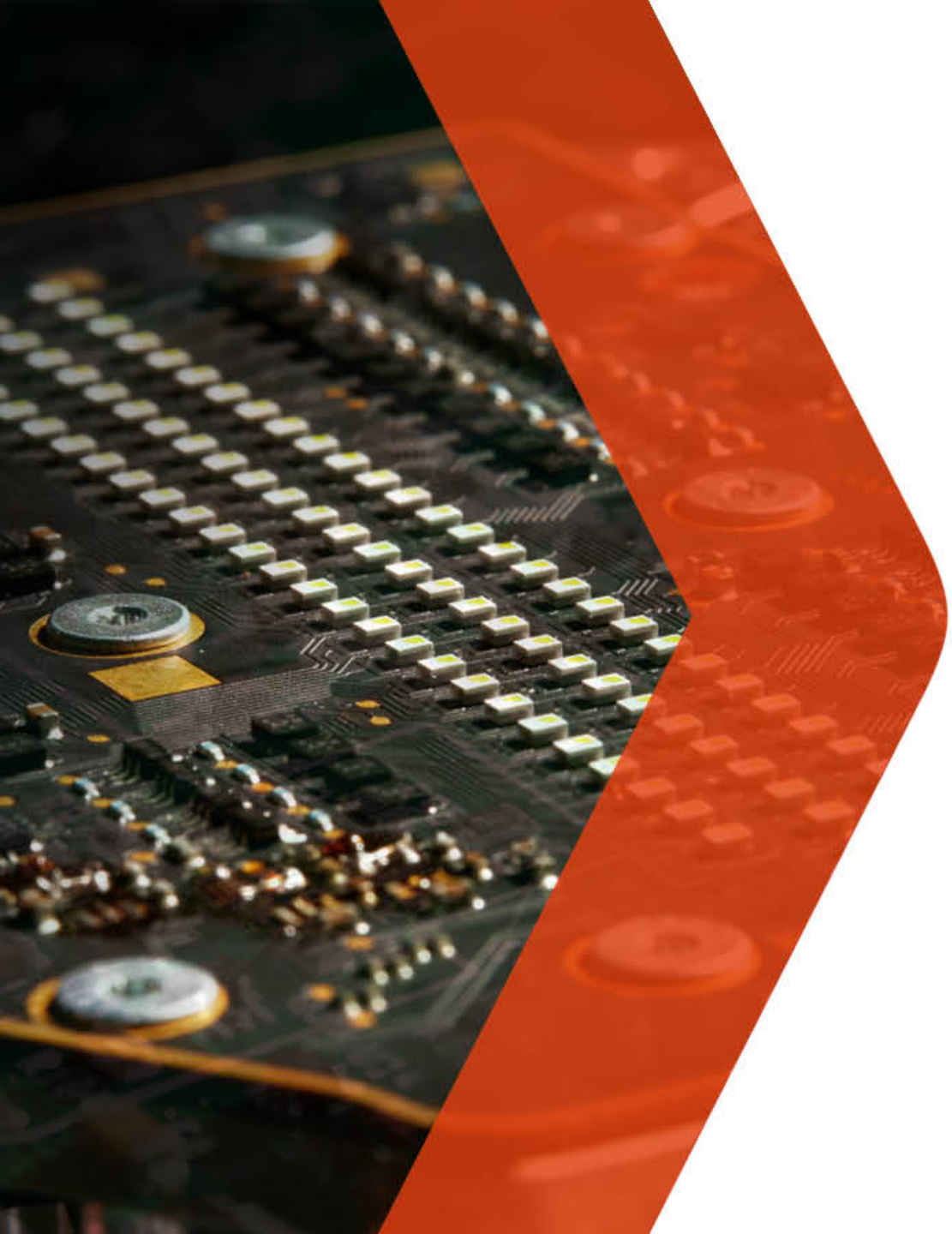


nexperia

ESD Protection for Automotive Ethernet Applications

A. Hardock, L. Droemer

IEEE SA STANDARDS ASSOCIATION

Ethernet & IP @ Automotive Technology Week

3rd/4th November 2021

Agenda

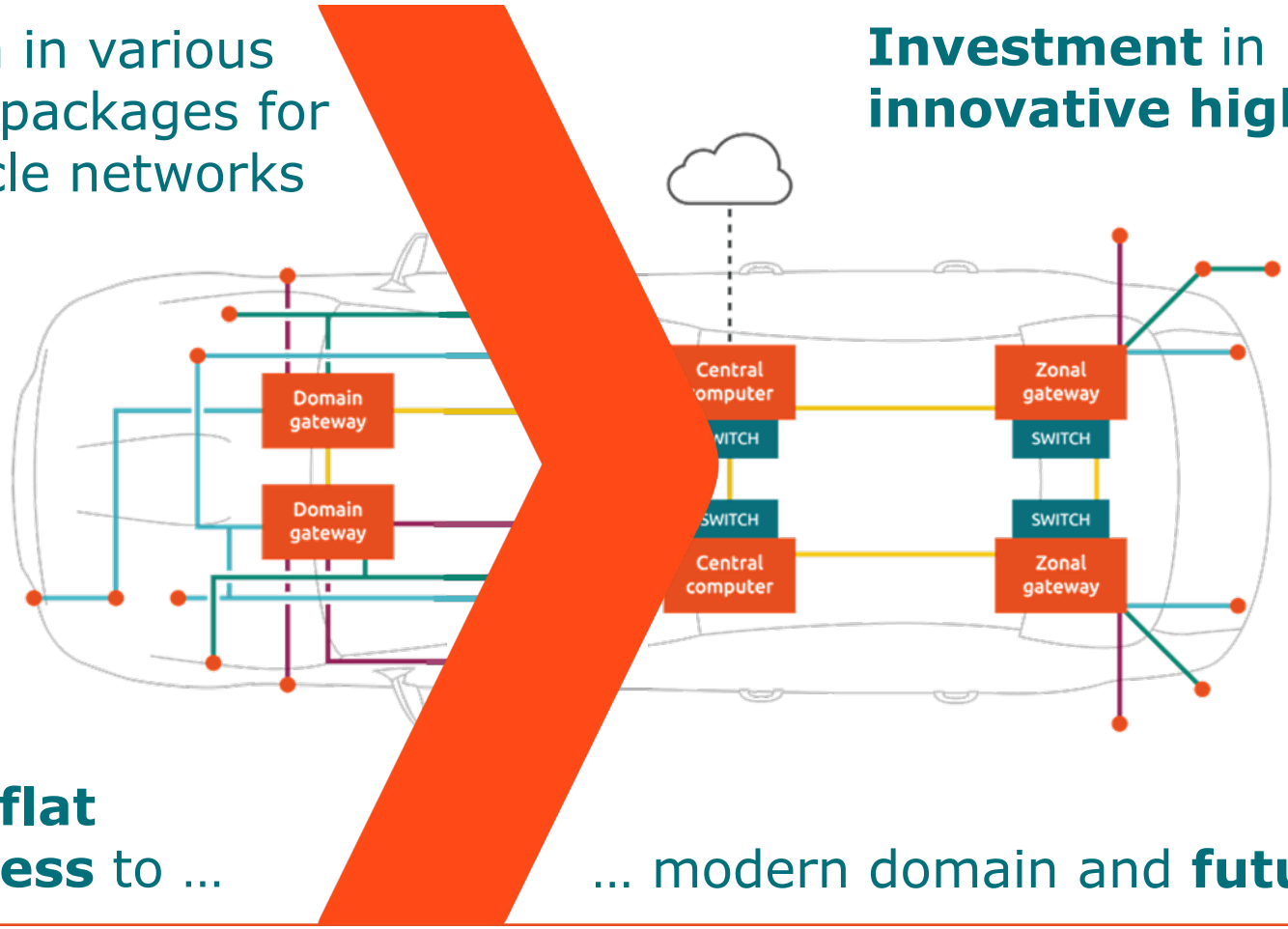
- Introduction to ESD
- SEED Simulation for robust system design
- Multigigabit Ethernet
- Conclusion and Outlook

Automotive mega trends shaping IVNs

ESD protection fulfillig ISO norms exceeding AEC-Q101 qualification

ESD protection in various footprints and packages for classic in-vehicle networks

- LIN
- CAN
- FlexRay
- SENT
- USB2.0
- HDMI



Investment in **R&D** with focus on **innovative high-speed solutions**

- LIN
- CAN-FD/XL
- 10BASE-T1S
- 100BASE-T1
- 1000BASE-T1
- MGBASE-T1
- SerDes
- USBx
- HDMIx
- ILaS
- 5G

From classic **flat wiring harness** to …

… modern domain and **future zonal architecture**

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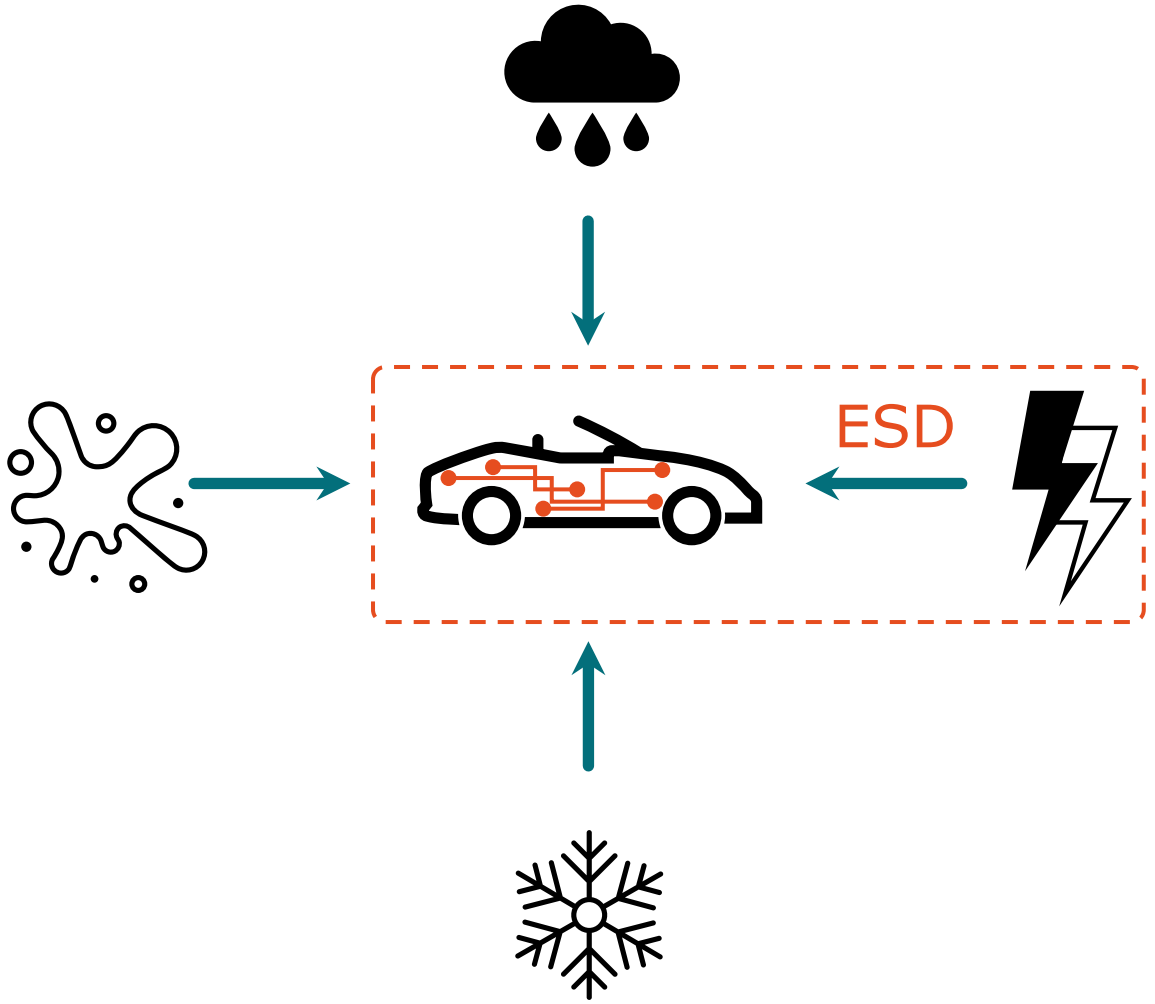
Automotive Compliance Testing

Environmental Testing

- Life Profile
- Mechanical
- Climate
- Chemical
- …

Electrical Testing

- Functional
- Board net Pulses
- EMC
- **ESD (e.g. IEC61000-4-2)**
- …



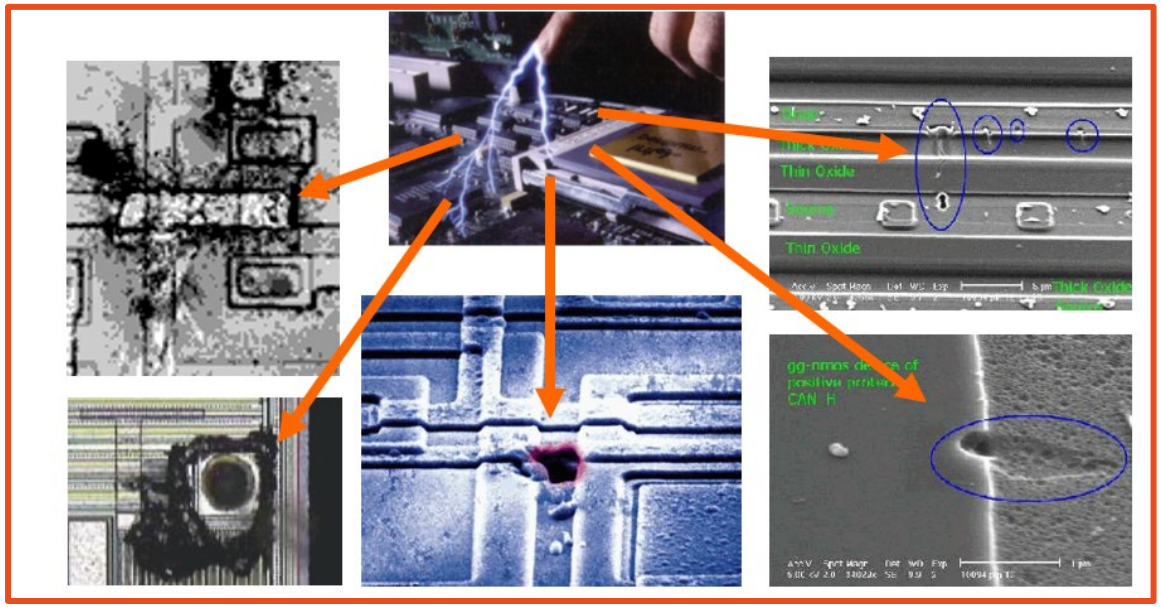
ESD – Electro Static Discharge

WHAT

A sudden discharge between persons, devices or components

HOW

- A charged person touches an integrated circuit (IC)
- An electrostatic field is induced by high voltages
- A charged IC drops on a grounded metal plate
- A charged machine touches an IC



PROBLEM

- Causing malfunction (reversible by power-off-on cycle)
- Destruction of electrical components (irreversible): gate oxide, metallisation or PN junctions

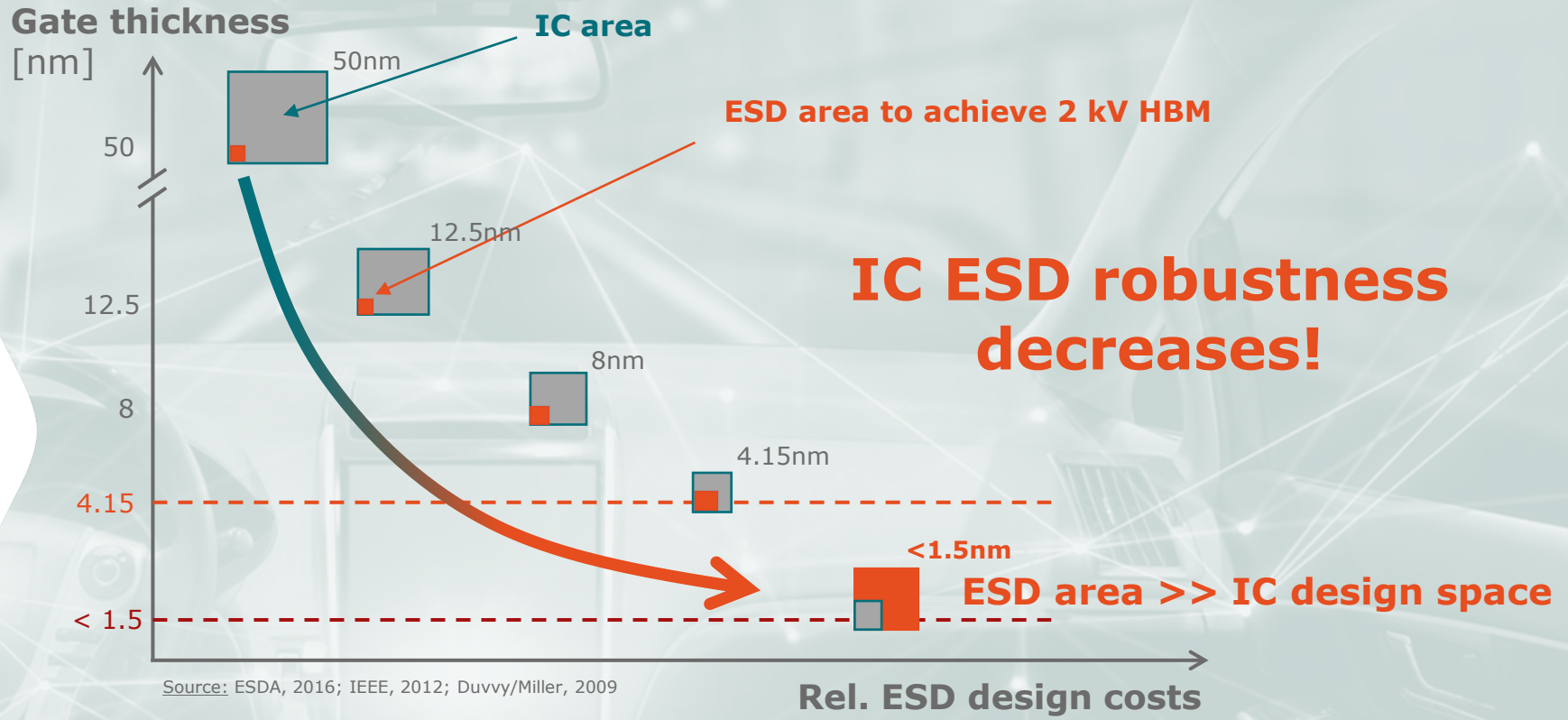
New IC requirements shape ESD threat

MEGA TRENDS

Connected & Autonomous

Electrified

Shared Mobility



That requires dedicated system-level ESD solutions!

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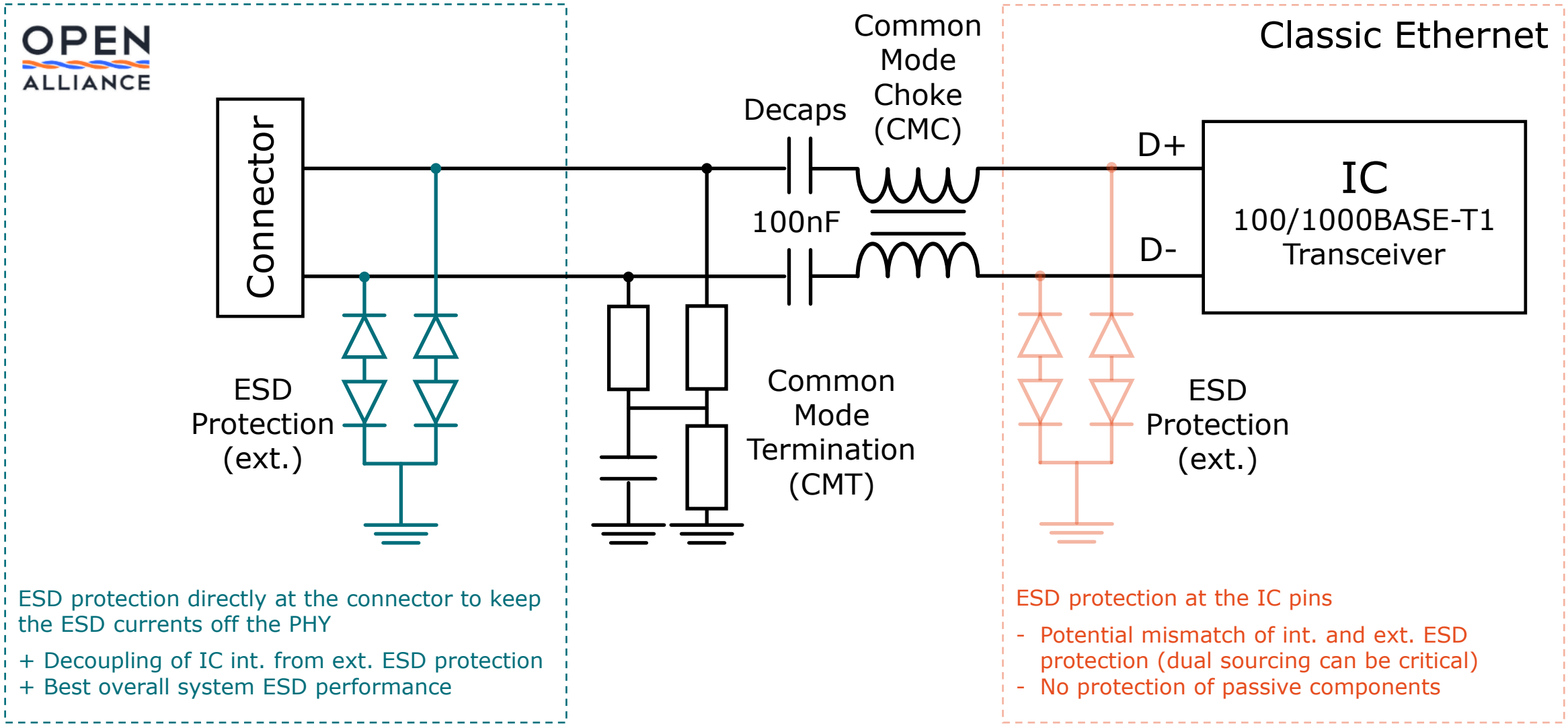
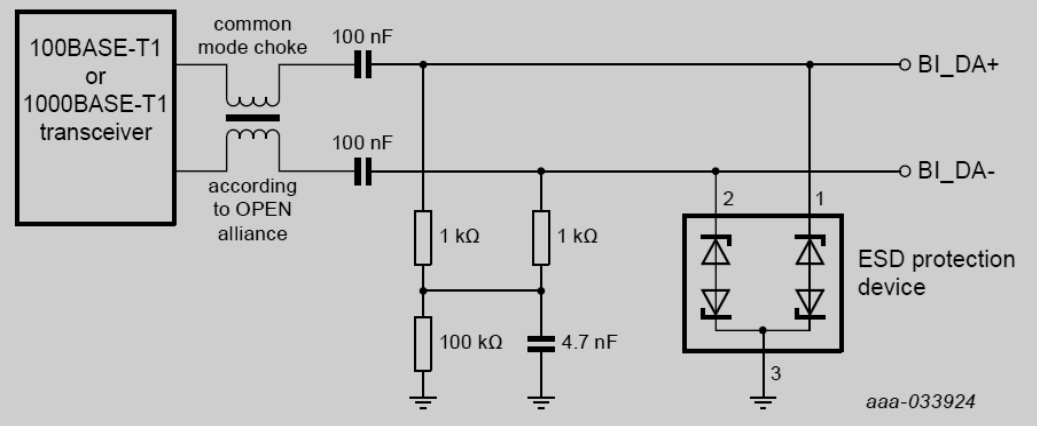
OPEN Alliance vs. Classic Ethernet



OPEN Alliance Spec. for ESD protection devices

General requirements



General requirements for 100/1000BASE-T1

- **Trigger voltage > 100V, $V_{DC,max}$ > 24V**
- **Bi-direction device, 15kV IEC, 1000 discharges**

ESD discharge current measurement

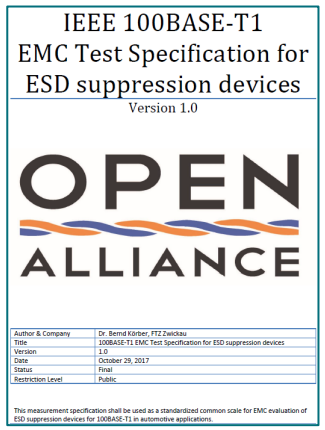
- **Quantification of the current that would flow into the PHY**

Additional tests:

- Mixed mode S-parameter measurements
  - To evaluate transmission, symmetry, and mode conversion, replaces requirements on C_p and matching
- Damage from ESD
  - To verify degradation, first measure S-parameters, apply ESD (8kV) discharges, and check S-parameters again
- Unwanted clamping
  - Evaluate impact of ESD device onto RF immunity testing

Proof of Concept via measurements

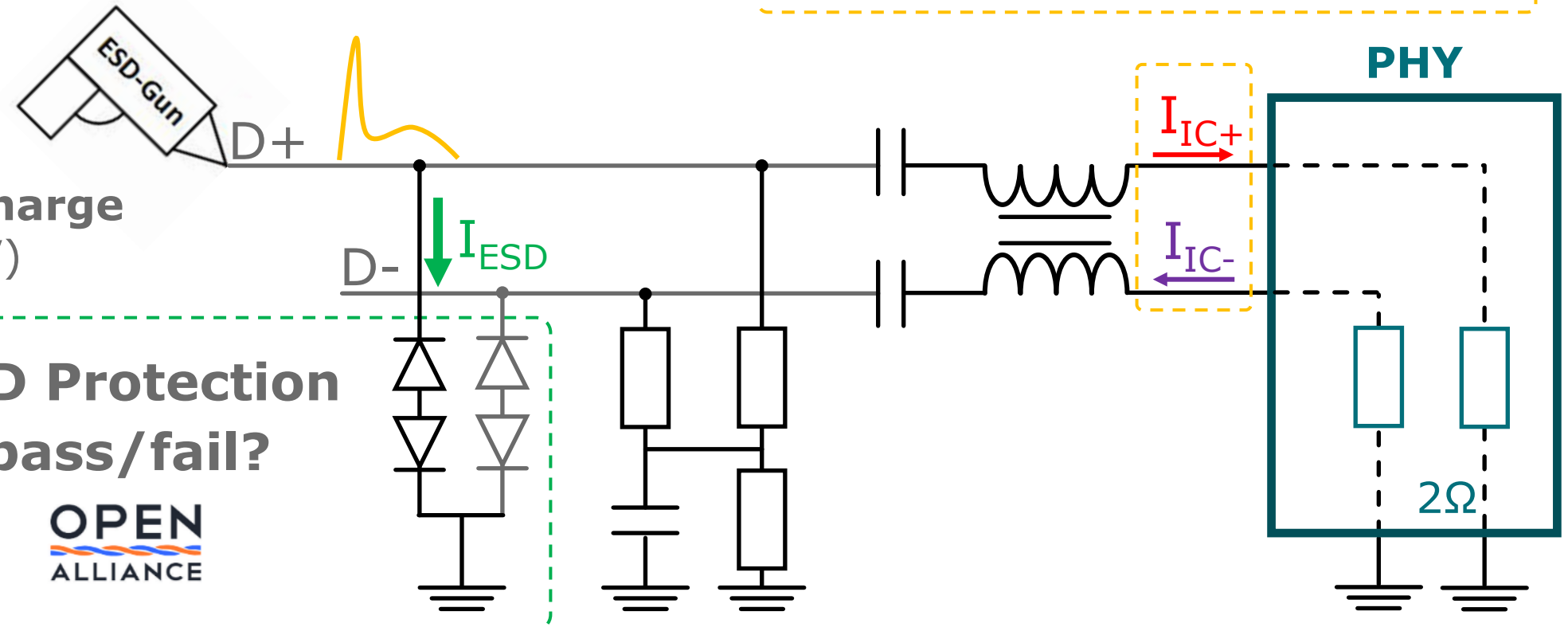
Determines the residual current flowing into IC (PHY) during an ESD event



ESD Gun Test on PCB
(acc. IEC61000-4-2)

Contact discharge
4kV (6kV)

Evaluation of
IC current limits acc. HBM



ESD Protection
pass/fail?

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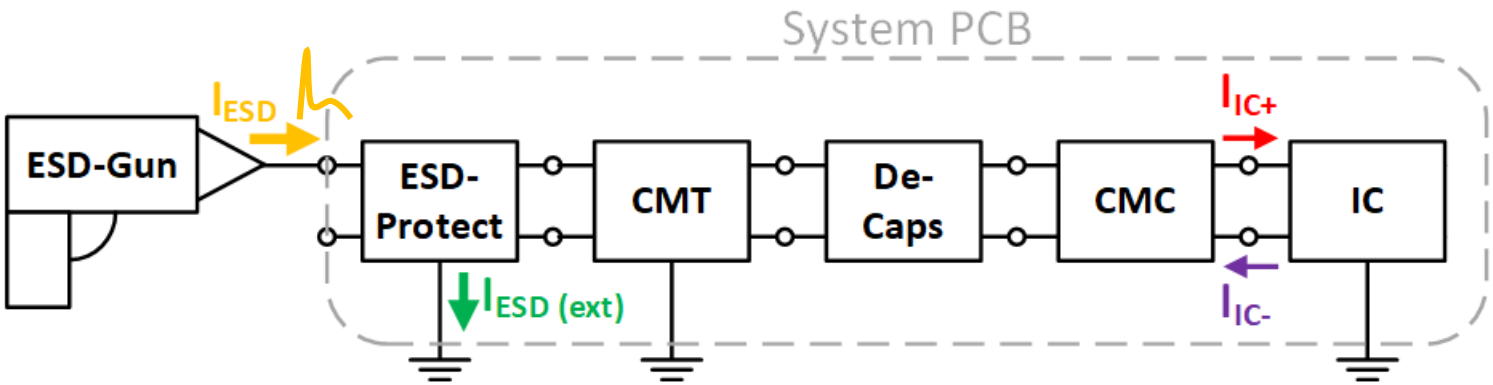
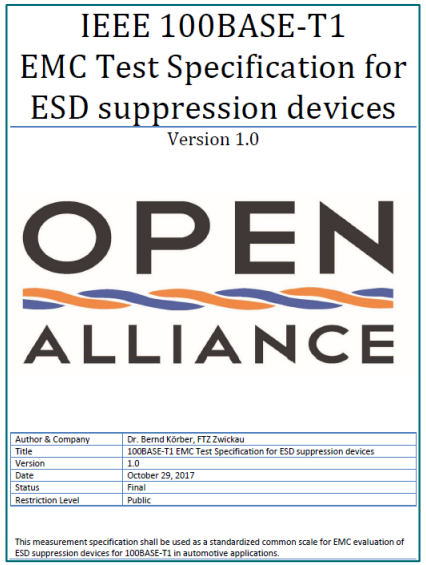
Idea of System Efficient ESD Design (SEED)

System modelling for transient system-level ESD analysis via simulation



ESD Current Test

- Evaluation of currents into IC during ESD event
- Prediction of System-level ESD Robustness
- System improvement using Virtual Prototyping
- Reduction of engineering loops (time & cost)


IEEE 100BASE-T1
EMC Test Specification for
ESD suppression devices
Version 1.0

OPEN ALLIANCE

Author & Company	Dr. Bernd Körber, FTZ Zwickau
Title	100BASE-T1 EMC Test Specification for ESD suppression devices
Version	1.0
Date	October 29, 2017
Status	Final
Restriction Level	Public

This measurement specification shall be used as a standardized common scale for EMC evaluation of ESD suppression devices for 100BASE-T1 in automotive applications.

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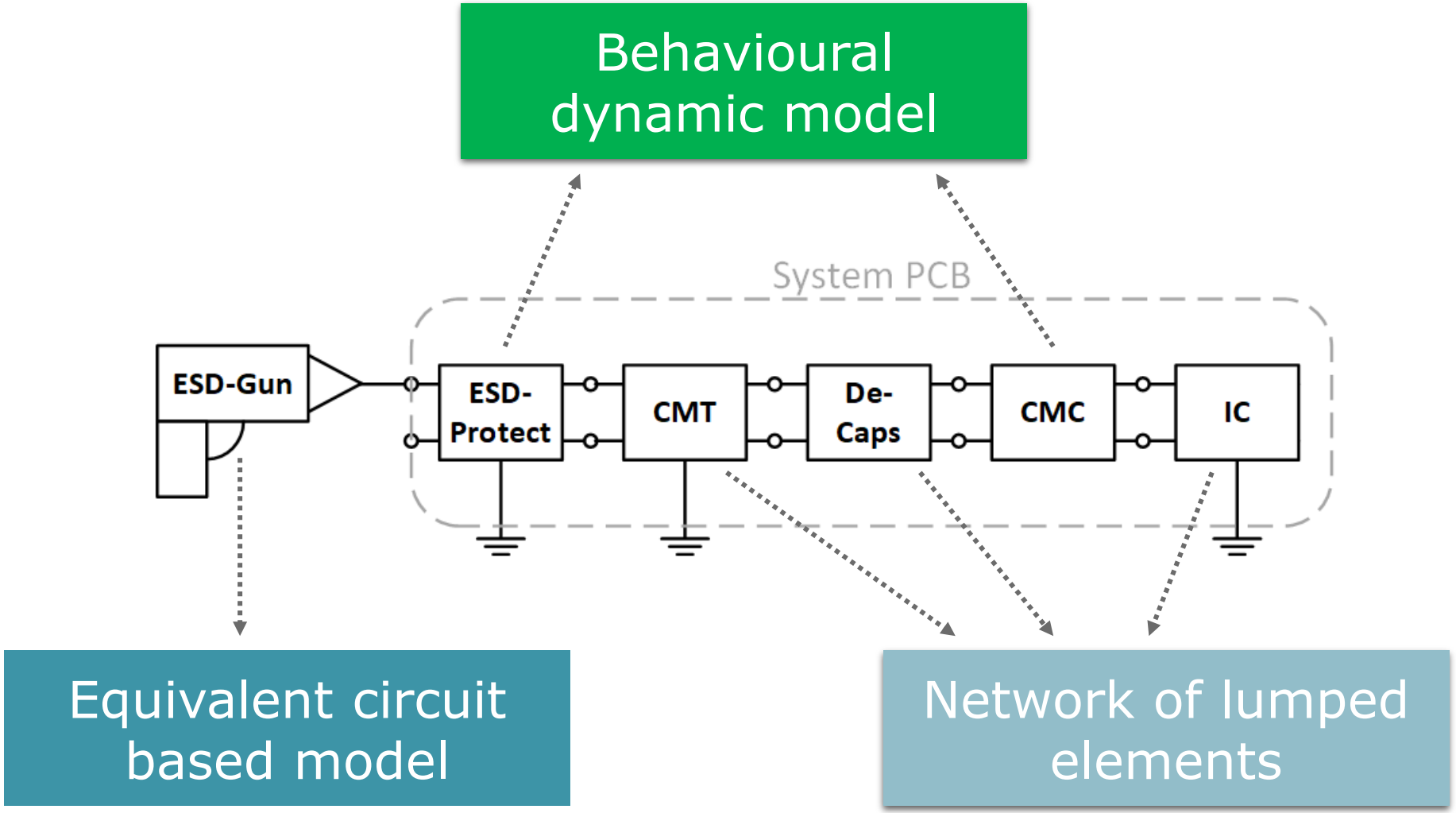
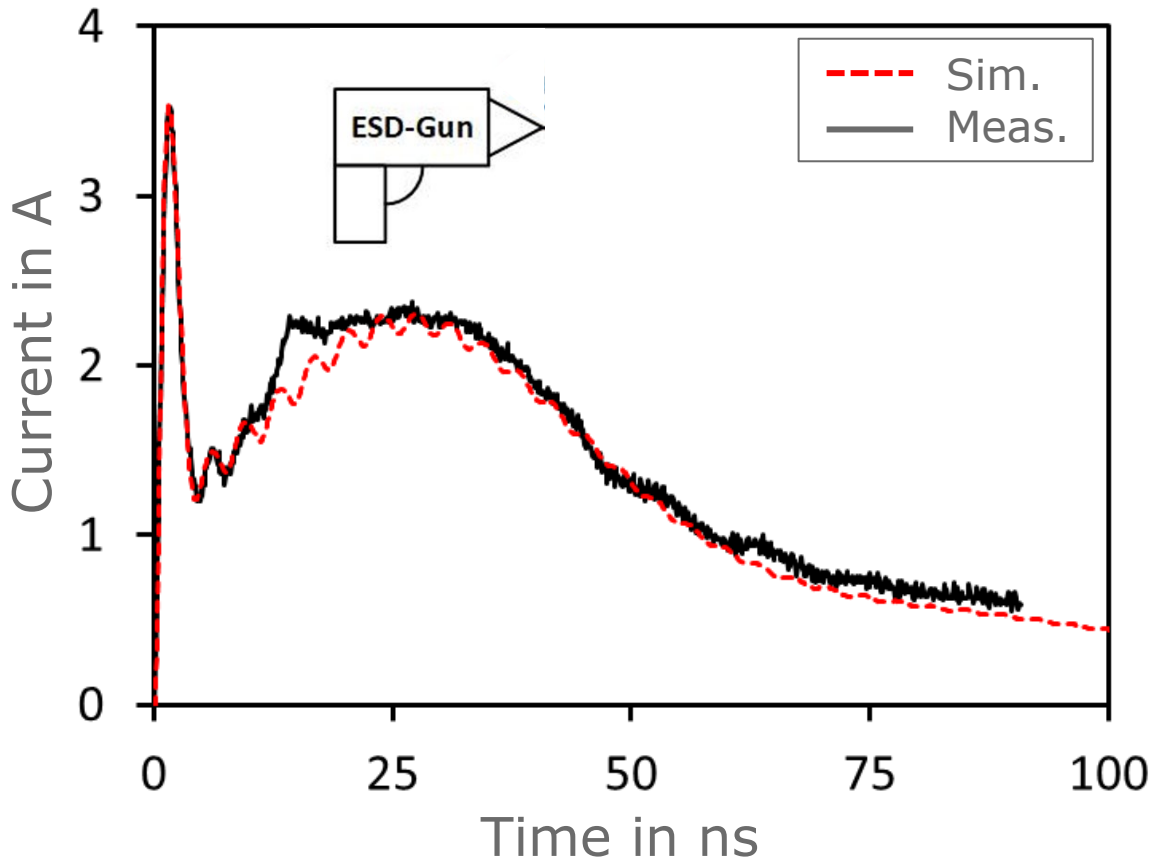
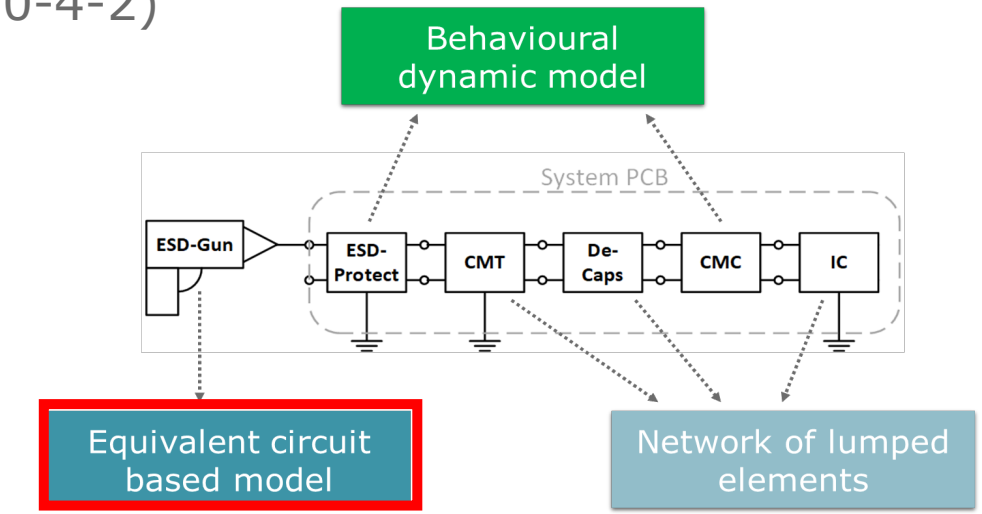
Model Types Applied to Realise the SEED Model



Modelling of ESD Generator

1 kV discharge in 2 Ohm Pellegrini Target (acc. IEC 61000-4-2)





- Entire shape of ESD generator model is **replicated with very high precision** and corresponds to IEC61000-4-2

The extended ESD generator model used here, is based on paper: S.Yang et al., "Effect of Different Load Impedances on ESD Generators and SPICE Models", IEEE 2017

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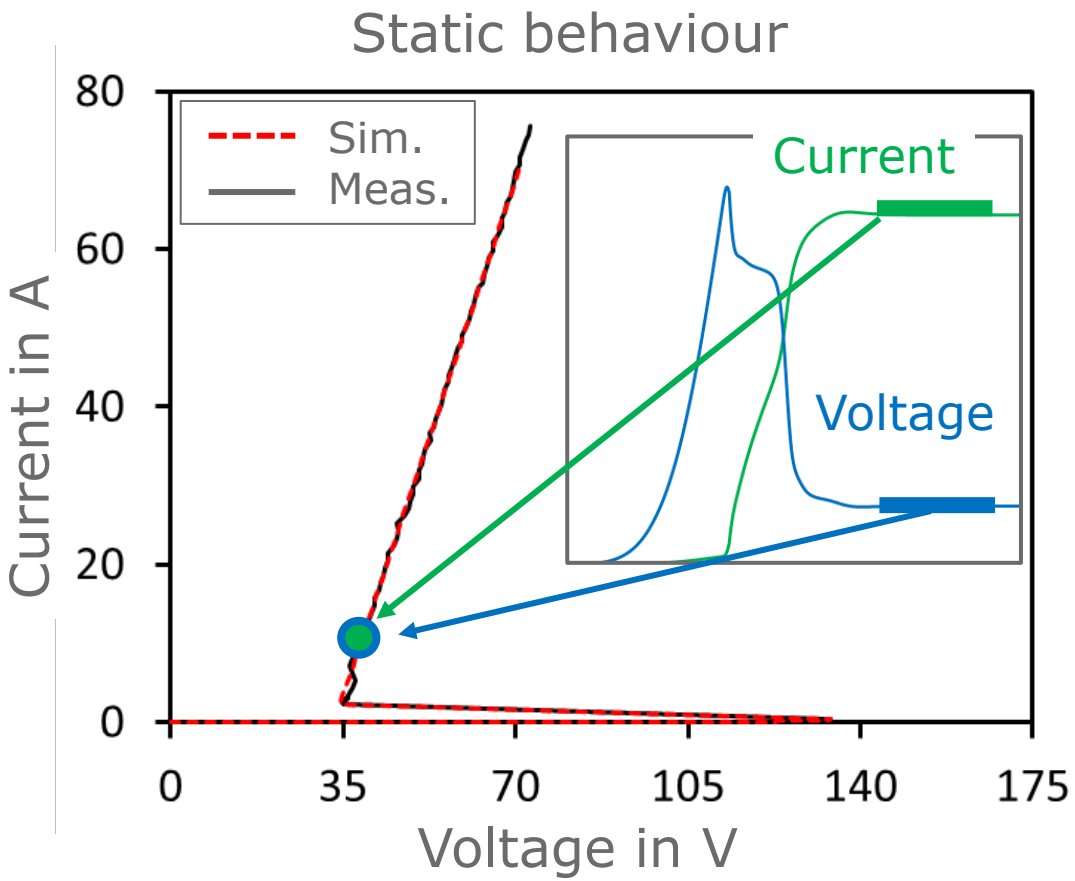
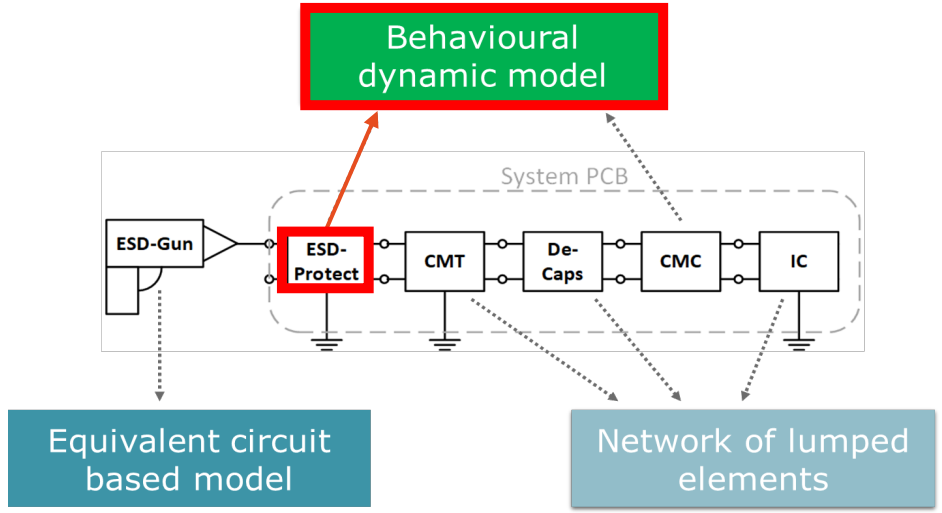
Modelling of ESD Protection Device

Fully dynamic model of the ESD Protection Device



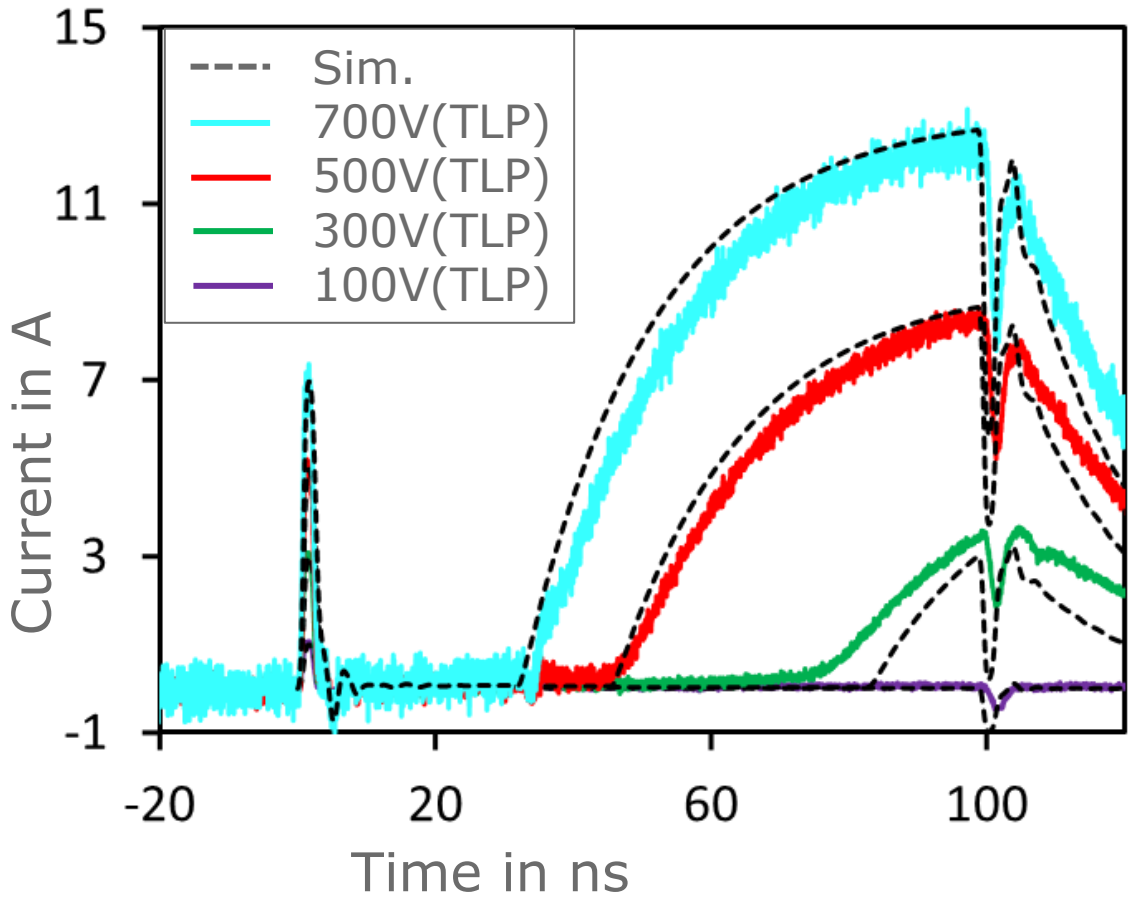


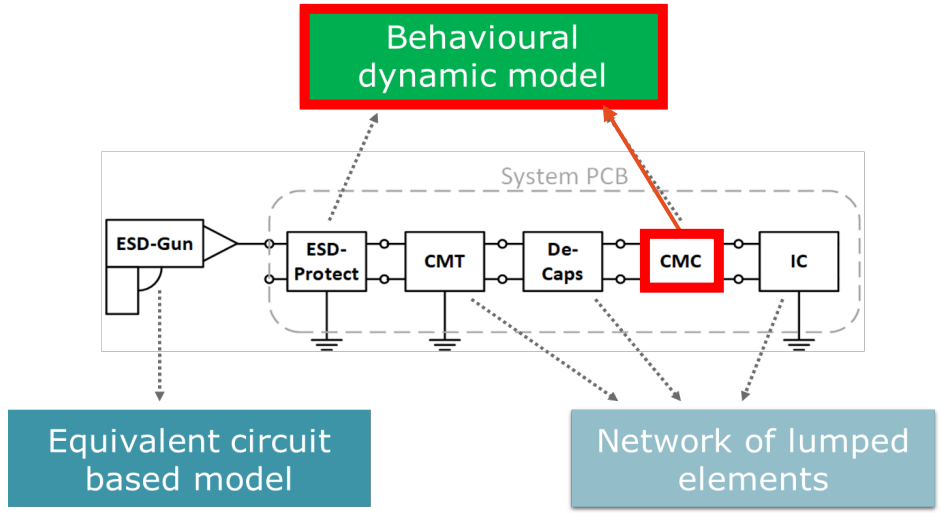
- The ESD Protection is modeled using TLP. Not only the static behavior is modeled but also the dynamic behavior using peak voltages of each TLP pulse

The extended dynamic model used here, is based on paper: P.Wei et al., "TVS Transient Behavior Characterization and SPICE-Based Behavior Model", 40th EOS/ESD Symposium, 2018

Modelling of CMC

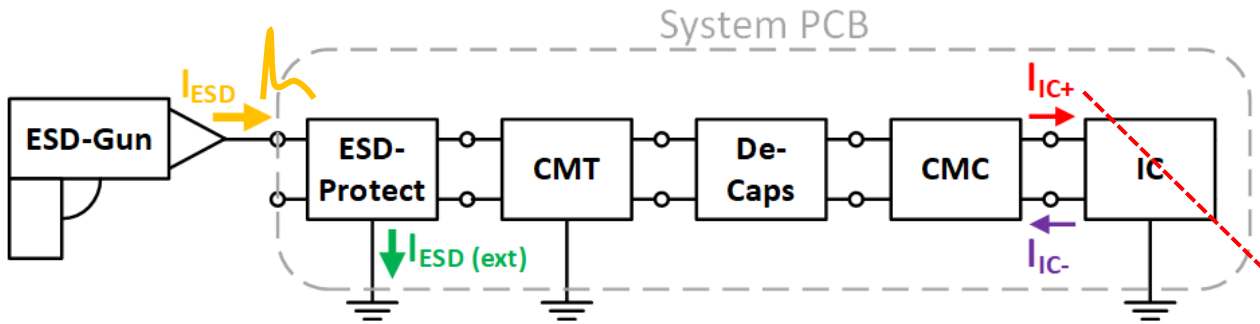
Simulation fits well the measurements

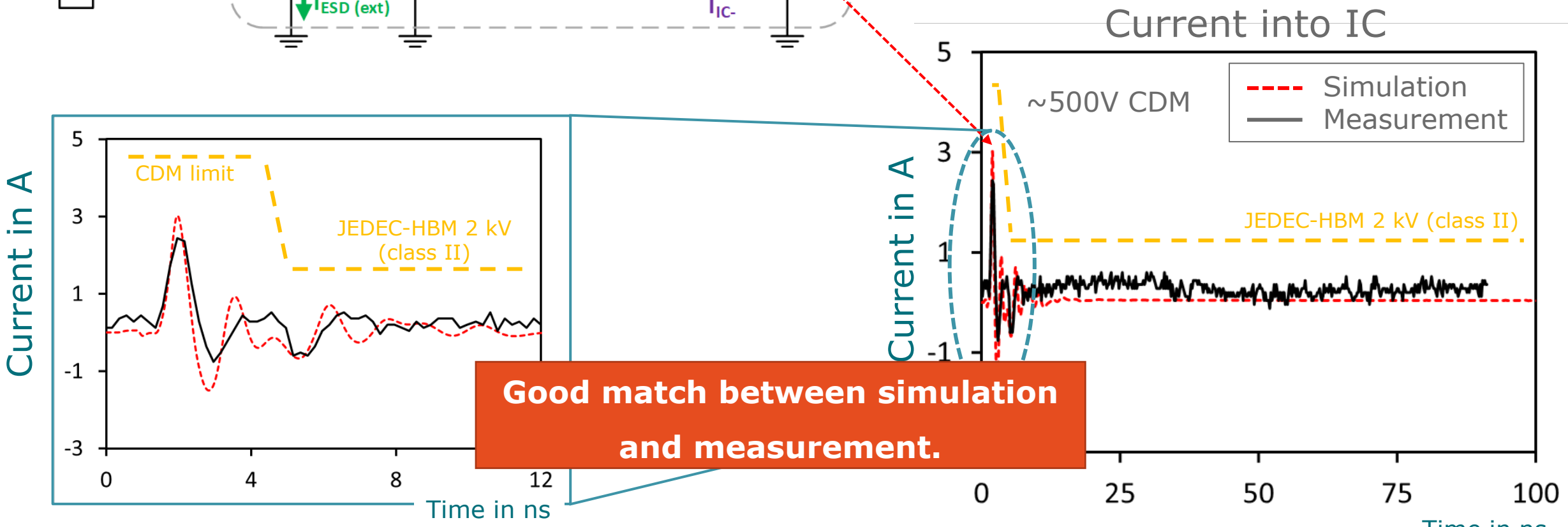




- The CMC Protection is modeled using TLP measurement similar to the modeling of the ESD device.

IC Current after ESD Generator Pulse of 4kV





Good match between simulation and measurement.

S.Bub, et al., "Efficient prediction of ESD discharge current according to OPEN Alliance 100BASE-T1 specification using SEED", White Paper, 2020

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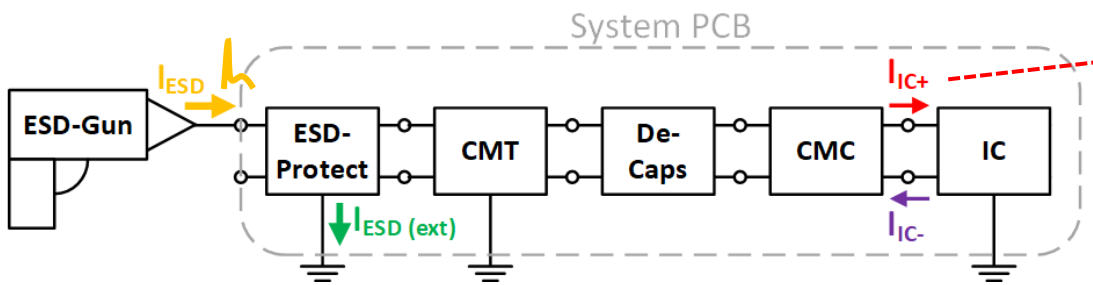
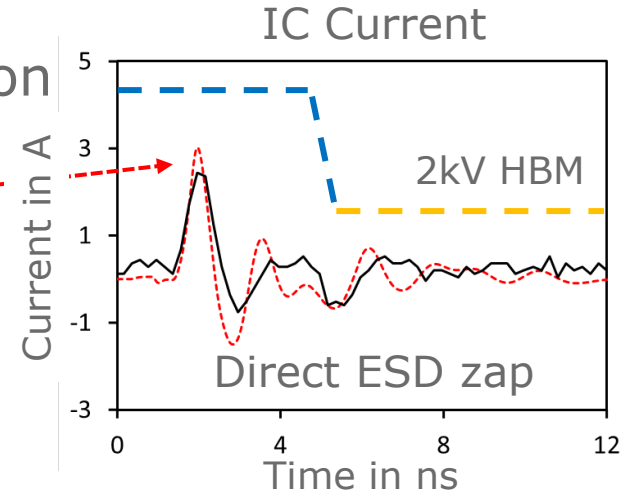
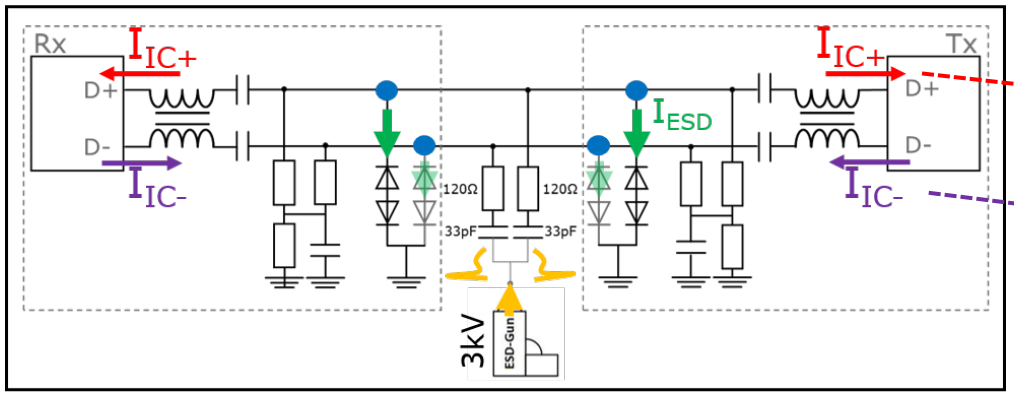
Summary SEED Simulation

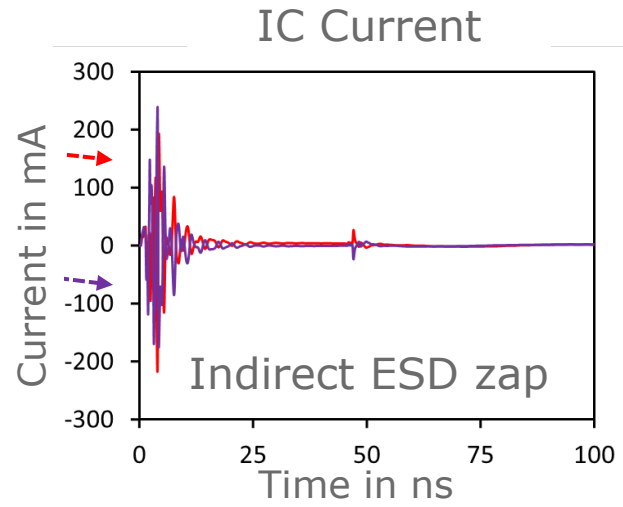
- SEED predicts rest currents into the IC for direct ESD injection





- System Model can be also extended for transient analysis of coupled ESD injections





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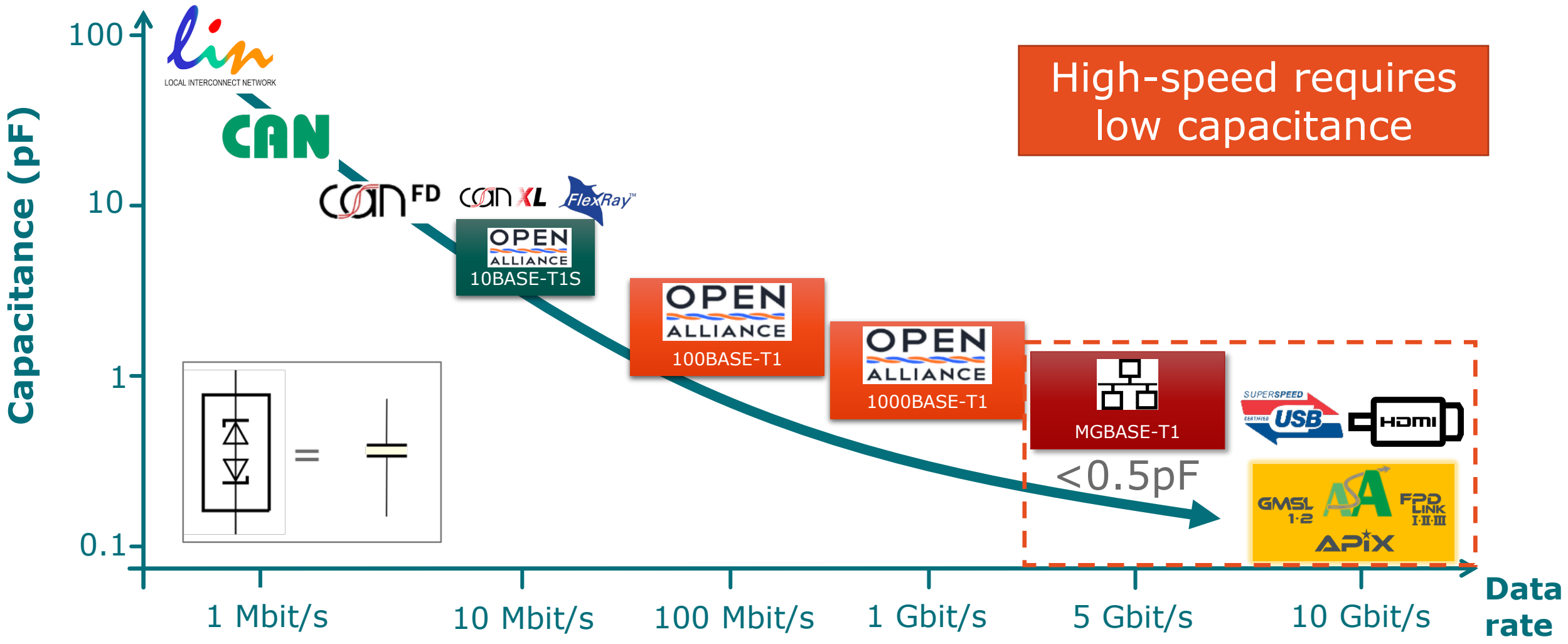
Application overview: capacitance vs. datarate



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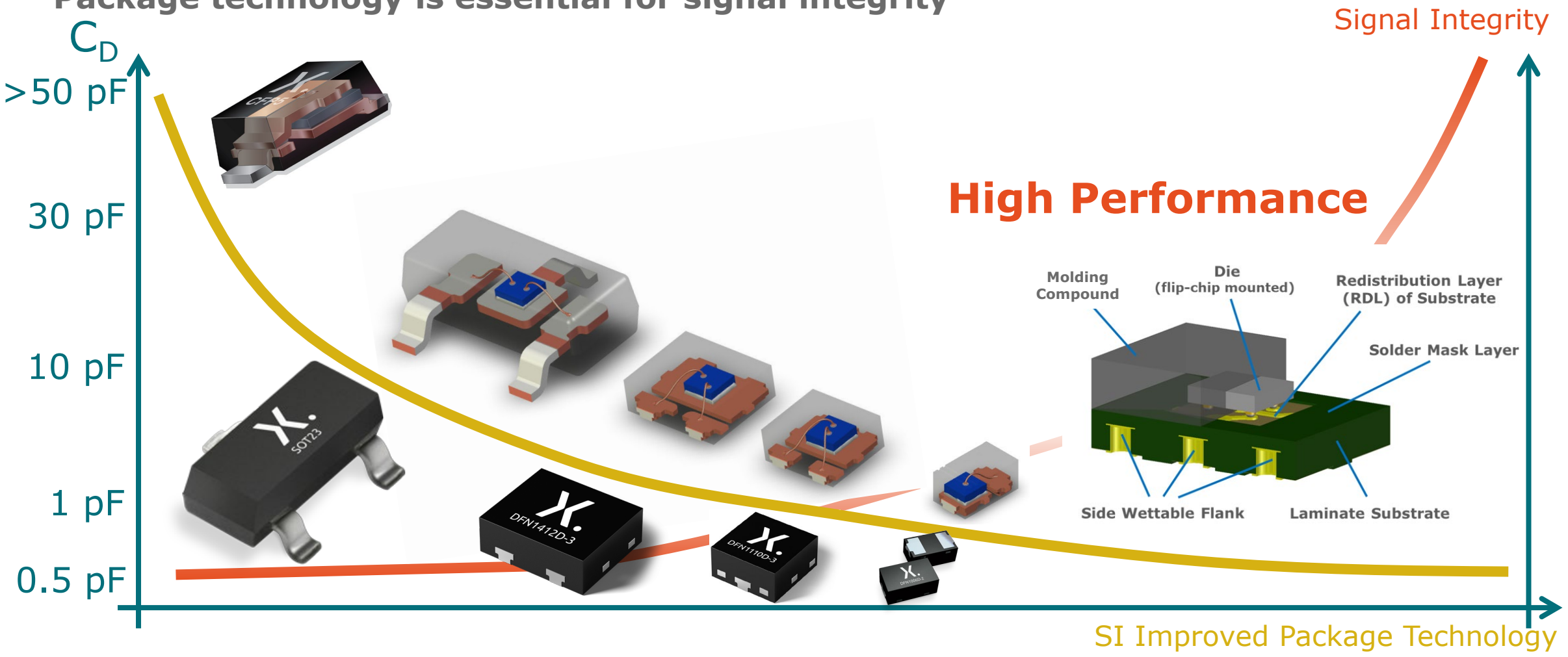
High performance package approaches: FCLGA

Package technology is essential for signal integrity



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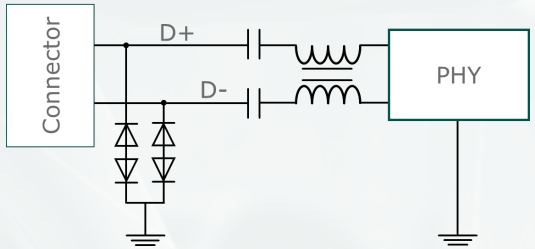
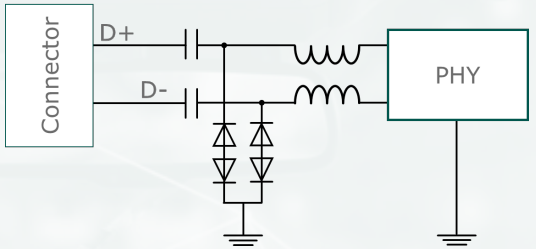
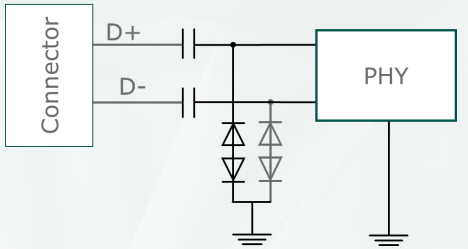
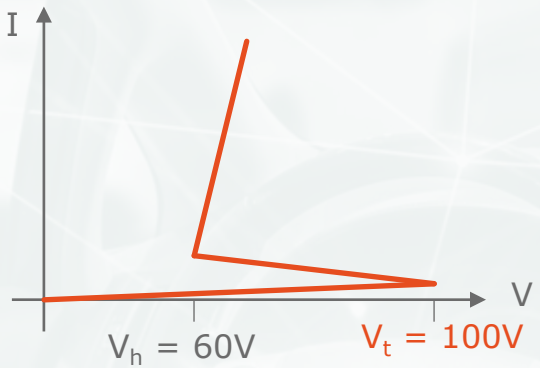
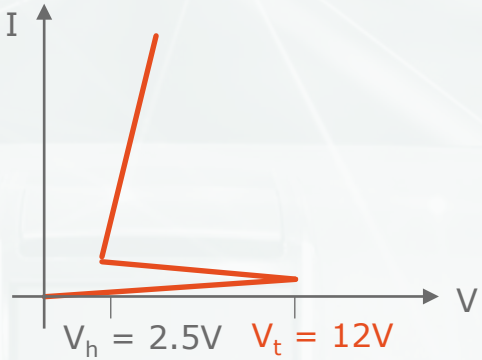
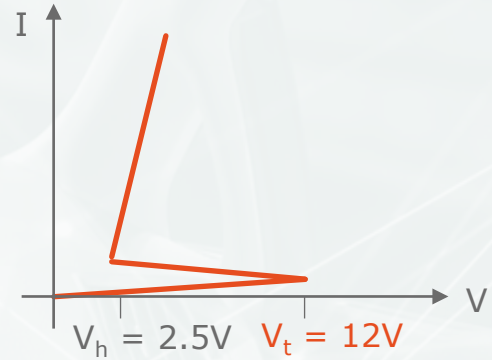
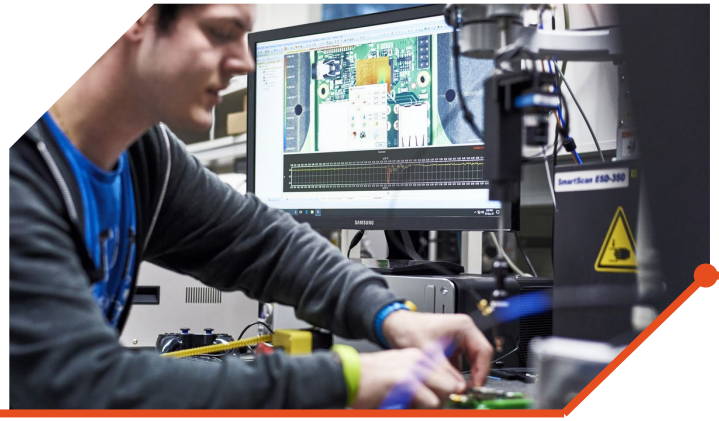
Multigigabit Ethernet: Possible ESD Circuitry

	1. Differential HV ESD + CMC	2. Differential LV ESD w CMC	3. Differetial LV ESD wo CMC
SCH			
Electrical Performance			
CMC	~µH Range	~nH Range	--
Benefits	• ESD Performance • All circuitry is protected • HV Boardnet 48V • PoDL - ready • EM immunity	• Best clamping • ESD and EMI	• Low cost • SI Performance

Plus further application & quality requirements e.g. 2x AEC-Q101 / T_J = 175 °C

Conclusion & Outlook

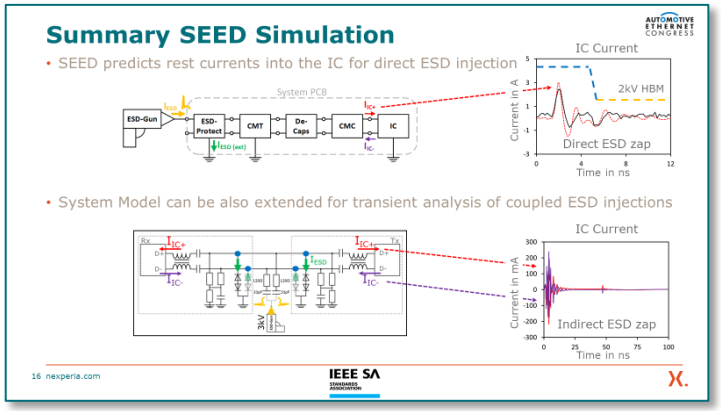
More on nexperia.com



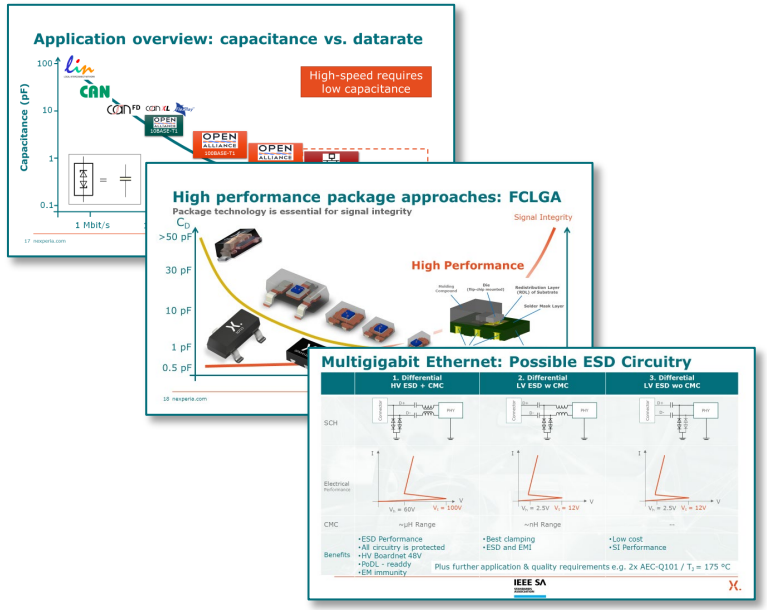
Automotive Trends

- Electrification
- Connectivity
- Autonomous Driving

Efficiency through Simulations



New requirementes – new solutions



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EFFICIENCY WINS.