Technical feasibility

How to ensure EMC by measurements

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Contributors

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Disclaimers

- This presentation attempts to show the way EMC measurements for automotive bus systems are done today and how requirements can be derived.
- This presentation attempts to describe what technical feasibility means for car manufacturers from an EMC perspective.

- The presentation does not focus on further requirements which are requested by car manufacturers.
- The presentation does not cover dedicated requirements.

Agenda

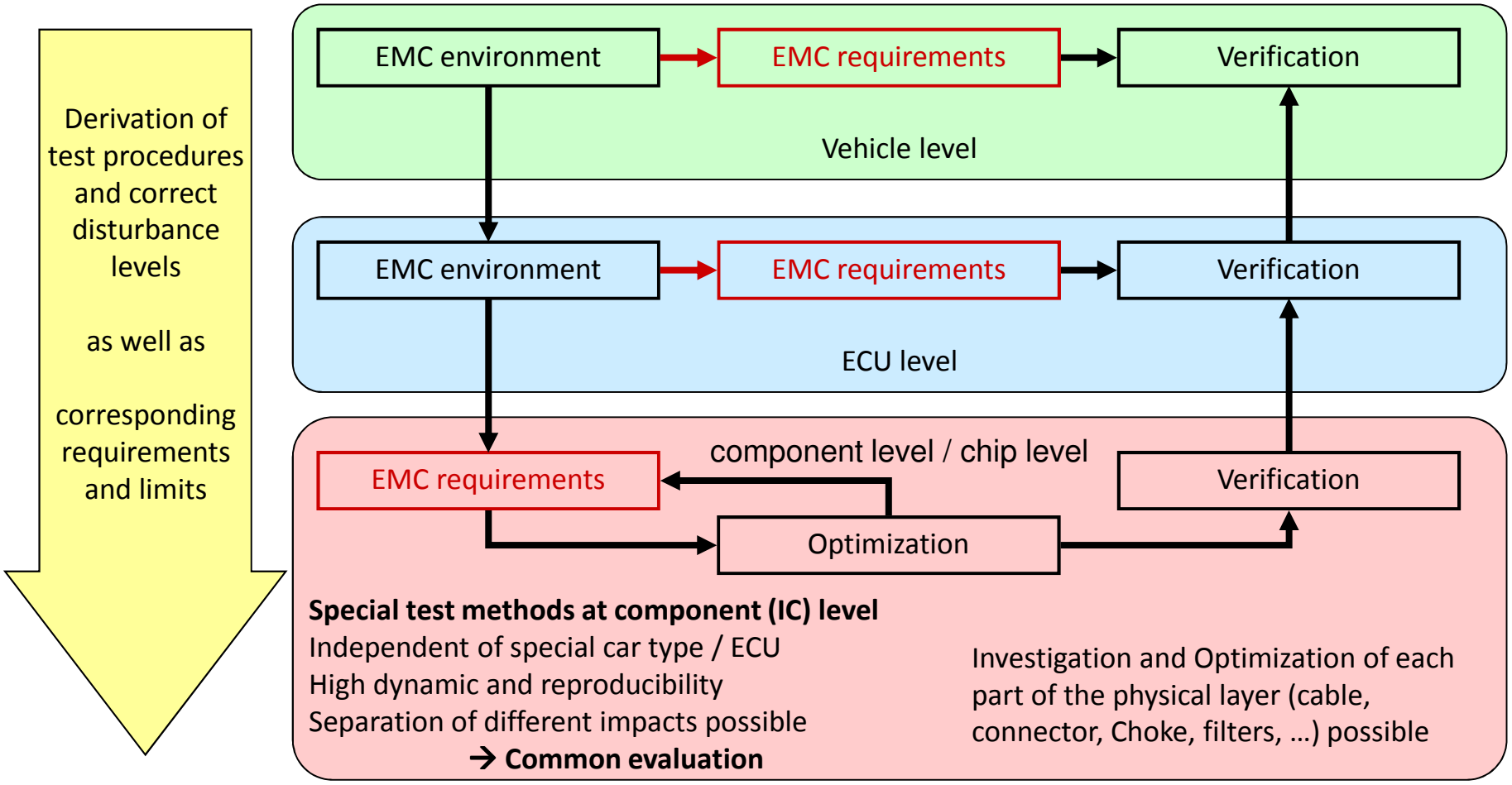
- Motivation
- Procedure to ensure EMC for automotive bus systems
- Automotive Environment
- Exemplary tests at Component level
- Conclusion

Motivation

- Show the way EMC is ensured in automotive environment.
- Give you a feeling about the EMC requirements of the car manufacturers.
- Show how EMC measurements on component/chip level are done and what are (roughly) the typical requirements for those measurements.

- Discuss what is necessary to be done to show “technical feasibility” or more explicitly “good electromagnetic compatibility” from the car manufacturer’s point of view.
- Discuss what is necessary/what is possible to show electromagnetic compatibility for the upcoming RPGE solution.

Ensure EMC for automotive bus systems



Ensure EMC for automotive bus systems

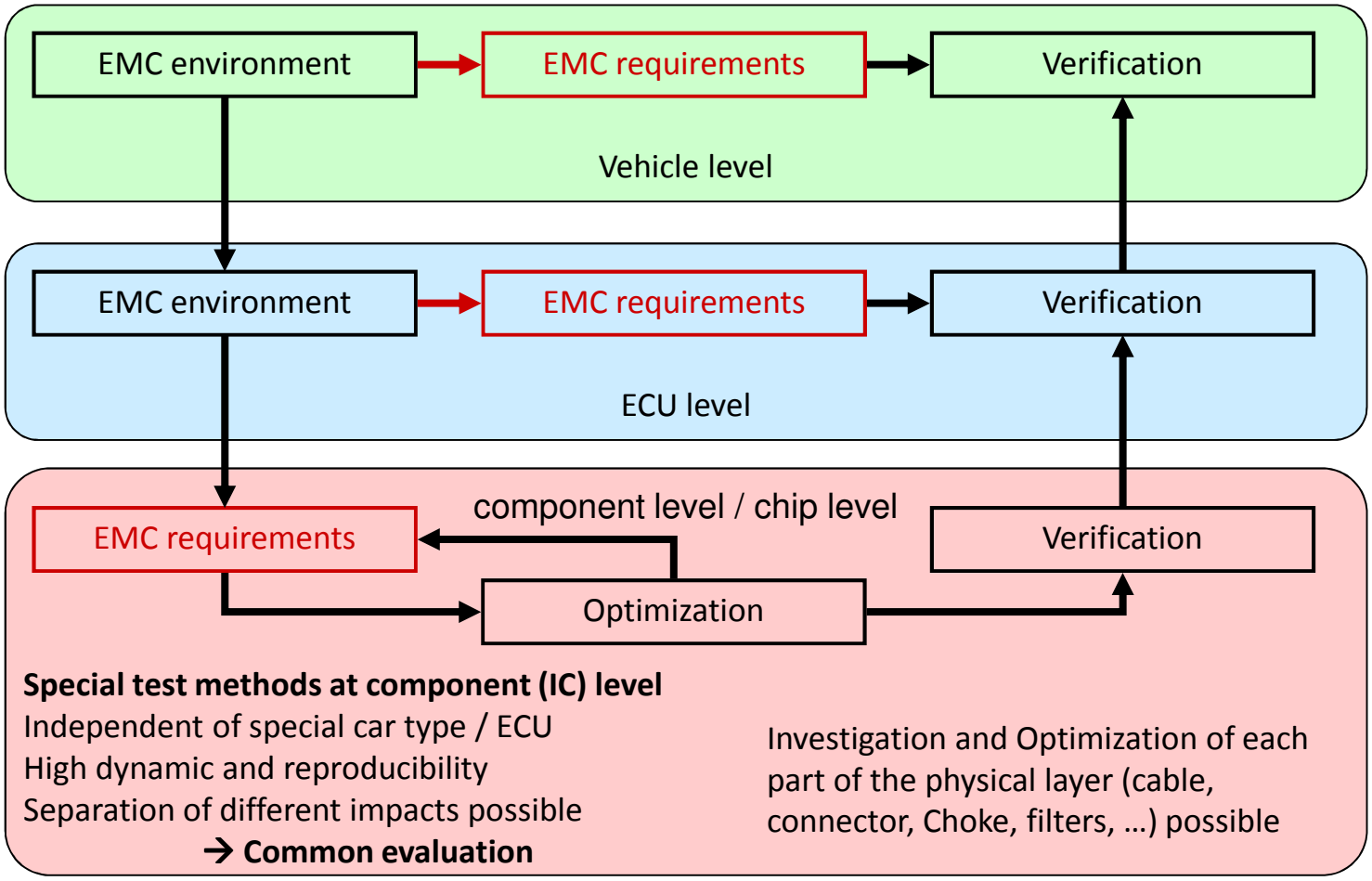
e.g. CISPR12/CISPR25/ ISO 11451

- radiated immunity
- radiated emission
- ESD

e.g. CISPR25/ISO11452

- radiated immunity
- radiated emission
- conducted immunity
- conducted emission
- Transients/ESD

- immunity against direct injected power (DPI)
- Direct conducted emission (150 ohms method)
- ESD



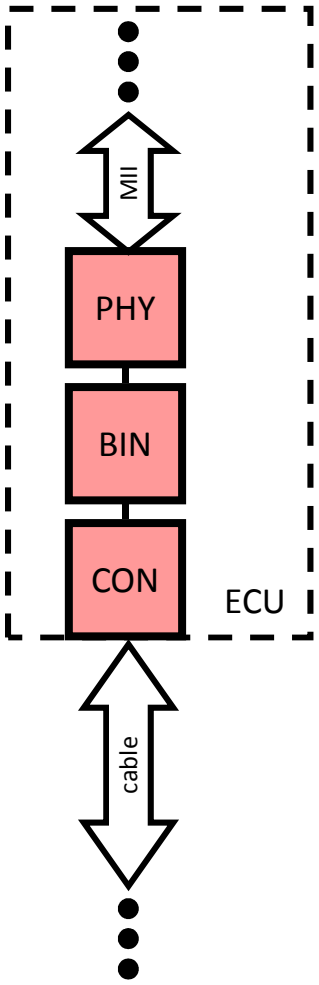
Overview of Automotive EMC requirements

- Comparison of industrial and automotive EMC requirements

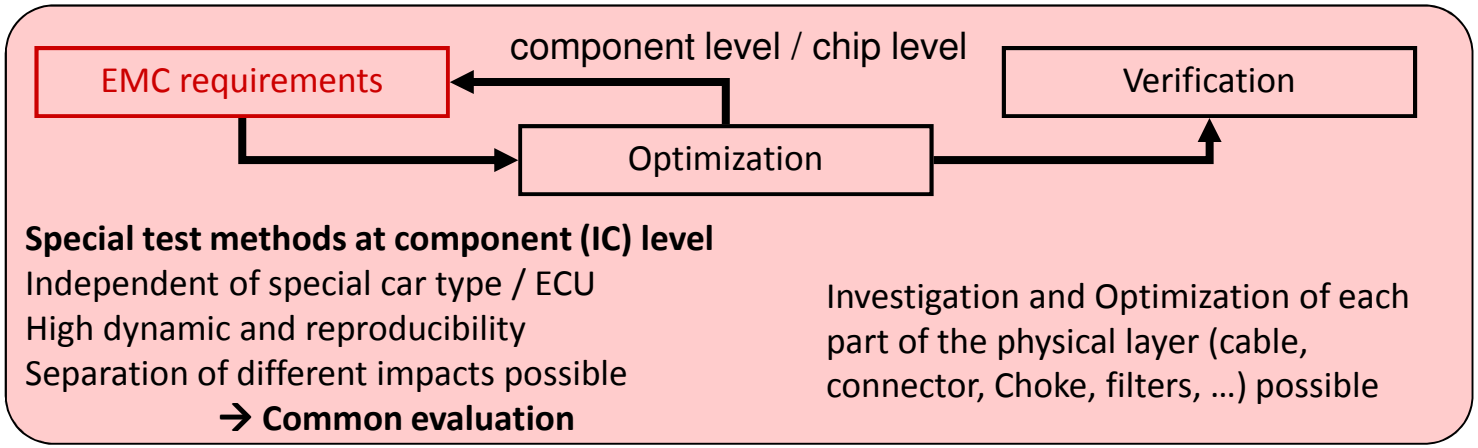
EMC requirements on electronically equipment		
	Industrial (typical)	**Automotive (different OEMs)**
Immunity		**e.g. ISO 11452, ISO 7637**
Transients	**Burst , High energy pulses → 2 kV / 4 kV**	**Burst , High energy pulses → 100 … 450 V**
EM fields	**80 MHz … 2 GHz → 18 V/m**	**100 kHz … 3 GHz → up to 400 V/m**
MF fields	**16,3 / 50 Hz → … 10 A/m**	**(DC) 16,3 Hz … 100 kHz → up to 1000 A/m**
RF conducted	**150 kHz … 80 MHz → 18 V**	**100 kHz … 400 MHz → up to 325mA/500mA (trucks)**
ESD	**up to 8 kV**	**up to 25 kV**
Emission		**e.g. CISPR 25**
EM fields	**30 … 1 GHz 30 (37) dBµV QP @10m (Cl. B)**	**100 kHz … 2,75 GHz 26 – 16 – 24 dBµV AV @ 1m**
RF conducted	**150 kHz … 30 MHz 56 to 46 dBµV AV (Cl. B)**	**150 kHz … 108 MHz 50 to 18 dBµV AV (Cl. 5)**

Automotive requirements are a summarization of highest requirements of different car manufacturers.

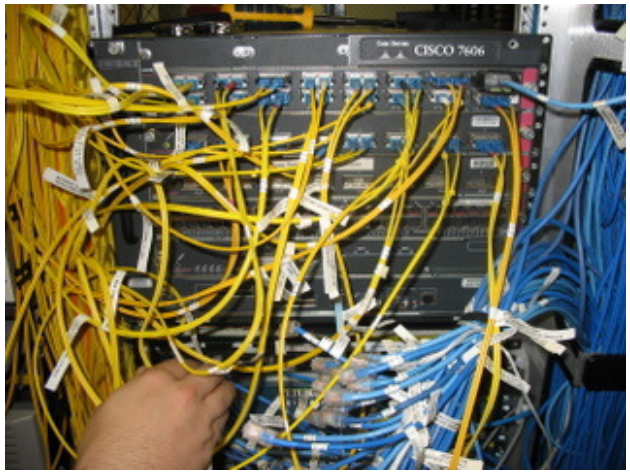
Ensure EMC for automotive bus systems



- to ensure EMC on component-/chip-level all parts of the communication system have to fulfill dedicated requirements:
  - Physical layer chip (PHY)
  - Bus interface network (BIN, this includes filters, chokes, etc)
  - Connector (CON)
  - Cable (including inline connectors)
  - Power supply (coupling to PHY path)
  - Higher layer interfaces (coupling to PHY path)

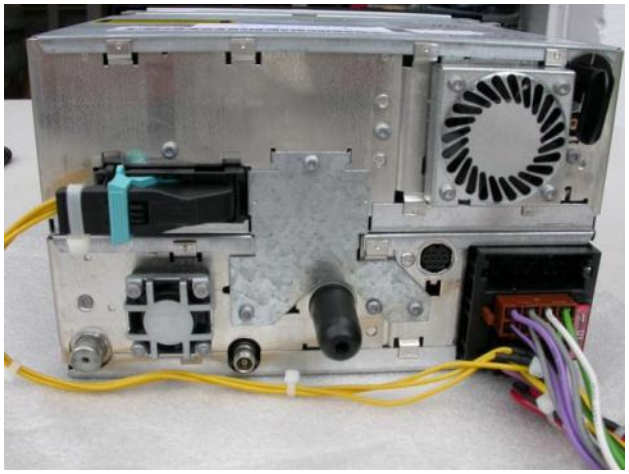


Automotive environment



- **Industrial/CE:**

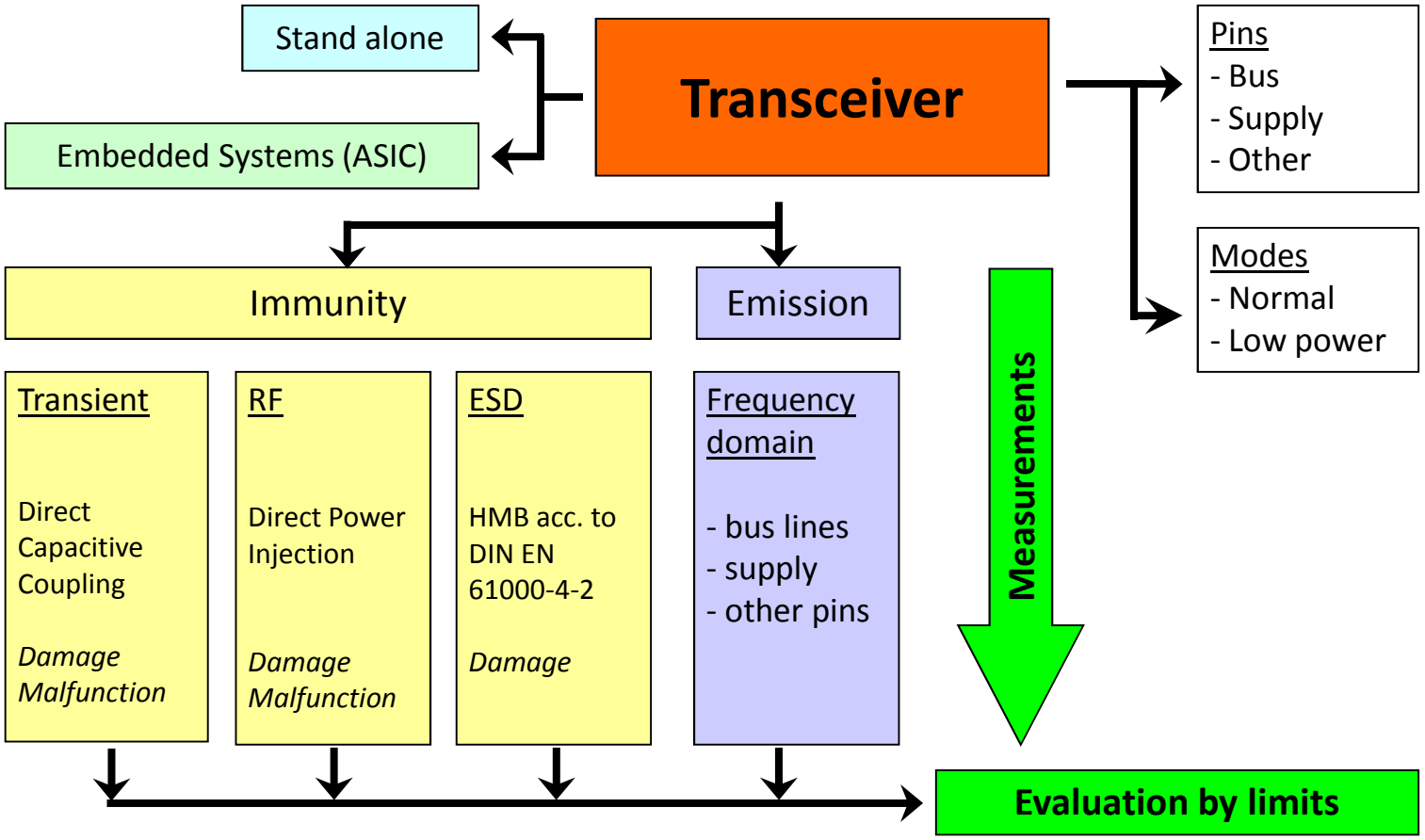
You have to cope with complex Switching Banks, etc. However you can use “RF-optimized” connectors



- **Automotive:**

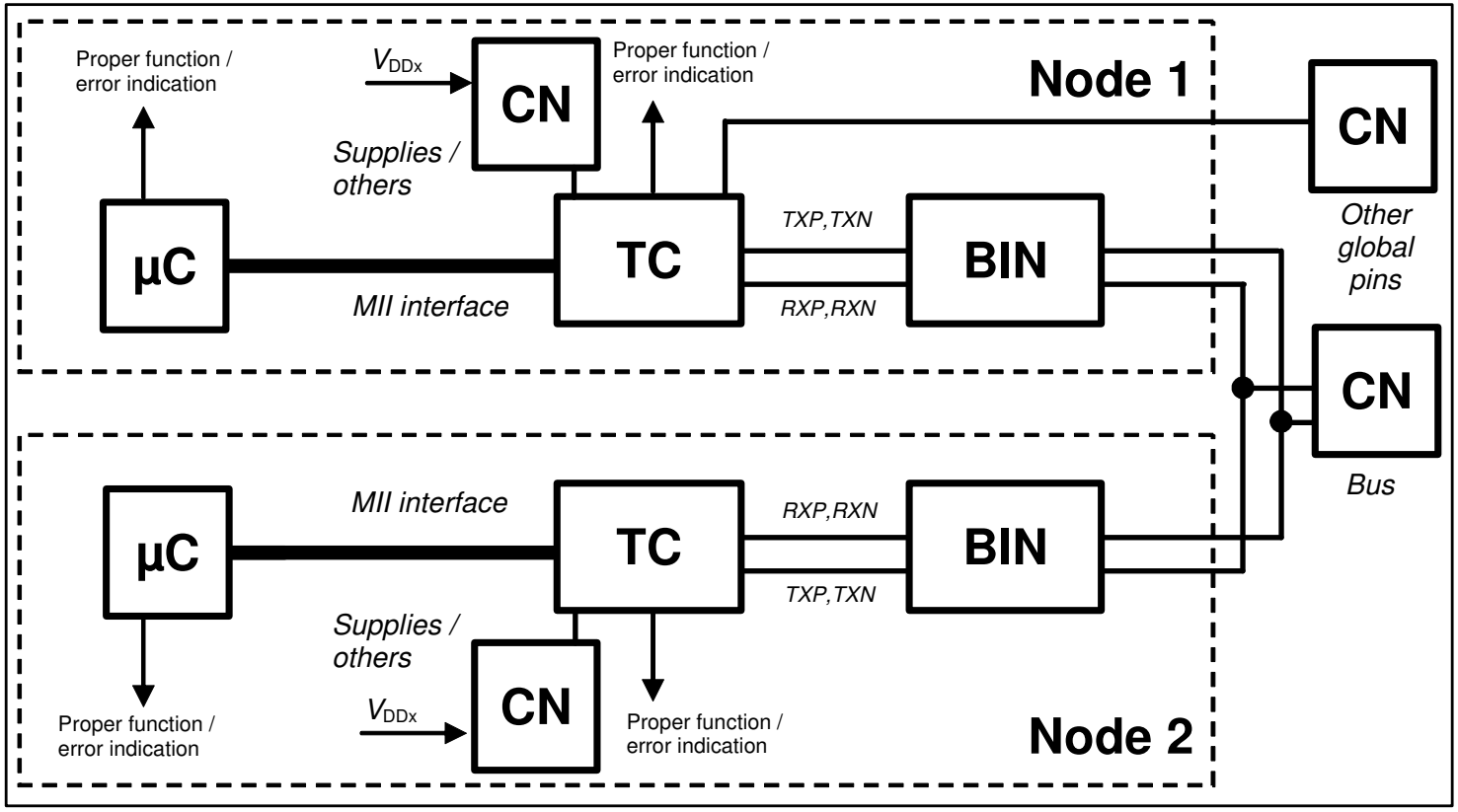
The amount of connectors is much less, however due to other automotive bus systems, space requirements and (of course) cost, the aim is to use connectors which do not have the RF-quality.

Example – conducted measurements



Example – conducted measurements

Exemplary for „off-the-shelf“ Fast Ethernet (100Mbit/s) components.



µC	Automotive microcontroller with MII interface	BIN	Bus interface network (including choke/transformer, termination, additional filter elements, ESD protection)
TC	Ethernet transceiver (device under test – DUT)	CN	EMC coupling network

Example – conducted measurements

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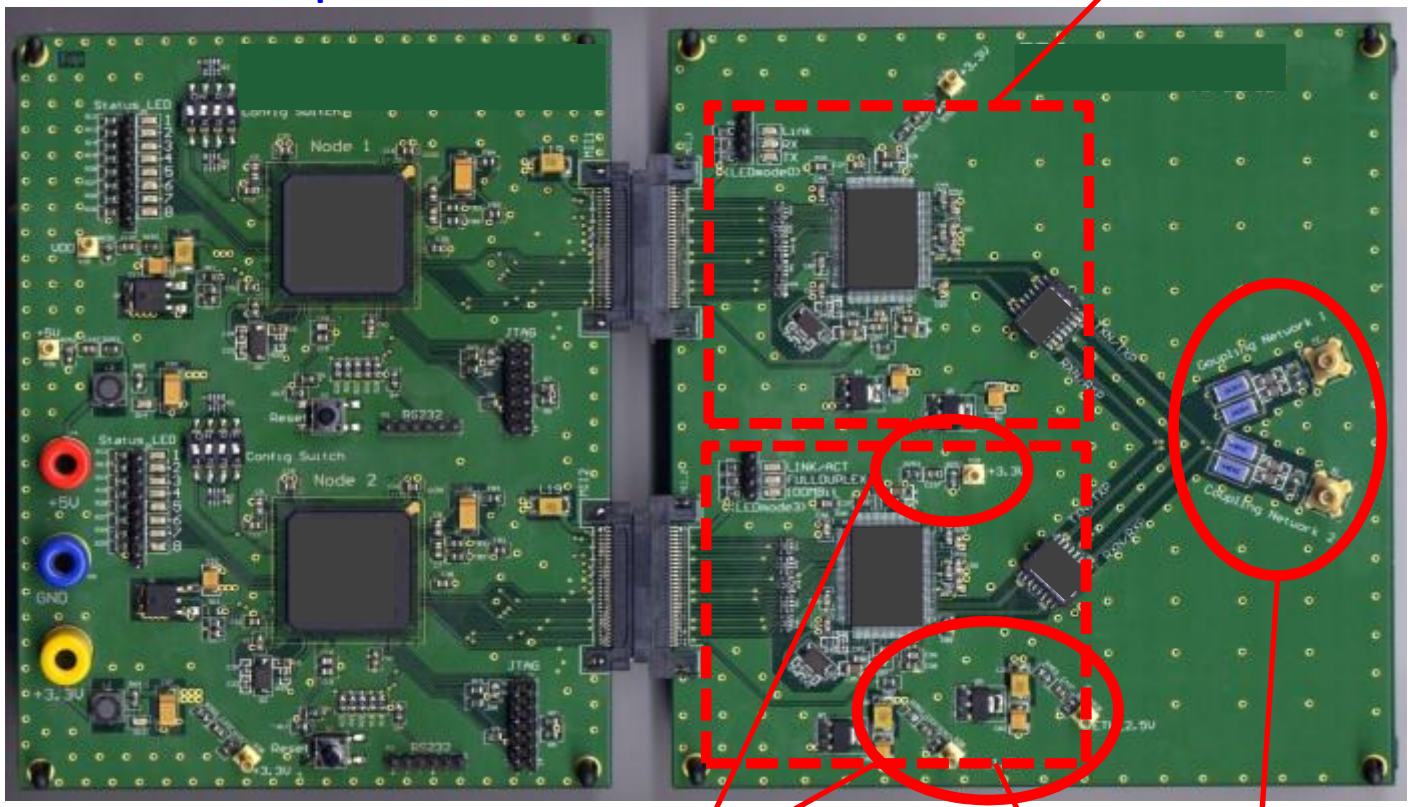

Example – conducted measurements

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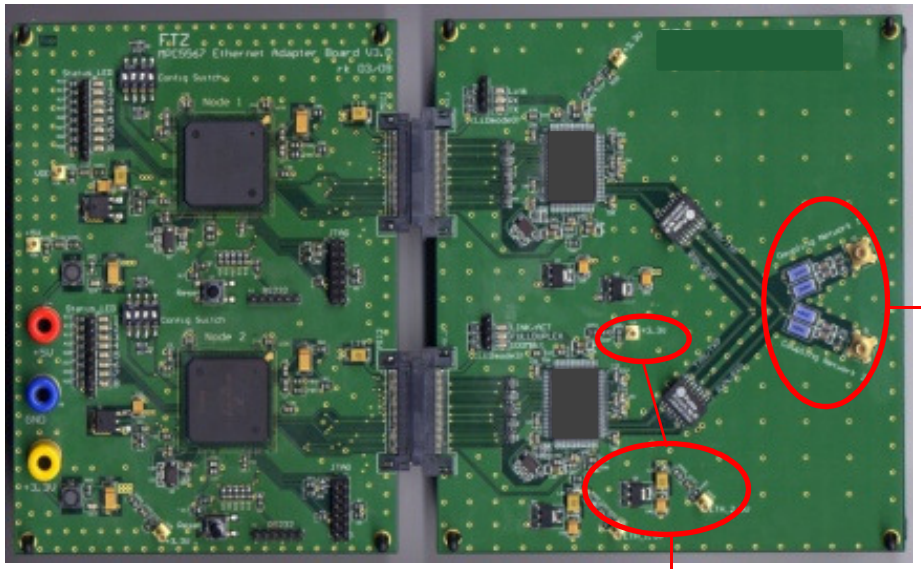
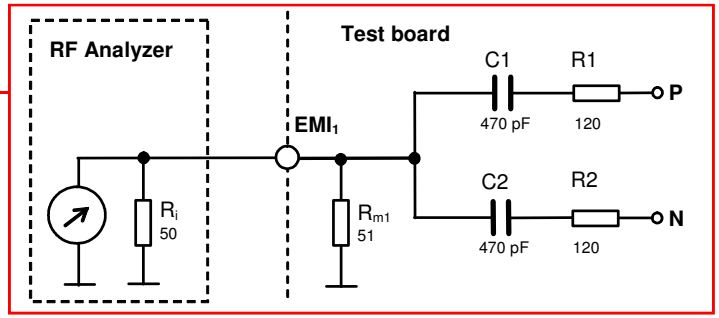
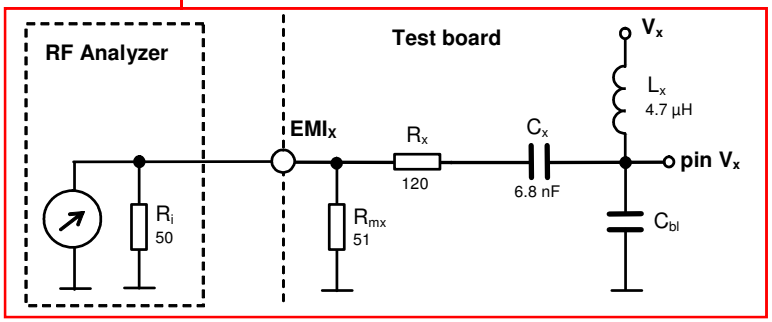


Measuring network ETN



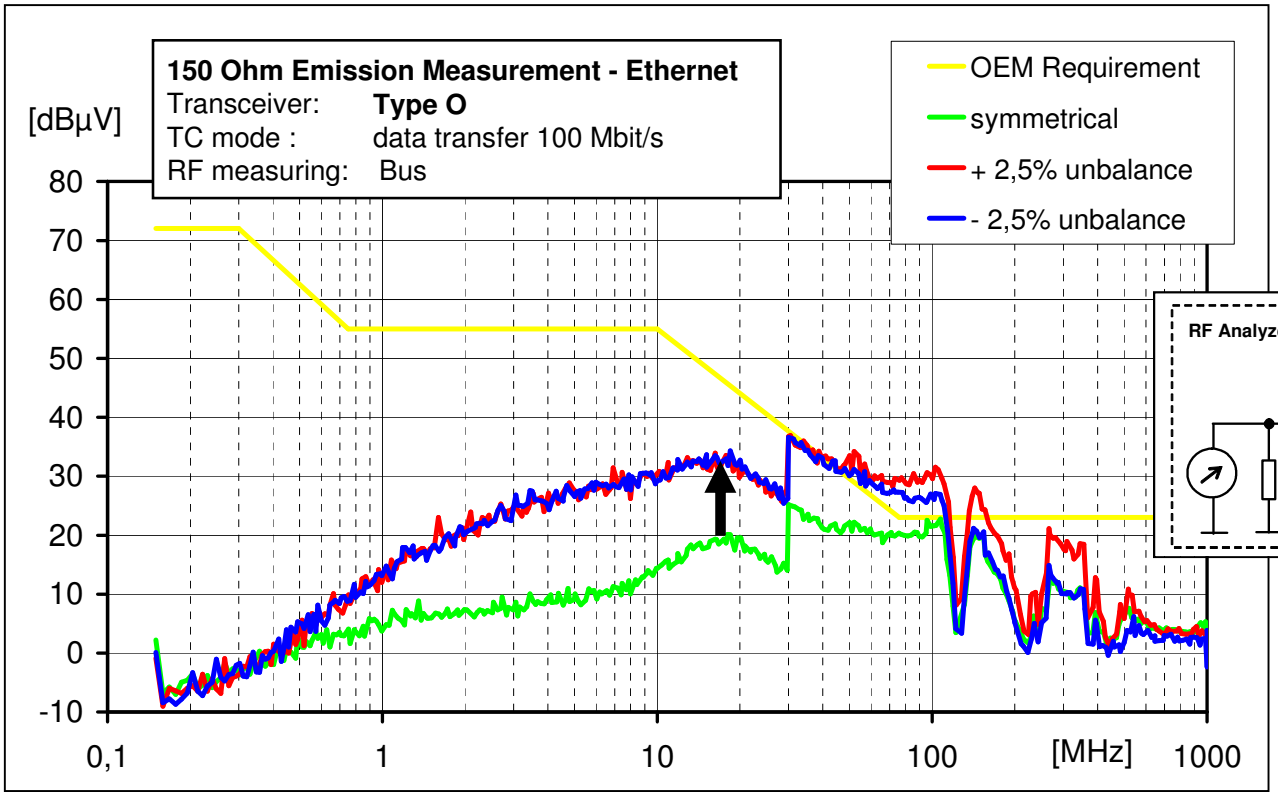


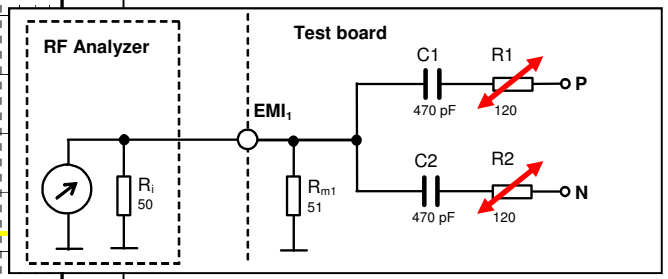
Measuring network Voltage supply

Exemplary for „off-the-shelf“ Fast Ethernet (100Mbit/s) components.

Example – conducted measurements

→ **Example for test results - 150 Ohm emission method**





→ **Impact of unsymmetry clearly visible**

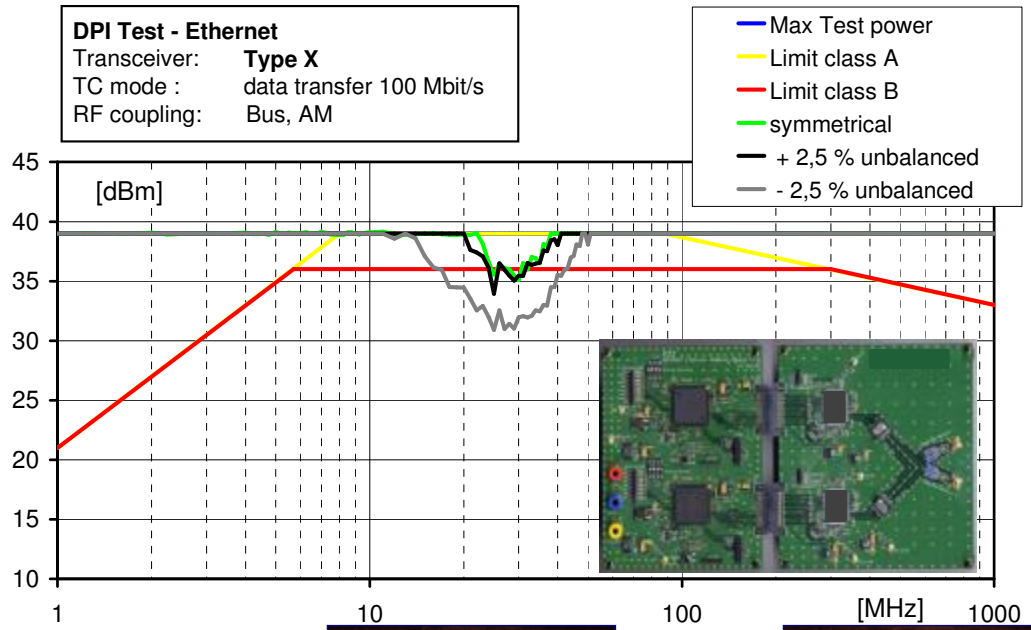
→ Increased emission caused by unbalance
→ simulates possible unsymmetry of connectors and cables

From: “Methodologies for EMC optimization of Automotive Ethernet Systems” by Dr. Bernd Körber, 1st Ethernet & IP @ Automotive Techday

Example – conducted measurements

Exemplary for „off-the-shelf“ Fast Ethernet (100Mbit/s) components.

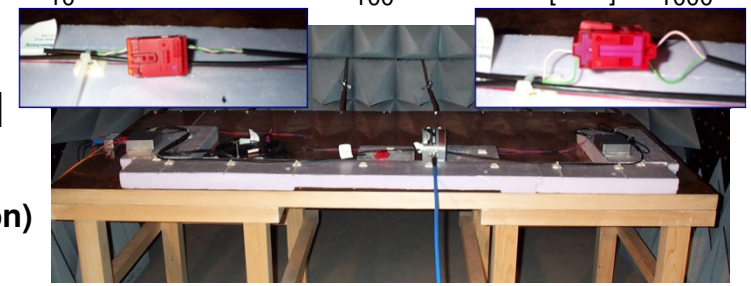
→ **Example for test results – DPI (direct power injection/RF immunity)**

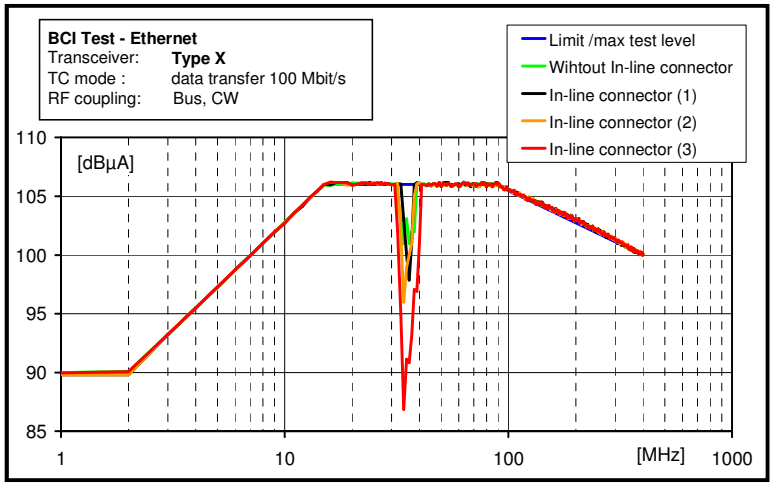


→ **Impact of unbalanced measurements clearly visible.**

→ **Correlation of unbalanced measurements and unsymmetrical components (inline connectors).**

Verification at ECU test level
BCI-Test
(bulk current injection)
106dBµA = 200mA





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Conclusion

- On the way from CE or Industrial to Automotive application Ethernet has to fulfill higher EMC requirements in a harsh environment.
- All parts of the physical layer have a strong impact on the EMC behavior of the communication system.
- In automotive environment unsymmetrical components and undefined common mode impedance are typical.

- To achieve the goal of EMC-optimized Ethernet in an automotive environment development and optimization at vehicle, ECU and component level are needed.
- Automotive bus systems have to cope with the unbalanced components and unknown common mode impedance.
- The behavior of the physical layer interface (transmitter/receiver) has to be investigated in detail to see, whether a possible solution can fulfill automotive EMC requirements in the automotive environment.

- The goal should be to find the optimum solution from a “system view” (this includes chip, BOM, connector and cable harness).

➔ e.g. if a solution with more effort on the cabling harness (sheathed UTP or coax cable) allows to spent much less effort on other parts to fulfill all requirements, this could also be an option.