

Empowering the All Electric Society 



Willkommen

Signal Integrity and Terminal Blocks



Motivation

- Transmission characteristics of terminal blocks (DIN-Rail mounted and PCB mounted) are from interest
- Common products and installation techniques should be possible
- The space requirement should not be too large
- Most important parameters to consider: IL, RL, TCL, NEXT
- Following the presentations `graber_3dg_01_01182023`, `graber_3dg_0103152023` and `graber3dg_0107112023` :


Measurements

- The following picture shows an example of the measurement setup with the DIN rails, keeping the terminal blocks, taped to the copper plate and 12 mm separation elements between the terminal blocks.
- The first two terminal block groups also have shielding elements on the left and right side (we only built a total of 10 shielding elements, so not on all terminal blocks shielding elements could be placed on the left and right side).

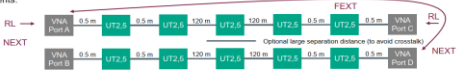


Link Segments

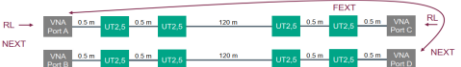
- Different neighbored link segments (with 120 m and 240 m length) with Phoenix Contact UT2.5 terminal blocks have been measured at room temperature related to crosstalk, insertion and return loss.
- The 0.5 m cable segments are using fine stranded shielded AWG18 fieldbus cables, the 120 m cable segments are using shielded AWG18/7 fieldbus cables.
- Two identical link segments running in parallel have been created to measure the crosstalk.
- For the measurements the AEM MMVNA-100 has been used. This VNA provides 4 differential ports (A, B, C, D) for the measurement of the following link segments:



5 terminal blocks (240 m):



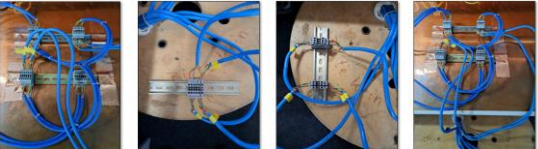
4 terminal blocks (120 m):



Optional large separation distance to avoid crosstalk


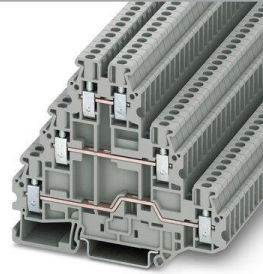

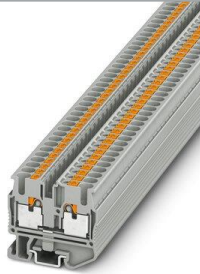


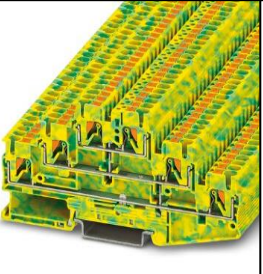
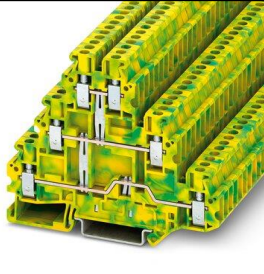


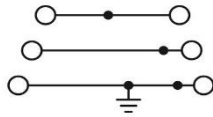
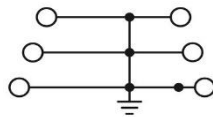
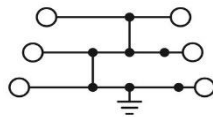
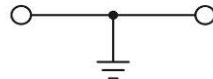
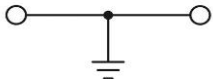
Measurement Setup

- The following pictures show an example of the measurement setup with the DIN rails, keeping the terminal blocks, taped to the copper plate.
- The 4 x 120 cable segments are placed on a cable drum, bundled and running in parallel.
- For the 240 m link segment for one measurement the middle terminal blocks are placed close to each other, for a second measurement they have been separated to reduce the influence of the middle terminal blocks to the overall crosstalk (simulation of one common 240 m cable segment instead of 2 x 120 m related to crosstalk).



Product candidates

Consideration:
first choose the most attractive
and at the same time the most
difficult products

<p>3210499 PT 2,5-3L Multi-level terminal block</p> 	<p>3214259 UT 2,5-3L Multi-level terminal block</p> 	<p>3248030 MUT 2,5 Mini feed-through terminal block</p> 	<p>3248125 MPT 2,5 Mini feed-through terminal block</p> 	<p>1045923 PTFIX 2X1,5 GY Distribution block</p> 
<p>3210541 PT 2,5-3PE/L/L Ground terminal</p> 	<p>3210525 PT 2,5-3PE Ground terminal</p> 	<p>3214275 UT 2,5-3PE Ground terminal</p> 	<p>3248032 MUT 2,5-PE Mini ground terminal block</p> 	<p>3248125 MPT 2,5 Mini ground terminal block</p> 
				

1



2



3

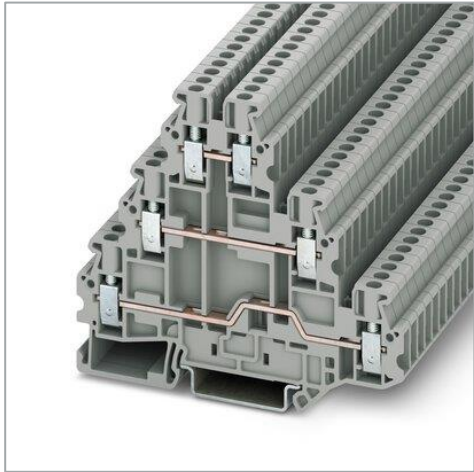


4

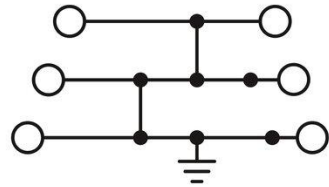
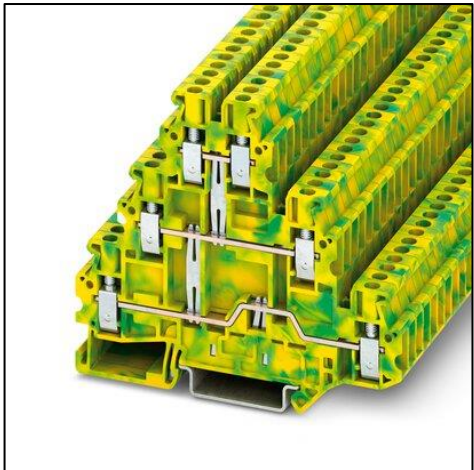


Klemme	Klemme	Stecker	Stecker	Stecker
1729160	1991134	1110633	1778027	1858808
MKDSN 1,5/ 6-5,08	SPT 2,5/ 6-V-5,0	LPC 2,5/ 6-STF-5,08	MSTB 2,5/ 6-STF-5,08	GMSTB 2,5/ 6-STF-7,62
				
Grundleiste	Grundleiste	Grundleiste		
1954731	1954731	1806261		
CC 2,5/ 6-GF-5,08 P26THR	CC 2,5/ 6-GF-5,08 P26THR	GMSTB 2,5/ 6-GF-7,62		

First test samples



DIN-Rail mounted
3-Level connection
Screw termination
All levels with different path length



Nested conductor layout

Wiring scheme:

1L	0	1	2	3	4	5	6
	S	+	-	S	+	-	S

3L-A	0	1	2	3	4	5	6
Top	S			S			S
Mid	S	+	-	S	+	-	S
Bot	S	+	-	S	+	-	S

3L-B	0	1	2	3	4	5	6
Top	S	+	-	S	+	-	S
Mid	S	+	-	S			S
Bot	S	+	-	S			S

=> Same path length per channel

Measuring principle - Acquisition of the complete S-Parameter set

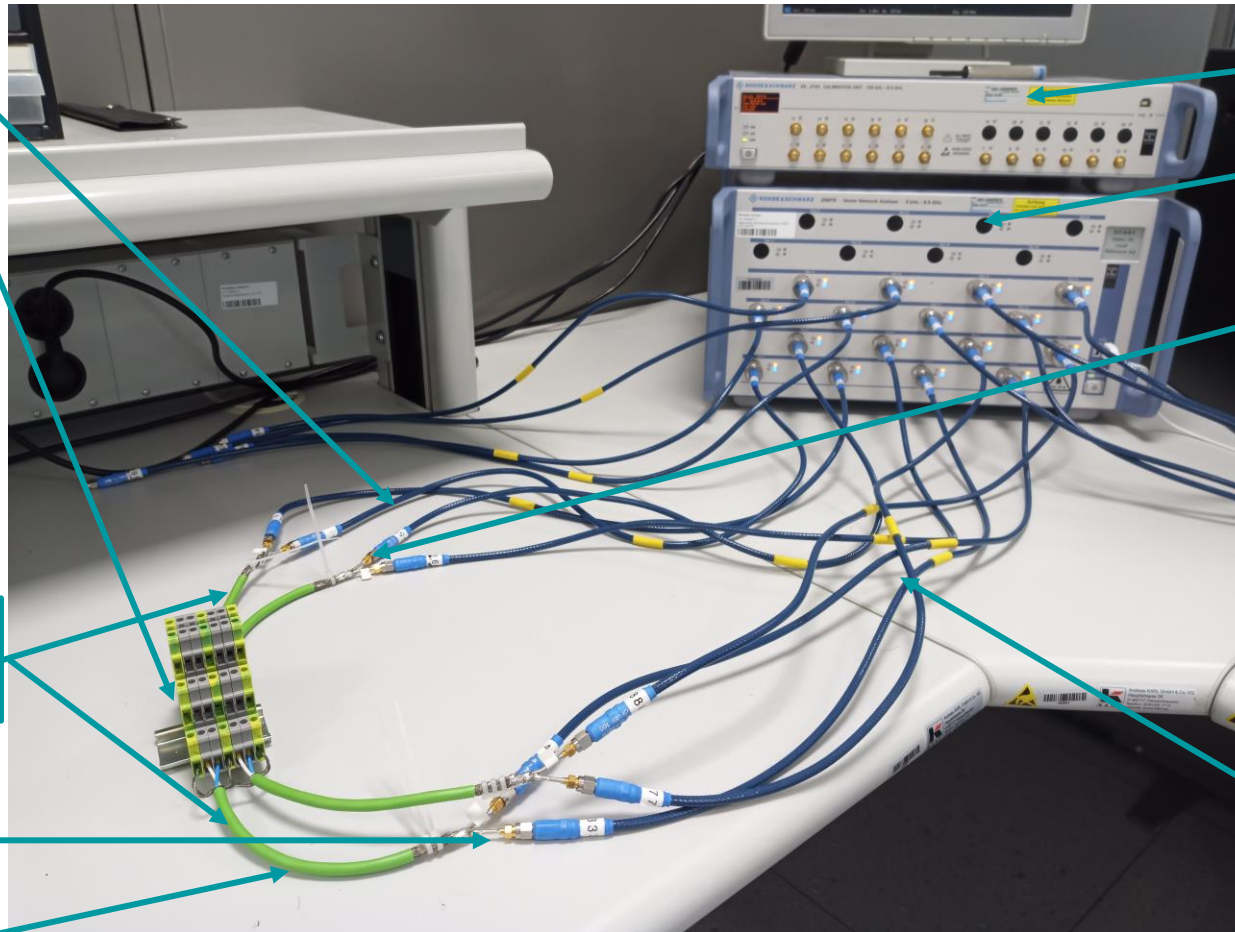
Measuring cables
Port 9-16

Terminal Block
on DIN-Rail

SPE connection cables

Semi rigid SMA connector

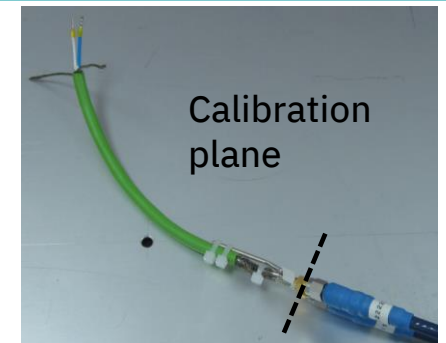
5 0,2m Cable length in order to
avoid $\lambda/2$ -resonances



Calibration Unit

Vektor Network Analyzer

Calibration plane:
End of SMA connector

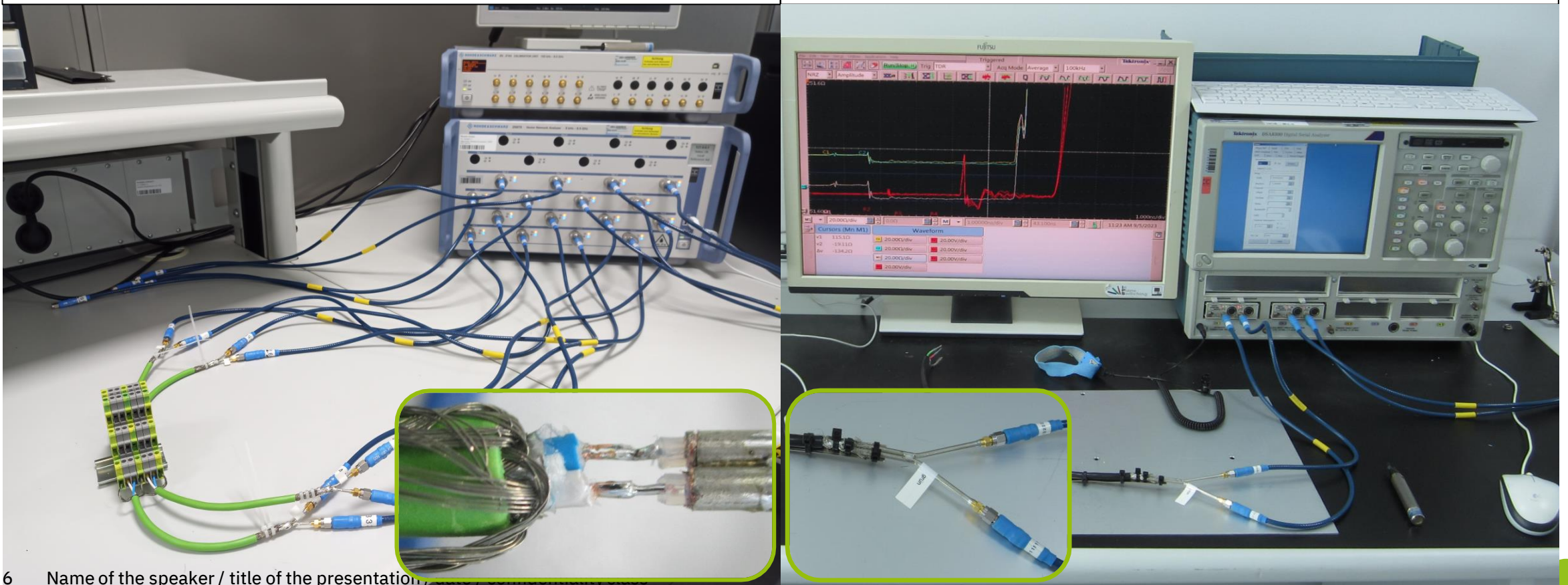


Measuring cables
Port 1-8

Measuring equipment

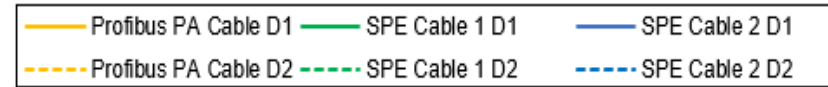
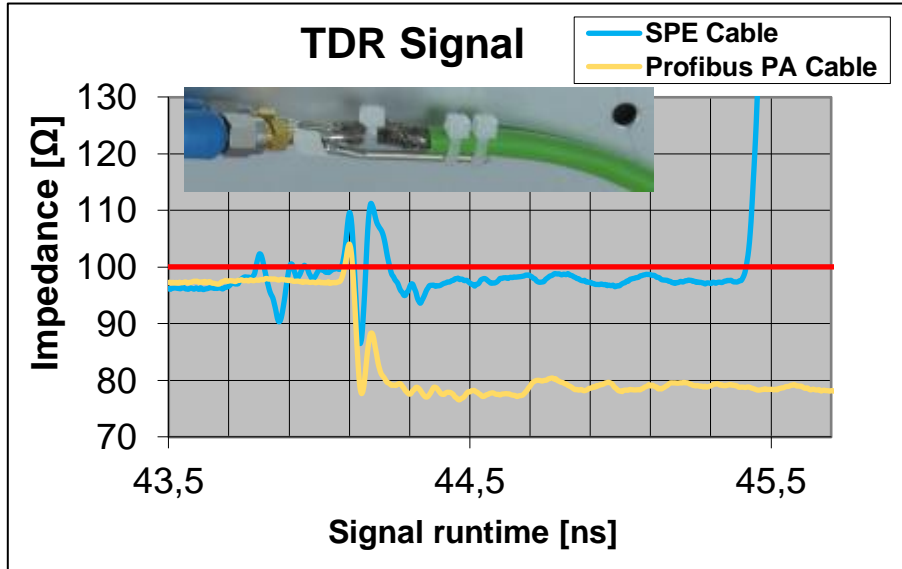
- 16 Ports VNA
- 8.5 GHz Bandwidth

- Oscilloscope with TDR Sampling Module
- 20 GHz Bandwidth

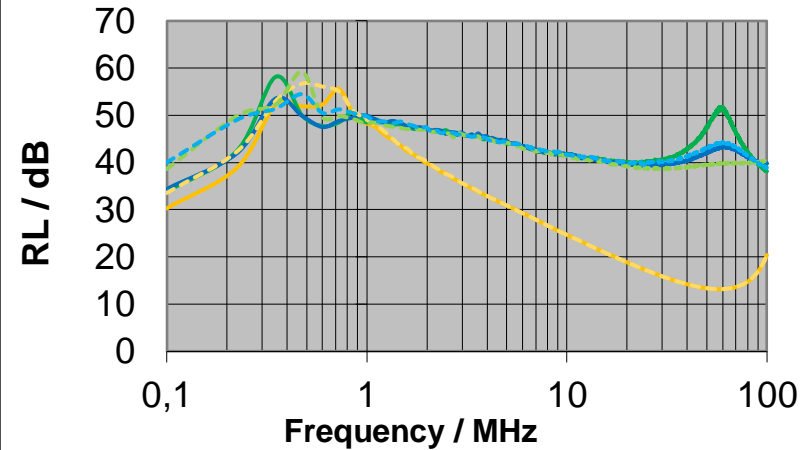


Chosen cable type

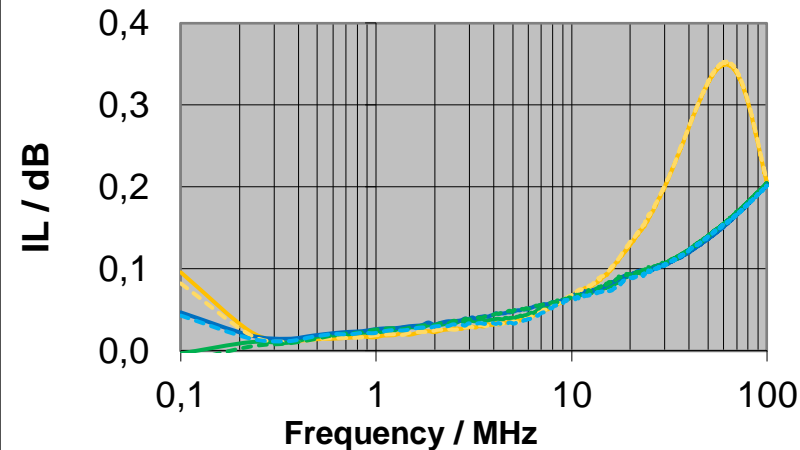
Datasheet	Profibus PA Cable	SPE Cable
Conductor	2 x 18 AWG	2 x 22 AWG
Shield	Foil + Braid	Foil + Braid
Nominal attenuation (Datasheet)	0.3 dB/100 m @ 39 kHz	2.9 dB/100 m @ 1 MHz 8.5 dB/100 m @ 10 MHz 21.7 dB/100 m @ 62,5 MHz
Impedance (Datasheet)	100 Ω \pm 20 Ω @ 31.25 kHz	100 Ω \pm 5 Ω @100 MHz
Impedance measured	80 Ω	100 Ω



Cable (1 m) Return Loss



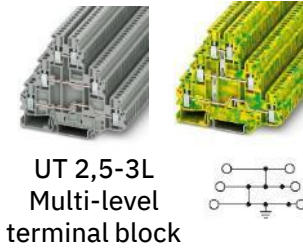
Cable (1 m) Insertion Loss



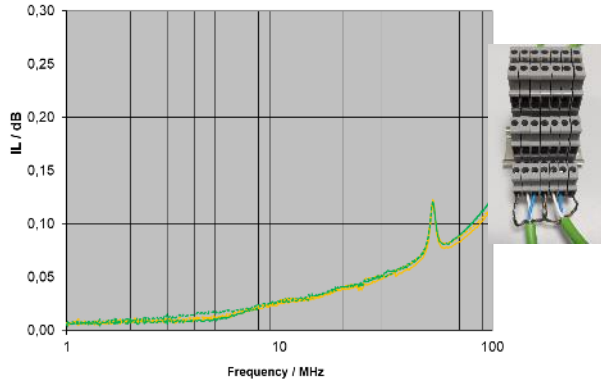
The measured values below 1 MHz have limited significance due to the electronic calibration of the VNA.

Conclusion:
The 22 AWG SPE cable will be used for the following measurement due to the impedance deviation of the Profibus PA cable

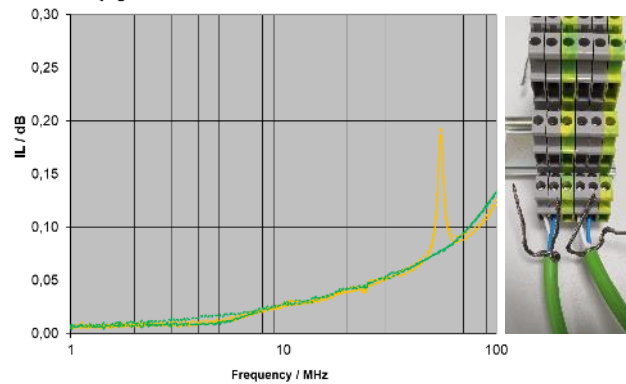
Multi-level terminal block , 1st level IL depending on shielding



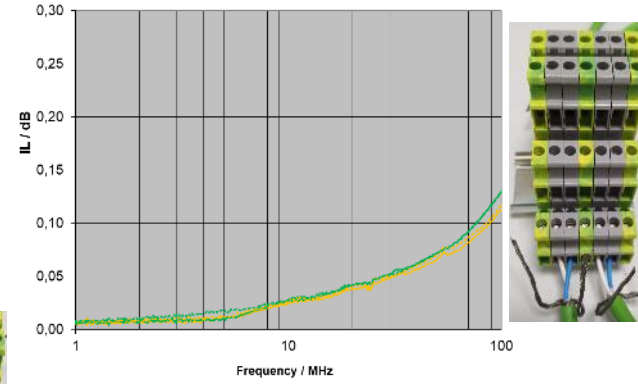
Insertion Loss
6x UT 2,5-3L
pigtaills not connected



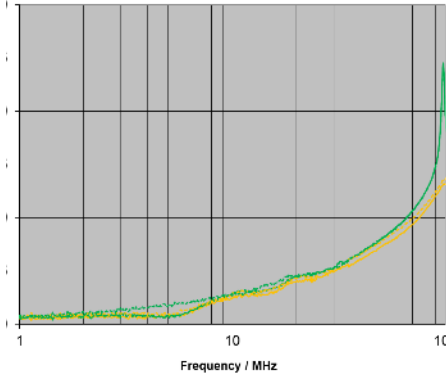
Insertion Loss
2x UT 2,5--PE--2x UT 2,5--PE
pigtaills not connected



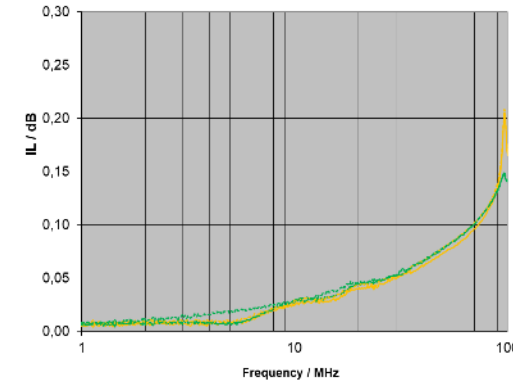
Insertion Loss
PE--2x UT 2,5--PE--2x UT 2,5--PE
pigtaills not connected



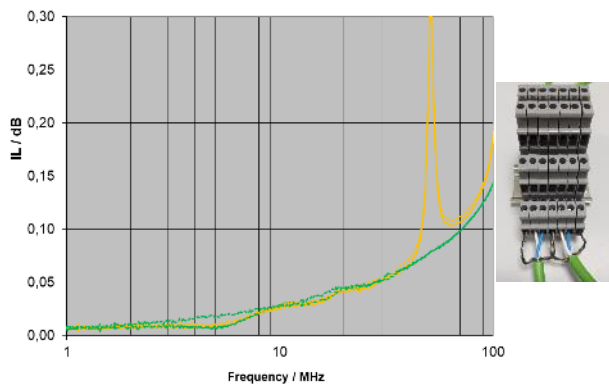
PE--2x UT 2,5--PE--2x UT 2,5--PE
pigtaills connected on right side



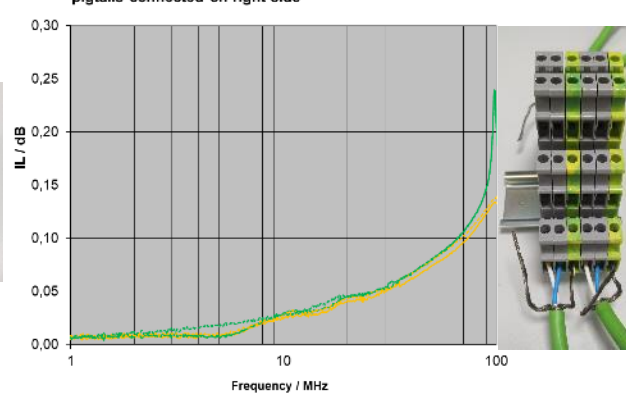
Insertion Loss
PE--2x UT 2,5--PE--2x UT 2,5--PE
pigtaills connected on left side



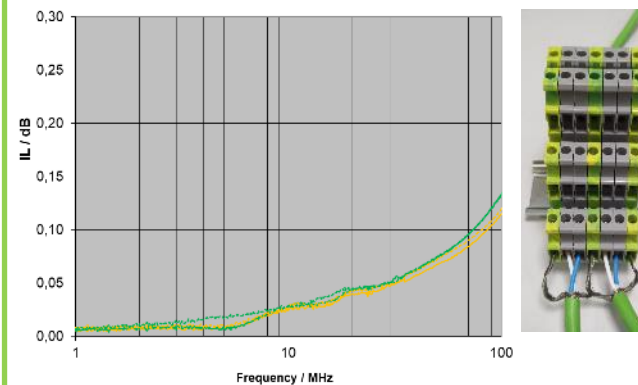
Insertion Loss
6x UT 2,5-3L
pigtaills connected on left side



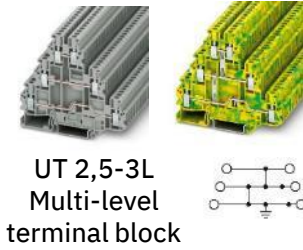
Insertion Loss
2x UT 2,5--PE--2x UT 2,5--PE
pigtaills connected on right side



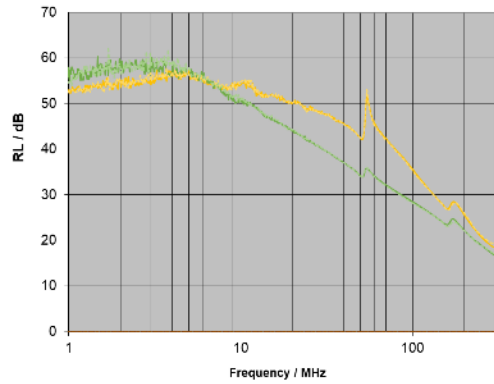
Insertion Loss
PE--2x UT 2,5--PE--2x UT 2,5--PE
pigtaills connected on both sides



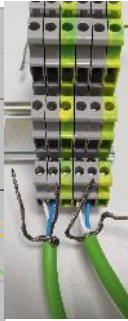
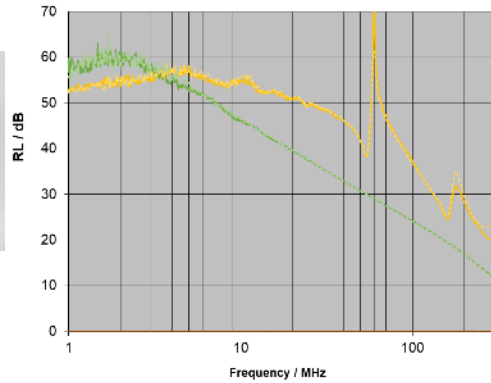
Multi-level terminal block , 1st level RL depending on shielding



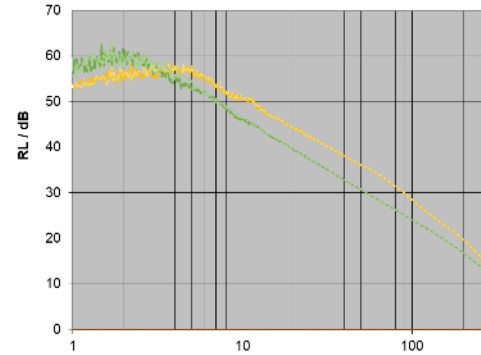
Return Loss
6x UT 2,5-3L
pigtails not connected



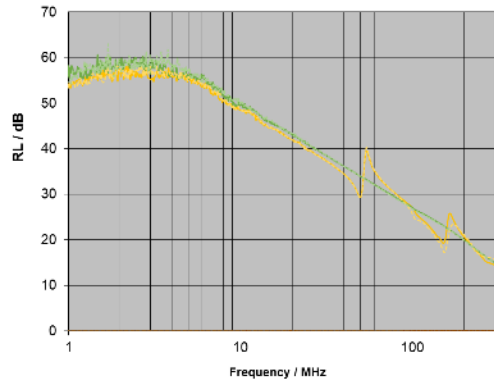
Return Loss
2x UT 2,5--PE--2x UT 2,5--PE
pigtails not connected



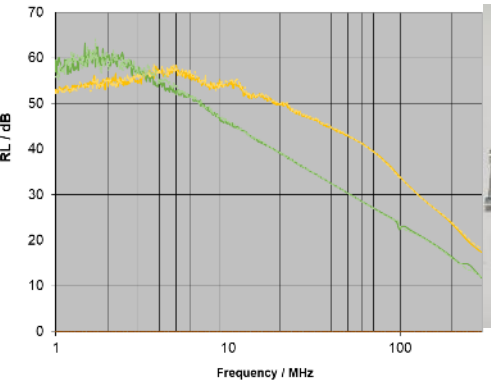
Return Loss
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pigtails not connected



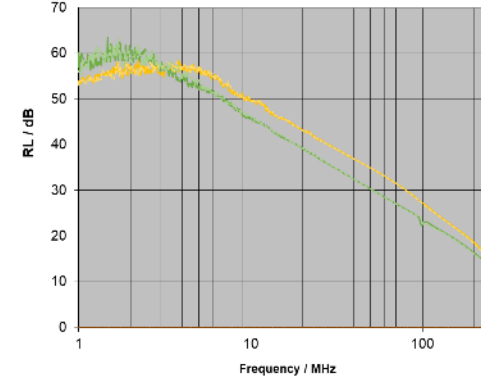
Return Loss
6x UT 2,5-3L
pigtails connected on left side



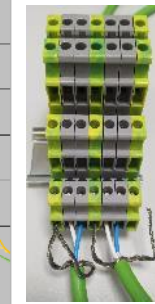
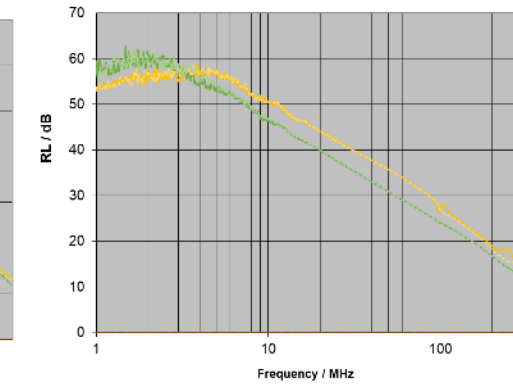
Return Loss
2x UT 2,5--PE--2x UT 2,5--PE
pigtails connected on right side



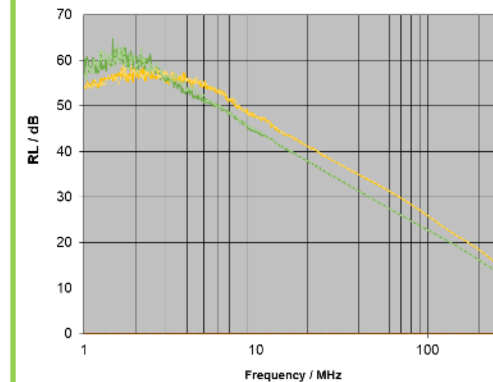
Return Loss
PE--2x UT 2,5--PE--2x UT 2,5--PE
pigtails connected on right side



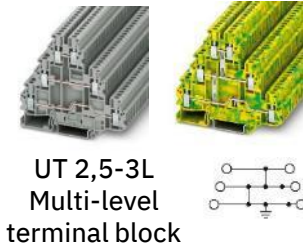
Return Loss
PE--2x UT 2,5--PE--2x UT 2,5--PE
pigtails connected on left side



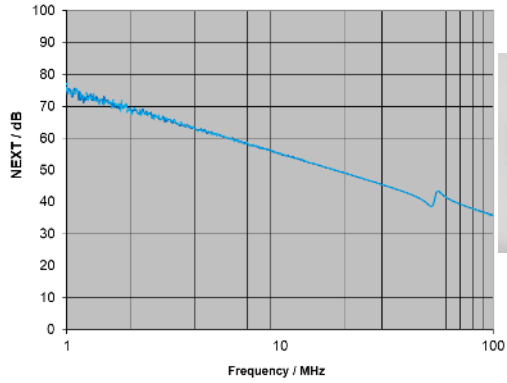
Return Loss
PE--2x UT 2,5--PE--2x UT 2,5--PE
pigtails connected on both sides



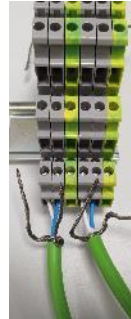
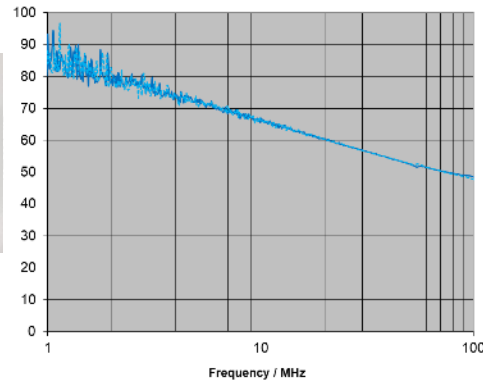
Multi-level terminal block , 1st level NEXT depending on shielding



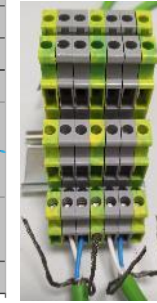
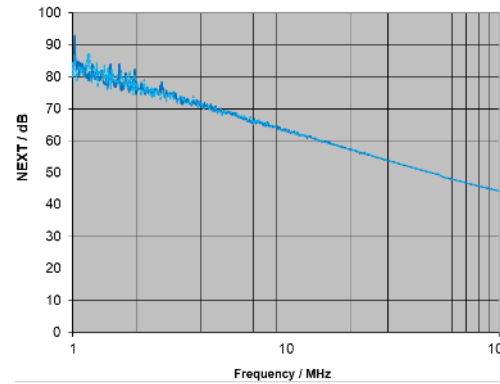
Near-End Cross-Talk
6x UT 2,5-3L
pigtaills not connected



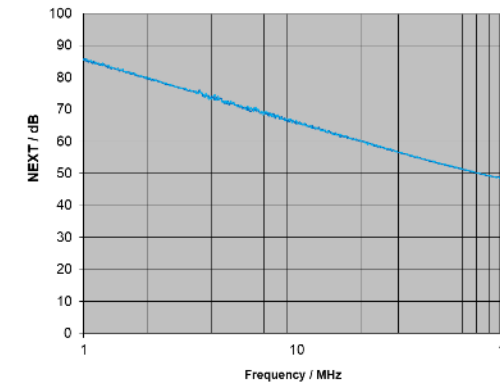
Near-End Cross-Talk
2x UT 2,5--PE--2x UT 2,5--PE
pigtaills not connected



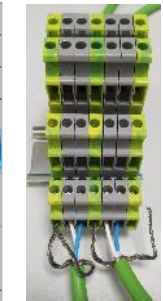
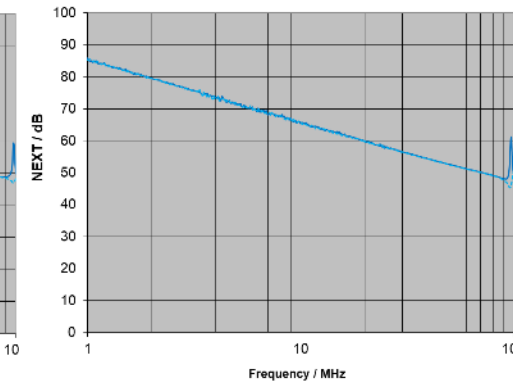
Near-End Cross-Talk
PE--2x UT 2,5--PE--2x UT 2,5--PE
pigtaills not connected



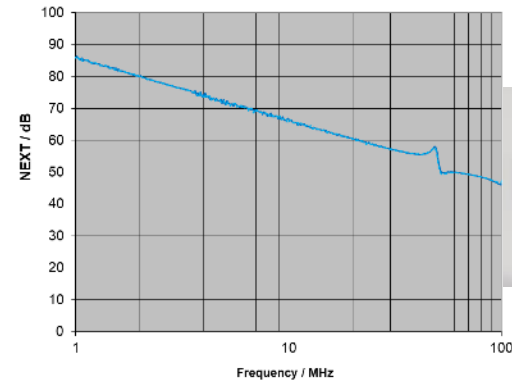
Near-End Cross-Talk
PE--2x UT 2,5--PE--2x UT 2,5--PE
pigtaills connected on right side



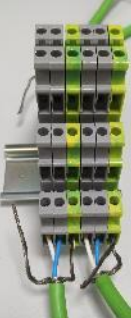
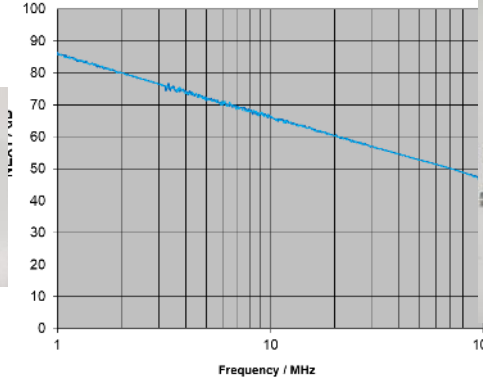
Near-End Cross-Talk
PE--2x UT 2,5--PE--2x UT 2,5--PE
pigtaills connected on left side



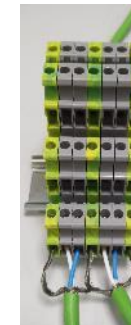
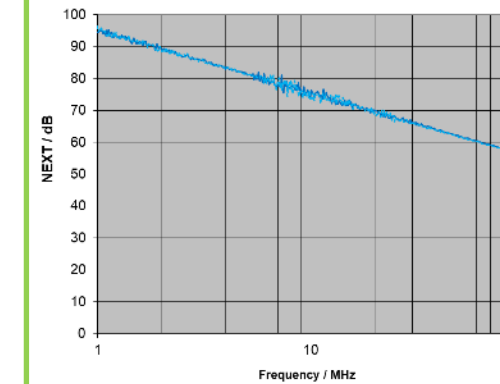
Near-End Cross-Talk
6x UT 2,5-3L
pigtaills connected on left side



Near-End Cross-Talk
2x UT 2,5--PE--2x UT 2,5--PE
pigtaills connected on right side

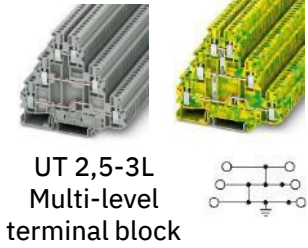
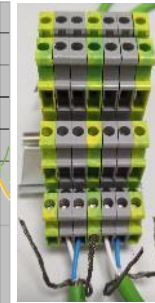
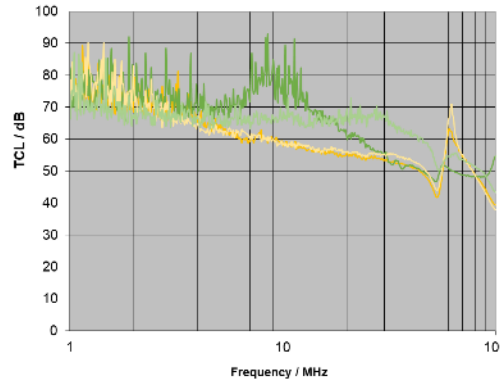


Near-End Cross-Talk
PE--2x UT 2,5--PE--2x UT 2,5--PE
pigtaills connected on both sides

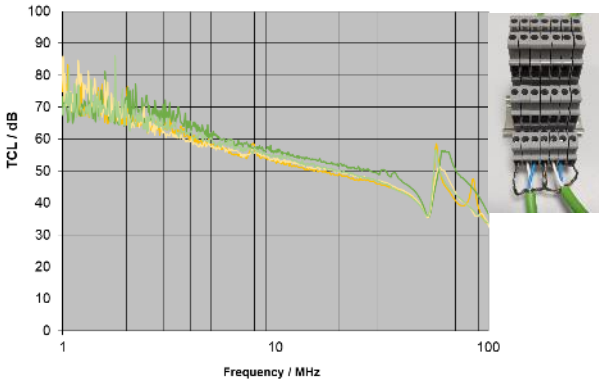


Multi-level terminal block, 1st level TCL depending on shielding

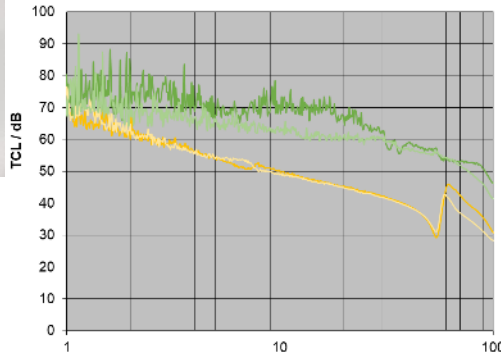
Transverse Conversion Loss
PE--2x UT 2,5--PE--2x UT 2,5--PE
pigtaills not connected



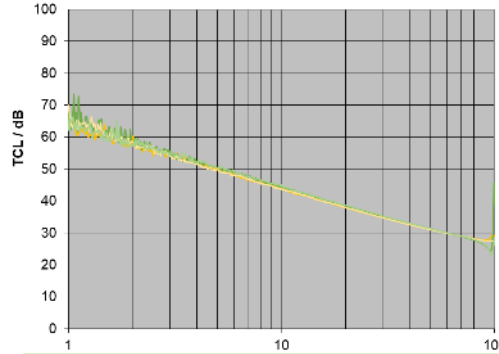
Transverse Conversion Loss
6x UT 2,5-3L
pigtaills not connected



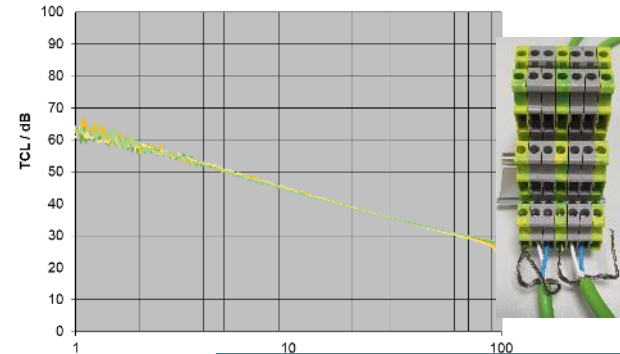
Transverse Conversion Loss
2x UT 2,5--PE--2x UT 2,5--PE
pigtaills not connected



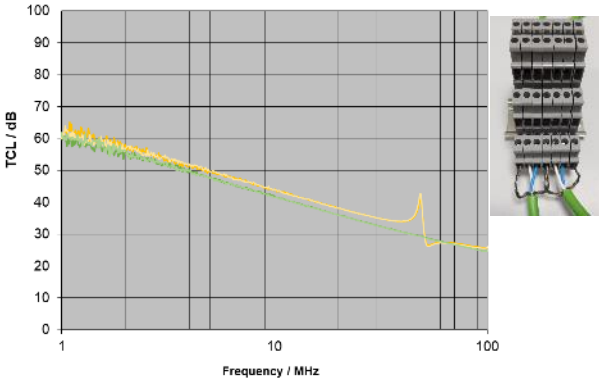
Transverse Conversion Loss
PE--2x UT 2,5--PE--2x UT 2,5--PE
pigtaills connected on right side



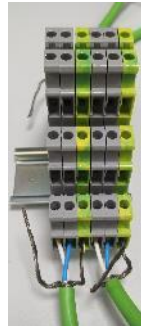
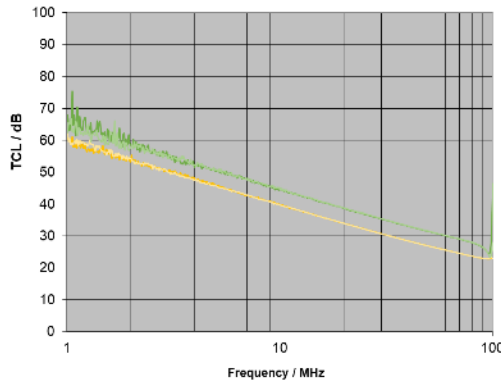
Transverse Conversion Loss
PE--2x UT 2,5--PE--2x UT 2,5--PE
pigtaills connected on left side



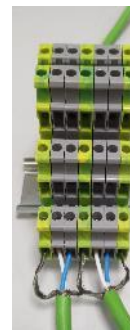
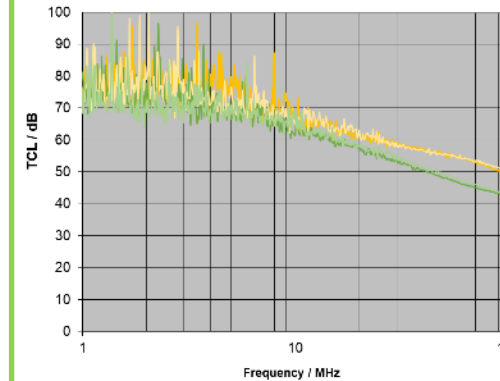
Transverse Conversion Loss
6x UT 2,5-3L
pigtaills connected on left side



Transverse Conversion Loss
2x UT 2,5--PE--2x UT 2,5--PE
pigtaills connected on right side



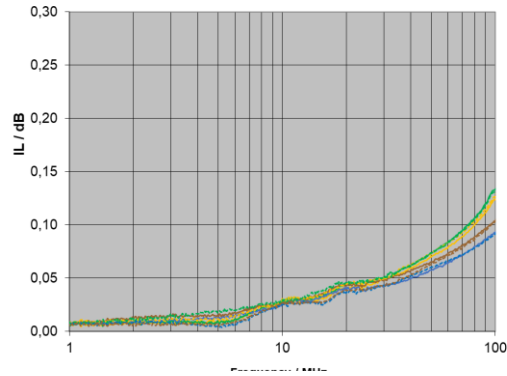
Transverse Conversion Loss
PE--2x UT 2,5--PE--2x UT 2,5--PE
pigtaills connected on both sides



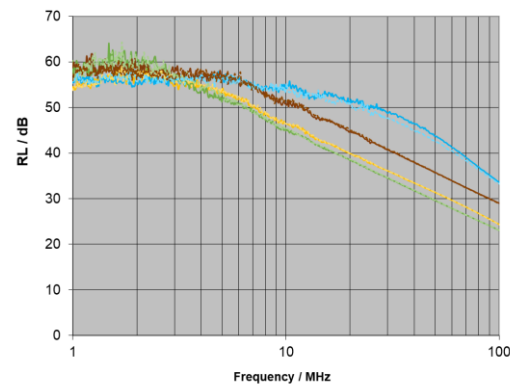
Conclusion:
Symmetrical pigtail
connection to the
Ground Terminal
Blocks on both side of
the data pair will used
for the further
evaluations.

Multi-level terminal block, all levels IL, RL, TCL

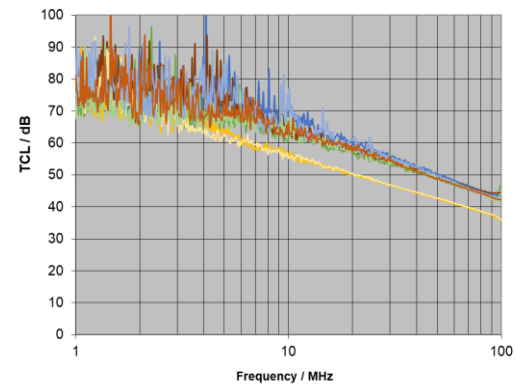
Insertion Loss
Configuration A



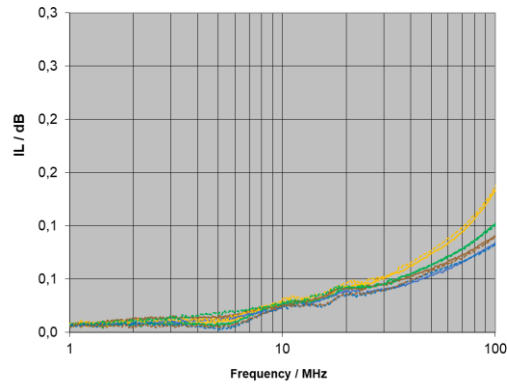
Return Loss
Configuration A



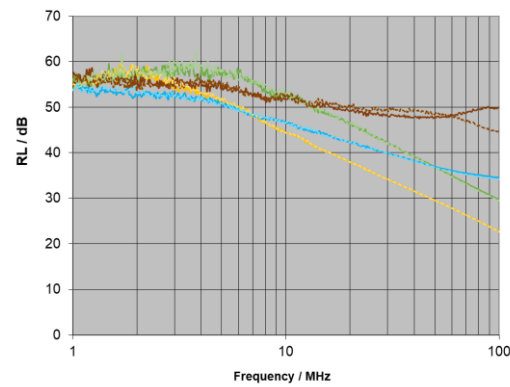
Transverse Conversion Loss
Configuration A



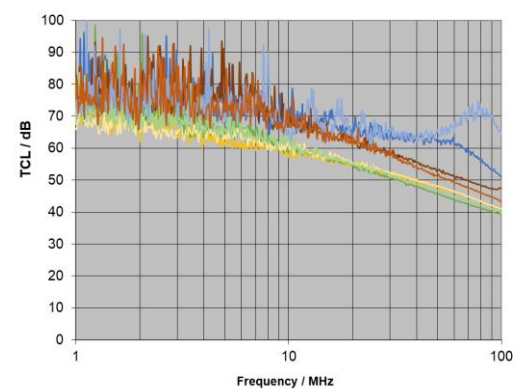
Insertion Loss
Configuration B



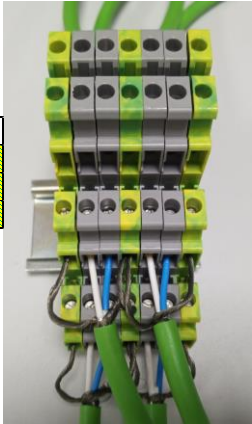
Return Loss
Configuration B



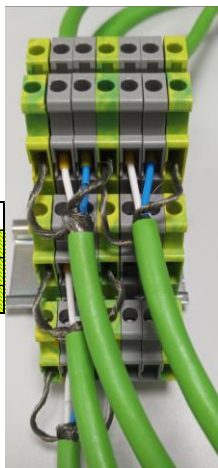
Transverse Conversion Loss
Configuration B



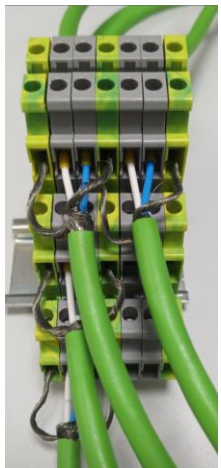
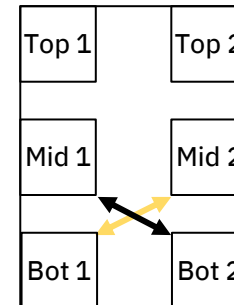
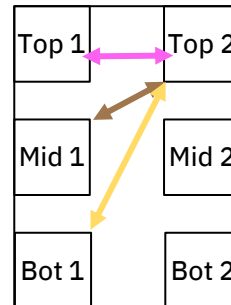
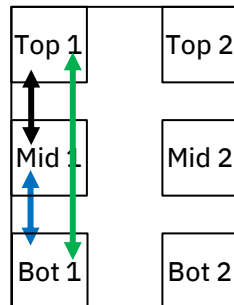
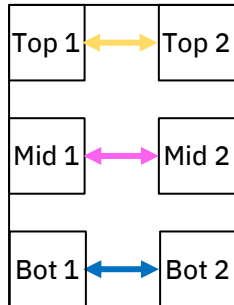
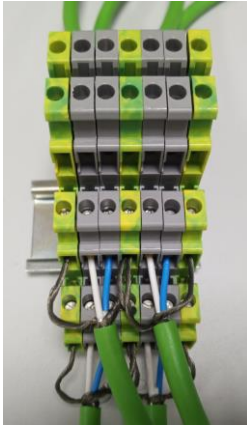
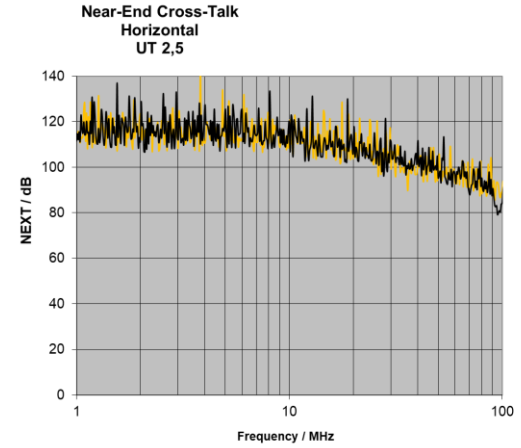
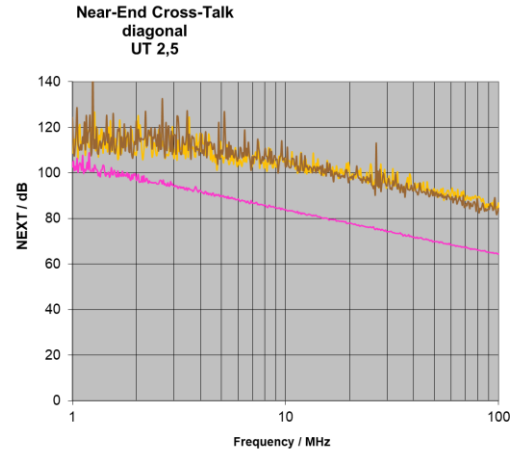
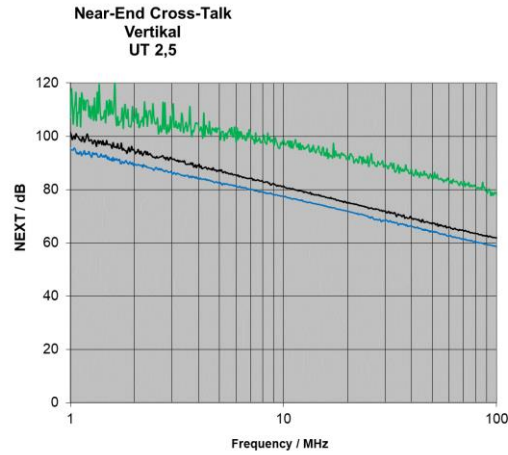
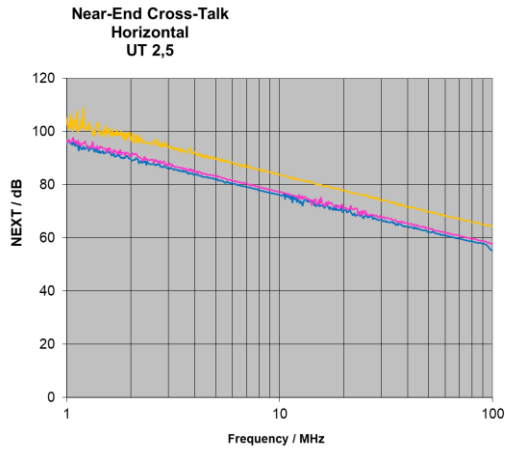
3L-A						
Top	§			§		§
Mid	§		§		§	§
Bot	§		§		§	§



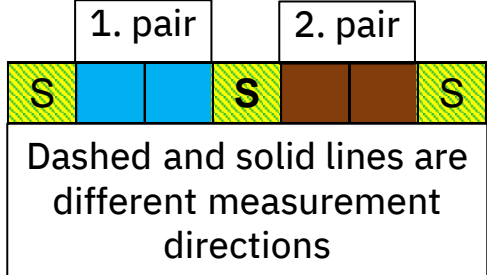
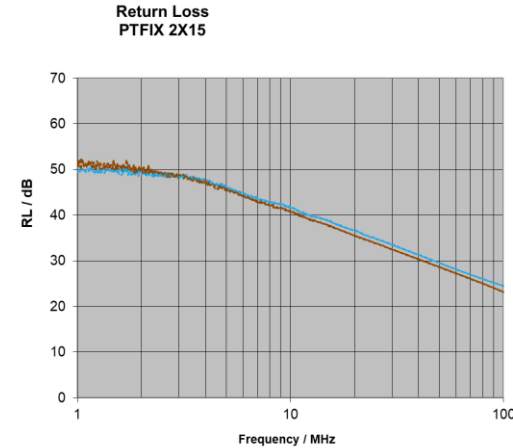
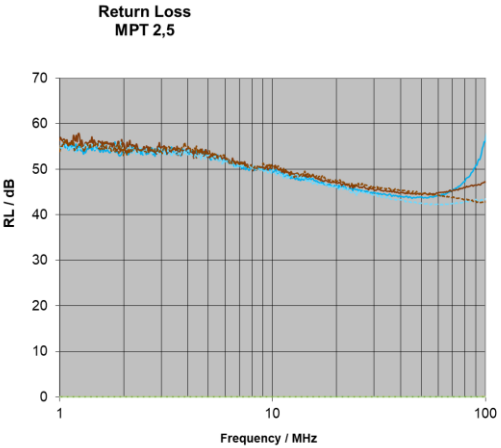
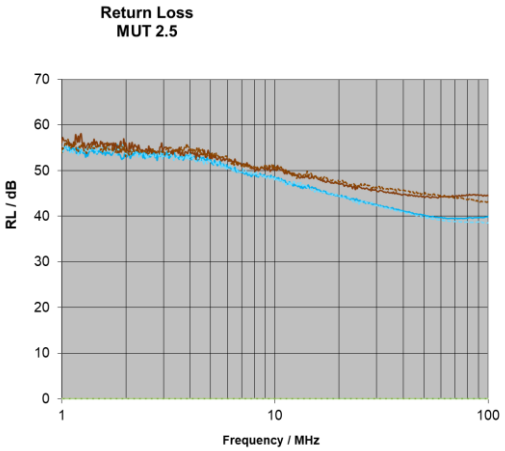
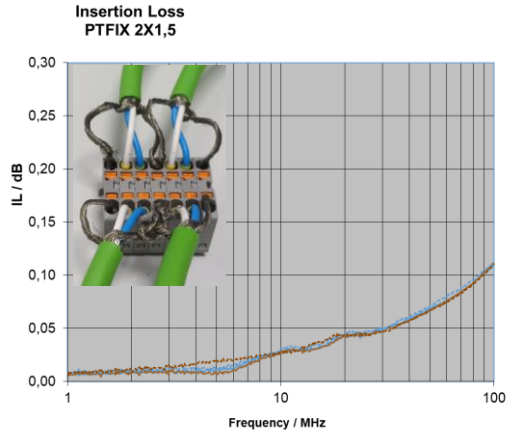
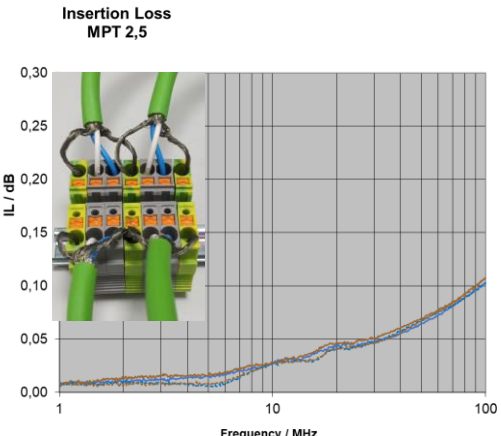
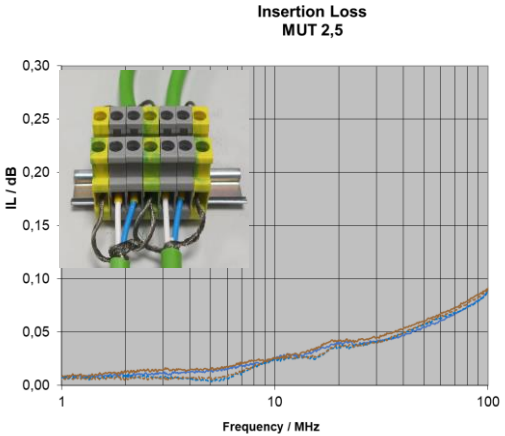
3L-B						
Top	§		§		§	§
Mid	§		§		§	§
Bot	§		§		§	§



Multi-level terminal block, all levels Crosstalk

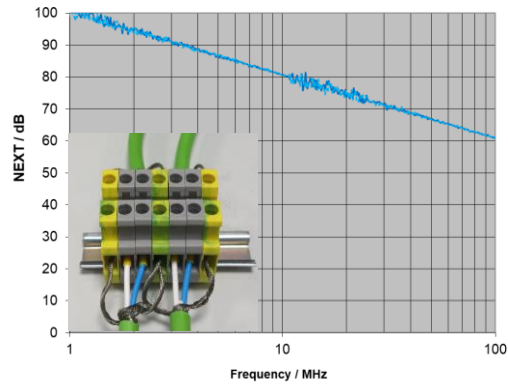


Single Level Terminal Blocks IL, RL

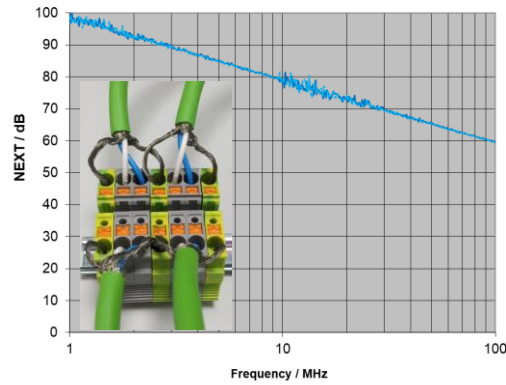


Single Level Terminal Blocks NEXT, TCL

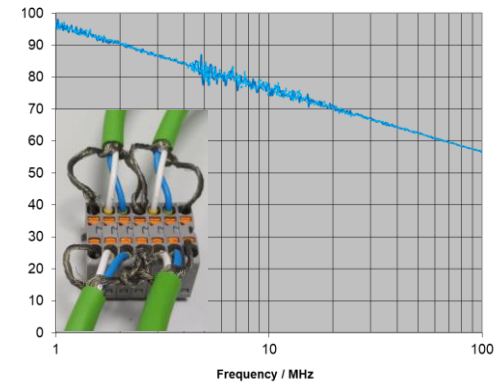
Near-End Cross-Talk
MUT 2,5



Near-End Cross-Talk
MPT 2,5

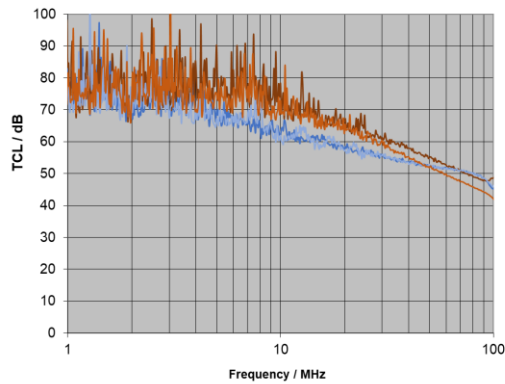


Near-End Cross-Talk
PTFIX 2X1,5

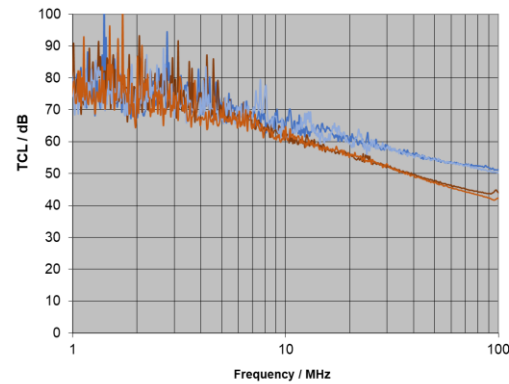


1. Pair to 2. pair

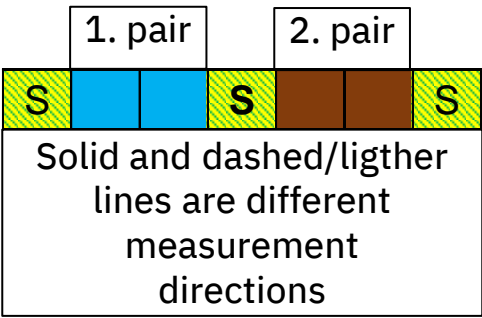
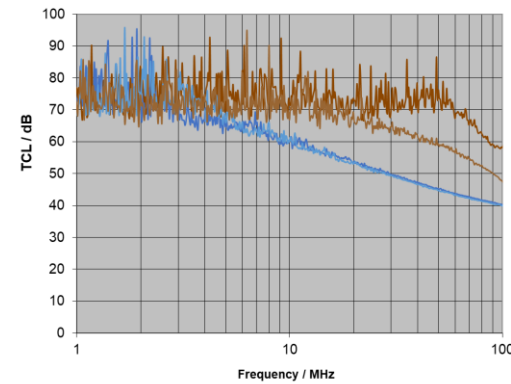
Transverse Conversion Loss
MUT 2,5



Transverse Conversion Loss
MPT 2,5



Transverse Conversion Loss
PTFIX 2X1,5



Conclusion and outlook

- Multi-level and one-level terminal blocks for DIN-rail-mounting seem to be reasonable in terms of signal integrity
- A symmetrical arrangement with a splitted shield connection seems to be helpful for a good result
- The use of PROFIBUS-PA cables is questionable. The field measurement of installed cables is necessary
- If this measurement approach is supported by dg, further measurements on selected PCB-mounted terminal blocks could follow in the next step
- It is not expected, that PCB-mounted terminal blocks have more worst characteristics