100 Jahre Leidenschaft für Technologie und Innovation

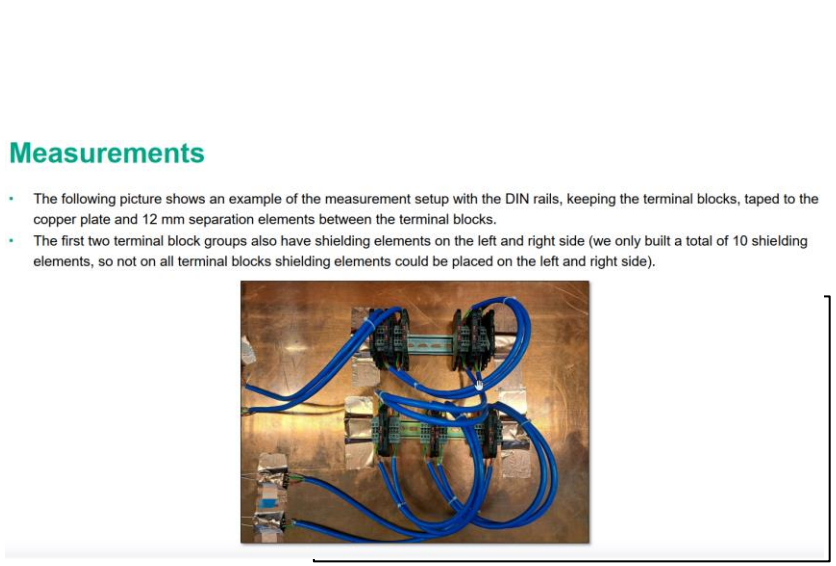
Willkommen

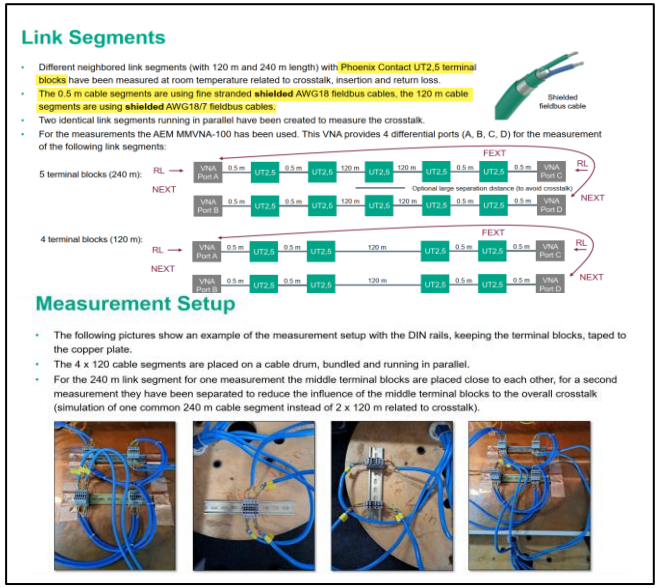
Signal Integrity and Terminal Blocks

PHOENIX CONTACT

Motivation

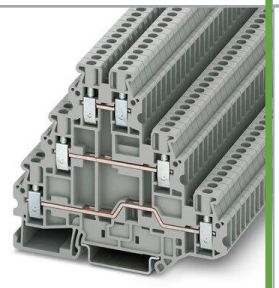
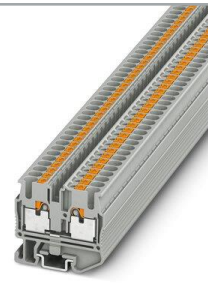
- Transmission characteristics of terminal blocks (DIN-Rail mounted and PCB mounted) are from interest
- Common products and installation techniques should be possible
- The space requirement should not be too large
- Most important parameters to consider: IL, RL, TCL, NEXT
- Following the presentations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

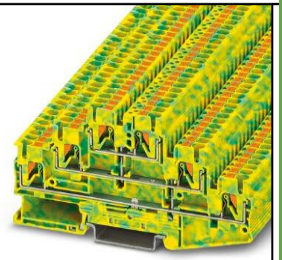
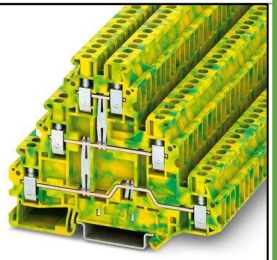
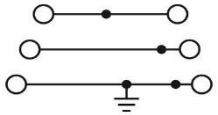
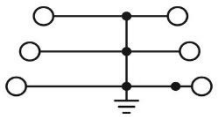
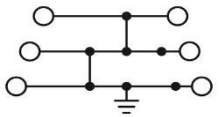


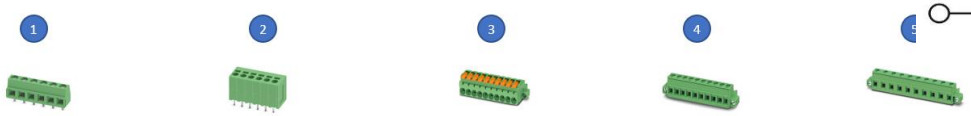


Product candidates

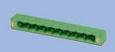
Consideration:
first choose the most attractive and at the same time the most difficult products

3210499 PT 2,5-3L Multi-level terminal block	3214259 UT 2,5-3L Multi-level terminal block	3248030 MUT 2,5 Mini feed-through terminal block	3248125 MPT 2,5 Mini feed-through terminal block	1045923 PTFIX 2X1,5 GY Distribution block
				

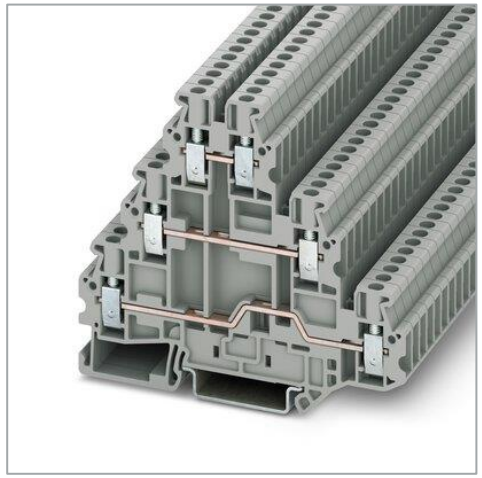
3210541 PT 2,5-3PE/L/L Ground terminal	3210525 PT 2,5-3PE Ground terminal	3214275 UT 2,5-3PE Ground terminal	3248032 MUT 2,5-PE Mini ground terminal block	3248125 MPT 2,5 Mini ground terminal block
				
				



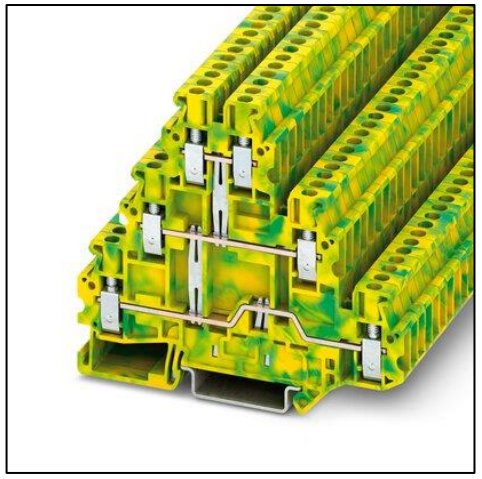
Klemme	Klemme
1729160	1991134
MKDSN 1,5/ 6-5,08	SPT 2,5/ 6-V-5,0

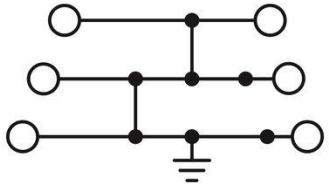
Stecker	Stecker	Stecker
1110633	1778027	1858808
LPC 2,5/ 6-STF-5,08	MSTB 2,5/ 6-STF-5,08	GMSTB 2,5/ 6-STF-7,62
		
Grundleiste	**Grundleiste**	**Grundleiste**
1954731	1954731	1806261
CC 2,5/ 6-GF-5,08 P26THR	CC 2,5/ 6-GF-5,08 P26THR	GMSTB 2,5/ 6-GF-7,62

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

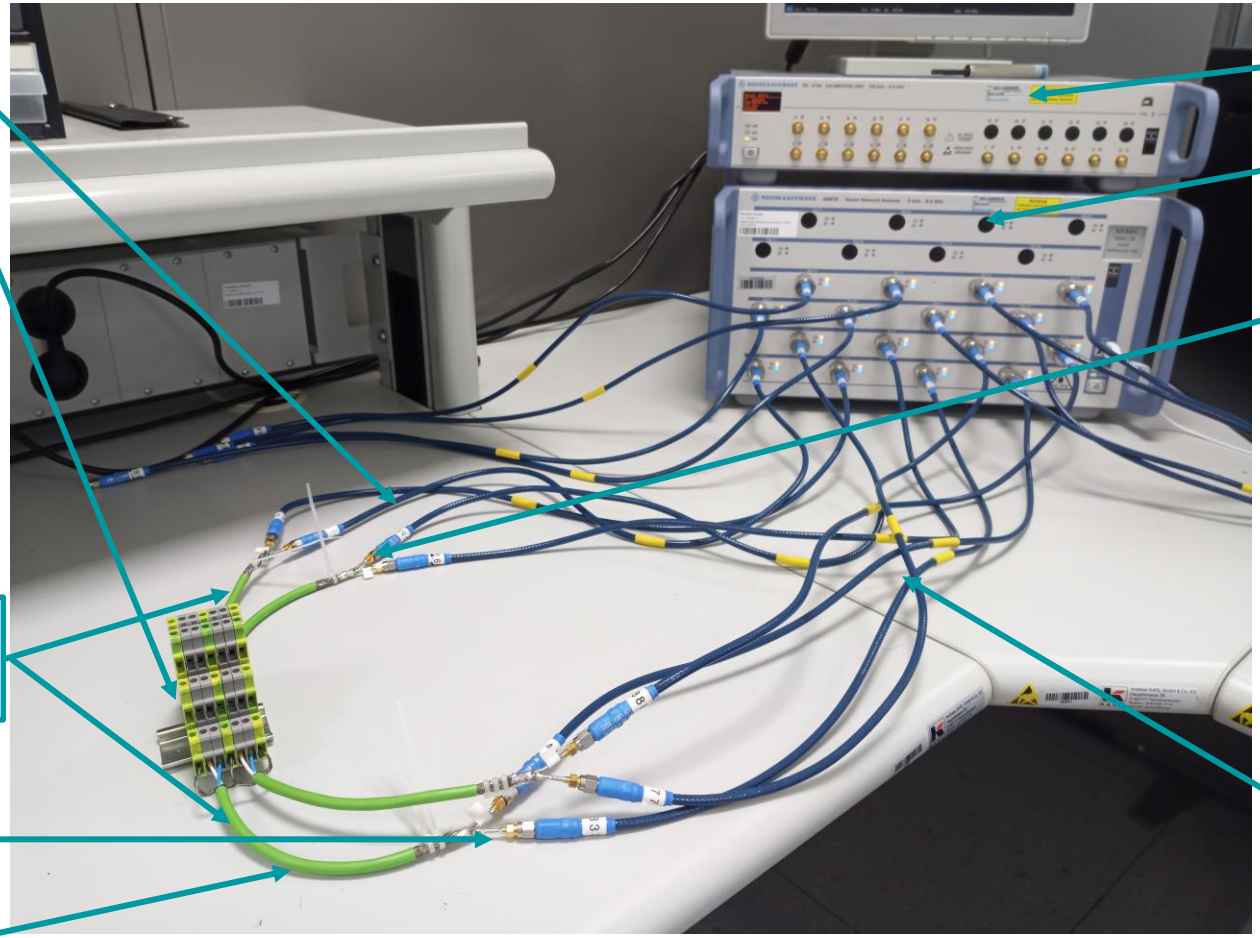
Measuring cables
Port 9-16

Terminal Block
on DIN-Rail

SPE connection cables

Semi rigid SMA connector

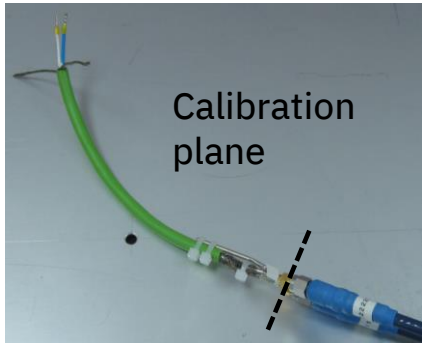
0,2m Cable length in order to avoid λ/2-resonances



Calibration Unit

Vektor Network Analyzer

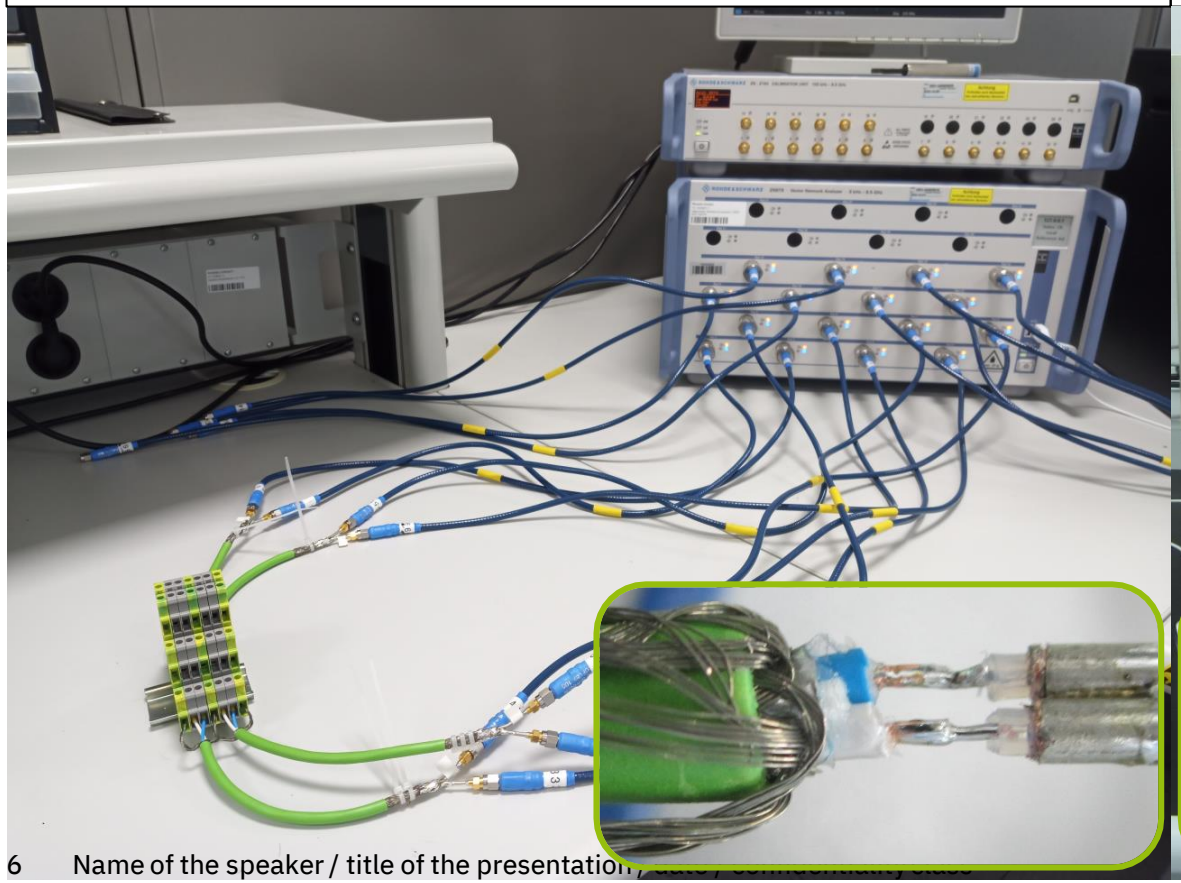
Calibration plane:
End of SMA connector



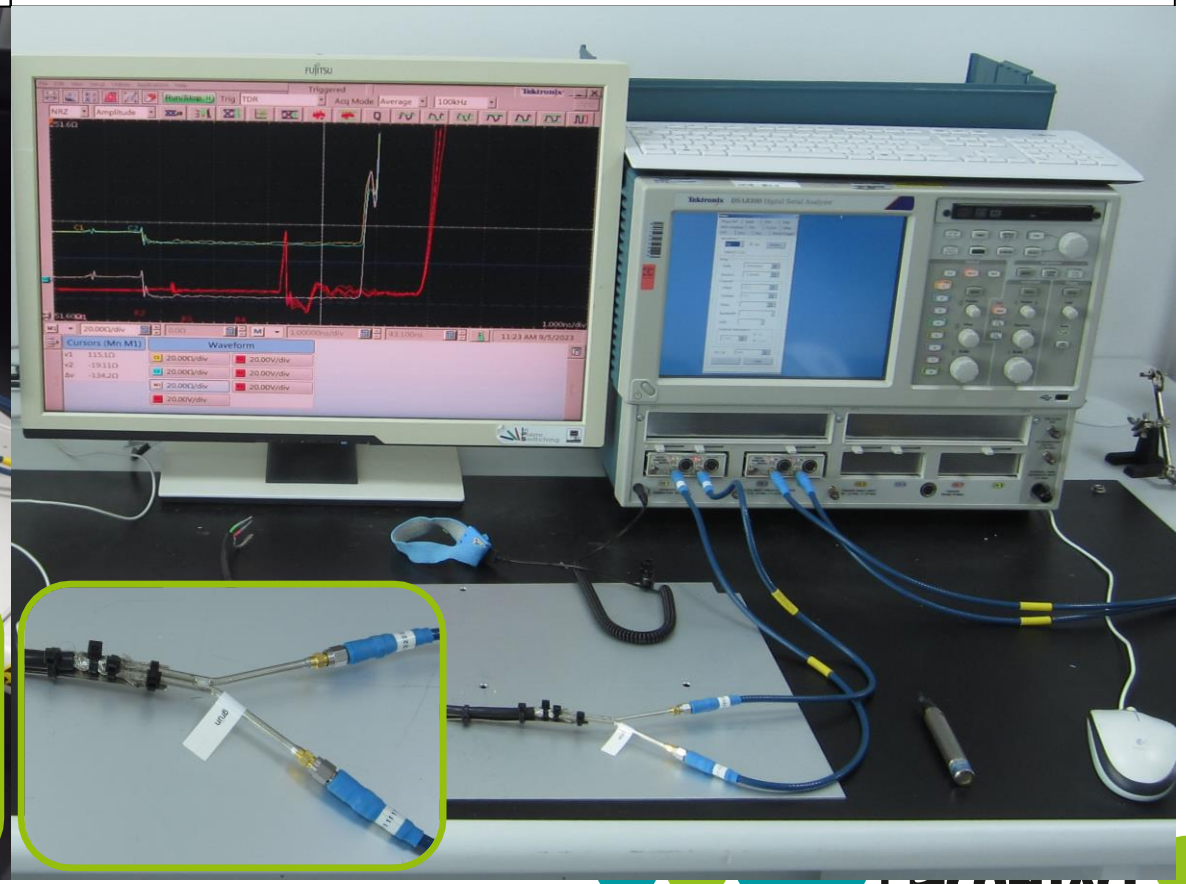
Measuring cables
Port 1-8

Measuring equipment

- 16 Ports VNA
- 8.5 GHz Bandwidth



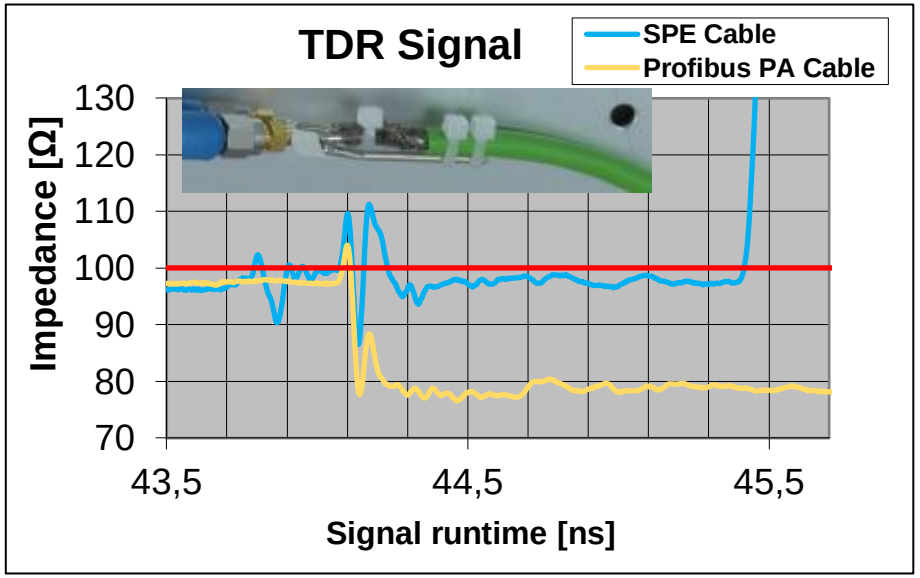
- Oscilloscope with TDR Sampling Module
- 20 GHz Bandwidth

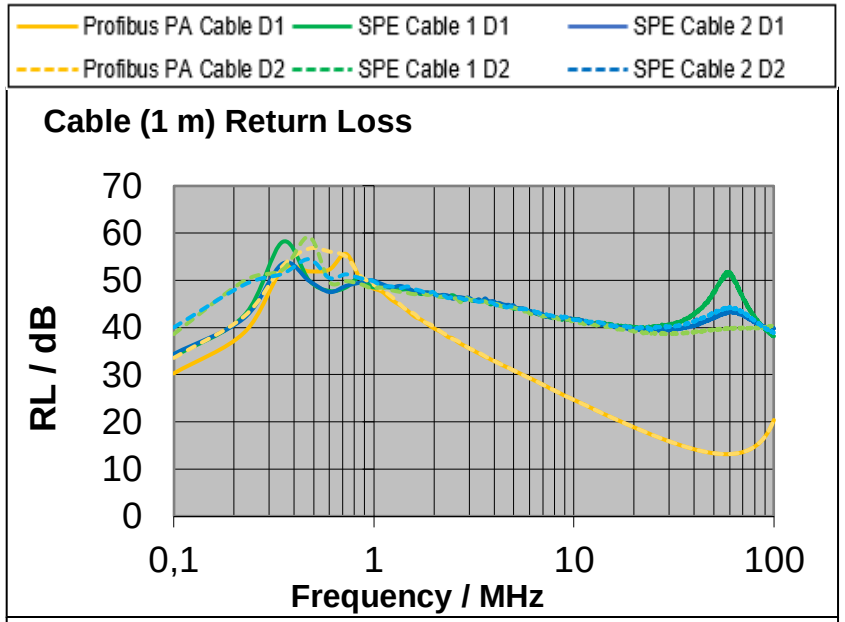


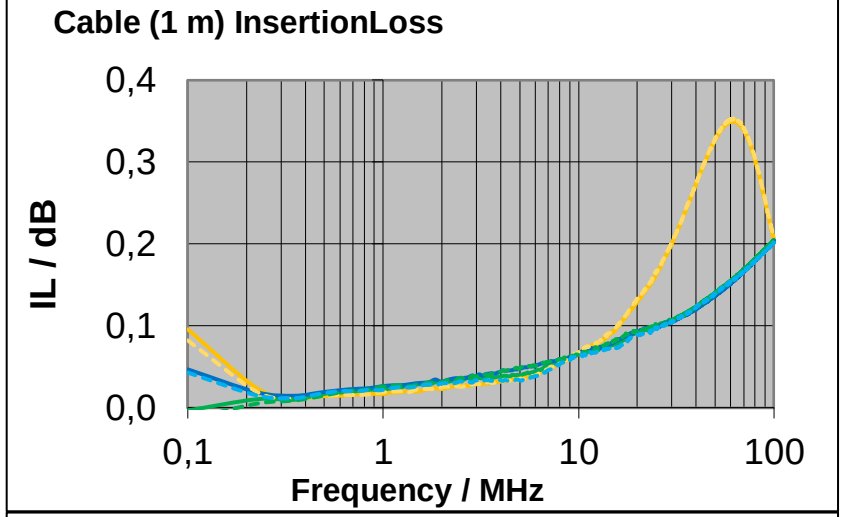
Semi rigid cable

Choosen 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 ± 20 Ω @ 31.25 kHz	100 Ω ± 5 Ω @100 MHz
Impedance measured	80 Ω	100 Ω



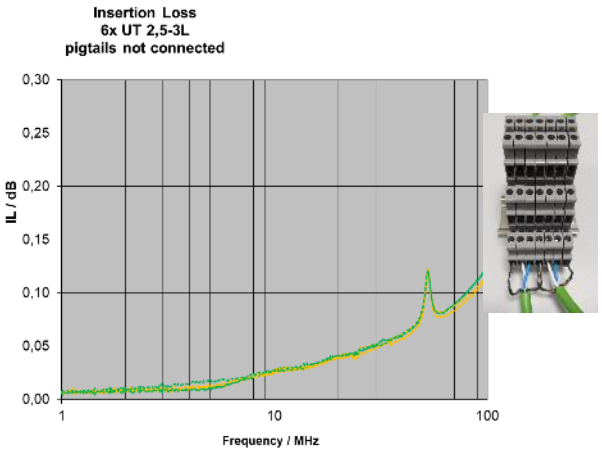


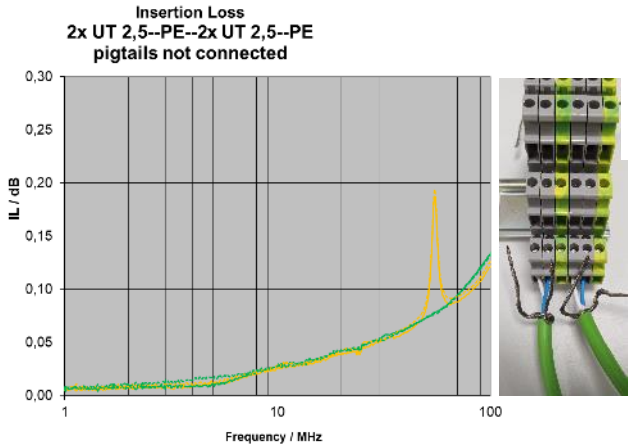


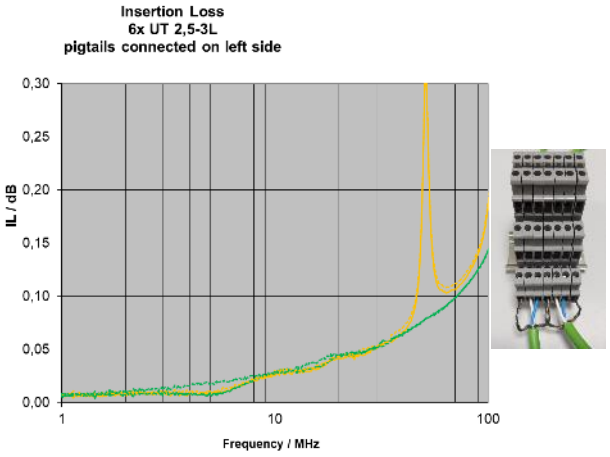
The measured values below 1 MHz have limited significance due to the electronic calibration of the VNA.

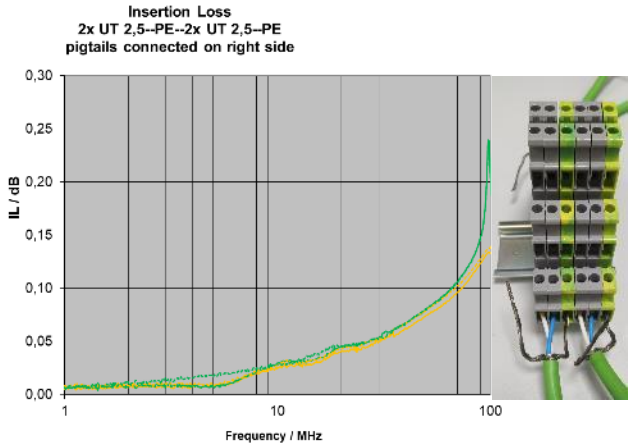
Conclusion:
The 22 AWG SPE cable will be used for the following measurement due to the impedance deviation of the Profibus PA cable

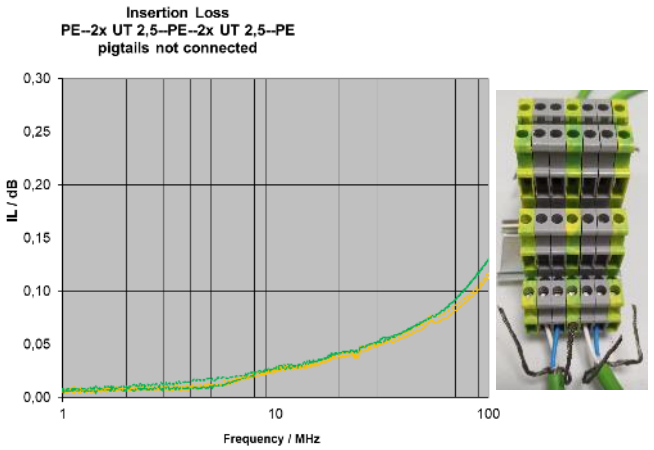
Multi-level terminal block , 1st level
IL depending on shielding

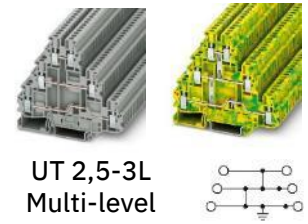




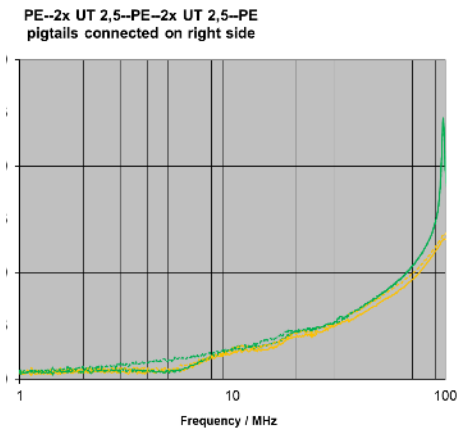


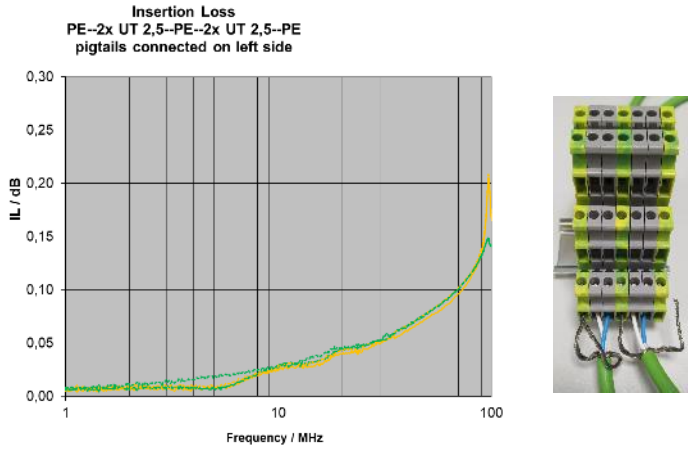


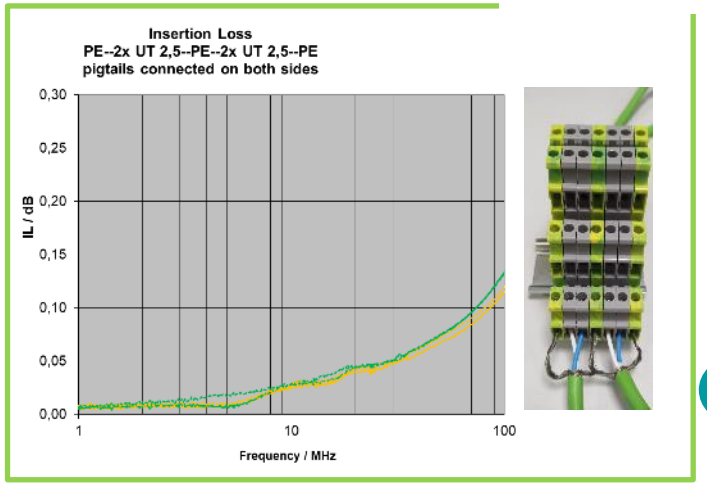




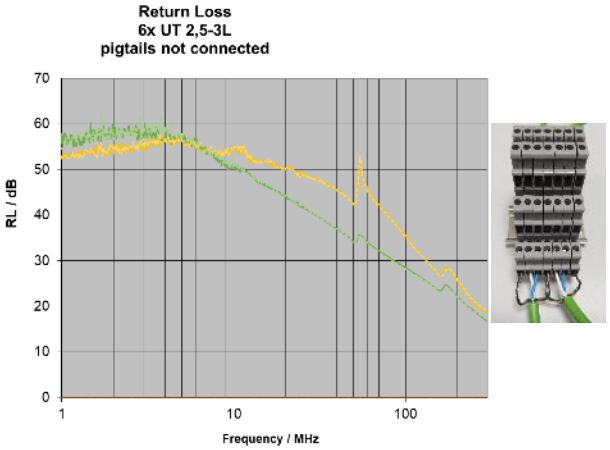
UT 2,5-3L
Multi-level
terminal block

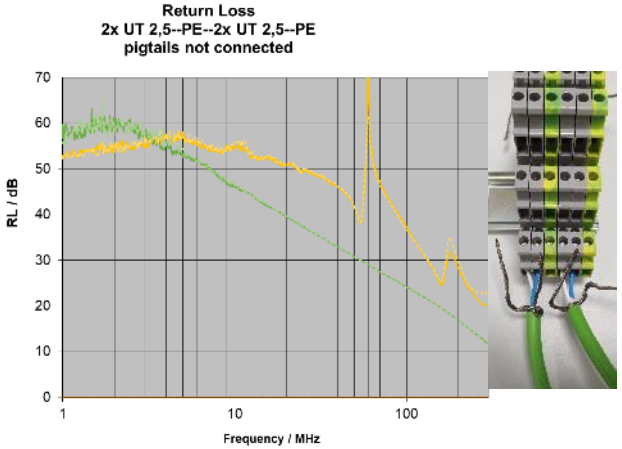


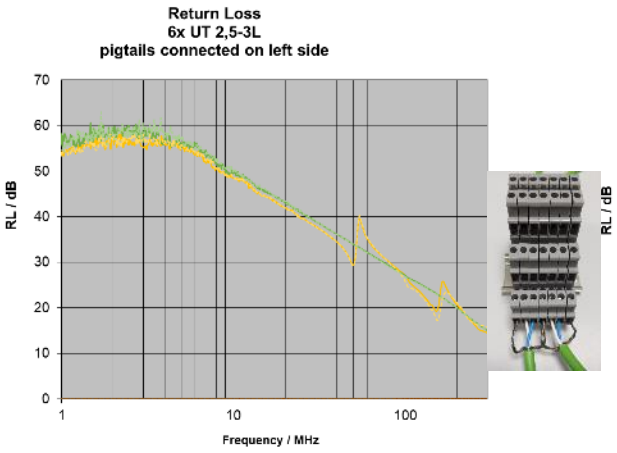


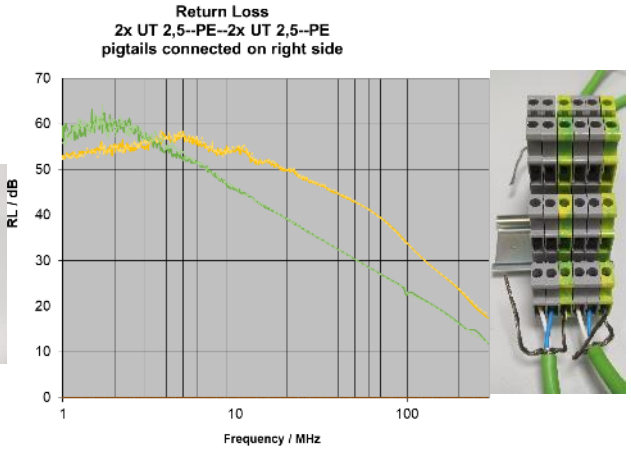


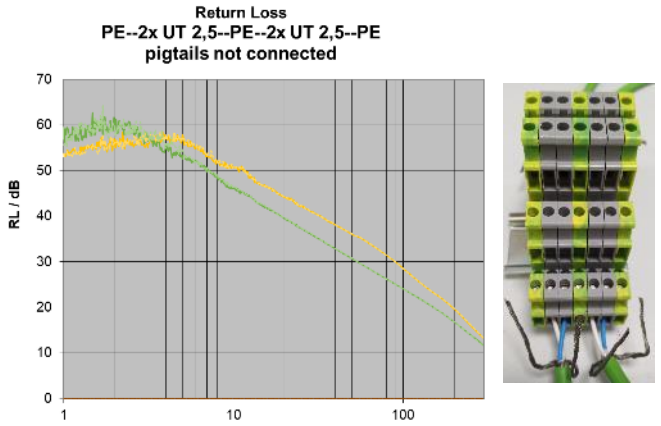
Multi-level terminal block , 1st level
RL depending on shielding

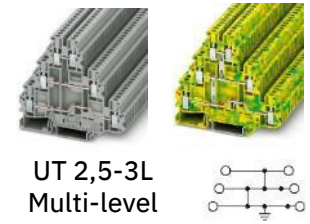




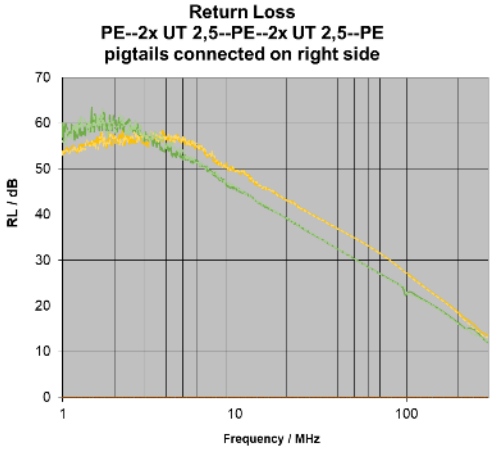


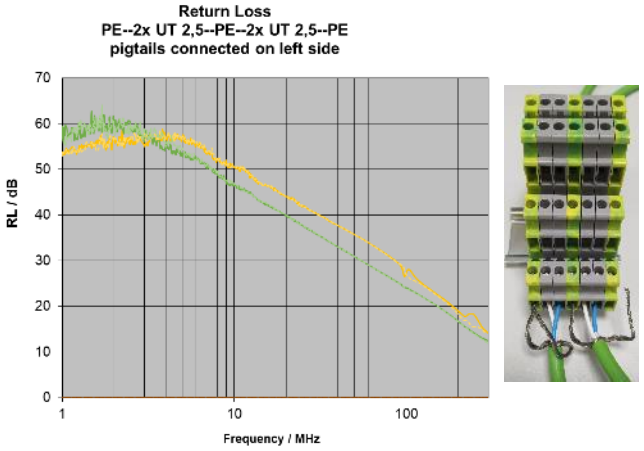


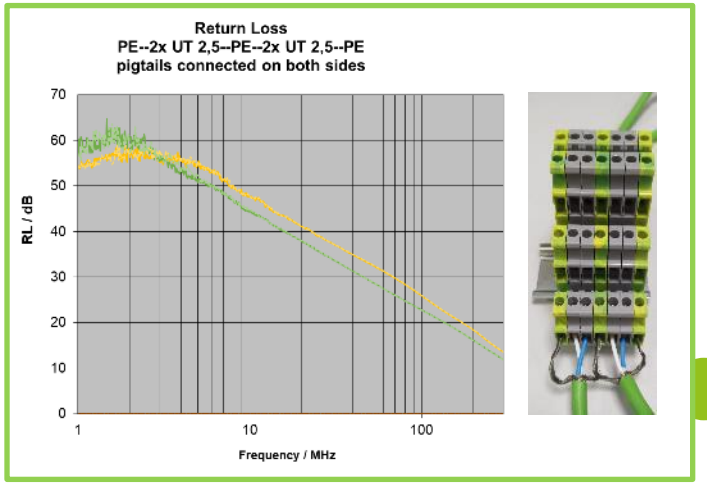




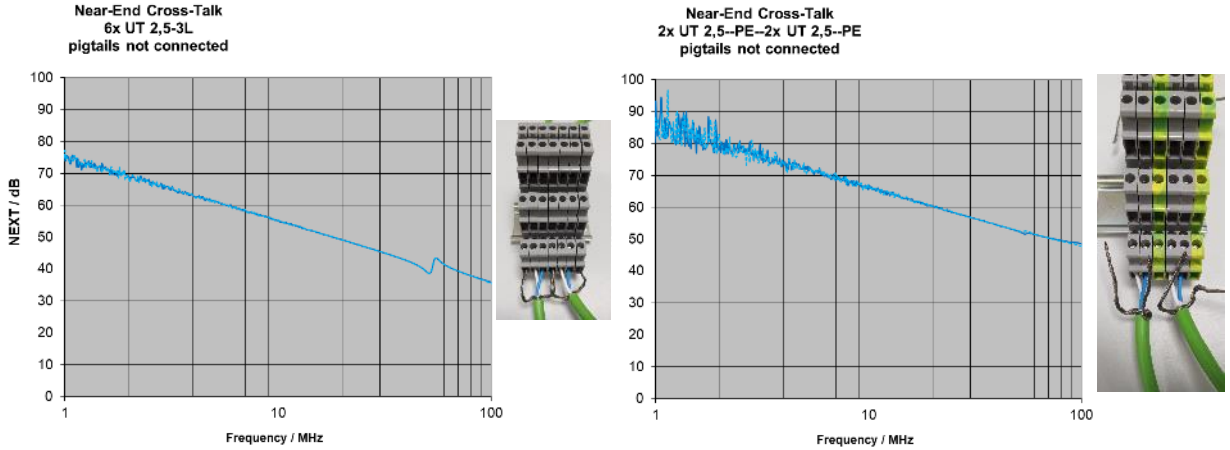
UT 2,5-3L
Multi-level
terminal block

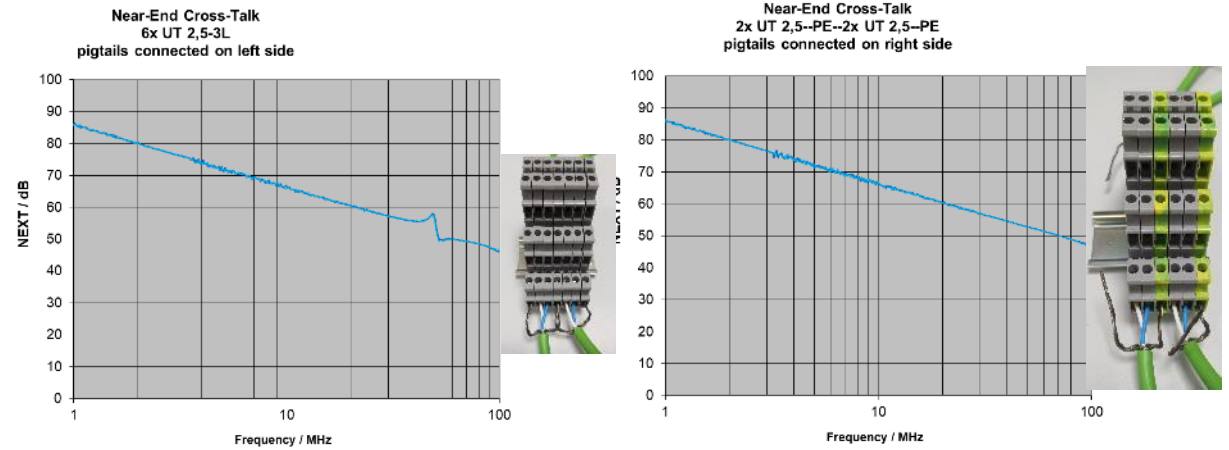


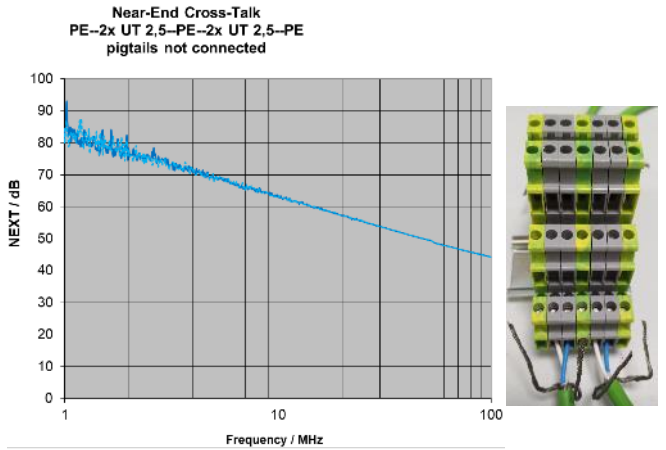


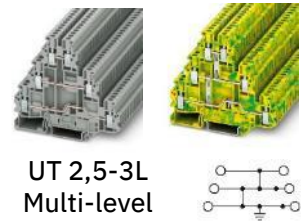


Multi-level terminal block , 1st level
NEXT depending on shielding

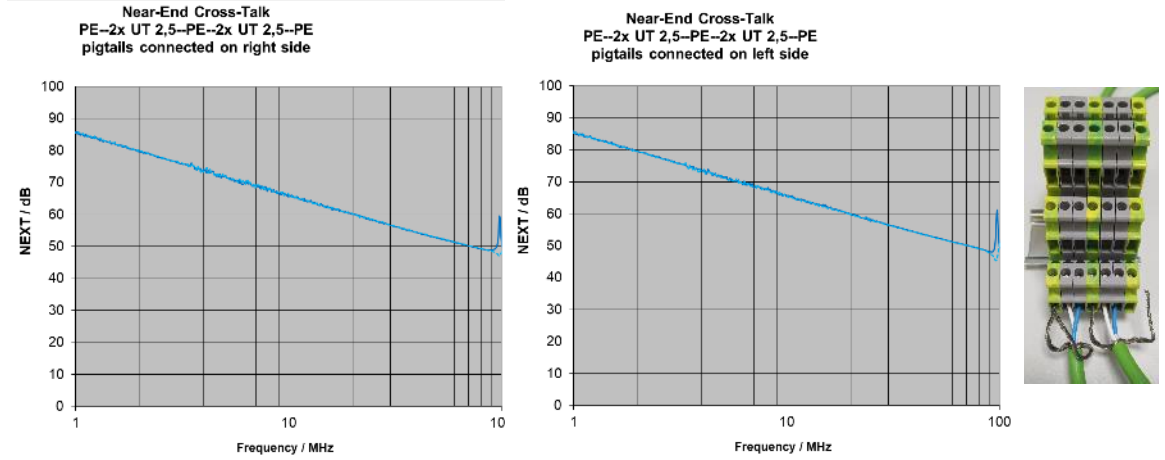


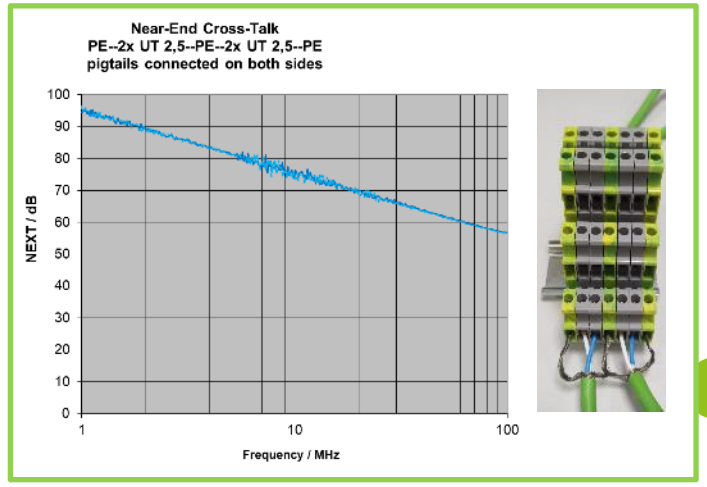




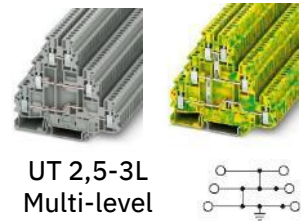


UT 2,5-3L
Multi-level
terminal block

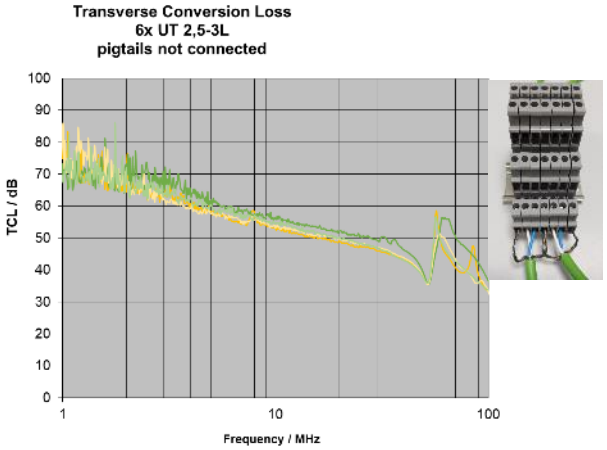


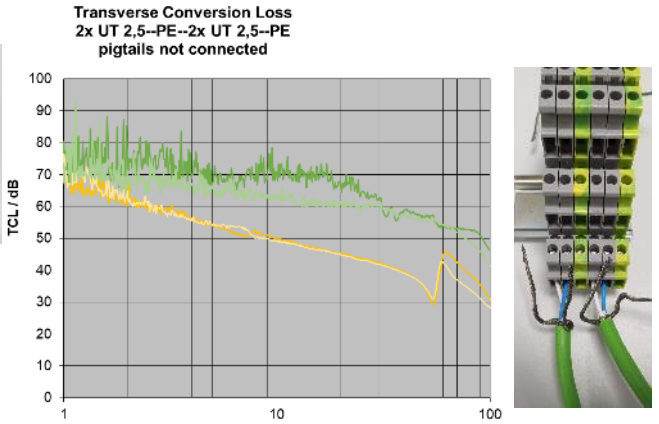


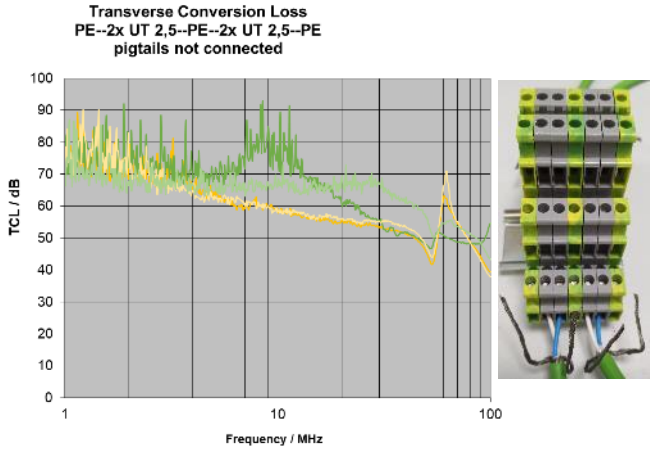
Multi-level terminal block, 1st level TCL depending on shielding

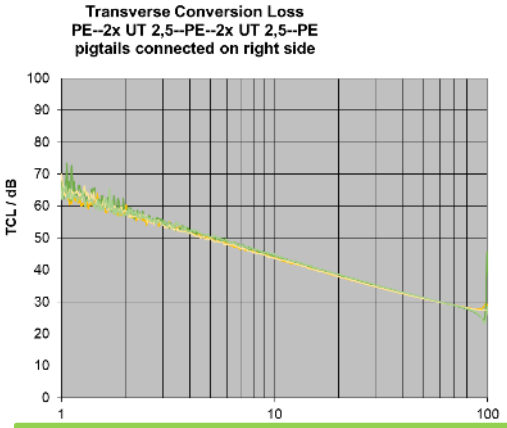


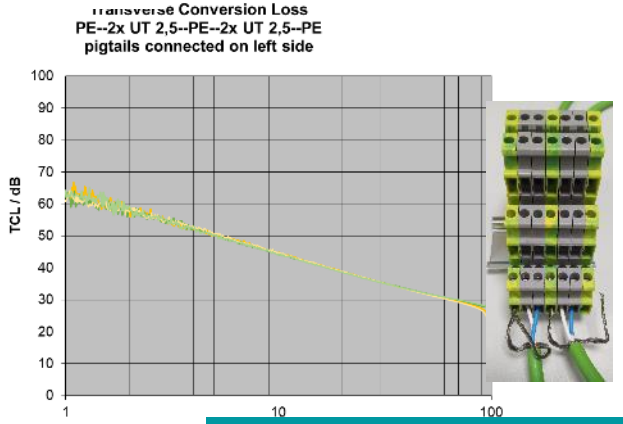
UT 2,5-3L
Multi-level
terminal block

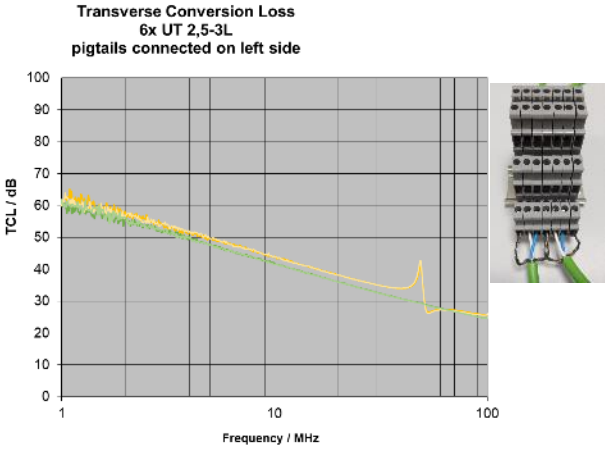


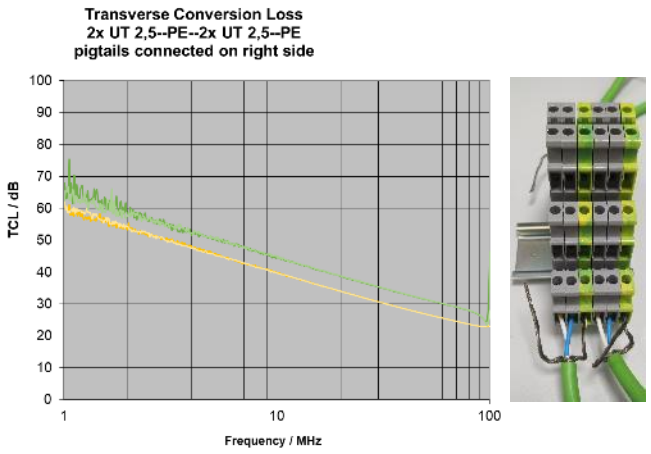


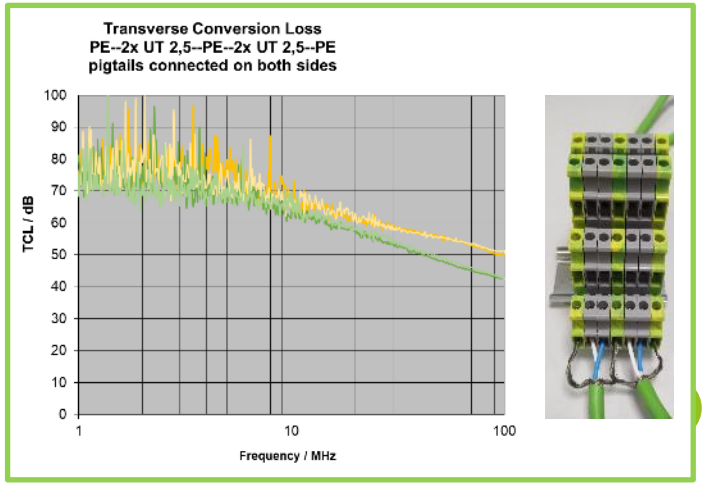








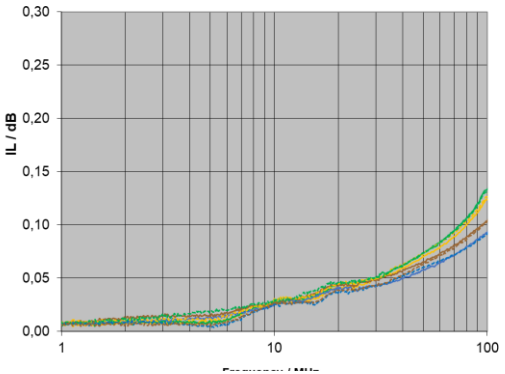




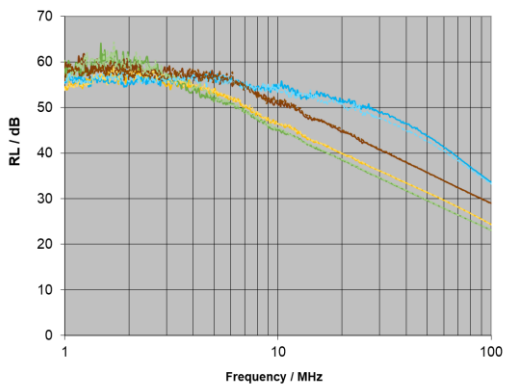
Conclusion:
Symmetrical pigtail connection to the Ground Terminal Blocks on both side of the data pair will used for the further evaluations.

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

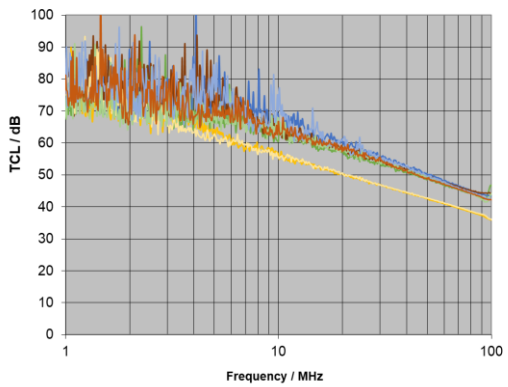
Insertion Loss
Configuration A



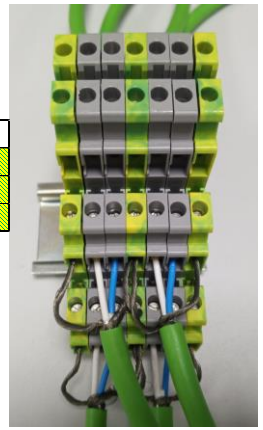
Return Loss
Configuration A



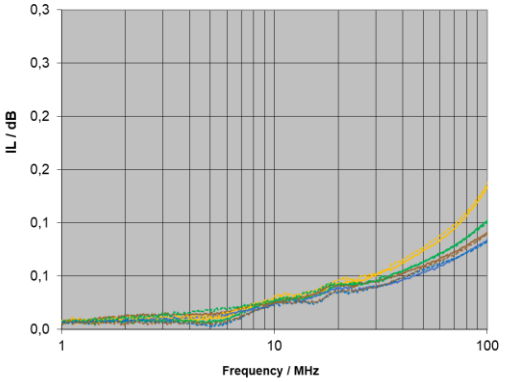
Transverse Conversion Loss
Configuration A



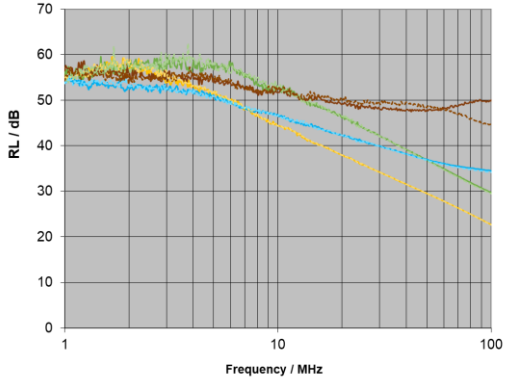
3L-A							
Top	S			S			S
Mid	S			S			S
Bot	S			S			S



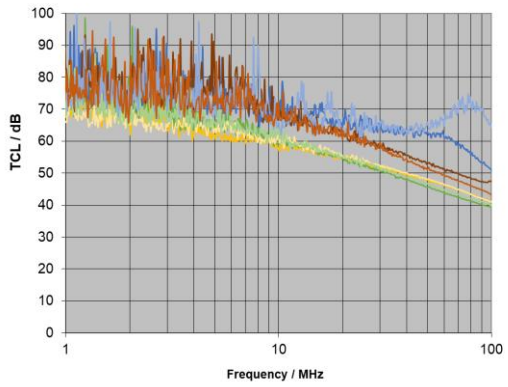
Insertion Loss
Configuration B



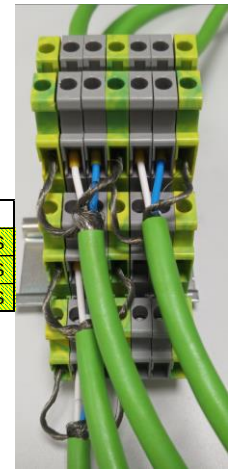
Return Loss
Cobnfiguration B



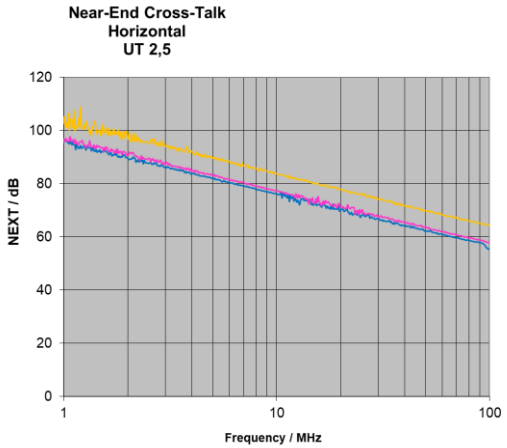
Transverse Conversion Loss
Configuration B

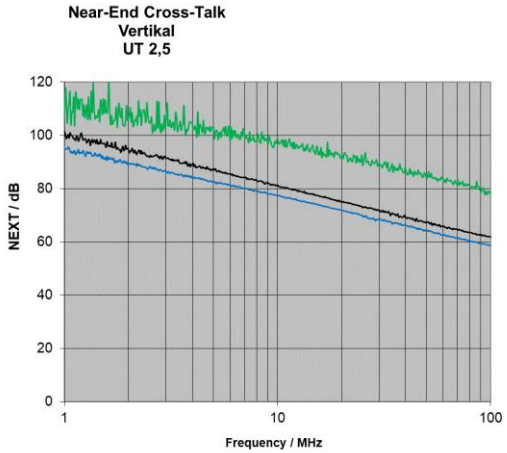


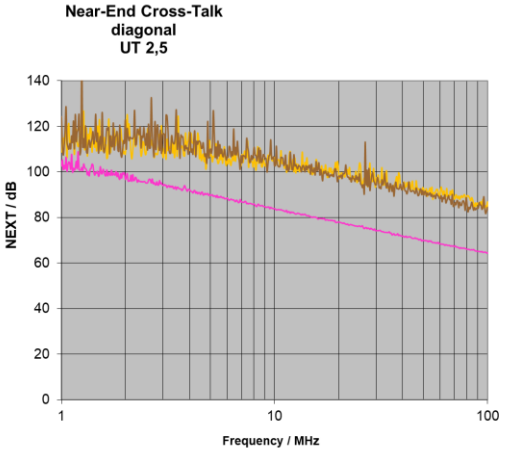
3L-B							
Top	S			S			S
Mid	S			S			S
Bot	S			S			S

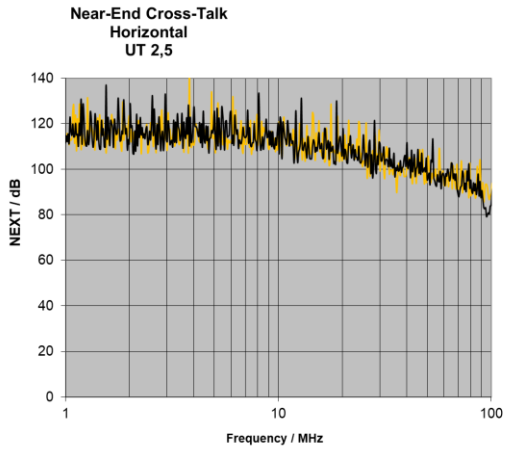


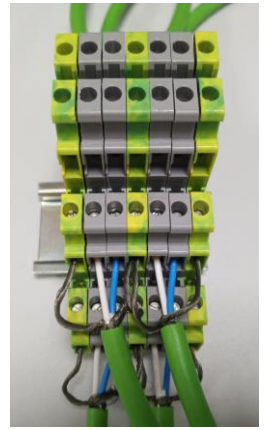
Multi-level terminal block, all levels
Crosstalk

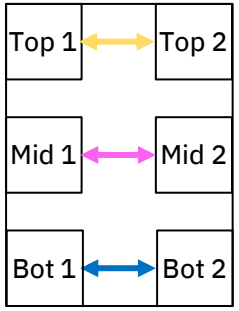


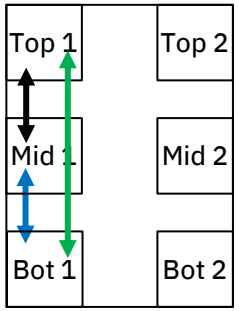


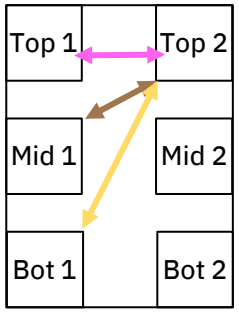


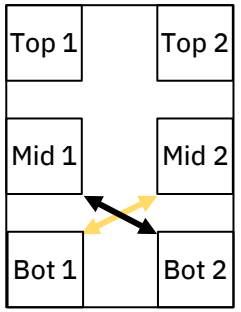




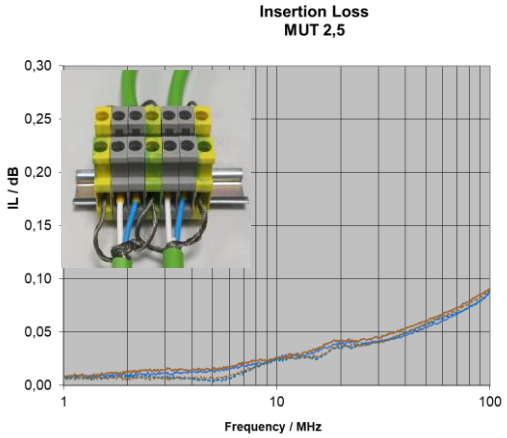


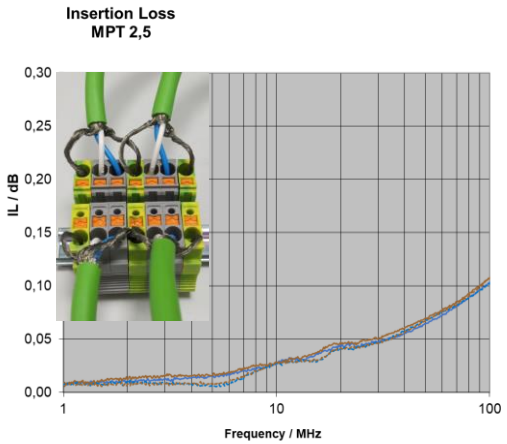


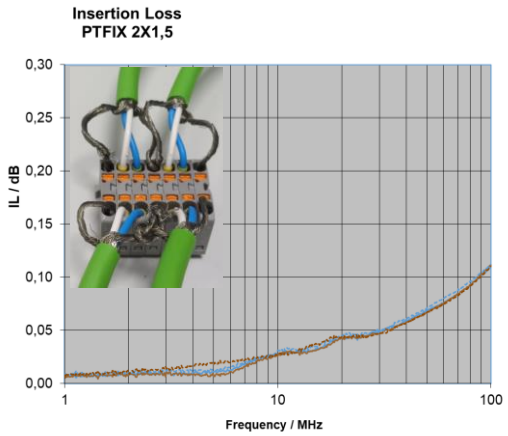


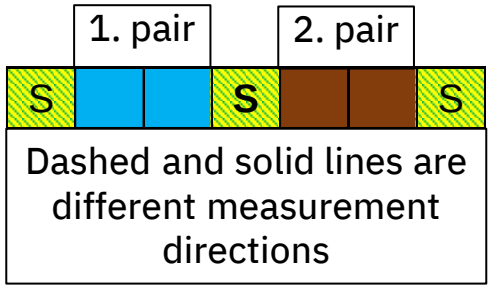


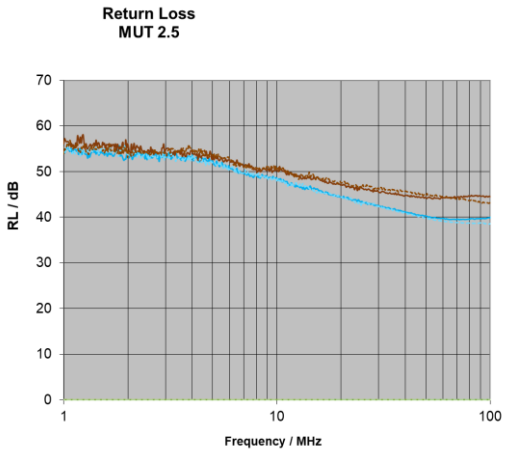
Single Level Terminal Blocks IL, RL

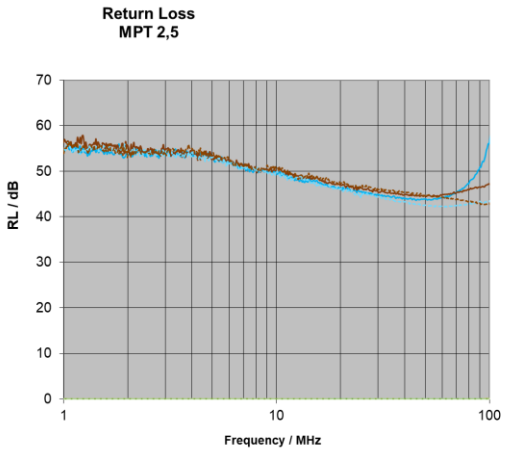


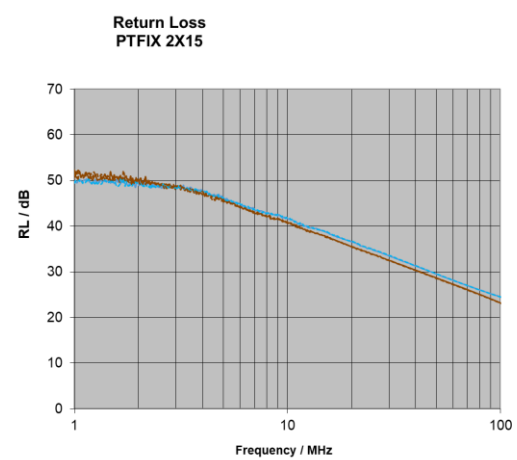




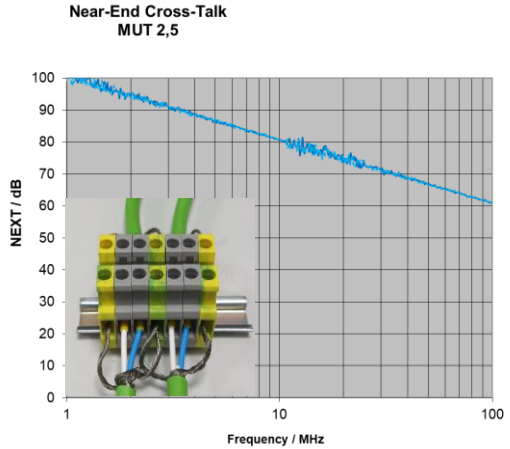


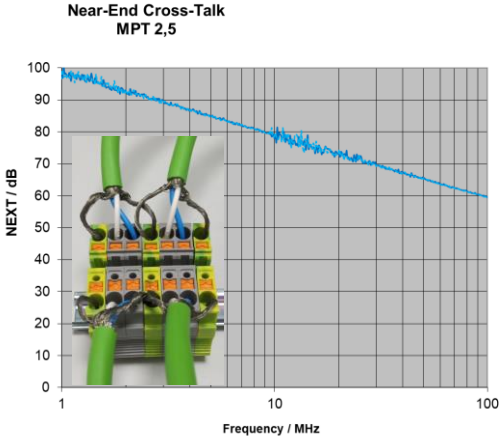


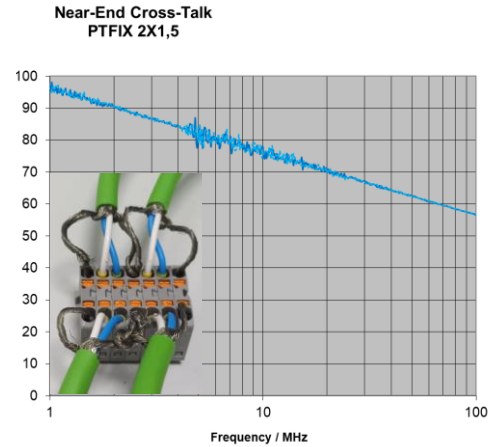




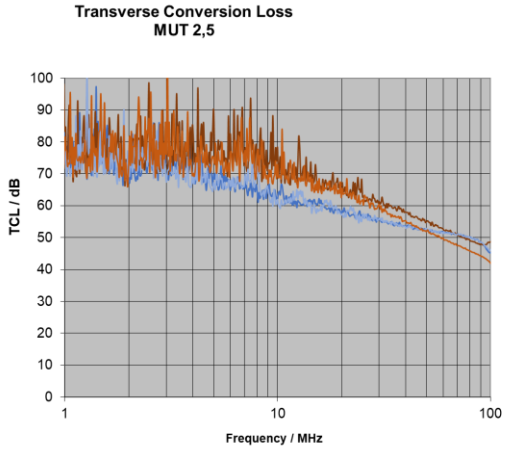
Single Level Terminal Blocks NEXT, TCL

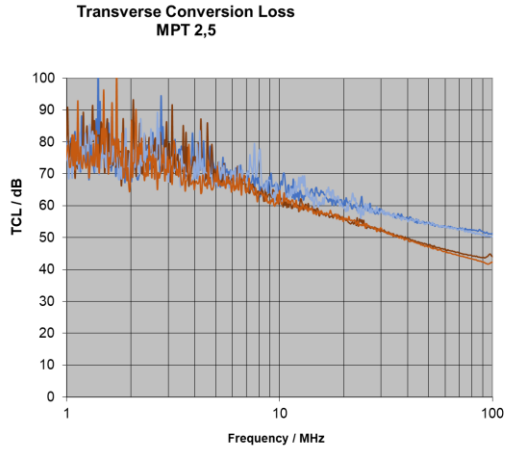


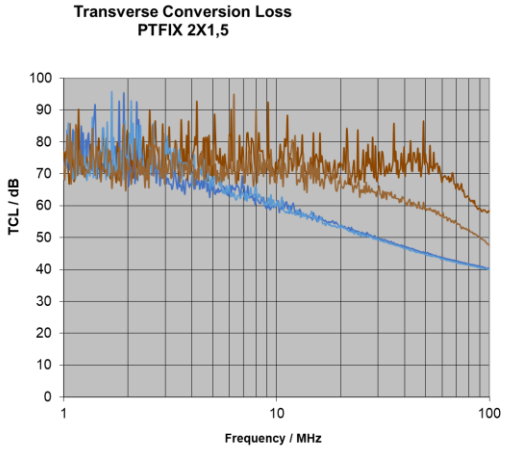


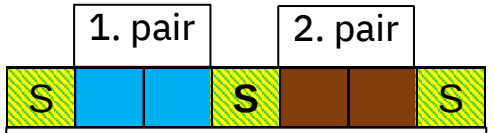


1. Pair to 2. pair









Solid and dashed/ligther lines are different measurement directions

Conclusion and outlock

- 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