Electro Magnetic Immunity Performance of 10BASE-T1S PHYs

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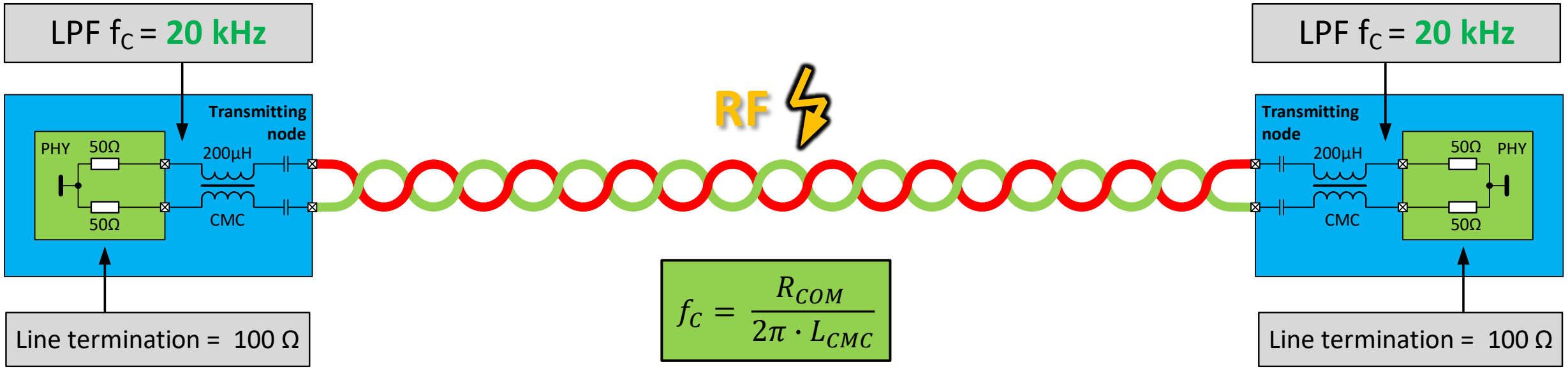
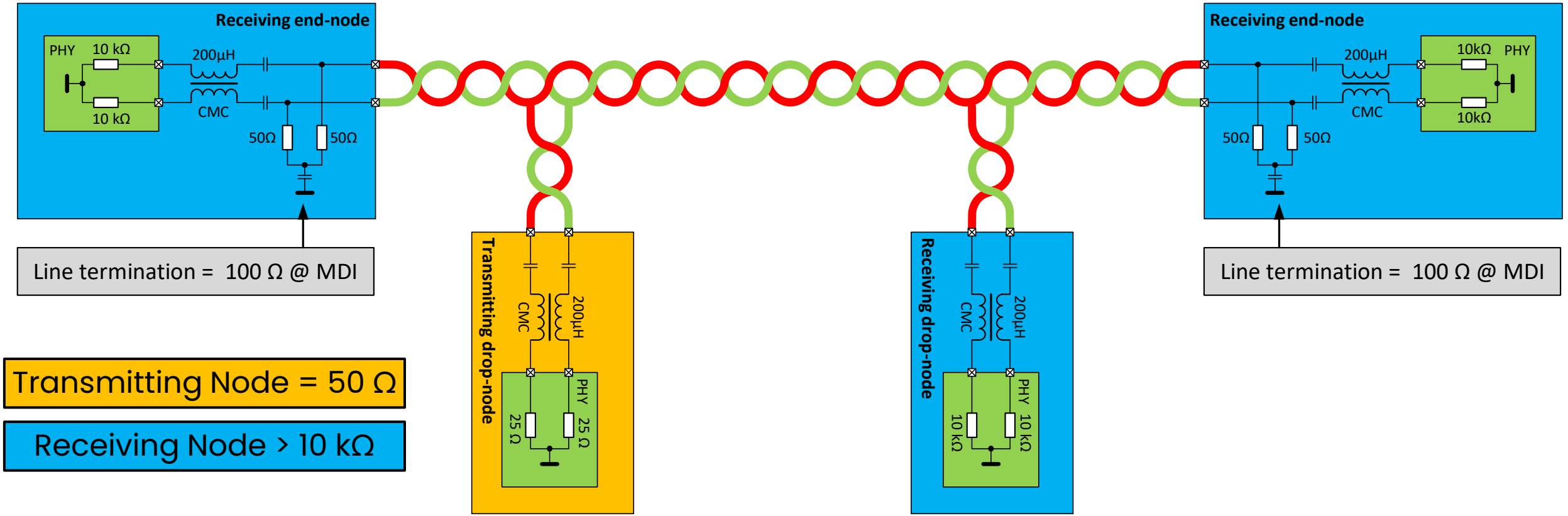
EMI : point-to-point ethernet, full-duplex



- The transmitter impedance + CMC act as a low-pass-filter (LPF)
- The high common-mode RF voltage is attenuated (34 dB @ 1 MHz)
- LV-CMOS technology can be used for the PHY's

Terminated PHY's -> RF noise is effectively filtered out

EMI : Multi-drop ethernet , half duplex

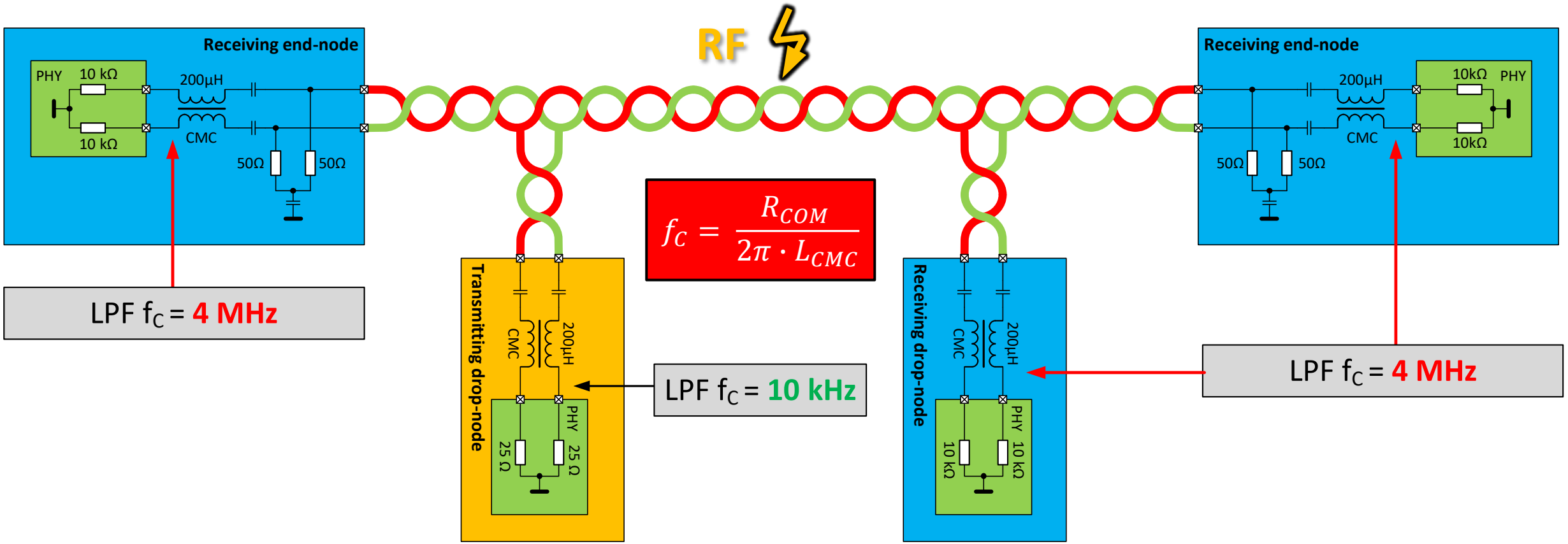


Transmitting Node = 50 Ω

Receiving Node > 10 kΩ

- Multi-drop, half-duplex : one transmitter node, other nodes are receivers
- Requirement for receiver drop nodes : minimum input impedance > 10 kΩ
- Termination resistors at MDI since end-node PHY's can be a receiver node

EMI : Multi-drop ethernet , half duplex



- Drop nodes > 10 kΩ ➡ LPF > 1 MHz ➡ NO ATTENUATION of HV RF voltage
- Due to CMC resonance the voltage at PHY pins even higher then at MDI

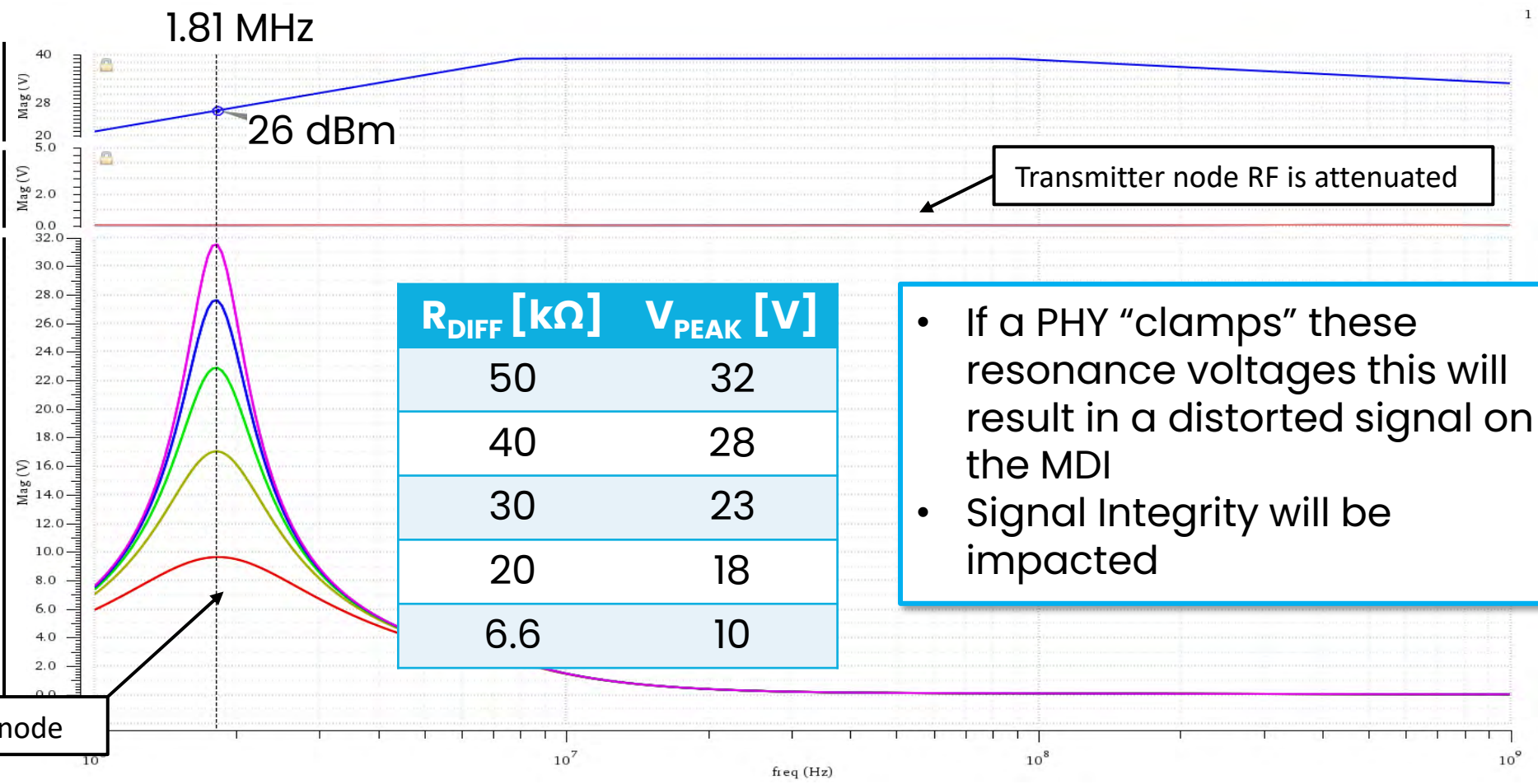
Receiving nodes -> RF noise is NOT filtered out

Resonance of the Common-Mode-Choke at receiving node

DPI test limit

Voltage at PHY pins Transmitting node

Voltage at PHY pins Receiving node



R_{DIFF} [kΩ]	V_{PEAK} [V]
50	32
40	28
30	23
20	18
6.6	10

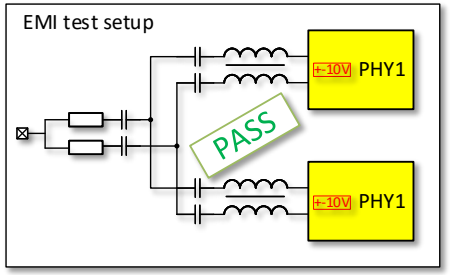
- If a PHY "clamps" these resonance voltages this will result in a distorted signal on the MDI
- Signal Integrity will be impacted

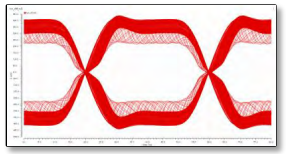
Receiving nodes subjected to high-voltage during EMI

Expected EMI interoperability in a car network

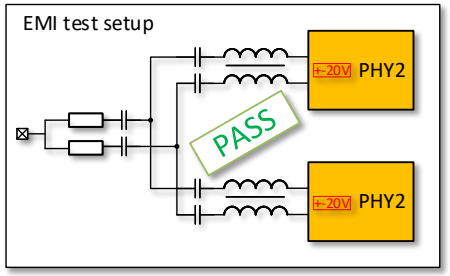
2-node single vendor DPI test

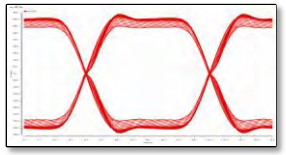
PHY1



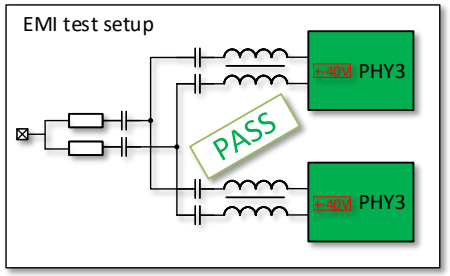


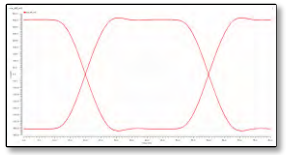
PHY2



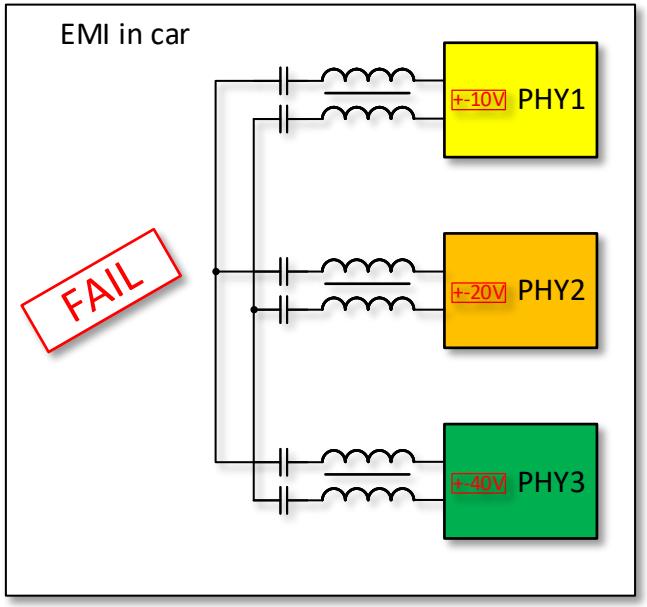


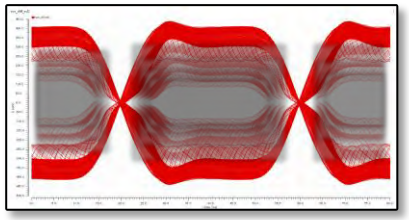
PHY3





multi-node multi-vendor DPI in-vehicle





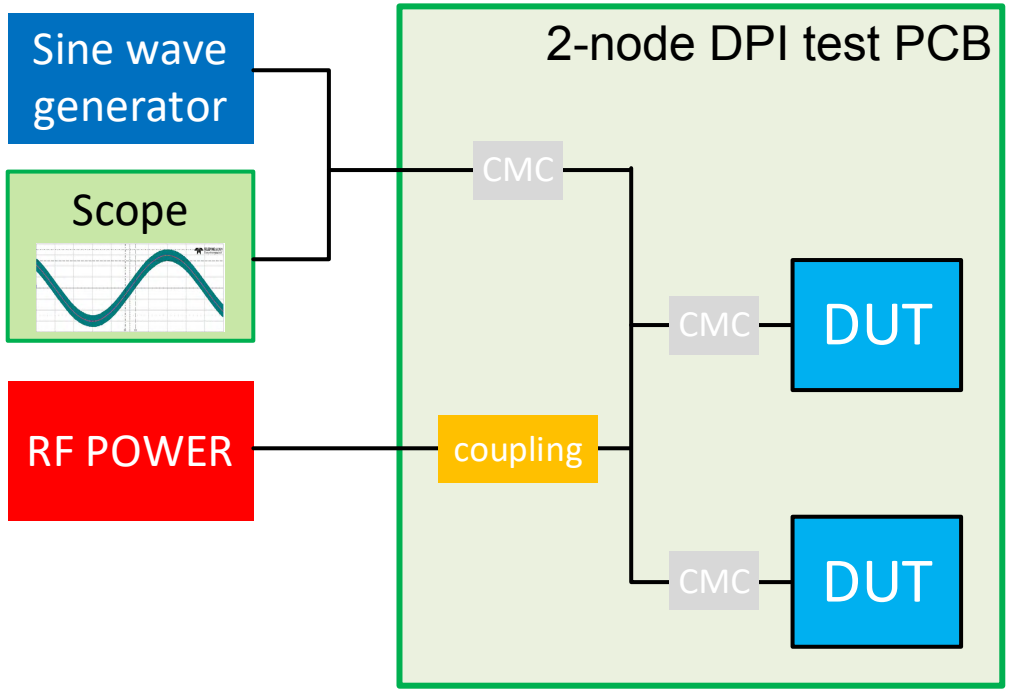
Single-vendor 2-node testing shows the best-case behavior and multi-vendor , multi-node is the worst-case network behavior

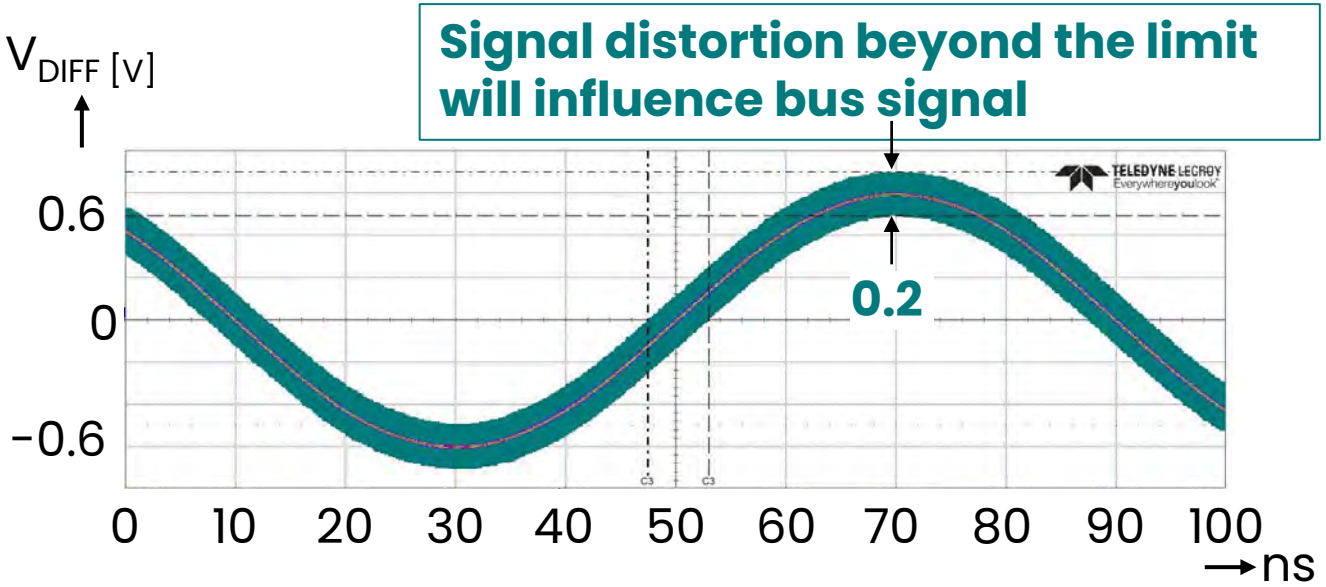
2-node DPI test pass does NOT guarantee EMI performance in a vehicle

Contents

OA TC14 EMC Test Specification - DPI distortion test

- Principle of multi-drop networks: no node shall impact the communication of other nodes
- Use 2-node DPI PCB setup for testing the behavior of a PHY in receiving mode with RF injection
- The failure mask is defined such that cumulative effects of multiple nodes are captured





12.5 MHz sine wave representing DME1's

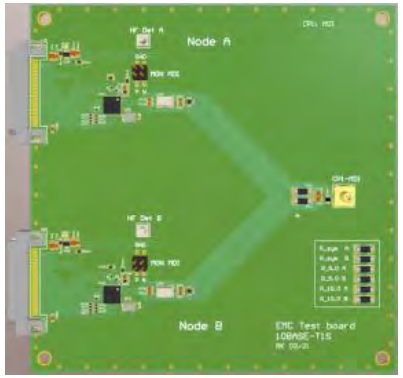
Test described in : *"OA 10Base-T1S_ Transceiver EMC Specification_ v0.4"*

EMC multi-drop test : a receiving node shall never influence the bus

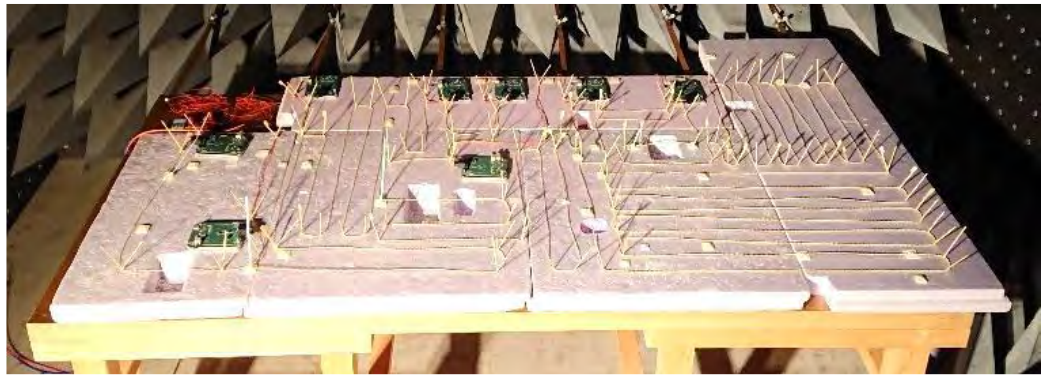
Contents

EMI testing: DPI vs BCI vs In-Vehicle

- Direct Power Injection (DPI) : IC level EMI test on PCB, two DUT's, floating termination represents multidrop network
- Bulk Current Injection (BCI): ECU level EMI test in a network, multiple nodes
- Vehicle test : complete vehicle tested in an EMC chamber



DPI



BCI

In-Vehicle

Source : Zwickau University of Applied Sciences (FTZ)

Correlation: DPI/BCI and In-Vehicle testing

- Dr. Körber of the University Zwickau (FTZ) has conducted DPI, BCI and vehicle EMI measurements on different 10BASE-T1S products.

- FTZ observed that PHY's that passed DPI/BCI tests were failing vehicle testing.

- There was **NO GOOD** correlation between DPI/BCI and vehicle testing !

- Measurements were performed on coupled RF noise for DPI/BCI and In-Vehicle

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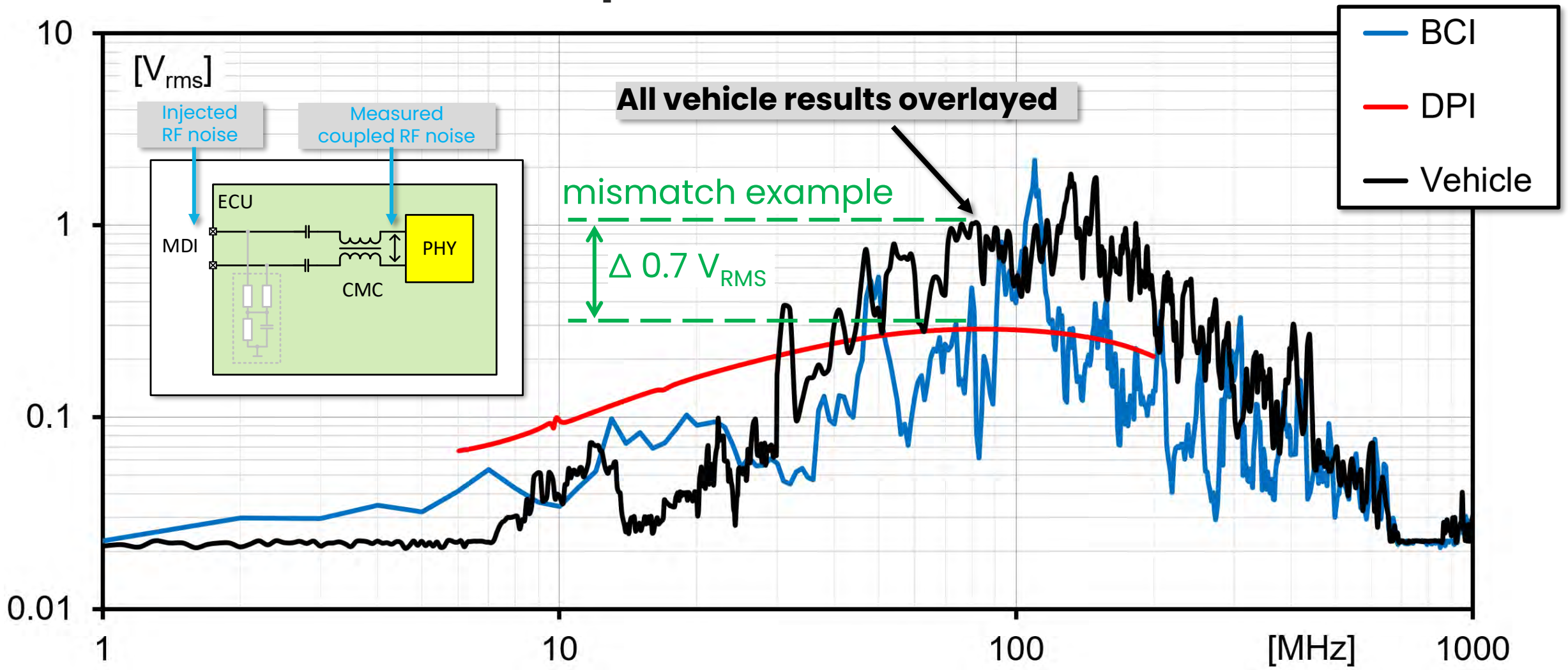
Measurement of coupled RF noise in DPI/BCI/Vehicles



BCI and DPI testing do NOT correlate with in-vehicle testing

Source : Zwickau University of Applied Sciences (FTZ)

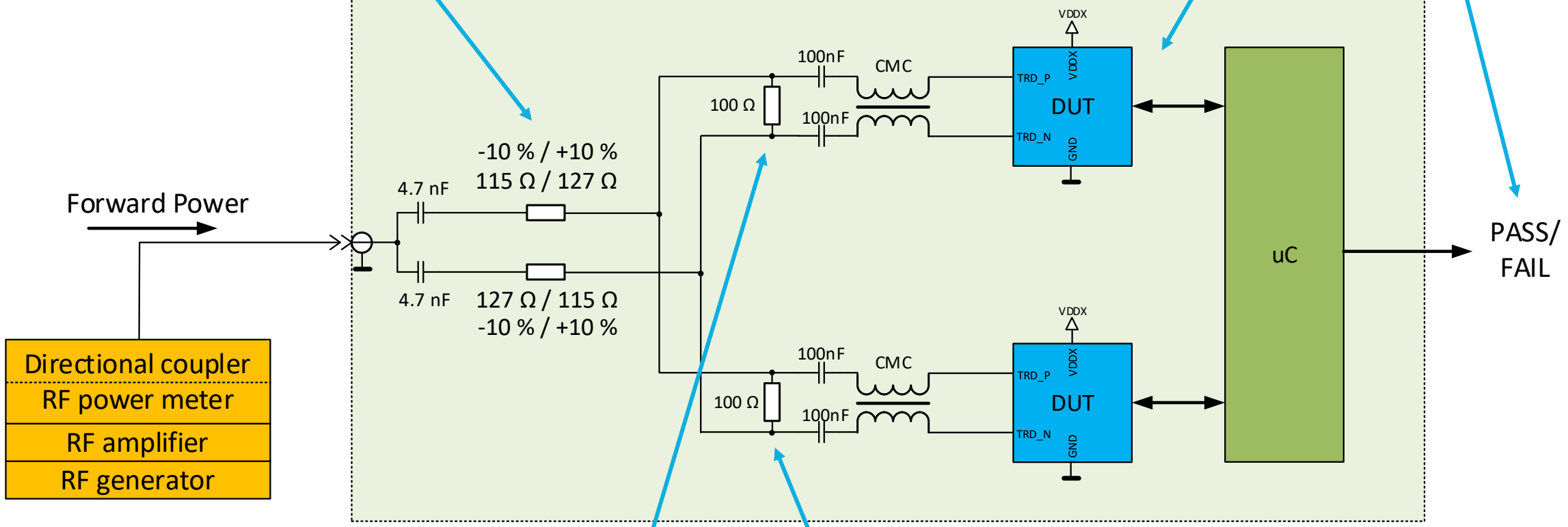
Contents

Old DPI test setup

Set-up also used in CAN, Flexray, etc

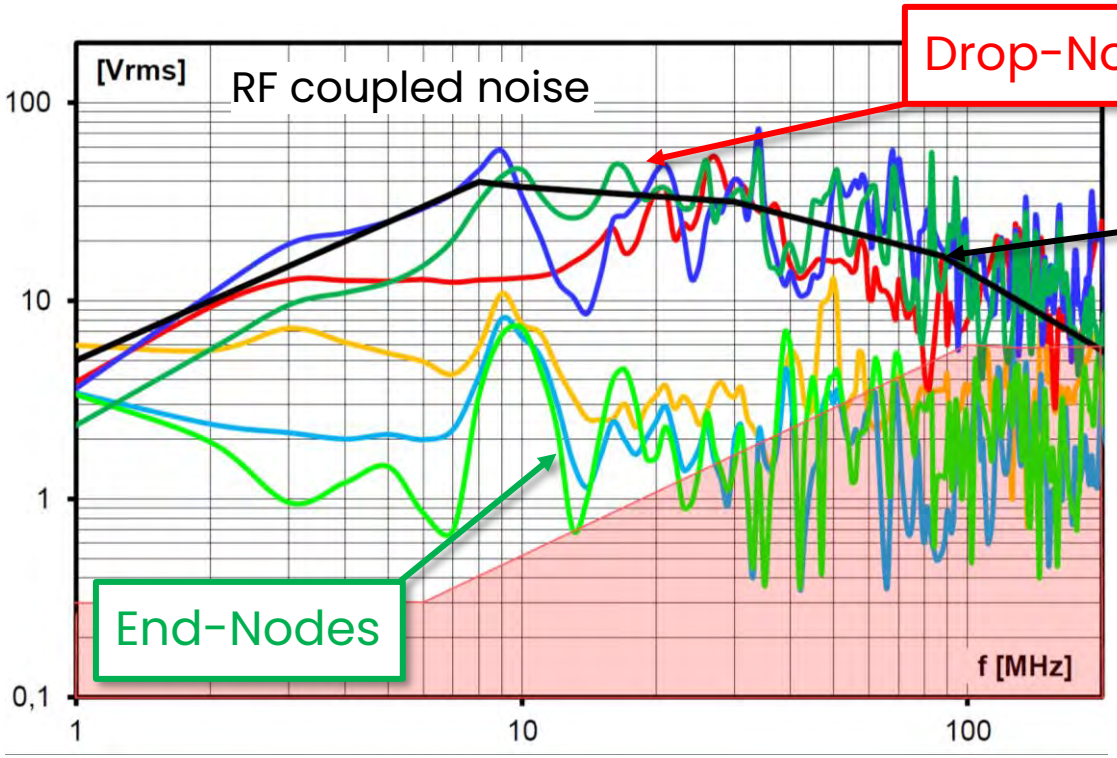
Unbalanced Coupling Network

Two nodes communicating



"Floating" Termination

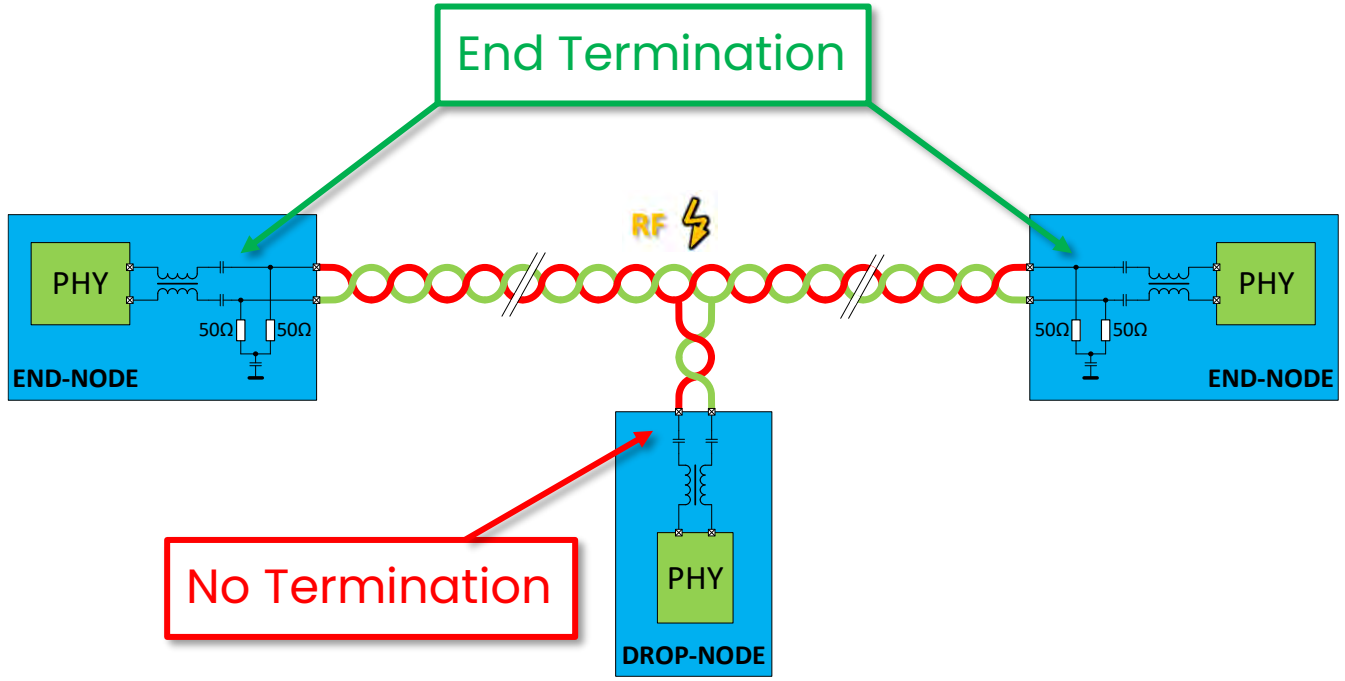
How a 2-node setup can be representative for multi-drop network



End-Node Termination :

Z_{MDI_DIFF} = 100 Ω

Z_{MDI_COM} = **25 Ω**



Source : Zwickau University of Applied Sciences (FTZ)

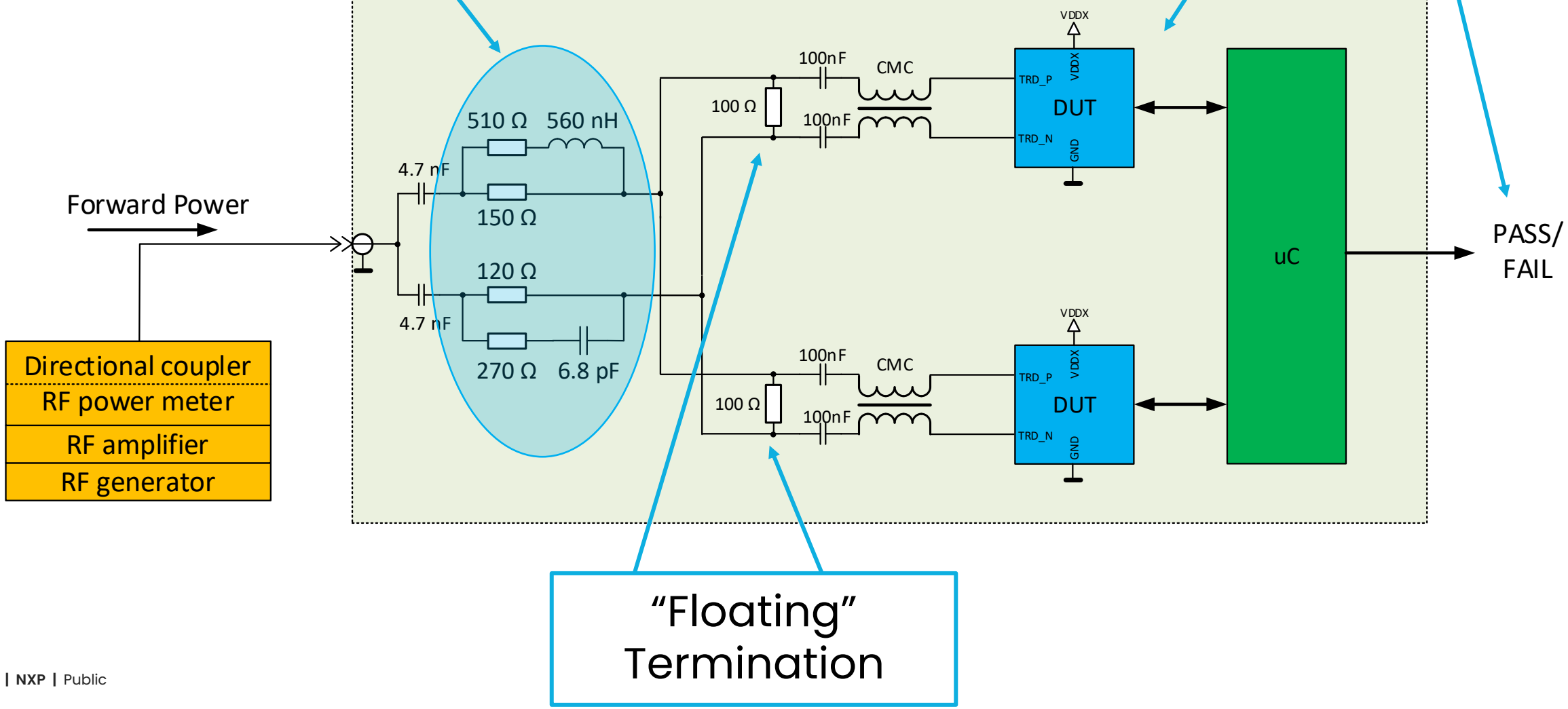
"Floating" termination emulates drop nodes

New DPI test setup

Proposed DPI test setup
Status : accepted in TC14

Updated Coupling Network

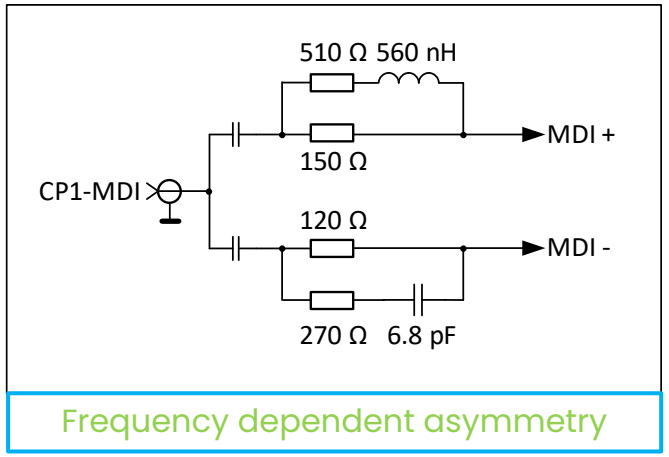
Two nodes communicating



"Floating" Termination

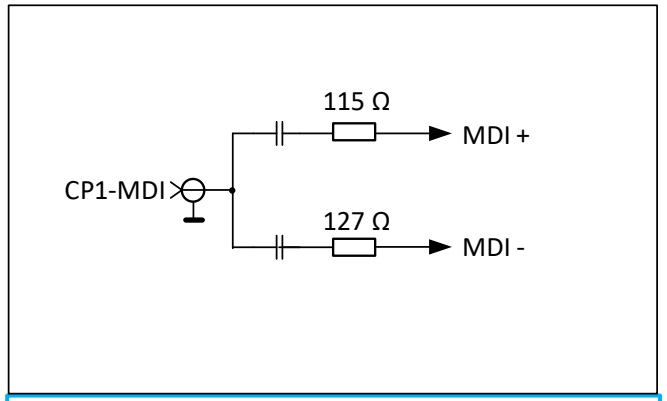
Frequency Dependent Unbalanced Coupling Network

New coupling network

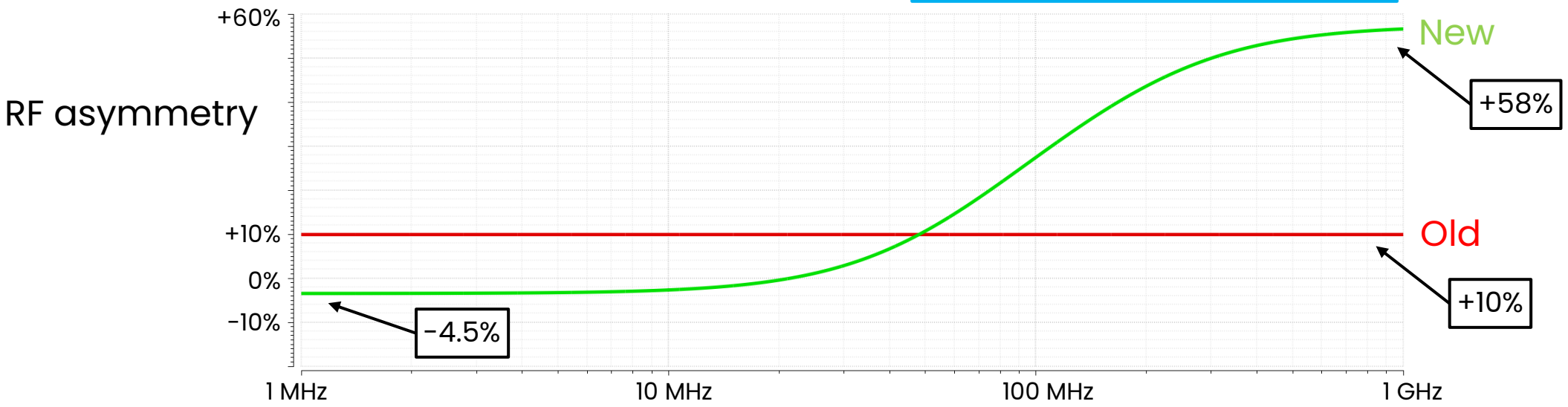


Frequency dependent asymmetry

Old coupling network

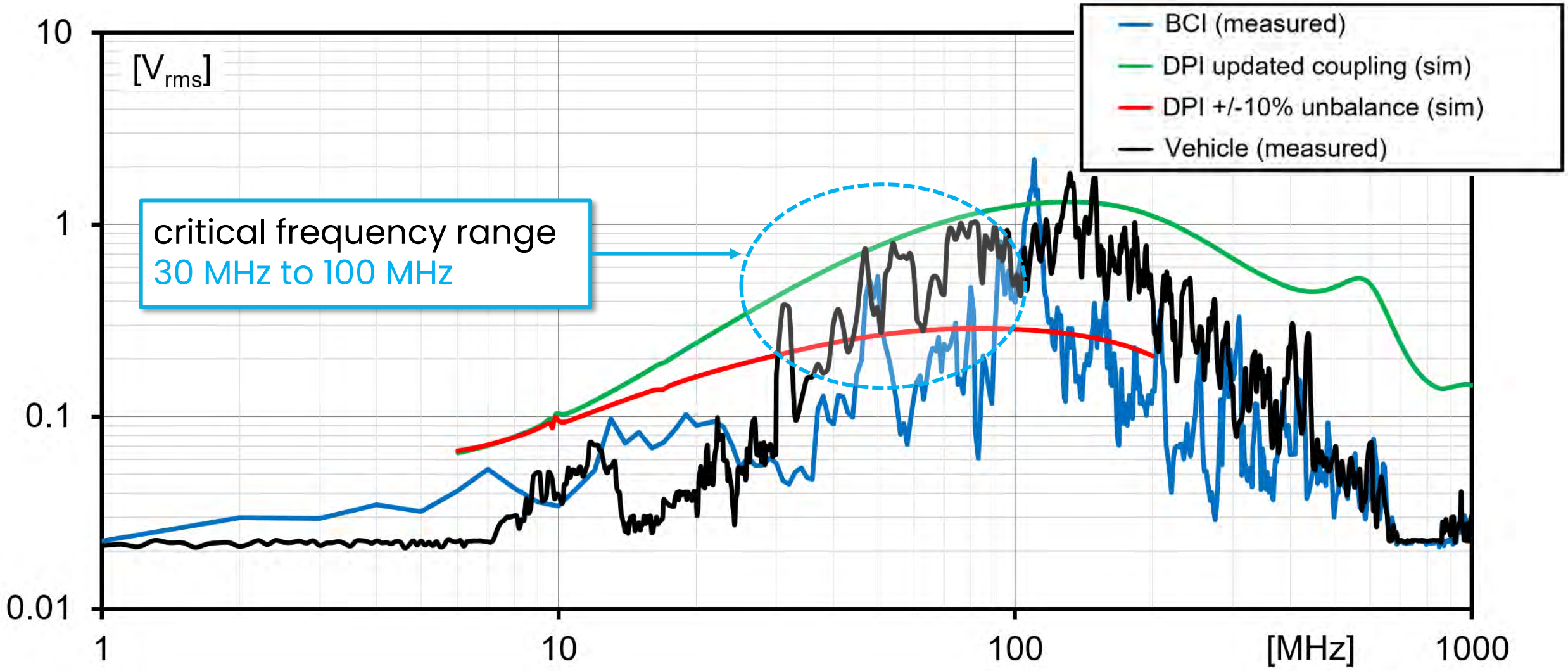


Frequency independent asymmetry



10BASE-T1S has high mode conversion modeled reliably with the frequency dependent coupling network

Simulation: Old DPI setup Vs New DPI setup



DPI simulation shows new setup covers the worst-case in-vehicle

Source : Zwickau University of Applied Sciences (FTZ)

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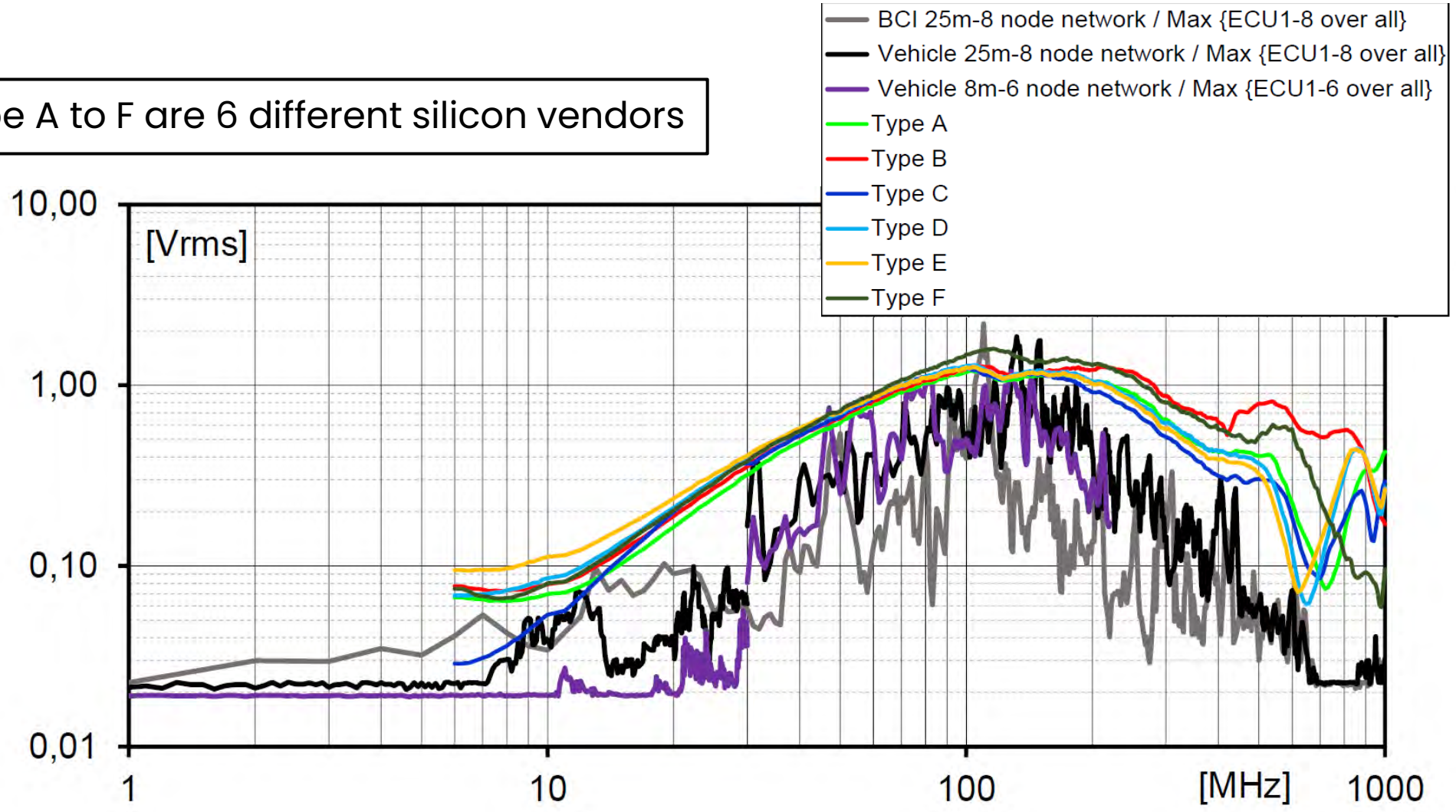
New DPI test and Vehicle measurements

Type A to F are 6 different silicon vendors



New DPI test covers the worst-case in-vehicle performance

Source : Zwickau University of Applied Sciences (FTZ)

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Summary

- **DPI distortion test**
  - Principle of multidrop networks: receiving nodes must not distort the bus
  - Receiving nodes in a 10BASE-T1S network are subjected to high voltage during EMI
  - A dedicated DPI distortion compliance test is part of the OA TC14 standard to prove the required behavior in all operating use cases including unpowered

- **DPI communication test**
  - A new DPI communication test has been developed for better correlation with in-vehicle networks
  - The updated DPI communication test will be part of OPEN ALLIANCE TC14 standard (pending)

Breakthrough in 10BASE-T1S testing to predict in-vehicle EMI performance

Credits and Thanks

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