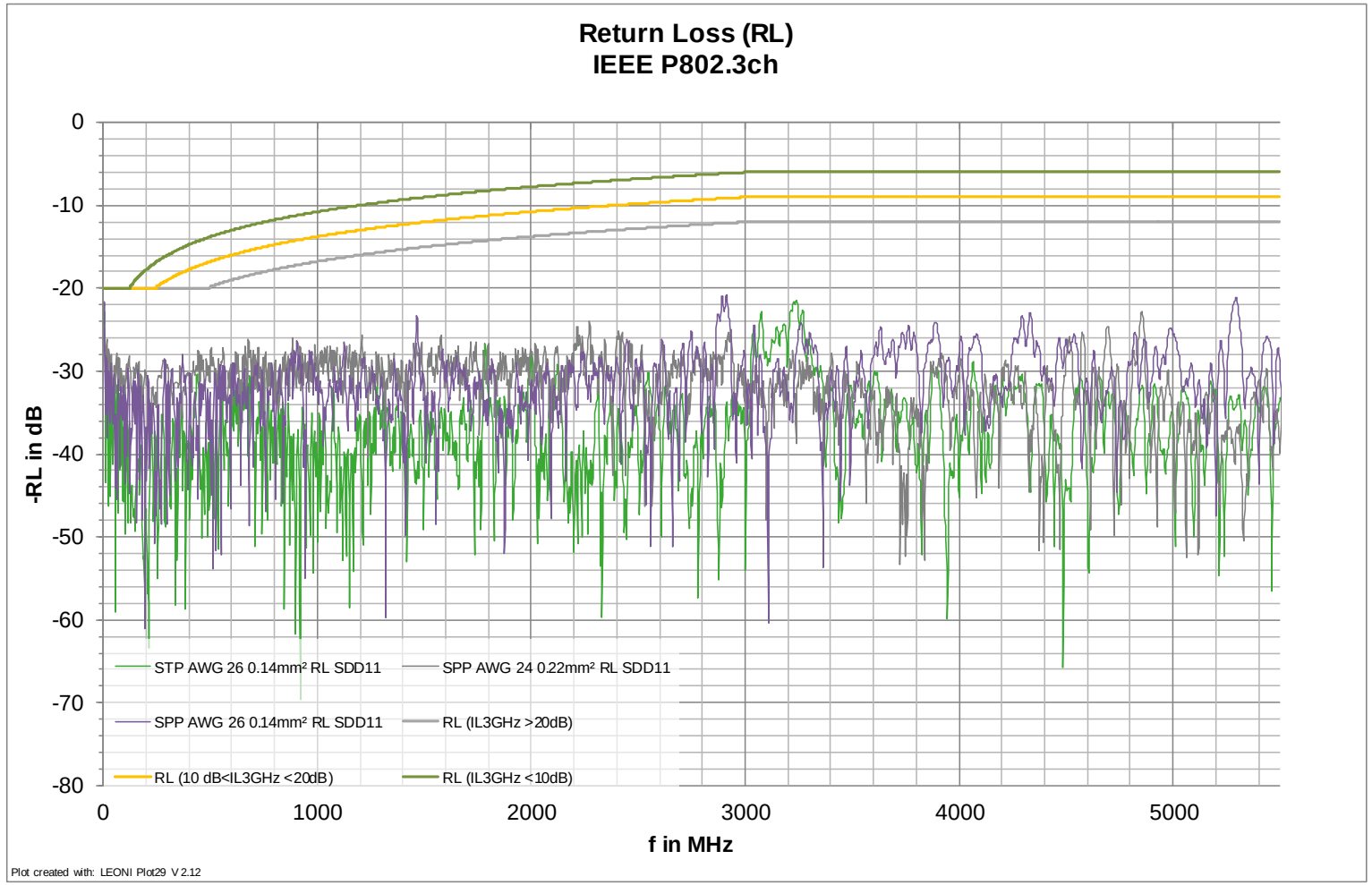
New Limit (TE proposal):

$ILdBf \leq 0.0031 * f + 0.30 * \sqrt{f} + 1.5$

Return loss measurements at 105°C



Length measured: 10m
Condition as delivered
Setup: Ring

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

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

(f in MHz)

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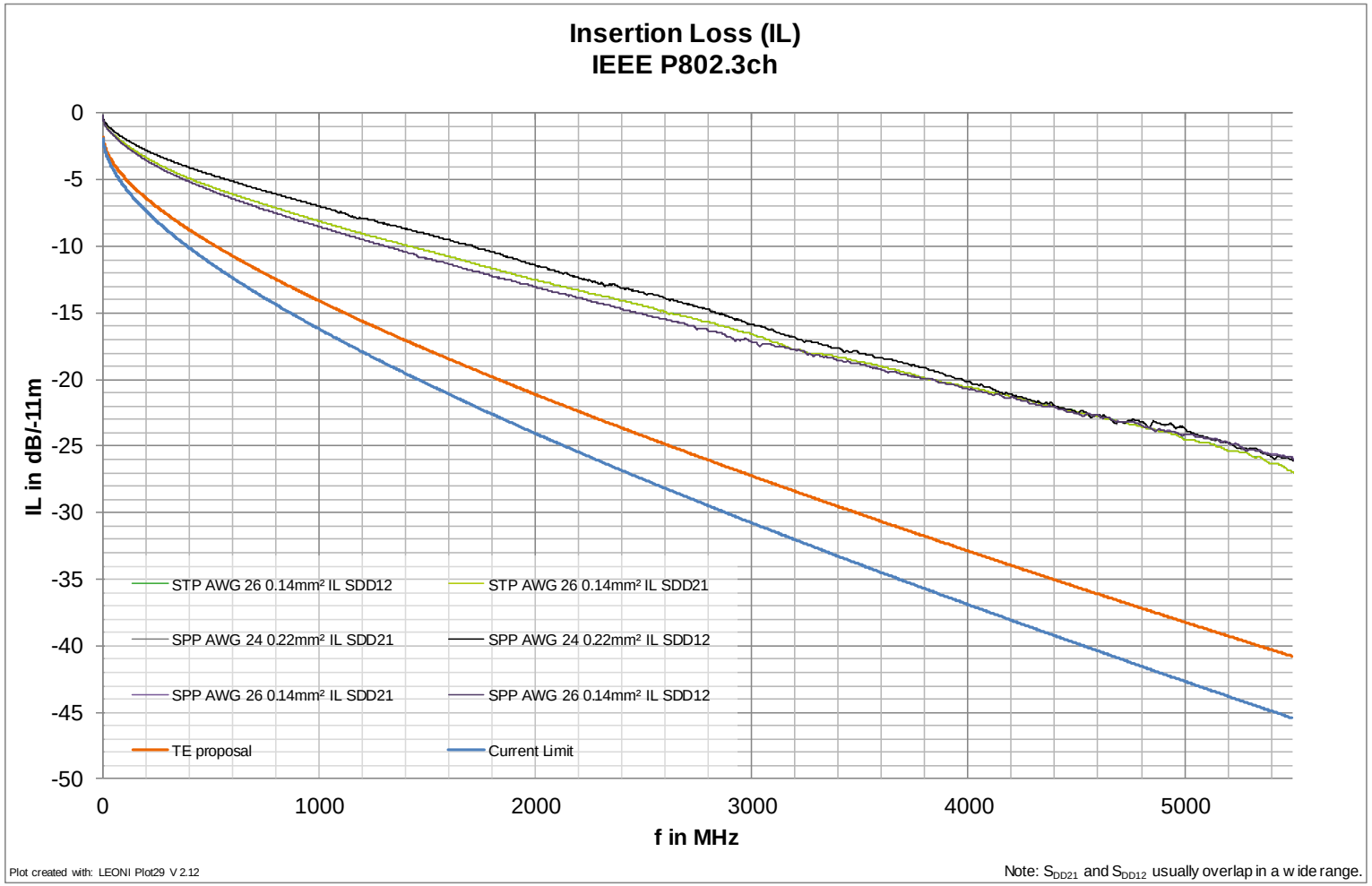
Insertion loss measurements at -40°C



Length measured: 10m
Calculated for 11m
Condition as delivered
Setup: Ring

No limit violation

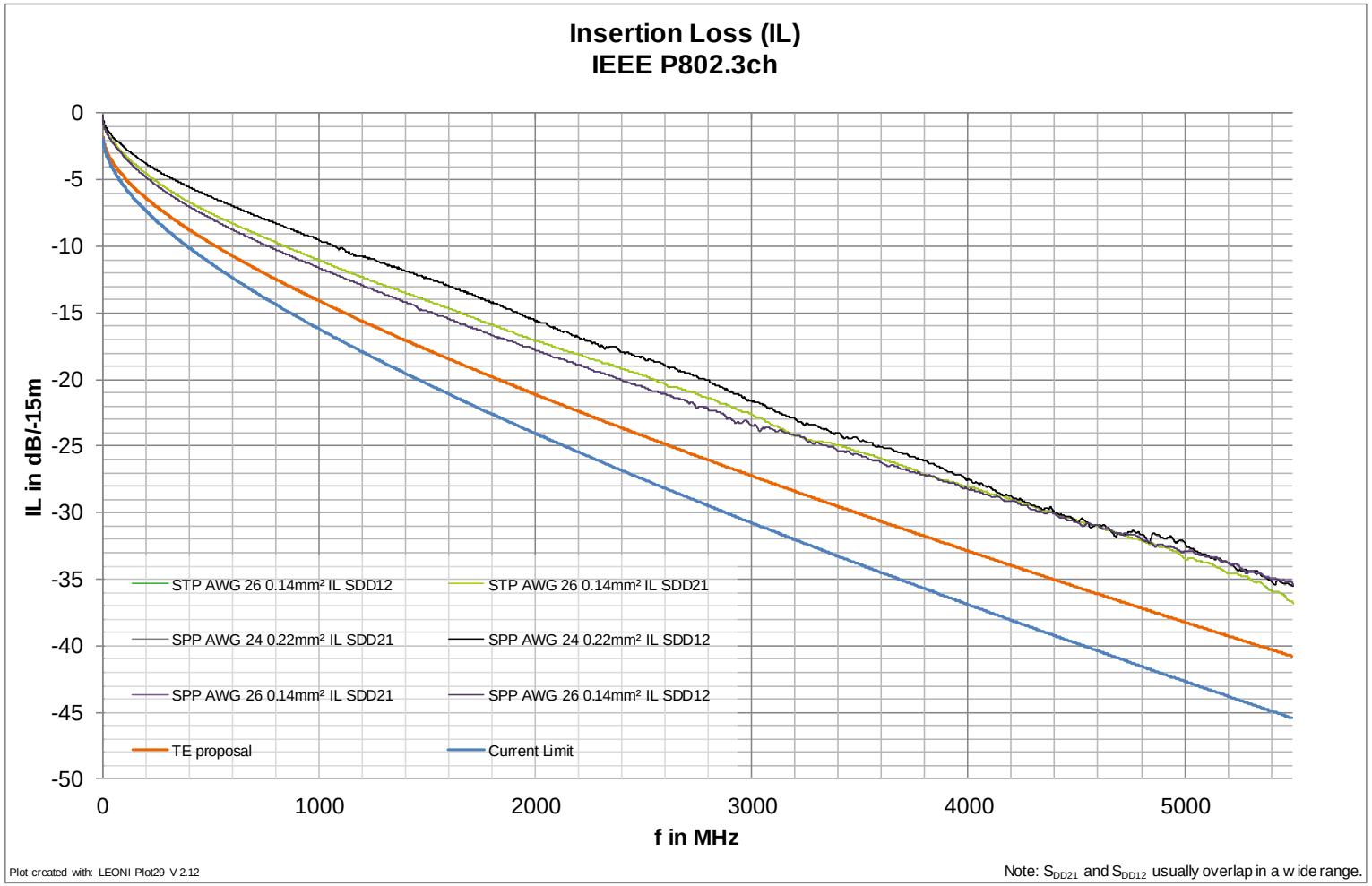
*Farjad_3ch_01b_0118.pdf
Current Limit:

$ILdBf \leq 0.0030 * f + 0.40 * \sqrt{f}$

*Bergner_DiBiaso_Mandel_3ch_01_0418.pdf:
New Limit (TE proposal):

$ILdBf \leq 0.0031 * f + 0.30 * \sqrt{f} + 1.5$

Insertion loss measurements at -40°C



Length measured: 10m
Calculated for 15m
Condition as delivered
Setup: Ring

No limit violation

*Farjad_3ch_01b_0118.pdf
Current Limit:

$ILdBf \leq 0.0030 * f + 0.40 * \sqrt{f}$

*Bergner_DiBiaso_Mandel_3ch_01_0418.pdf:
New Limit (TE proposal):

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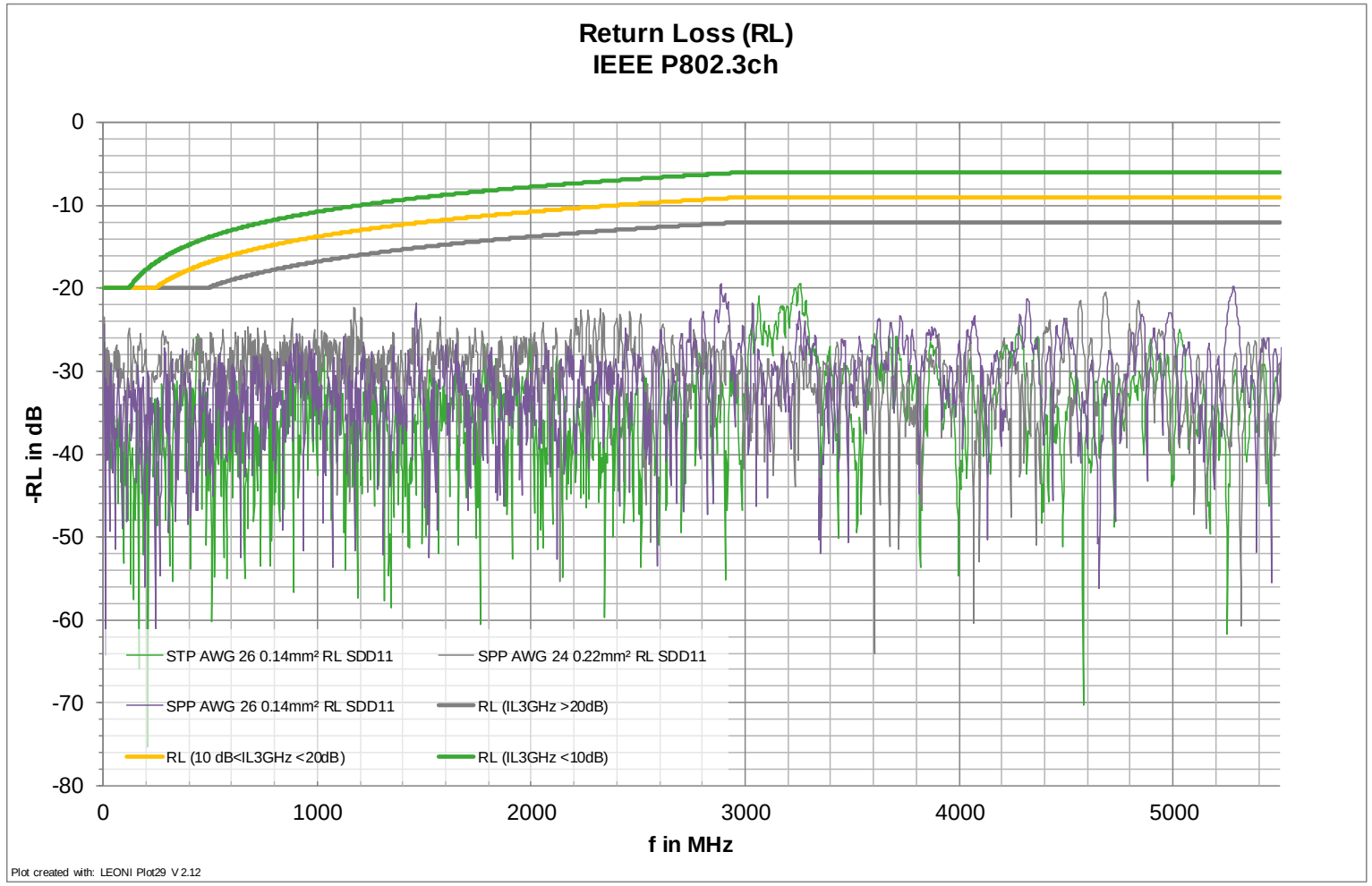
Return loss measurements at -40°C



Length measured: 10m
Condition as delivered
Setup: Ring

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

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

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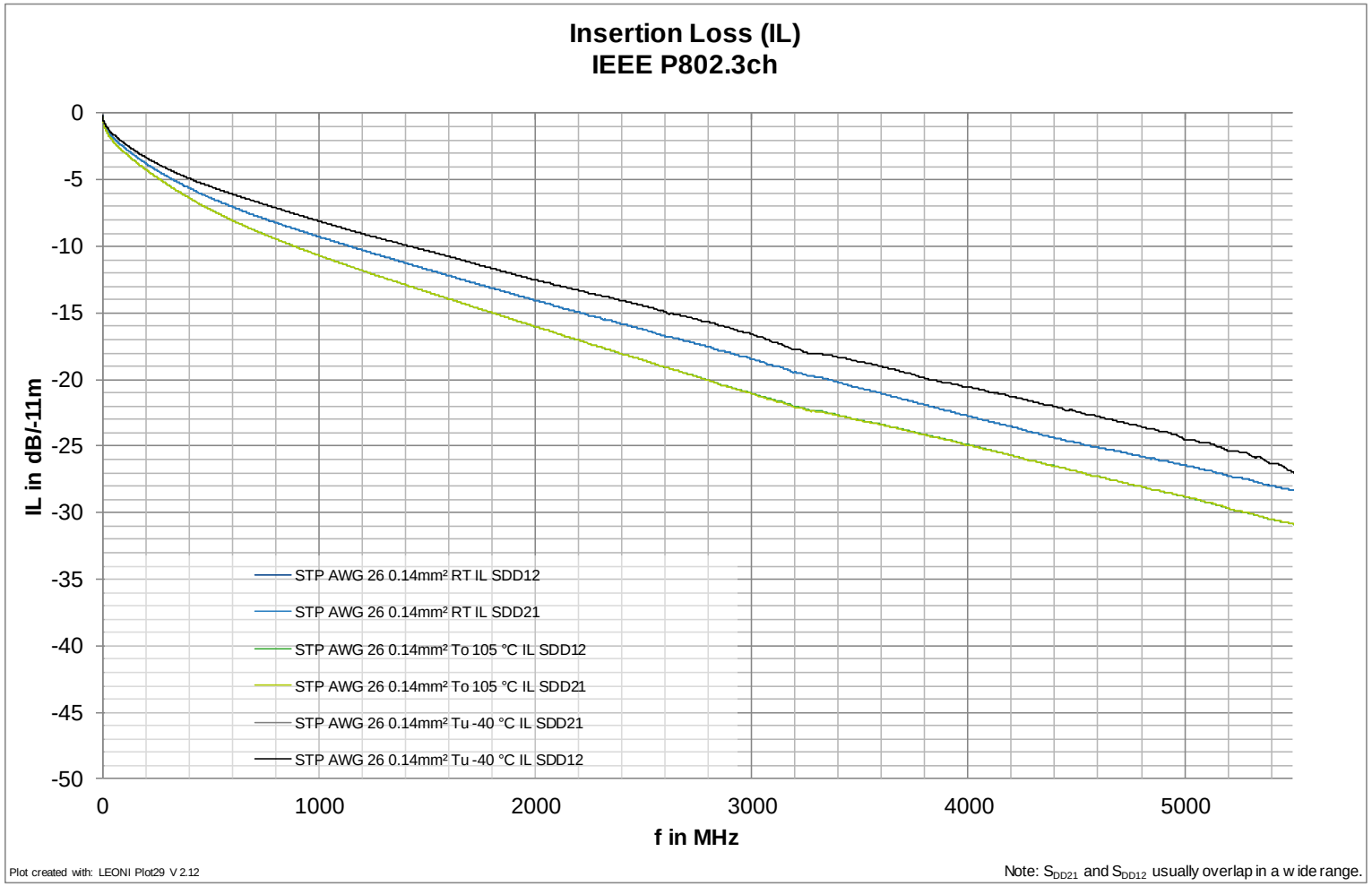
Insertion loss measurements STP AWG 26 0.14mm²

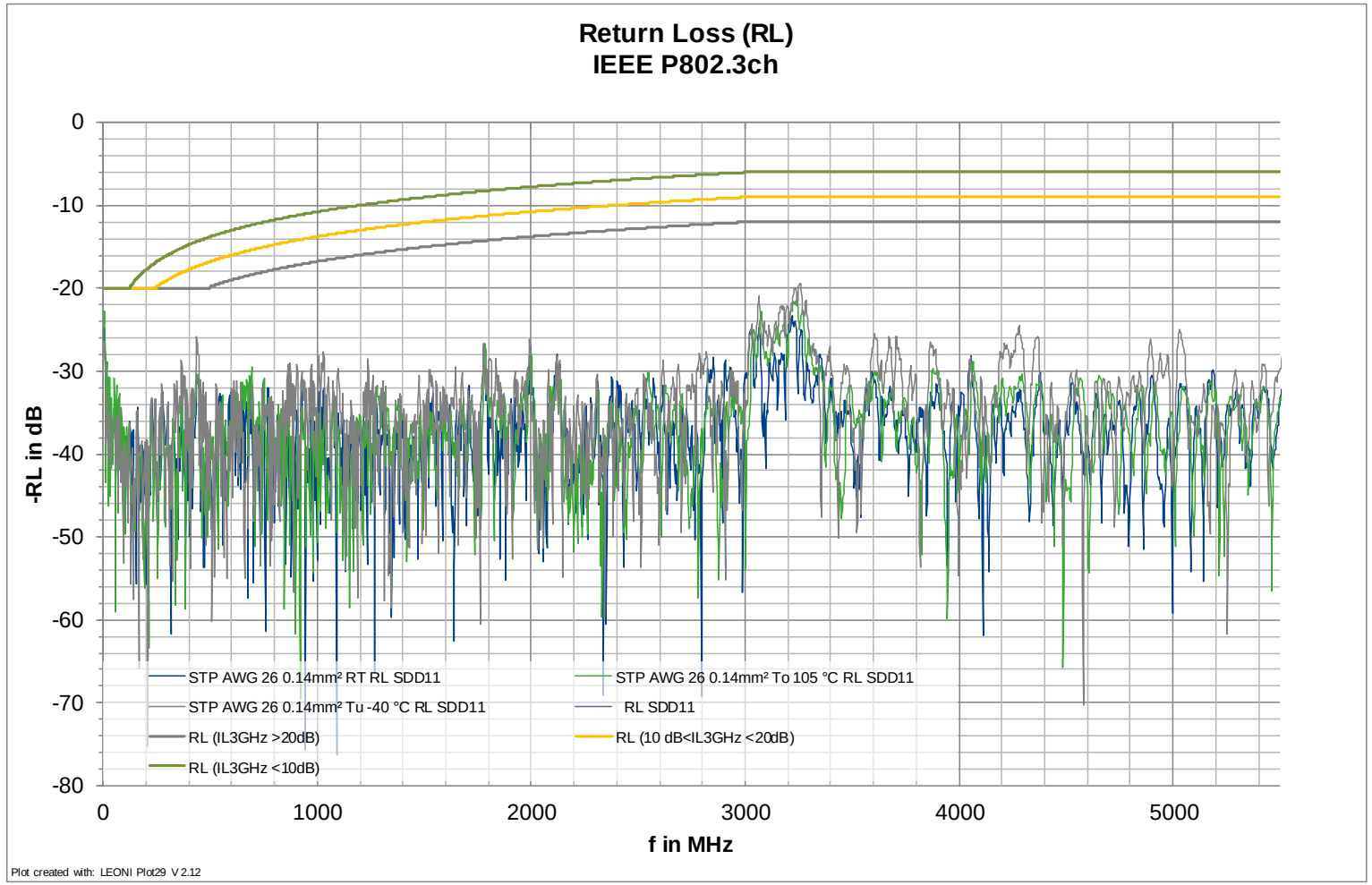


Length measured: 10m
Calculated for 11m
Condition as delivered
Setup: Ring

IL increases by approx.
3dB at 105°C at 3 GHz

IL decreases by approx.
1.5 dB at -40°C at 3 GHz

Return loss measurements at STP AWG 26 0.14mm²



Length measured: 10m
Condition as delivered
Setup: Ring

Gated measurement:

- Influence of measurement adapter compensated
- Pure cable data

RL Limit: * Farjad_3ch_01b_0118.pdf

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

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

(f in MHz)

Contributions from :
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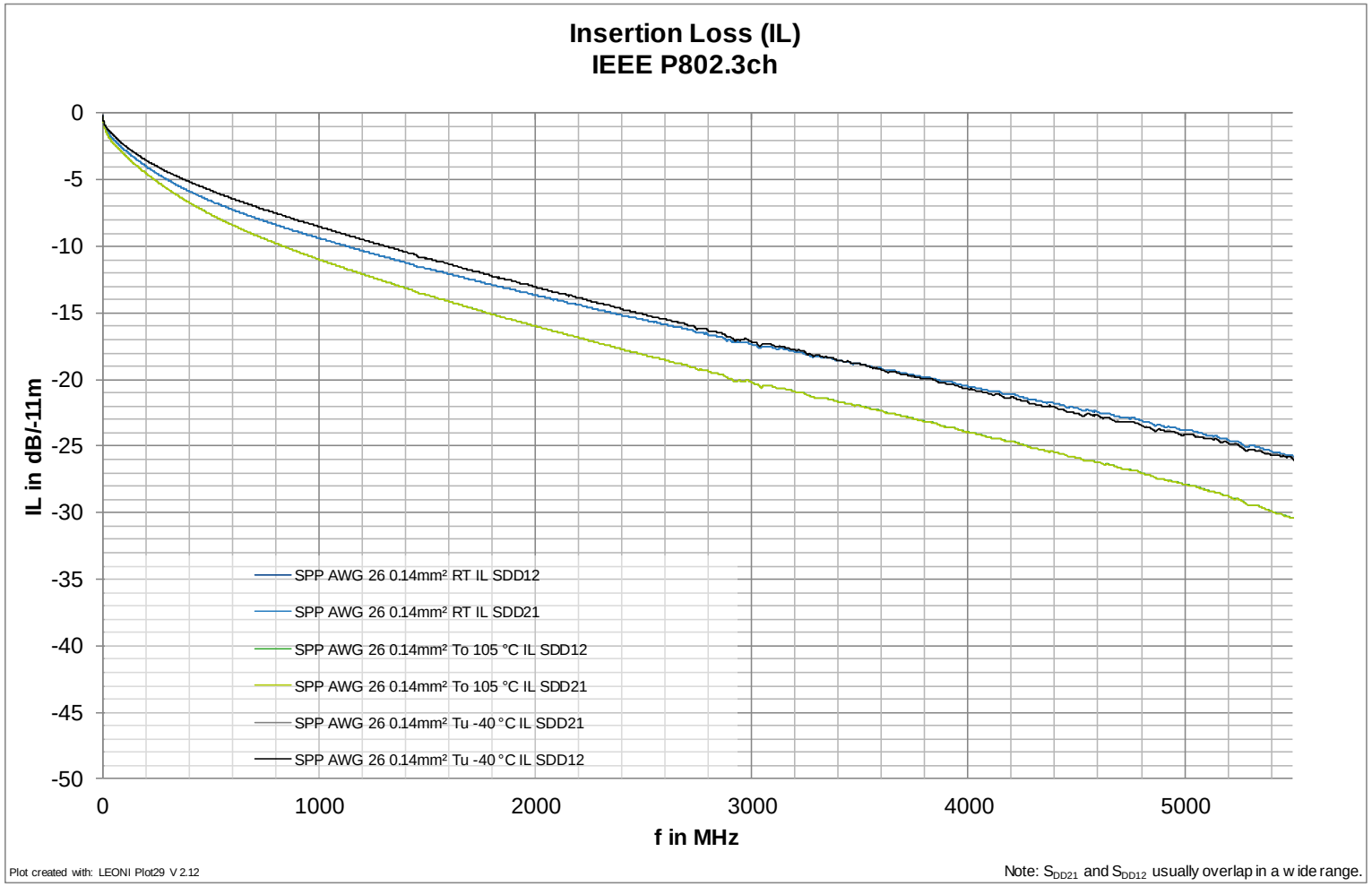
James Withey
Masood Shariff

No significant change in Return loss due to temperature change.

Insertion loss measurements SPP AWG 26 0.14mm²

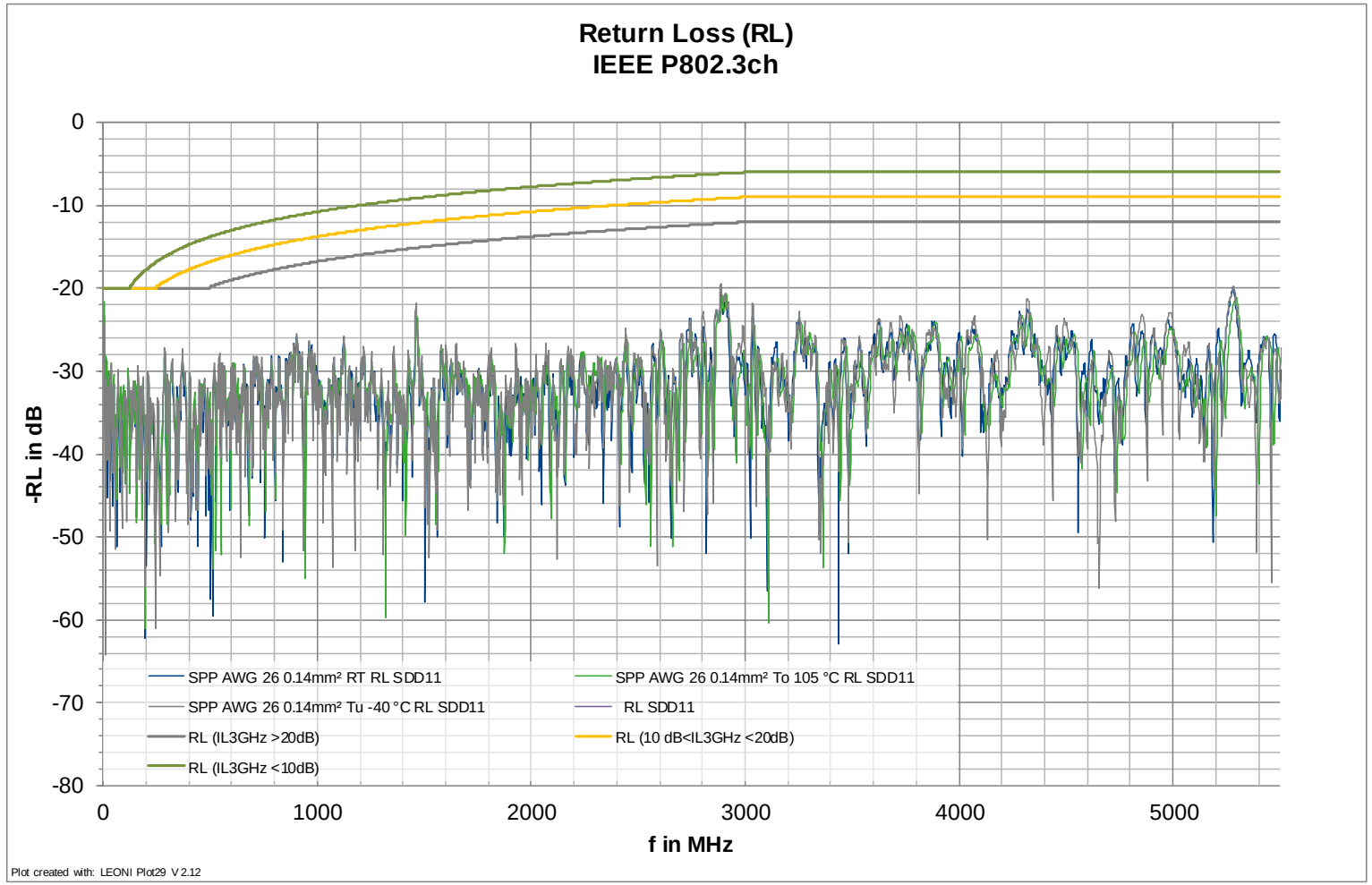


Length measured: 10m
Calculated for 11m
Condition as delivered
Setup: Ring

IL increases by approx. 3dB at 105°C at 3 GHz

No significant change at -40°C

Return loss measurements at SPP AWG 26 0.14mm²



Length measured: 10m
Condition as delivered
Setup: Ring

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

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

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

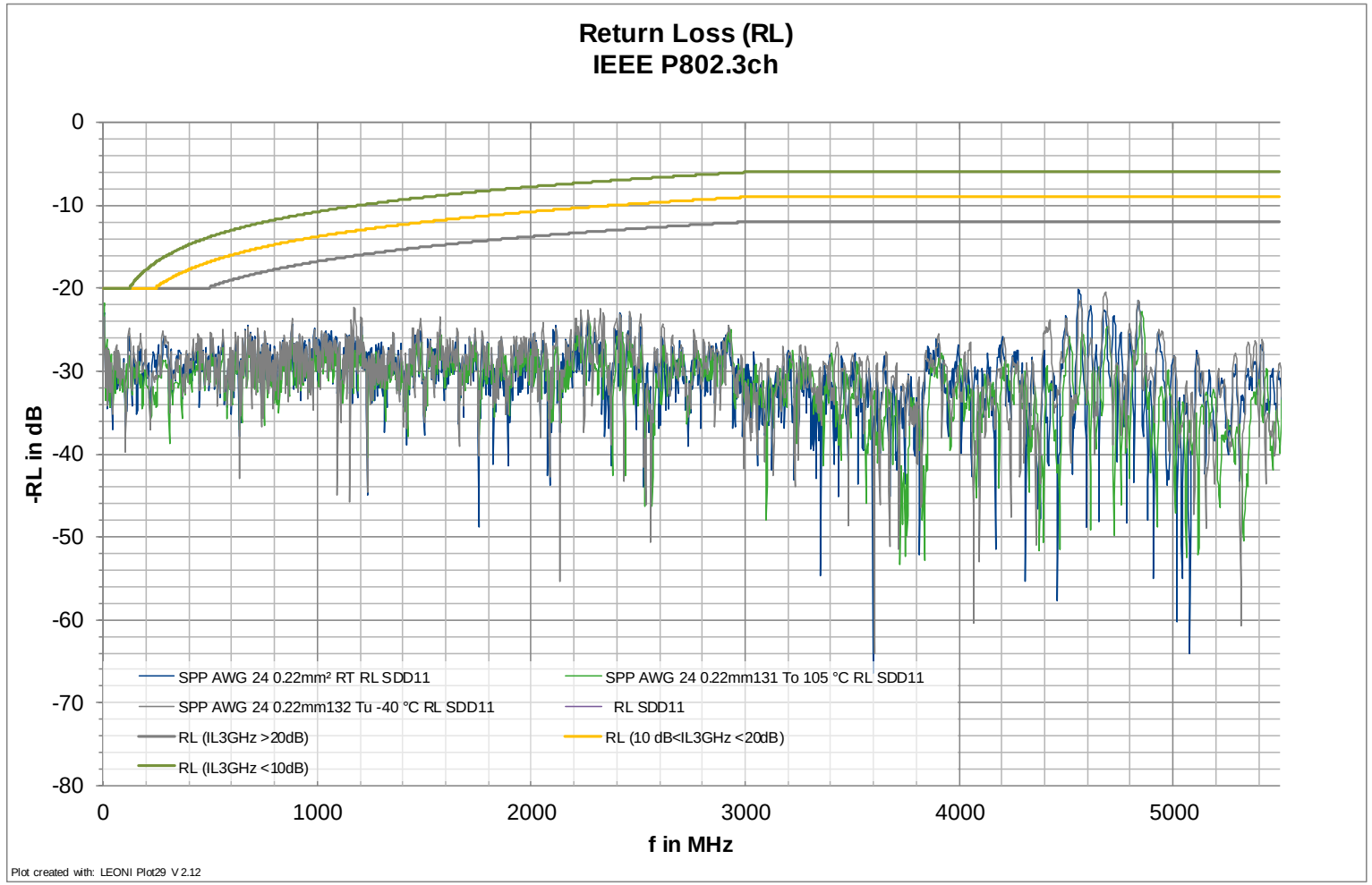
No significant change in Return loss due to temperature change.

Insertion loss measurements SPP AWG 24 0.22mm²

Length measured: 10m
Calculated for 11m
Condition as delivered
Setup: Ring

IL increases by approx.
2.5dB at 105°C and
-40°C at 3 GHz

Return loss measurements at SPP AWG 26 14mm²



Length measured: 10m
Condition as delivered
Setup: Ring

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

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

Contributions from :
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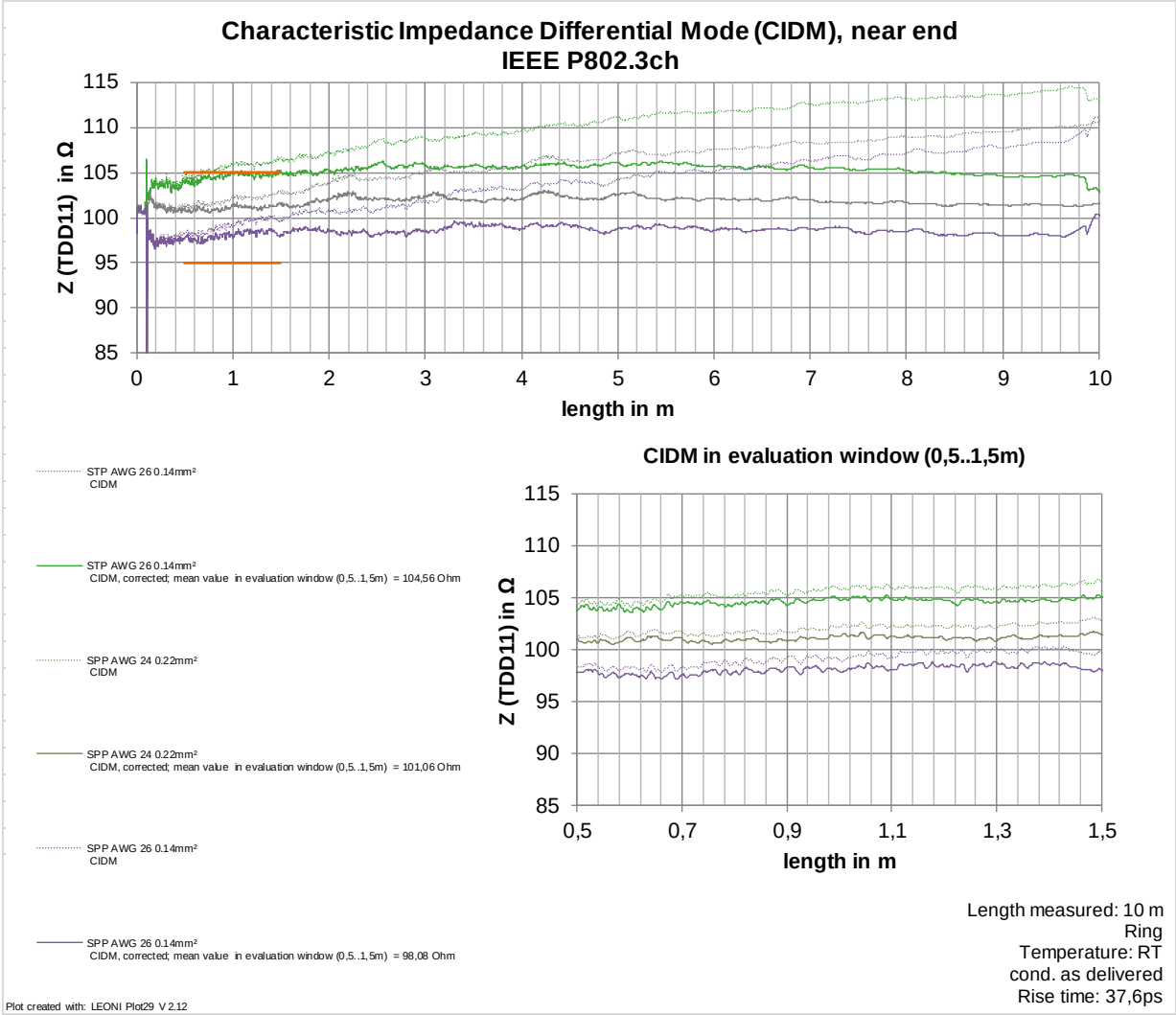
No significant change in Return loss due to temperature change.

CIDM measurements at room temperature



Temperature influence:

105°C +1Ω approx.
-40°C no significant change

Recommendation:
CIDM 100Ω ±5%

Correction:
The TDR was calibrated using an E-Cal-Kit. Then, a pair of airlines with $Z_{DM_{Airline}} = 100\Omega$ was measured. The measured sample impedance is corrected using the measured airline impedance using

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

and

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

Conclusions

STP AWG 26 0.14mm²:

- No violation of IL limit (TE proposal) for 11m length
- IL limit (TE proposal) violation for 15m length at 105°C, no limit violation for current limit at 105°C,
- No limit (TE proposal) violation for 15 m length at room temperature and -40°C
- No RL limit violation
- Worst IL and RL behaviour of all three cable types
- High impedance (improvement of impedance will lead to an increase of insertion loss)
- 5.5 GHz physical limitation

Conclusions

SPP AWG 26 0.14mm²:

- No violation of IL limit (TE proposal) for 11m length
- IL limit (TE proposal) violation for 15m length at 105°C, no limit violation for current limit at 105°C
- No limit (TE proposal) violation for 15 m length at room temperature and -40°C
- No RL limit violation
- Good IL and RL behaviour
- Good impedance
- Also works good beyond 5.5 GHz (future applications)

Conclusions

SPP AWG 24 0.22mm²:

- No violation of IL limit (TE proposal) for 11m and 15m length
- No RL limit violation
- Best IL and RL behaviour
- Low impedance
- Recommendation for cable/link length > 11m
- Also works good beyond 5.5 GHz (future applications)

Conclusions

- All three cable types fulfill the actual requirements (TE proposal) for 11m length
- SPP AWG24 0.22mm² fulfills the actual requirements (TE proposal) for 15m length
- TE proposal for insertion loss limit is acceptable from LEONI´s point of view, but requires a different cable type (AWG24) for 15m cable length
- The cables show no return loss violation
- Temperature drift is insignificant with respect to actual limits from LEONI´s point of view
- CIDM should be 100Ω ±5% (LEONI experience) to ensure safe product quality

Next steps: - discuss mode conversion requirements

- discuss impedance requirements

Thank you !!!