Influence of Aging Effects on RF behavior Including Mode Conversion of STP and UTP Cables

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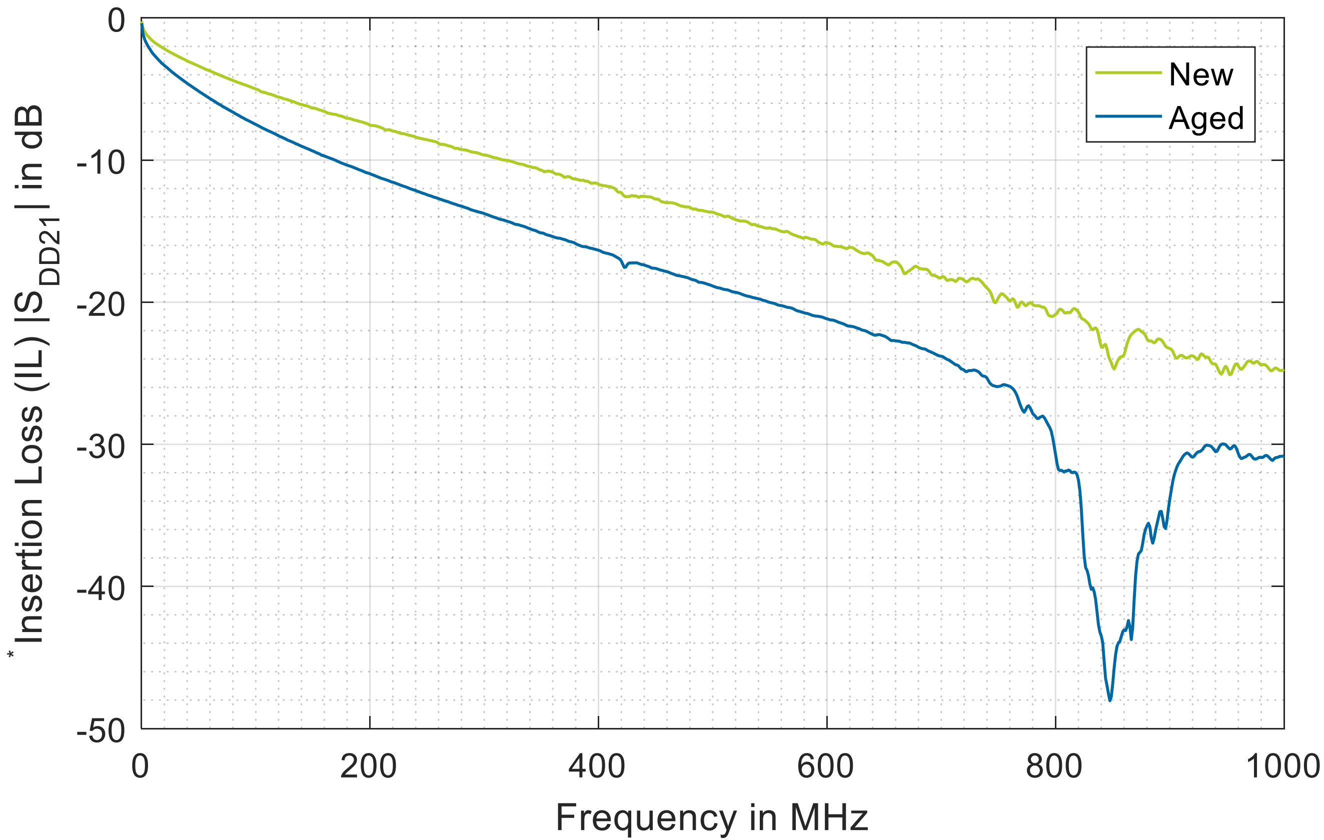
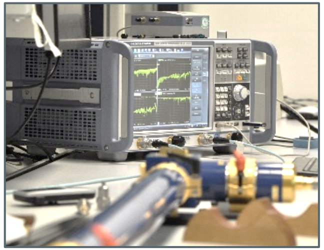
MD
ELEKTRONIK



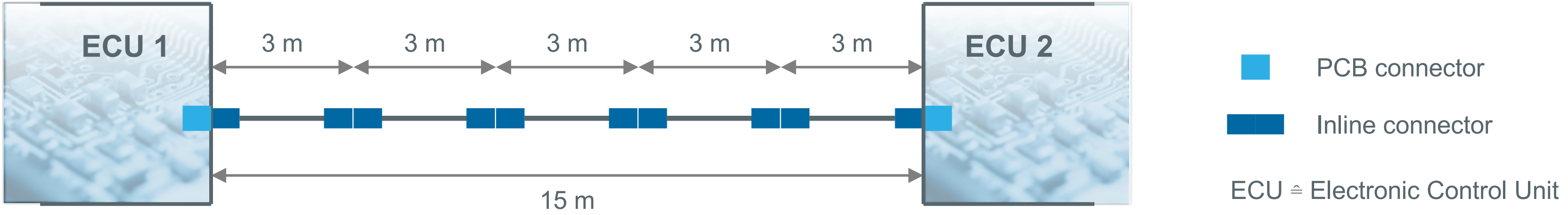
* Schematic representation

Table of contents



Physical Layer Medium

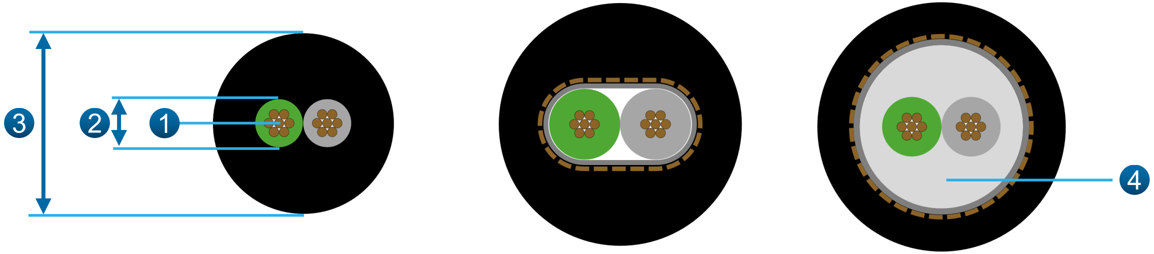
Cables and Communication Channel



- Physical layer medium between ECUs
- Two PCB connectors
- Link segment of twisted pair cables
- Length of 15 m
- 4 inline connectors

- Specified in IEEE 802.3bp Ch. 97.6 as link segment type A and OABR TC9 as Standalone Communication Channel (SCC)

Cable Overview



Cable type A | Cable type B | Cable type C

		Cable type A	Cable type B	Cable type C
1	Inner conductors	2 x 0.14 mm²	2 x 0.14 mm²	2 x 0.14 mm²
2	Core diameter	0.85 mm	1.26 mm	1.05 mm
	Insulation material	PP	PP	PP
4	Intermediate jacket	-	-	PP
	Shielding	-	Foil and braid	Foil and braid
3	Outer diameter	3.2 mm	4.3 mm	4.4 mm

RF Results

Cable Assemblies - New

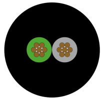
Mode Conversion

Comparison of the Unbalance Attenuation of Different Cable Assemblies

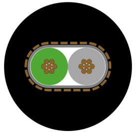
S_{CD11}

Differential mode excitation on logical port **1**

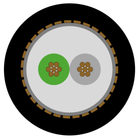
Common mode response on logical port **1**



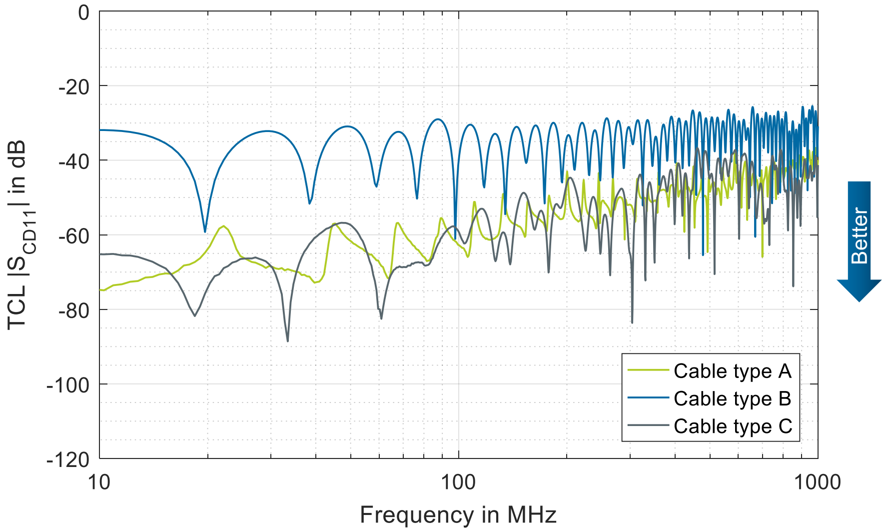
Cable type A

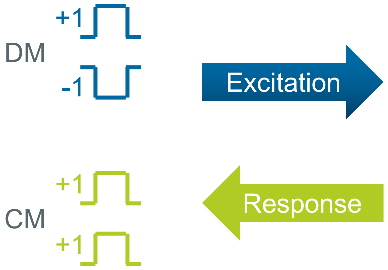


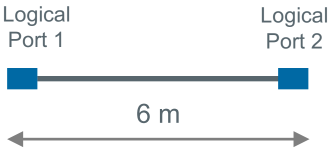
Cable type B



Cable type C



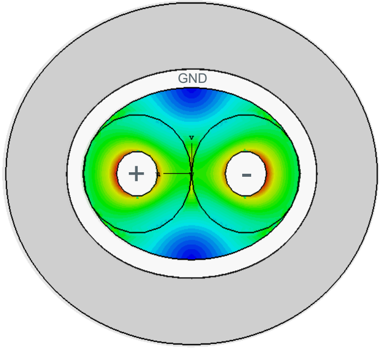




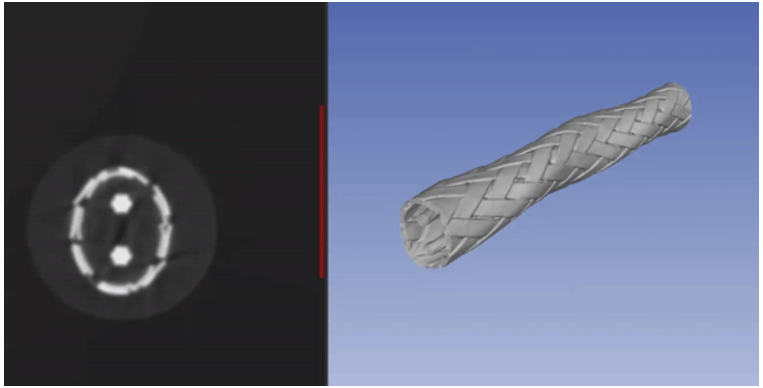
TCL ≙ Transverse conversion loss
DM ≙ Differential mode
CM ≙ Common mode

Cross-Sectional Analysis

Cable Type B



Cable Type B

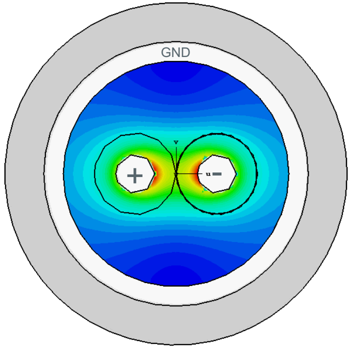


- Elliptical shape of the shield (foil and braid)
- The geometry relation inside the shield is constant
- The shape rotates along one lay length

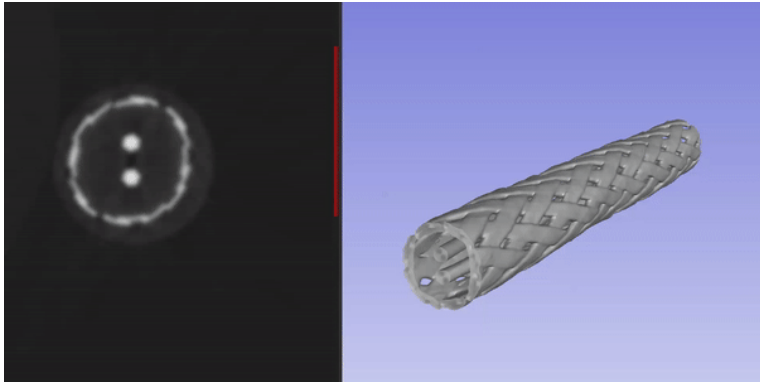
- Strong electrical field between shield and conductors
- Influence on wave impedance
- High mode conversion due to asymmetry of foil

Cross-Sectional Analysis

Cable Type C



Cable Type C



- Stabilization of the twisted inner conductors
- Improvement of consistency and distance between inner conductors and shield along one lay length

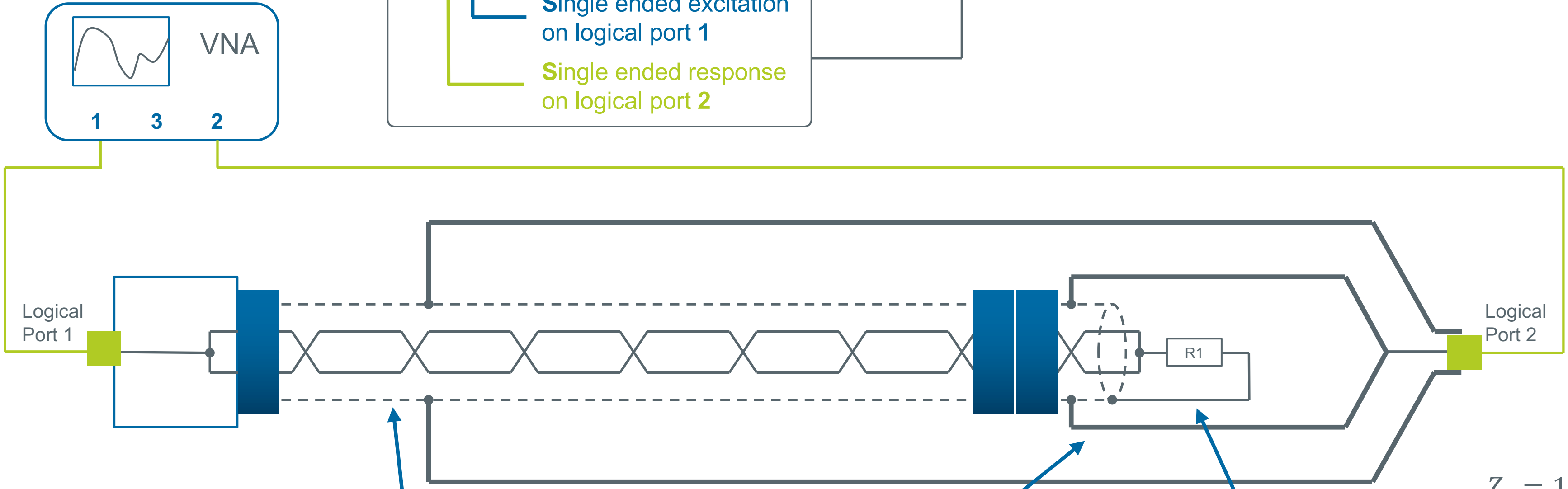
- Weak electrical field between shield and conductors
- Positive influence on wave impedance
- Improved lower mode conversion

Shielding Effectiveness a_S

Measurement Setup

$$a_s = S_{21} \; -10 \cdot \log_{10} \frac{2 \cdot Z_s}{Z_L} \; -10 \cdot \log_{10} \left[1 - \left(\frac{50\Omega - Z_L}{50\Omega + Z_L} \right)^2 \right]$$

S 2 1
Single ended excitation on logical port **1**
Single ended response on logical port **2**



Z_L ≙ Wave Impedance
VNA ≙ Vectorial Network Analyser
Connectors

$Z_s = 150\Omega$

$R_1 = Z_L$

Coupling Attenuation a_C

Measurement Setup

S_{SD21}

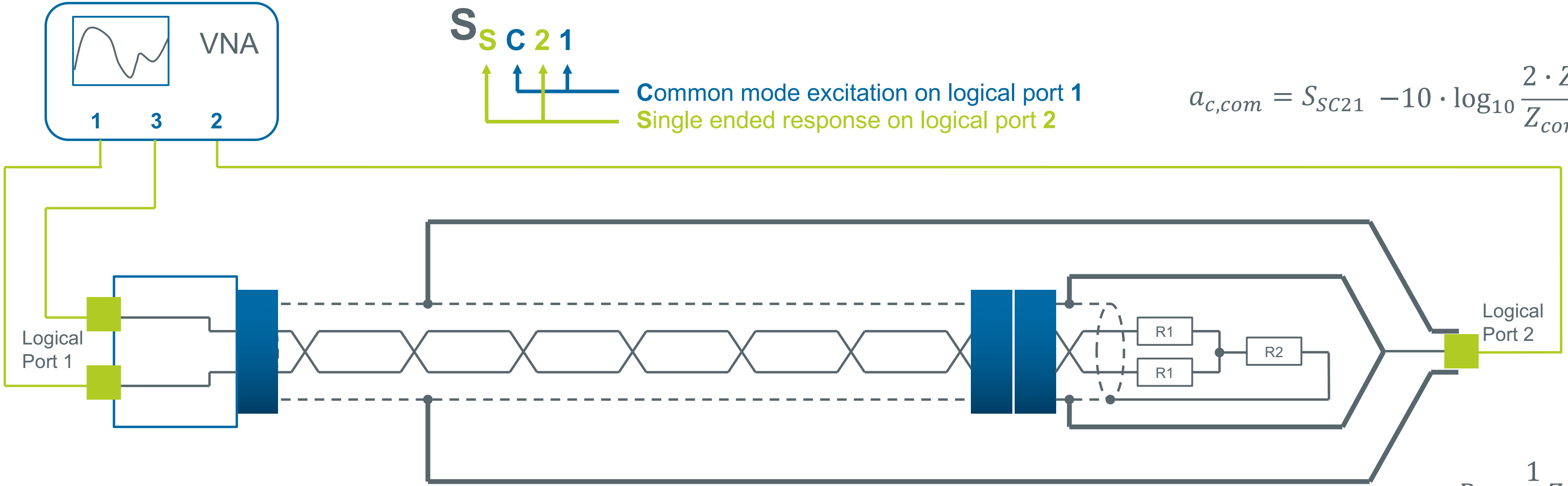
- D 2 1: Differential mode excitation on logical port **1**
- S 2: Single ended response on logical port **2**

$$a_{c,diff} = S_{SD21} - 10 \cdot \log_{10} \frac{2 \cdot Z_s}{Z_{diff}}$$

S_{SC21}

- C 2 1: Common mode excitation on logical port **1**
- S 2: Single ended response on logical port **2**

$$a_{c,com} = S_{SC21} - 10 \cdot \log_{10} \frac{2 \cdot Z_s}{Z_{com}}$$



Z_S = 150 Ω

VNA ≙ Vectorial Network Analyser

Connectors

Z_{diff} ≙ Differential mode wave impedance

Z_{com} ≙ Common mode wave impedance

$a_{c,diff}$ ≙ Differential mode coupling attenuation

$a_{c,com}$ ≙ Common mode coupling attenuation

$$R_1 = \frac{1}{2} Z_{diff}$$

$$R_2 = Z_{com} - R_1 || R_1$$

Results of Cable Type C

Comparison of Different Test Setups

Shielding effectiveness

Common mode coupling attenuation

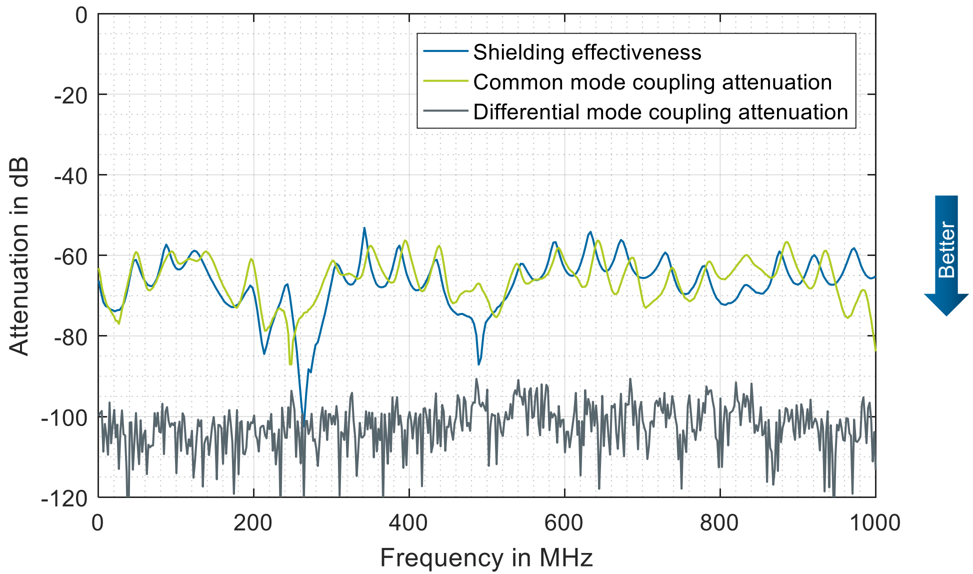
✓ Good comparability

Coupling attenuation

Common mode

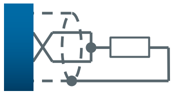
Differential mode

✓ Test setup for coupling attenuation provide more information

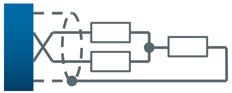


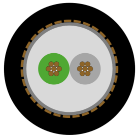
Termination network

Quasi coaxial



Common/Differential mode





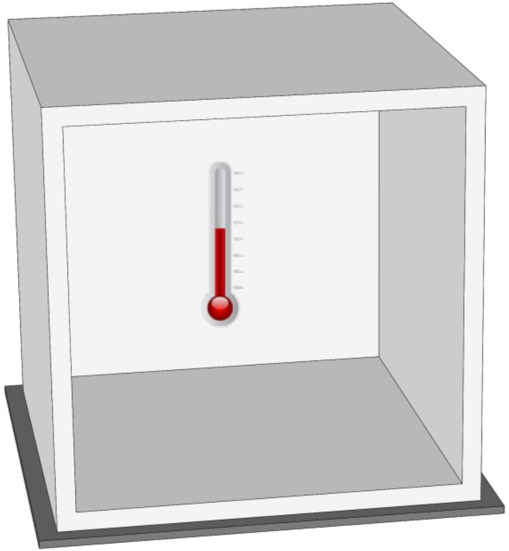
Cable type C

Aging Effects

Simulation of Aging and Resulting Influence

Simulation of Aging

Thermal and Mechanical Stress

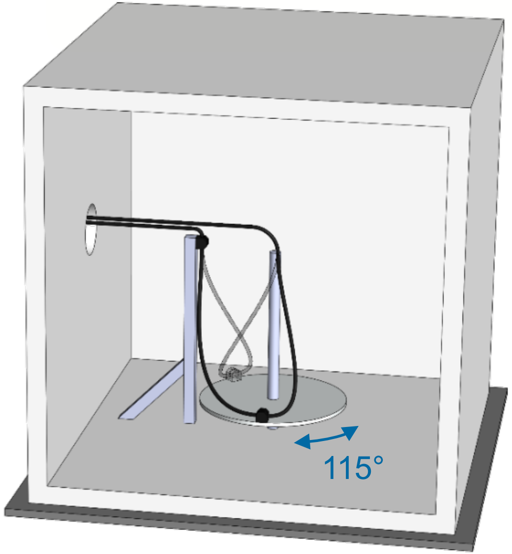


- 1000 h
- Dry heat 105°C
- ISO 6722

Long term heat aging

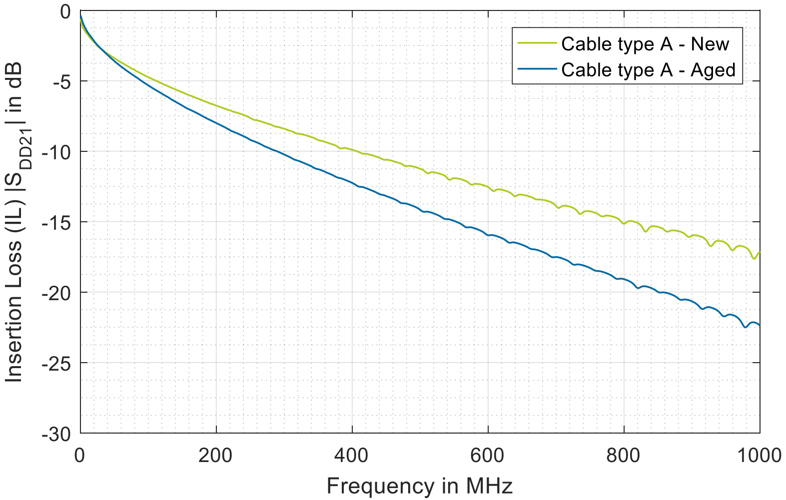
Combined torsion and reverse bending stress

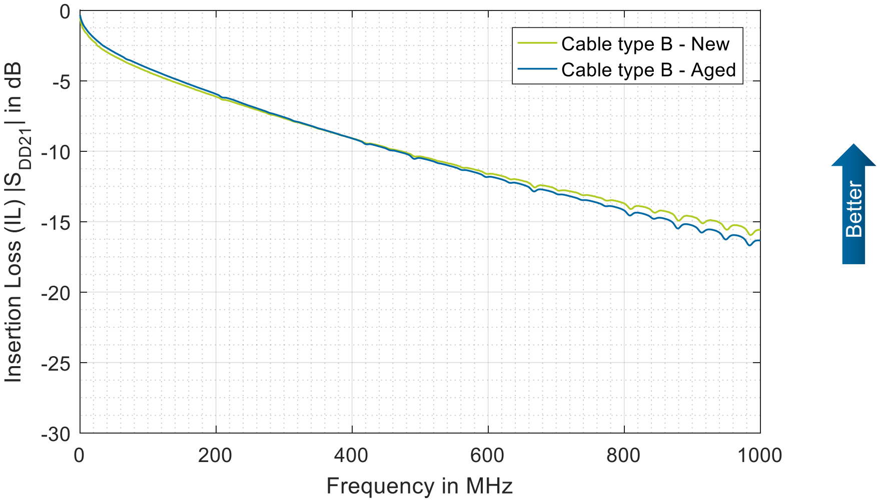
- In climatic chamber
- Dry heat 40°C
- 60,000 cycles

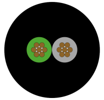


Insertion Loss – Cable Type A and B

Long Term Heat Aging – Thermal Stress

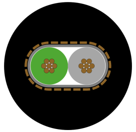




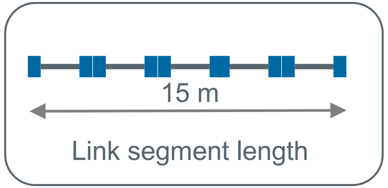


Cable type A

- Aged for a period of 1000 h at 105°C
- Cable type A shows the biggest change
- Cable types B and C show only a small change

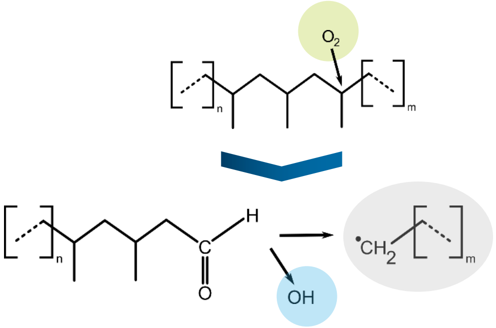


Cable type B

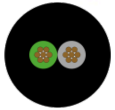


Polymer Analysis

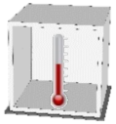
Examination of the Insulation in Cable Type A



15 m link	New state	After 1000 h
Capacity [C]	744 pF	756 pF
$\varepsilon_{r,eff}$ calculated	2.379	2.415



Cable type A



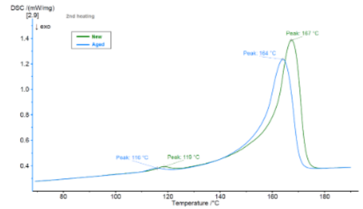
TGA and DSC show a change in the insulation material

Change of permittivity value

- Change of the insertion loss
- Change of the wave impedance

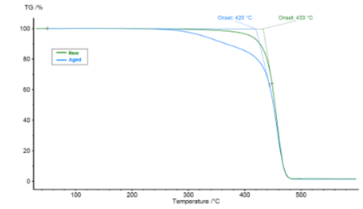
Differential Scanning Calorimetry (DSC)

- Change of melting curve shape and peak position
- Aged material is different to the unaged material



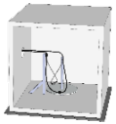
Thermogravimetric Analysis (TGA)

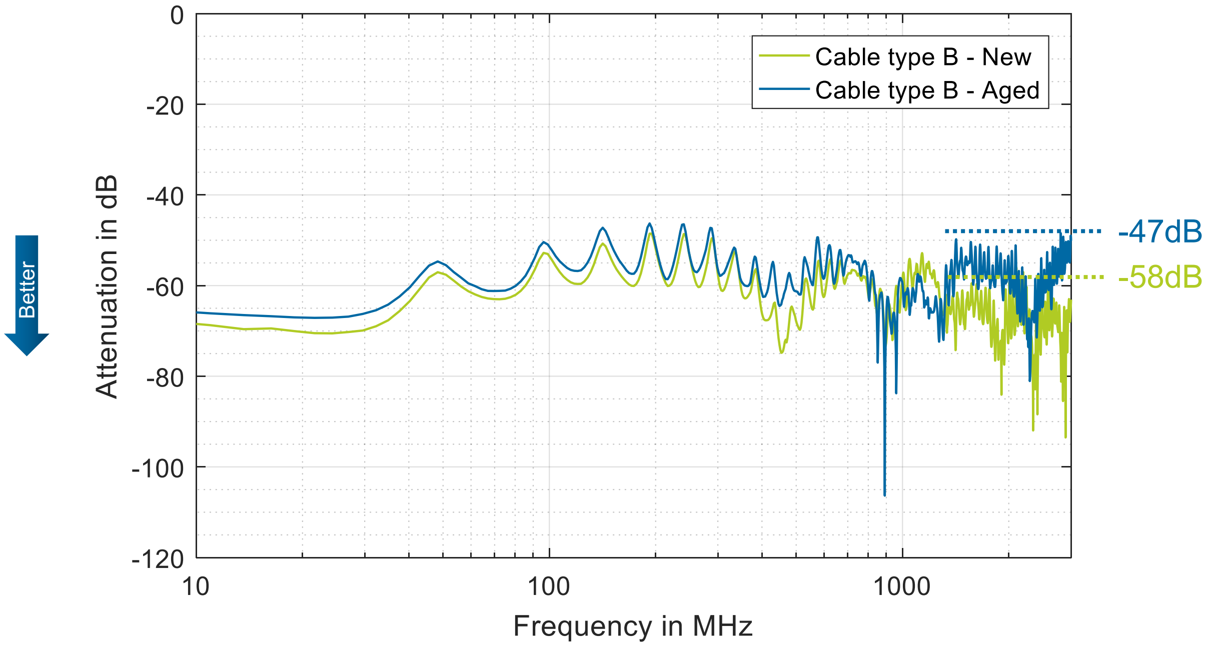
- Change of the thermal degradation behavior
- Degradation through chain scission



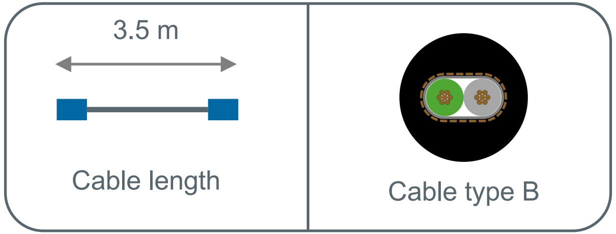
Results after Mechanical Stress

Combined Torsion and Reverse Bending Stress - 60,000 cycles



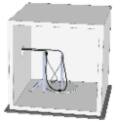


- Shielding attenuation of the cable type B
- Small change at frequencies below 1000 MHz
- Change approx. 11 dB at frequencies exceeding 1000 MHz

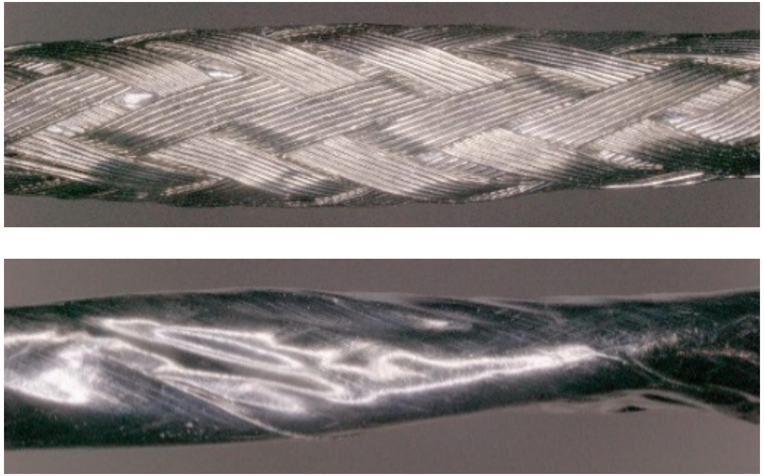


Mechanical Stress

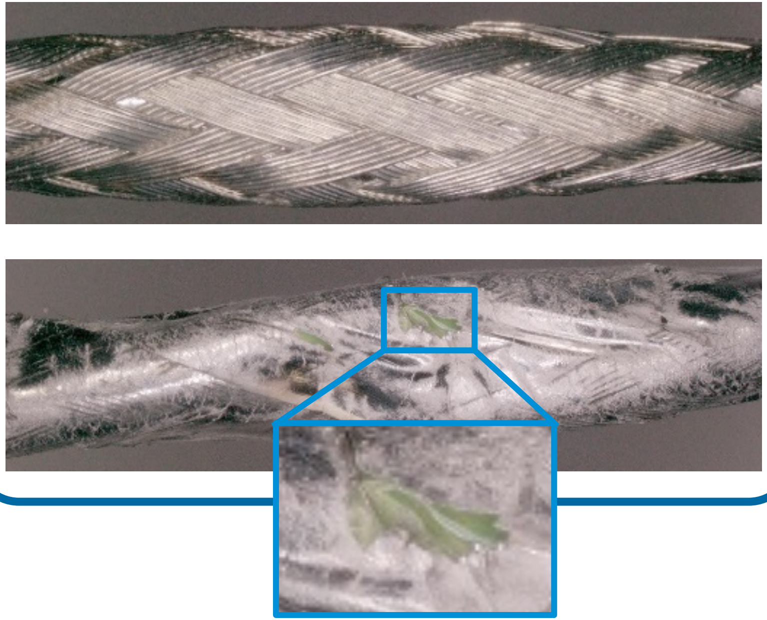
Influence on Shielding



New



Aged



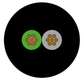
- Braid is in **good** condition
- Foil is damaged

Outlook

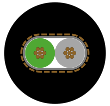
MultiGig & EMC

Outlook MultiGig

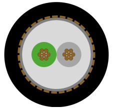
Insertion Loss



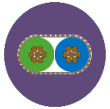
UTP
Unshielded Twisted Pair



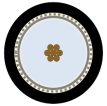
STP
Shielded Twisted Pair



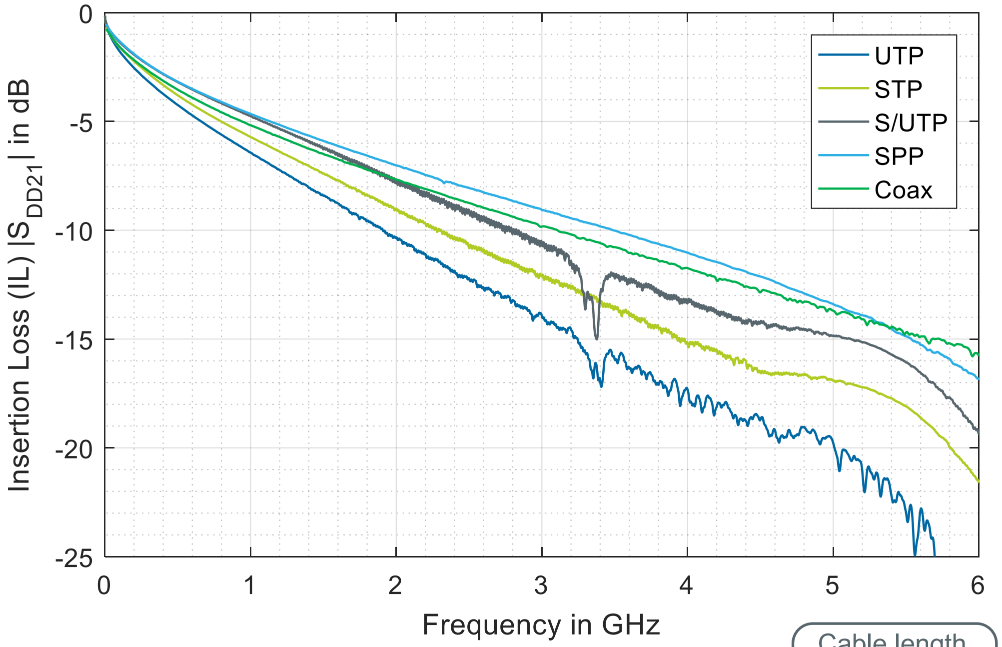
S/UTP
Stabilized Shielded Twisted Pair

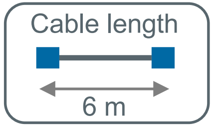


SPP
Shielded Parallel Pair



Coax
Coaxial Cable



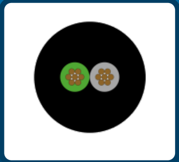


EMC of Cable Assemblies

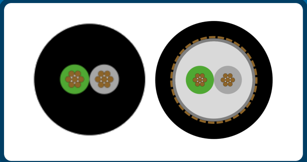
Test Method and Parameters

Unbalance attenuation	Screening attenuation	Coupling attenuation	Coupling attenuation
a_u	a_s	a_c	a_c
DIN EN 50289-1-9	DIN EN 62153-4-4	DIN EN 62153-4-9	IEC 62153-4-9
Conversion attenuation from differential mode signals to common mode	Screening attenuation of metallic communication cable **shields**	Screening attenuation of differential mode and common mode signals of **shielded** cables	Screening attenuation of differential mode signals of **shielded** and **unshielded** cables
Link Type A SCC	3,5 m cable	3,5 m cable	Link Type B
on 10mm foam	in tube	in tube $\sim a_u + a_s$	with absorbing clamp
Symmetric property of cable structure	Shielding efficiency	Symmetric property and Shielding efficiency	Symmetric property and Shielding efficiency

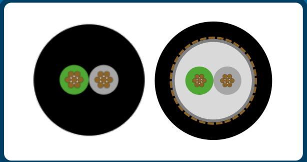
Summary



Coating Material of UTP very important

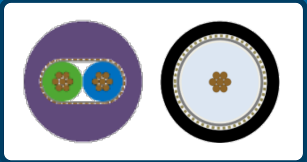


When mixing UTP and STP:
Need of intermediate jacket



EMC of STP: Coupling attenuation

EMC of UTP: Unbalanced attenuation



Recommendation of SPP and Coax
for MultiGig

IMPRINT

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