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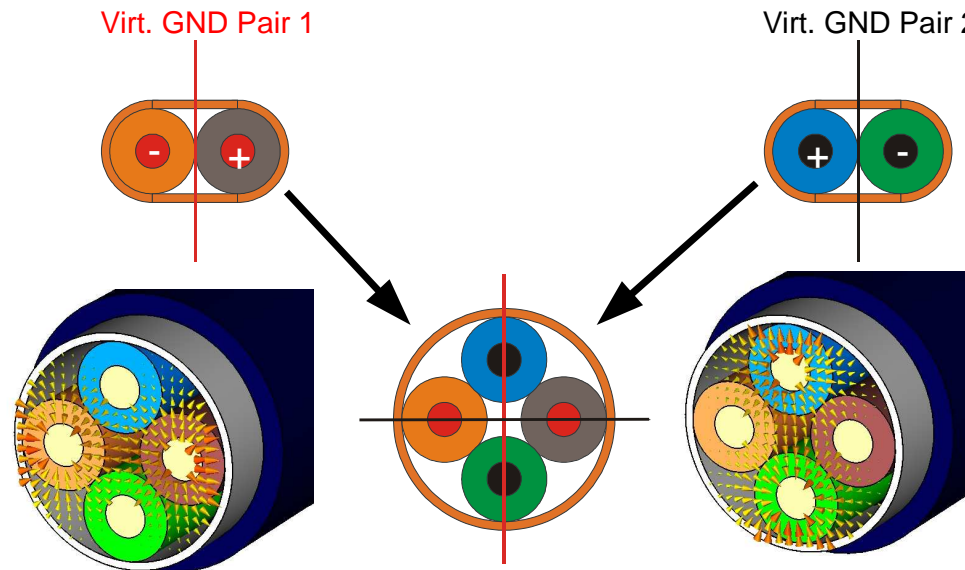
Automotive Datalinks over Twisted Quad Cabling

T. Müller, G. Armbrecht, S. Kunz

- Automotive Datalinks over Twisted Quad Cabling
 - Twisted Quad fundamentals
 - Twisted Quad connector interface

- EMC
 - Coupling to adjacent systems
 - Measuring EMC properties of components
 - Linking mode conversion to radiation

- Summary

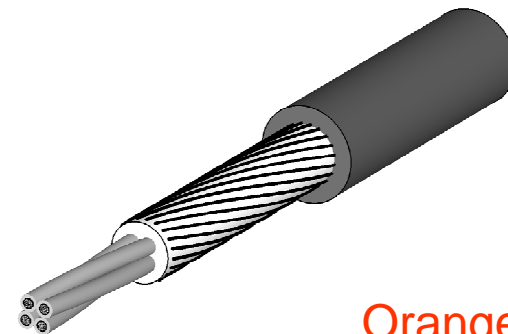
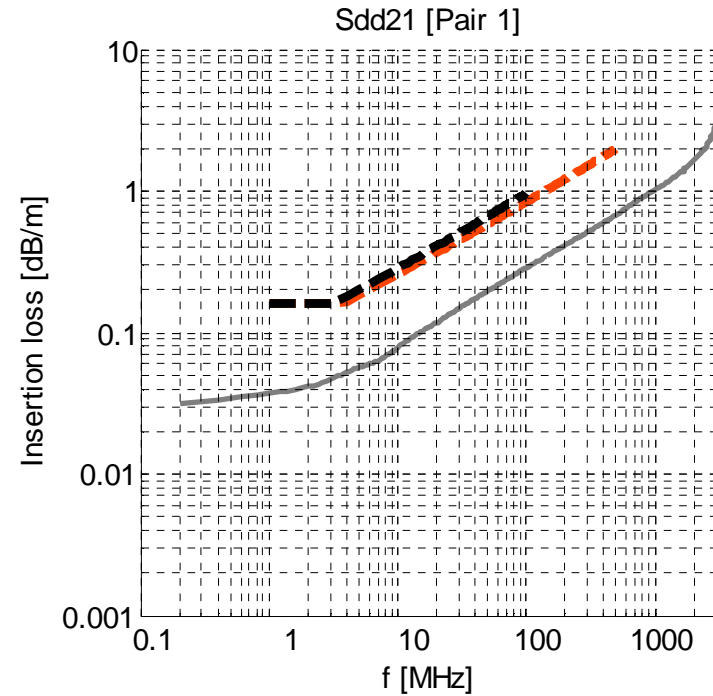
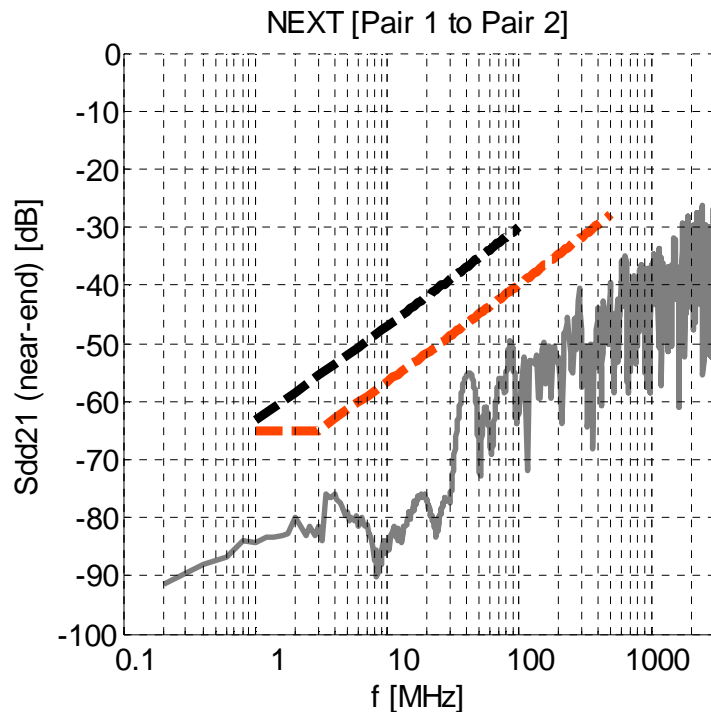


- Opposite conductors form a differential pair
- Fields cancel each other > virtual ground plane
- Independent transmission of two data streams over one cable
- Second pair can also be used for remote powering devices
- Compact size
- Round shape without fillers (mechanically stable)

Twisted Quad Fundamentals

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- Typical insertion loss 1 dB/m @ 1 GHz
- Low crosstalk
- Bidirektional communication up to 3 GBit/s over 10 m LVDS possible



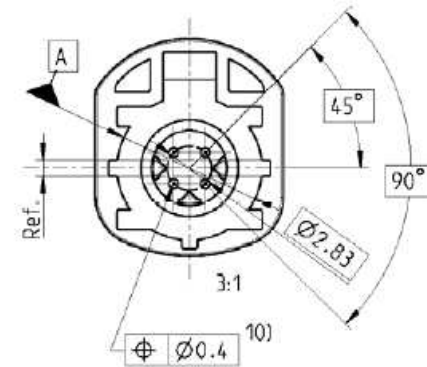
Orange: Cat 6a

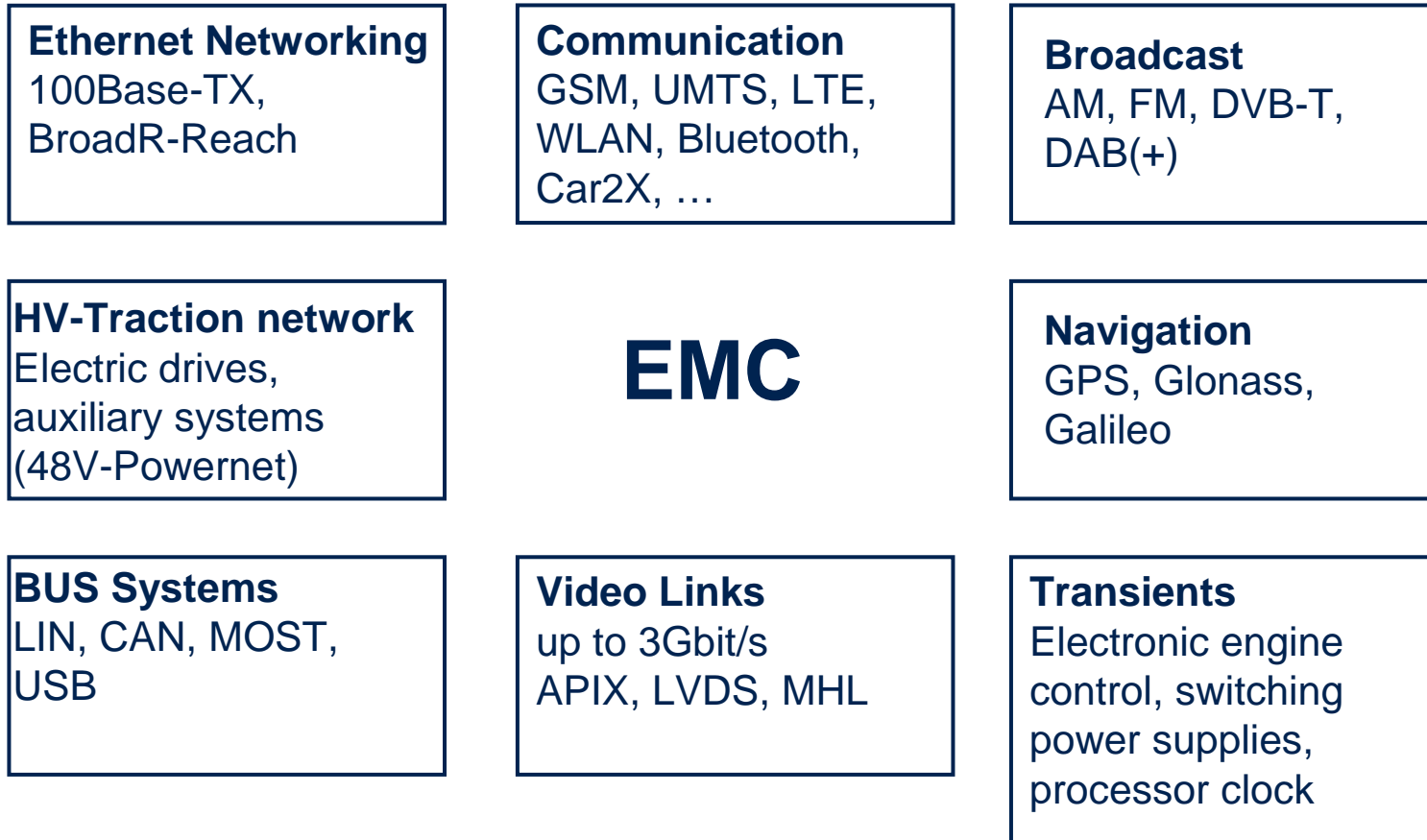
Black: Cat 5

STQ Connector Interface

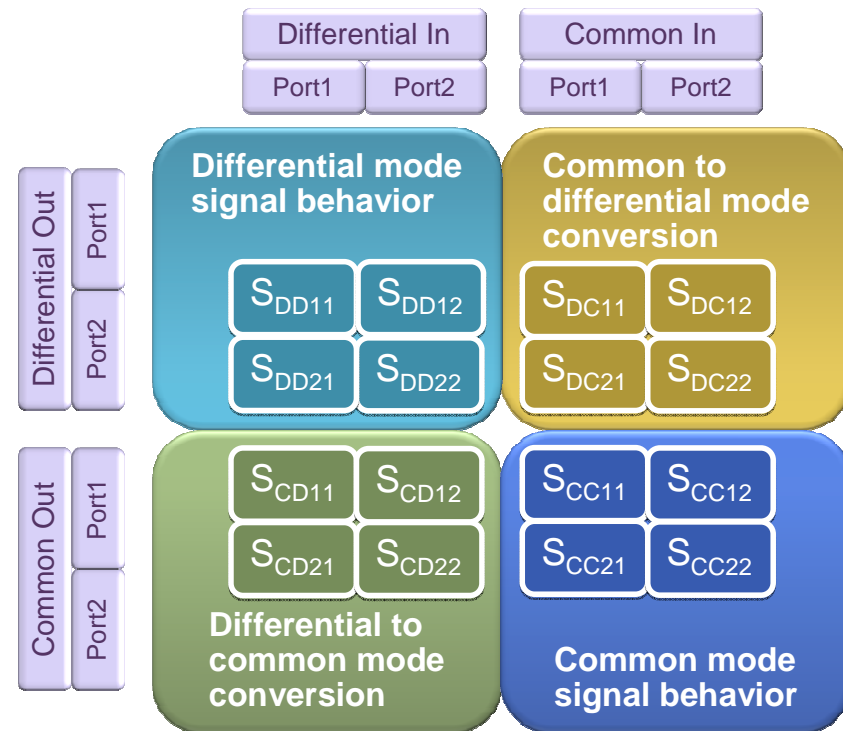
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- Open interface
(connectors are available from different vendors)
- Interface as described in automotive IEEE 1394 Copper Automotive Standard (Supplement to IDB-1394) Project TS2008001
- Designed to meet automotive requirements
 - Electrical (e.g. ISO/IEC 60603-7-51 CAT 6a, LV213)
 - Mechanical and environmental (forces, waterproofness, LV214, USCar)
 - Fully automated assembly process
- EMC
 - Radial shielding contact
 - Compatible with fully-shielded (braid + foil), semi-shielded (foil) and unshielded



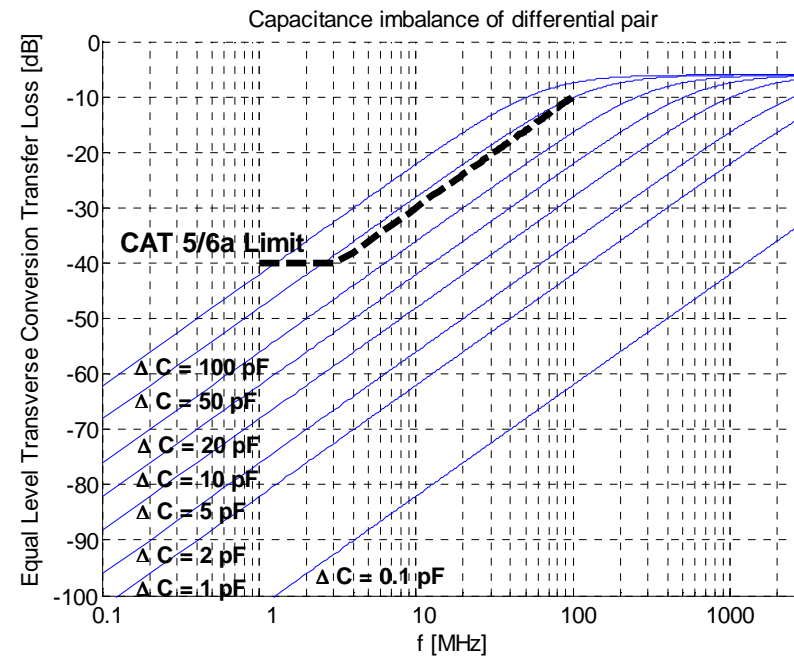
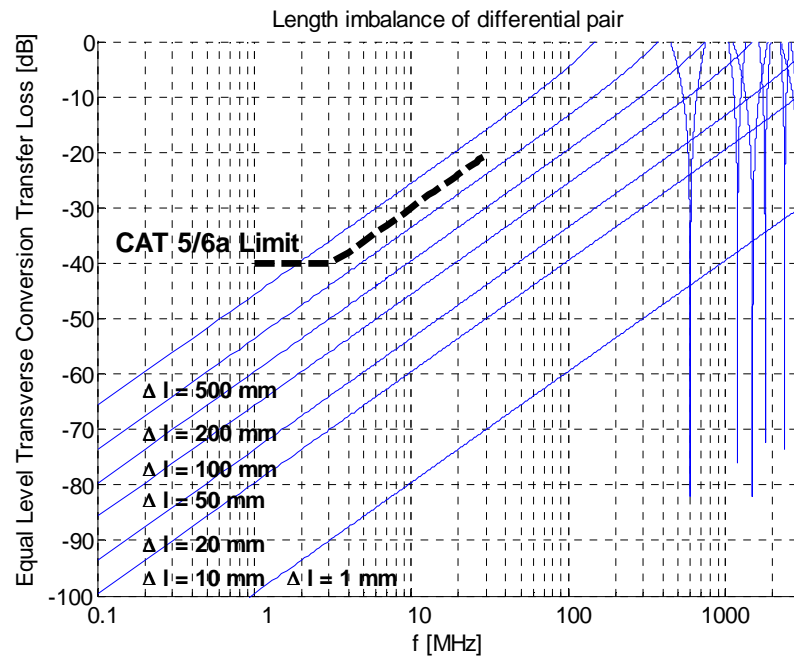
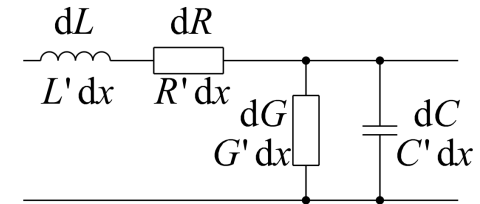


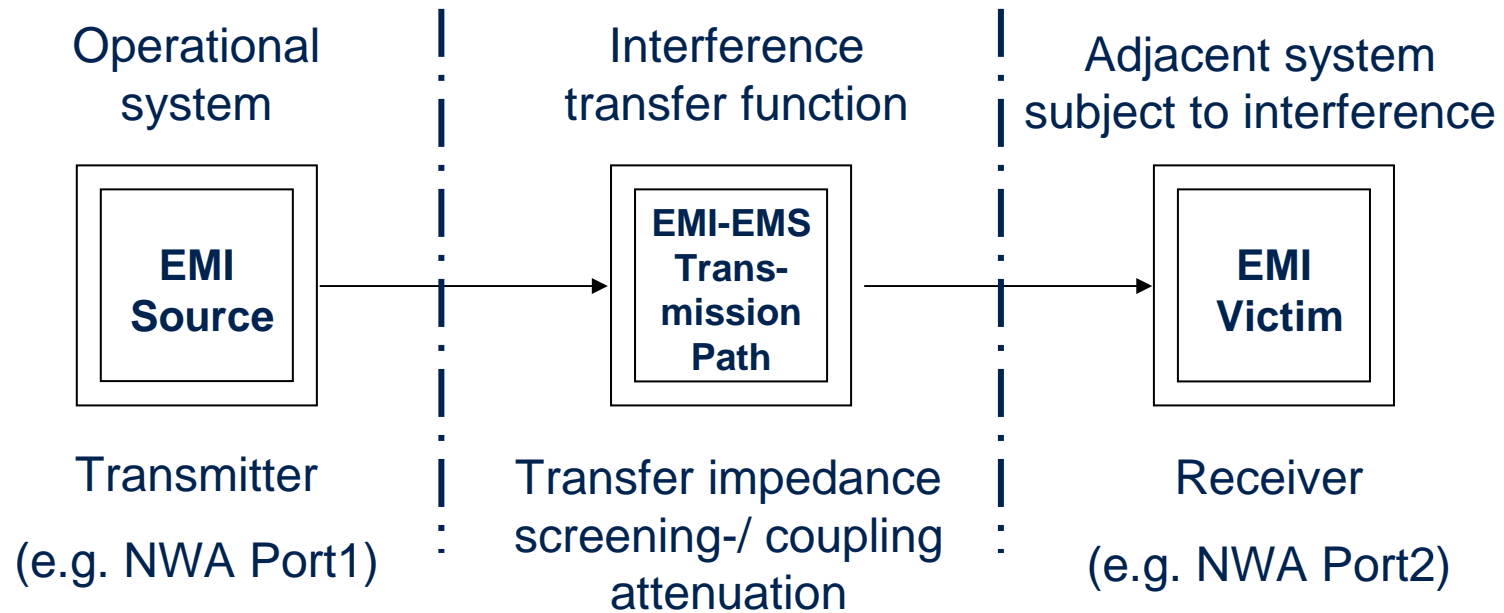
- Coupling attenuation determines the EMC properties of a differential channel as the sum of
 - Differential to common mode conversion attenuation
 - Shielding attenuation for screened cables
- Mode conversion measured with S-parameter measurements by Network Analyzer (NWA)
 - TCL (S_{dc11})
 - TCTL (S_{dc21})
 - ...



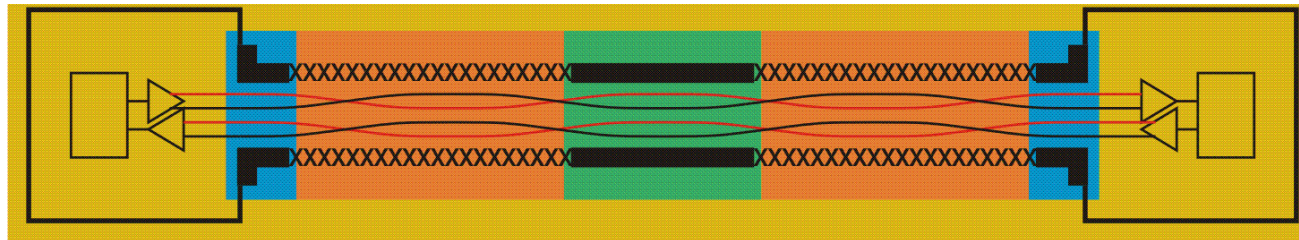
Measuring EMC properties

- Unbalance along the channel causes mode conversion
- Concentrated unbalance can be compensated (e.g. through optimized footprint design)
- Distributed unbalance is most critical (e.g. within cable)





- Measure transmission path
- Identify basic screening parameters



Component Tests

IEC 62153-4-4

IEC 62153-4-7

IEC 62153-4-10

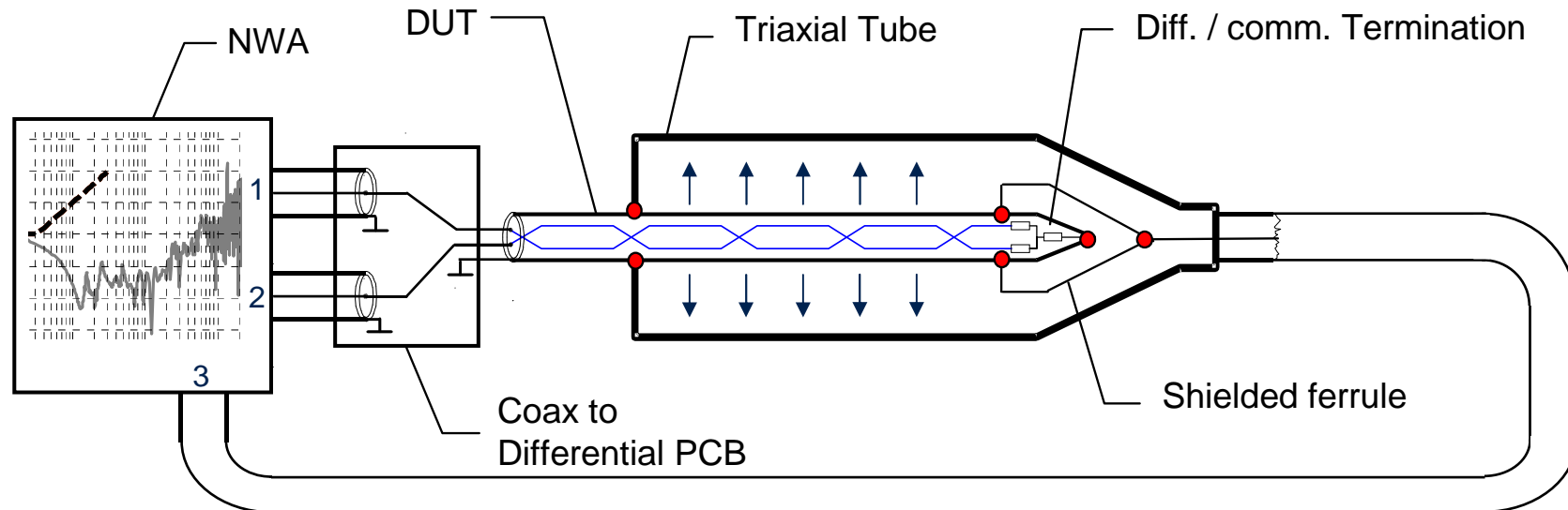
Cable

Inline connections

Feed-throughs

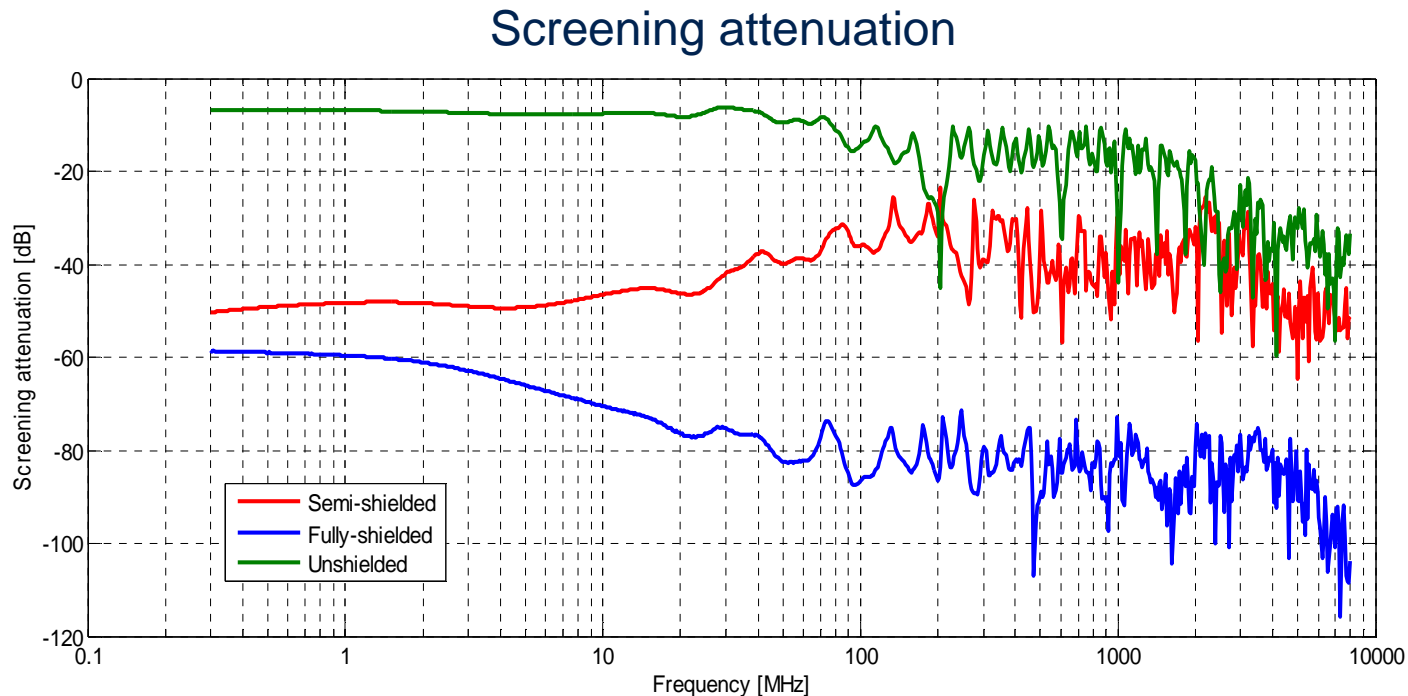
- Triaxial tube allows measuring screening properties of individual components along the channel





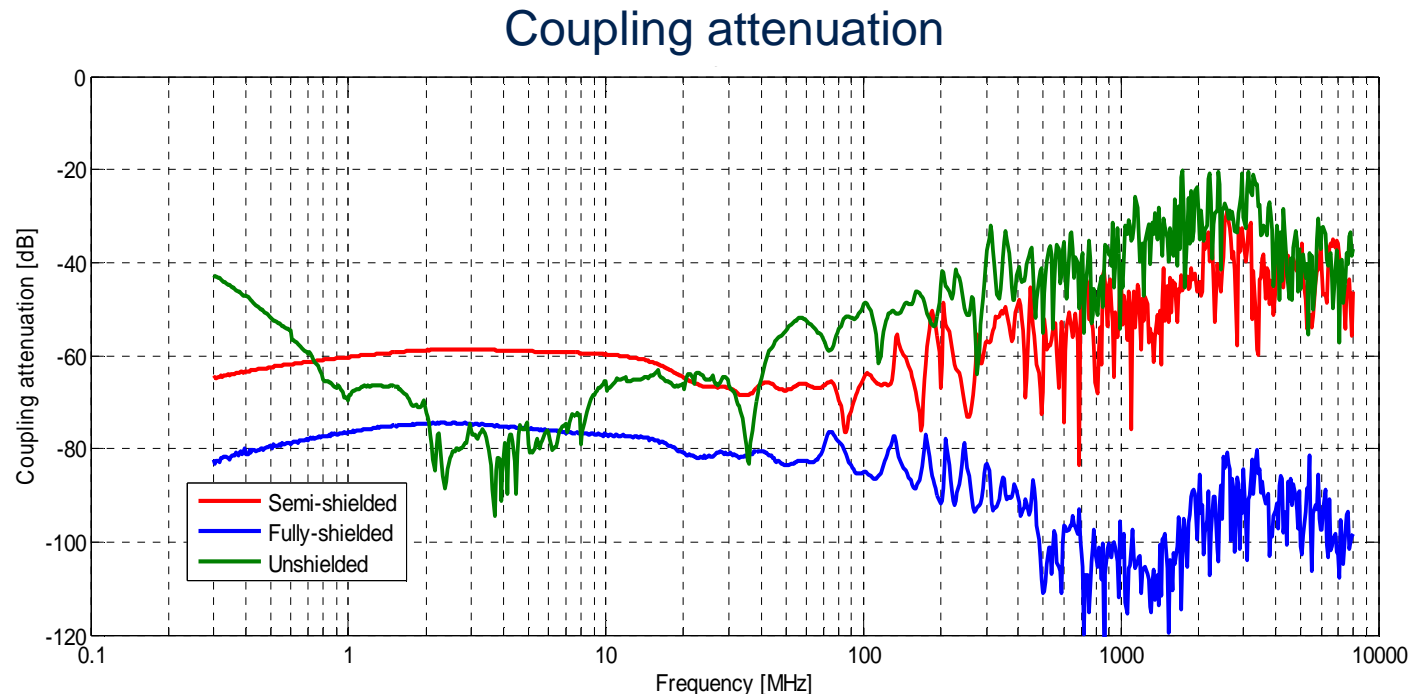
- Allows measuring screening properties of individual components along the channel by means of triaxial measurements
- The DUT can be fed from the NWA in common mode or differential mode to measure screening- or coupling attenuation
- Also applicable for unshielded differential pairs

- Twisted Quad cable assembly measurement examples



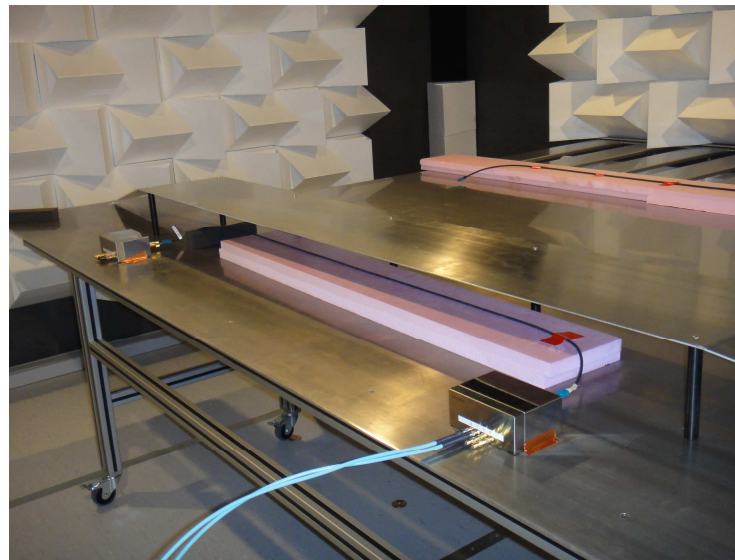
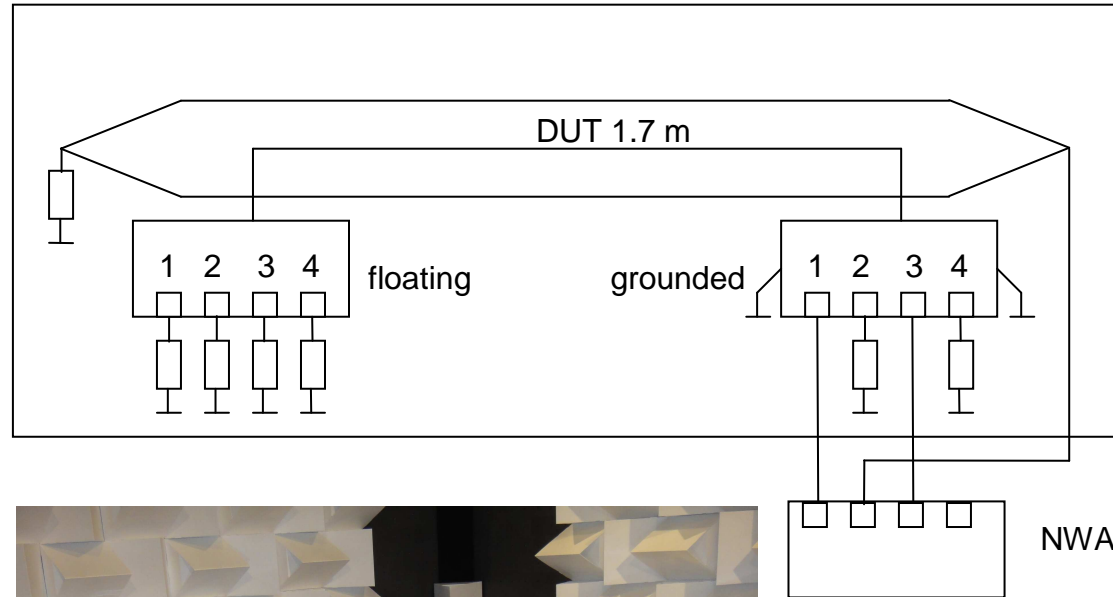
- Measurement of screening attenuation not intended for unshielded cables according to given standards
- Quality of shield may be adjusted by construction

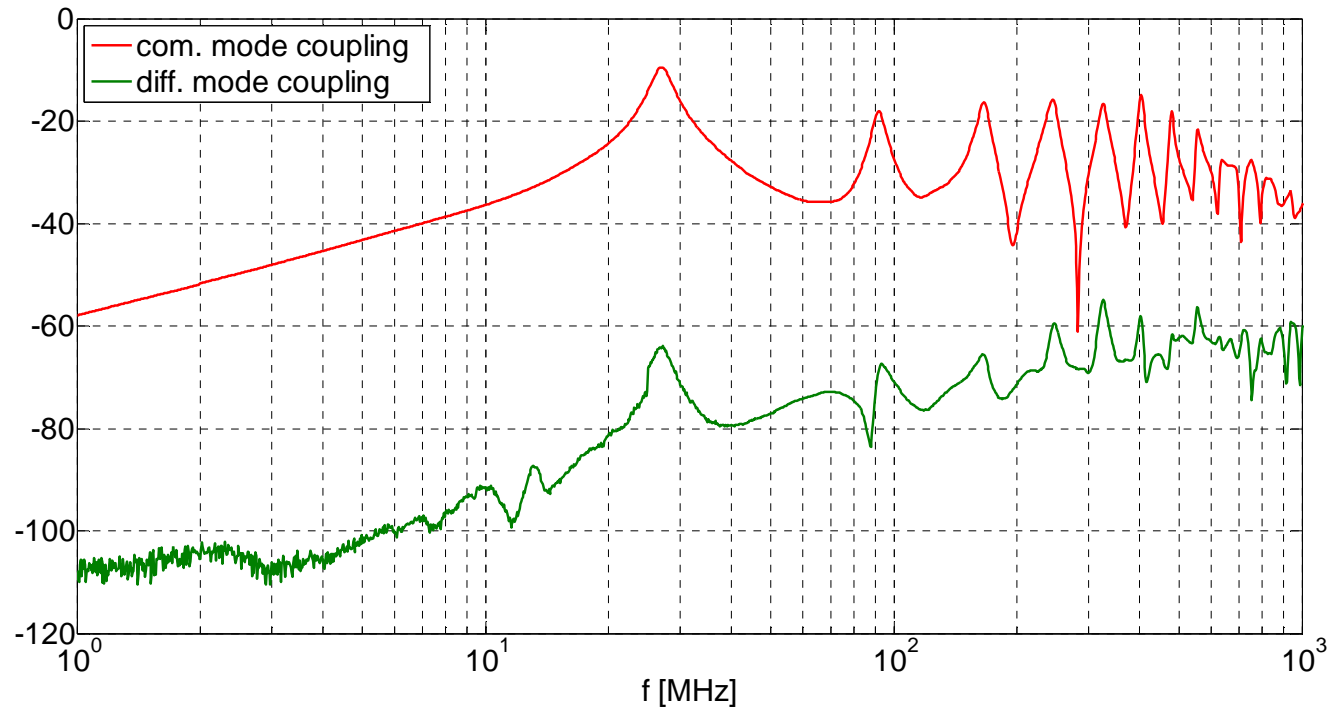
- Twisted Quad cable assembly measurement examples



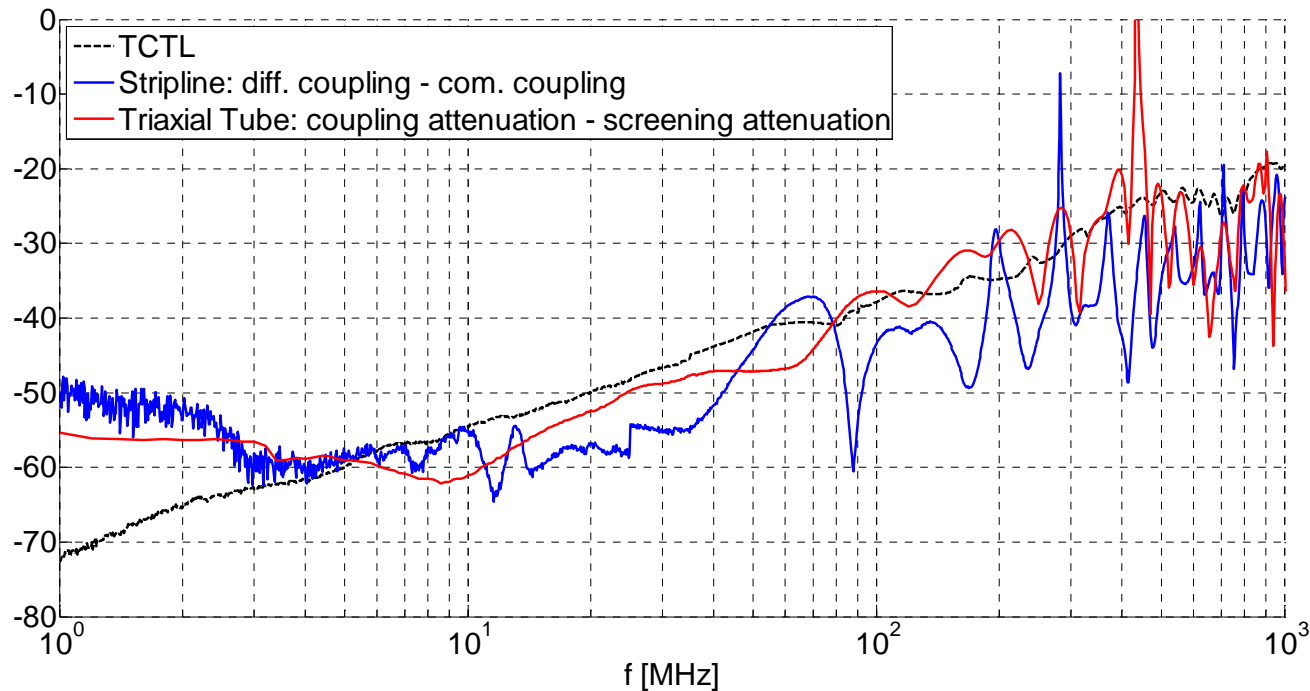
- Fully-shielded cables provide excellent coupling attenuation
- Unshielded cables can provide noticeable performance, if the balance throughout the channel is maintained (connector, cable, termination)
- Semi-shielded cables may be a viable compromise

- Measure differential and common mode coupling to stripline in a three port NWA measurement
- UTQ cable 1.7 m
- First end connected to ground plane
- Second end floating
- Measure TCTL in same setup
- Compare the results with triaxial tube





- Small coupling at low frequencies due to limited coupling length
- Resonances at quarter wavelength and odd multiples



- Coupling to stripline is linked to mode conversion properties of the DUT
- Mode conversion as difference between differential and common mode coupling can be reproduced
- Triaxial tube is less dependent on setup (e.g. DUT length, coupling length, grounding) and easier to handle (e.g. no need for shielded chamber)

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- Twisted Quad cables are widely used for differential signal transmission within vehicles.
 - In combination with the STQ connector interface the automotive requirements concerning mechanical and electrical properties are met.
 - The EMC properties of components along the channel can be evaluated by measuring mode conversion and coupling attenuation by means of a triaxial tube.
 - The grade of shielding may be adapted to bandwidth, topology and EMC-environment of the application to be implemented without the need to change the connector interface.