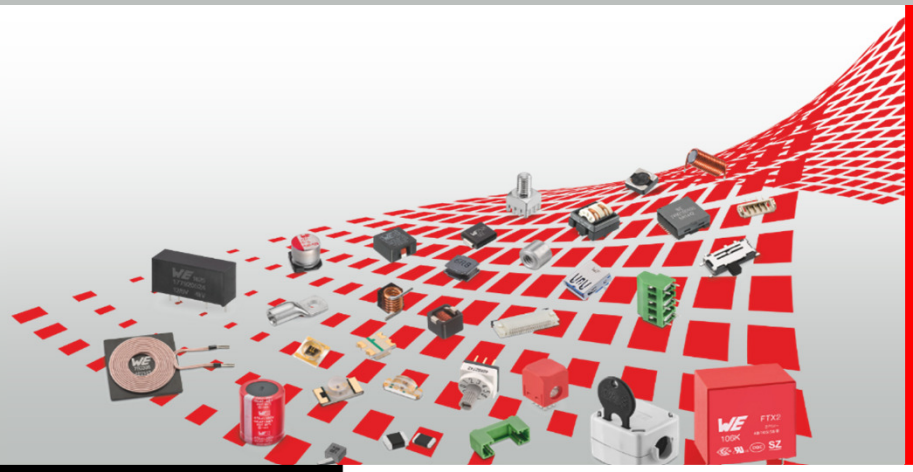
TECHNICAL ACADEMY

WÜRTH ELEKTRONIK

ESD & EMC protection of high speed signal lines



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more than you expect

de Nederlandse EMC-ESD Vereniging

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NH Conference Centre Koningshof Veldhoven

woensdag 20 november

WÜRTH ELEKTRONIK

The Würth Elektronik Group

Employees: 8.300
Sales: 848 Millionen Euro

Würth Elektronik eiSos Group

Printed Circuit Boards

Intelligent Power and Control Systems

Passive Components

Power Modules & Optoelectronics

Electromechanics

Automotive & eMobility

Wireless Connectivity & Sensors

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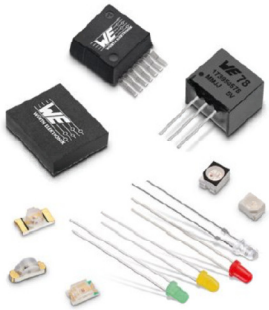

Electromechanical Components

Automotive & eMobility

Wireless Connectivity & Sensors

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Agenda

- A typical high speed system
- I added protecting, now what happened to my signal?
- Measurements results
- Solutions and summary

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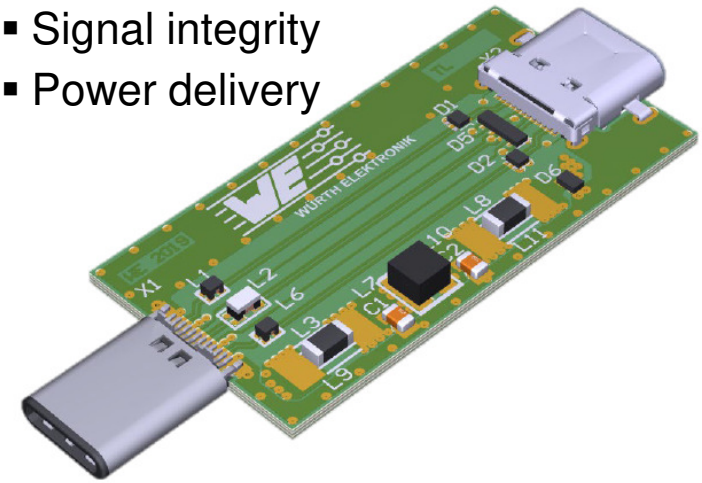
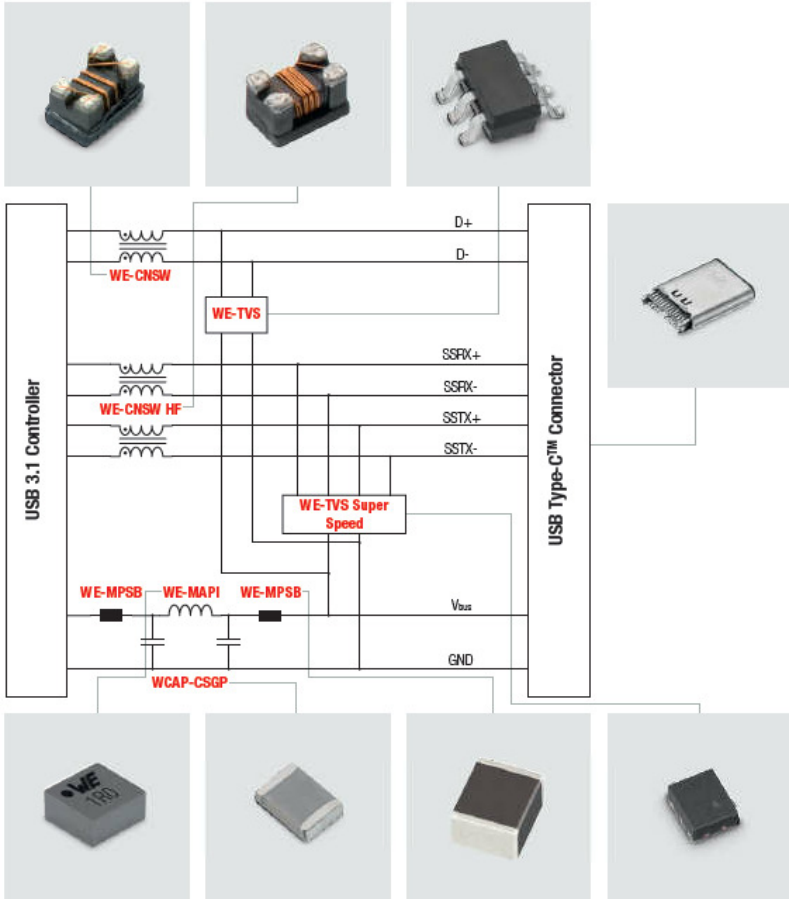
USB 3.1

- Up to 10GBit/s and 100Watt of power
- Challenges
  - EMI
  - Signal integrity
  - Power delivery





- 60W evaluation kit
- 100W evaluation kit

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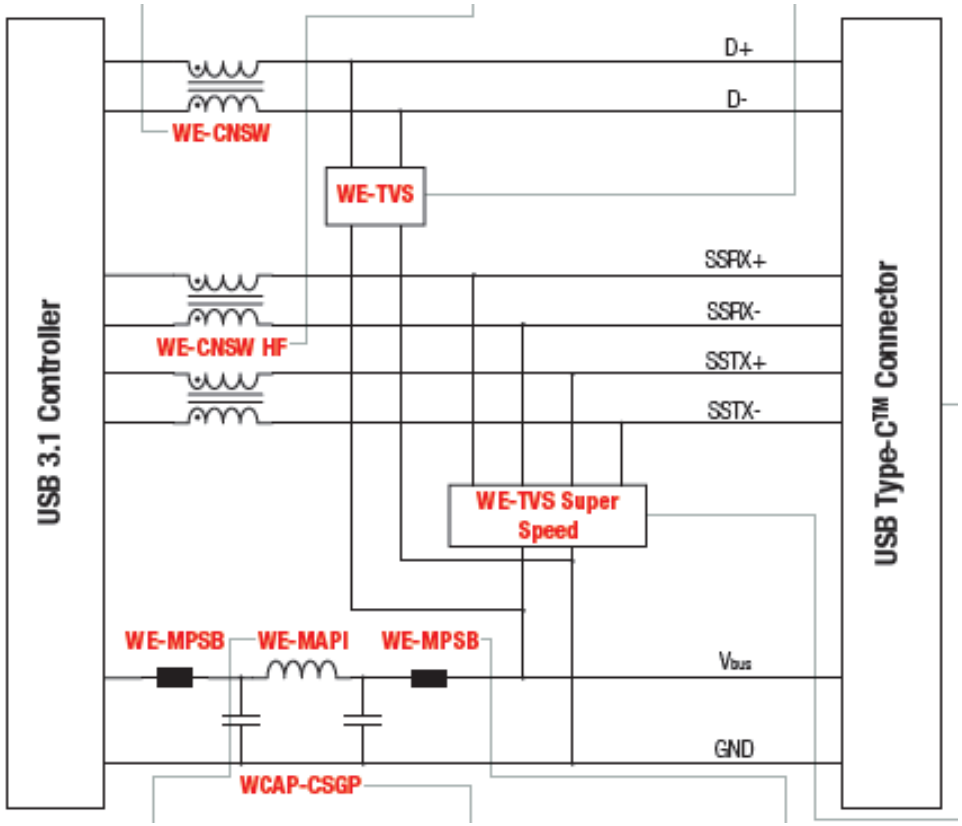
USB 3.1

- USB controller
  - Sensitive for High voltage transients
- Typically protected
  - 2kV HBM
- Need protection for surges



- USB 2.0 backwards compatible
- USB 3.1 high speed data lines
- Power stage, up to 100W

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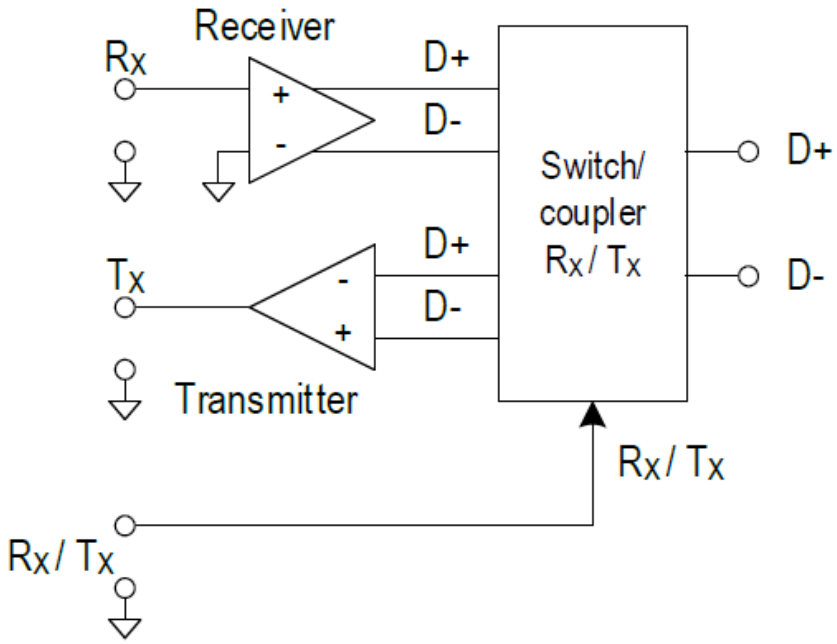
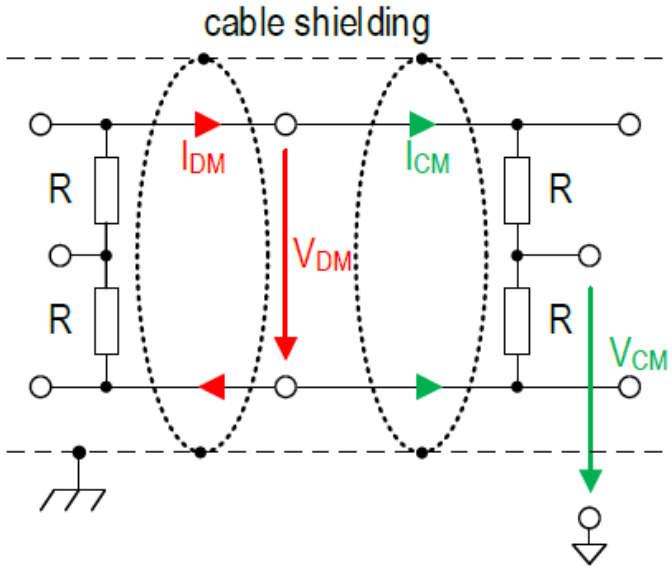
USB 3.1

- Transmission path is symmetrical
  - Both Tx and Rx are identical
- Interface can send and receive at the same time.
- Tx and Rx are referenced at the same ground
- Very similar to many other interfaces
- PCB layout very critical



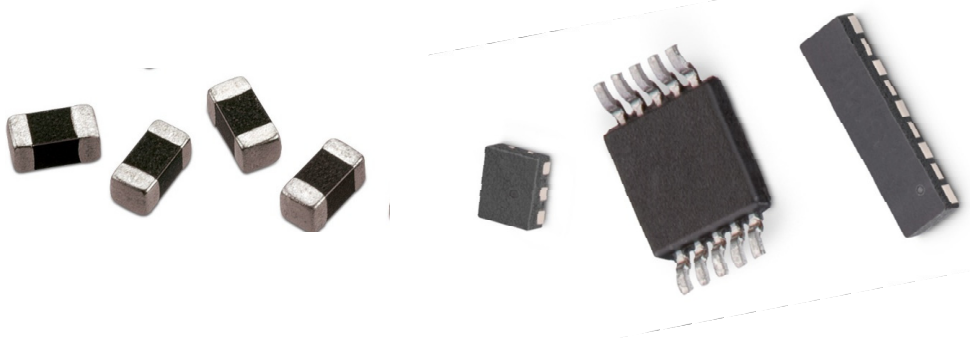
Susceptible for noise

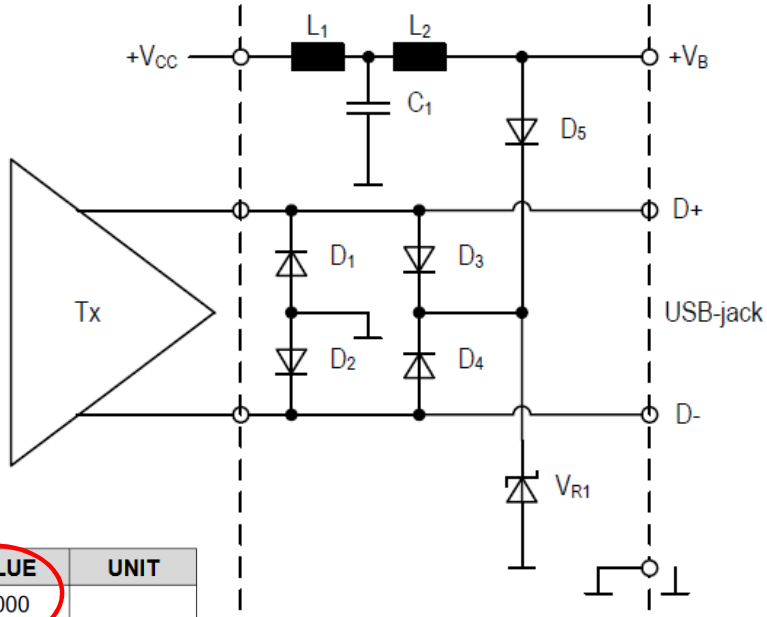
- The interface is susceptible for noise
  - Differential mode noise
  - Common mode noise
- Source can be the controller it self or some outside noise source. This could be coupled
  - Inductive
  - Capacitative
  - External radiated emissions



Susceptible for transients

- The controller needs to be protected form transient like ESD and surges.
  - Varistors or Diodes can be used to for protection





6.2 ESD Ratings

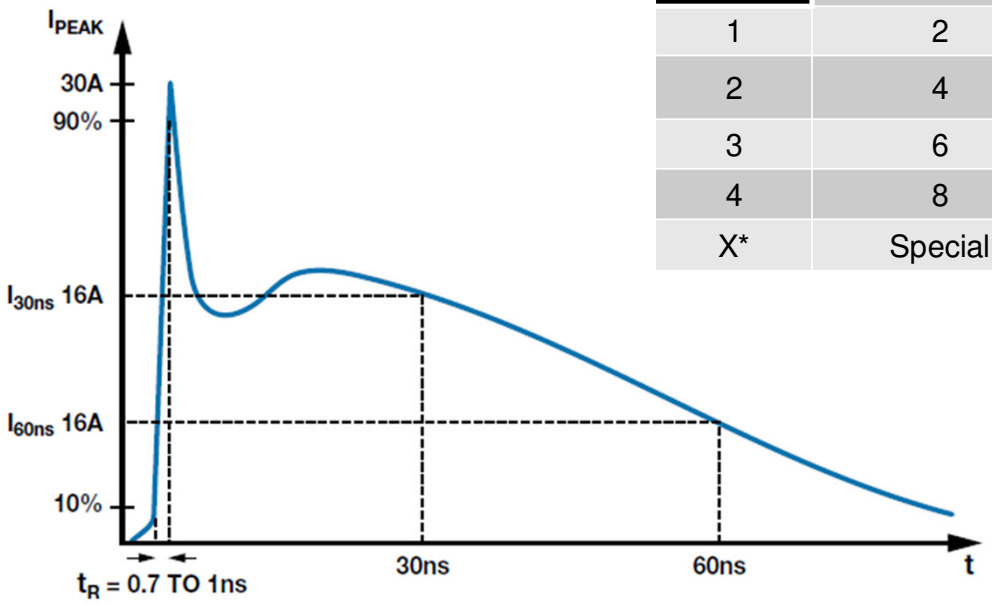
			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1)	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101 (2)	±500	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

Source Texas Instruments datasheet

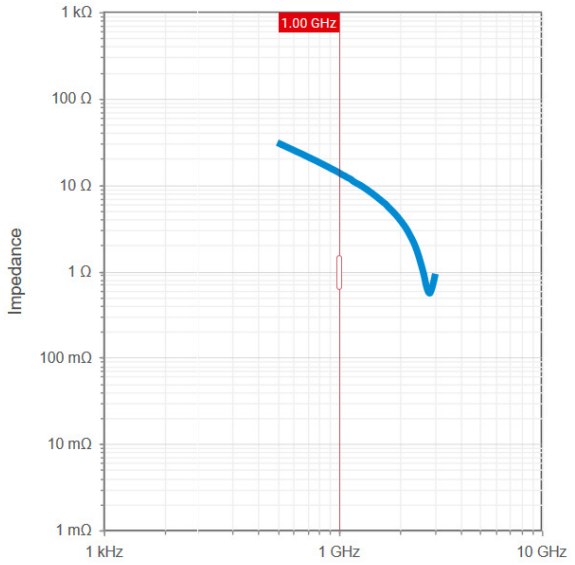
ESD Transient

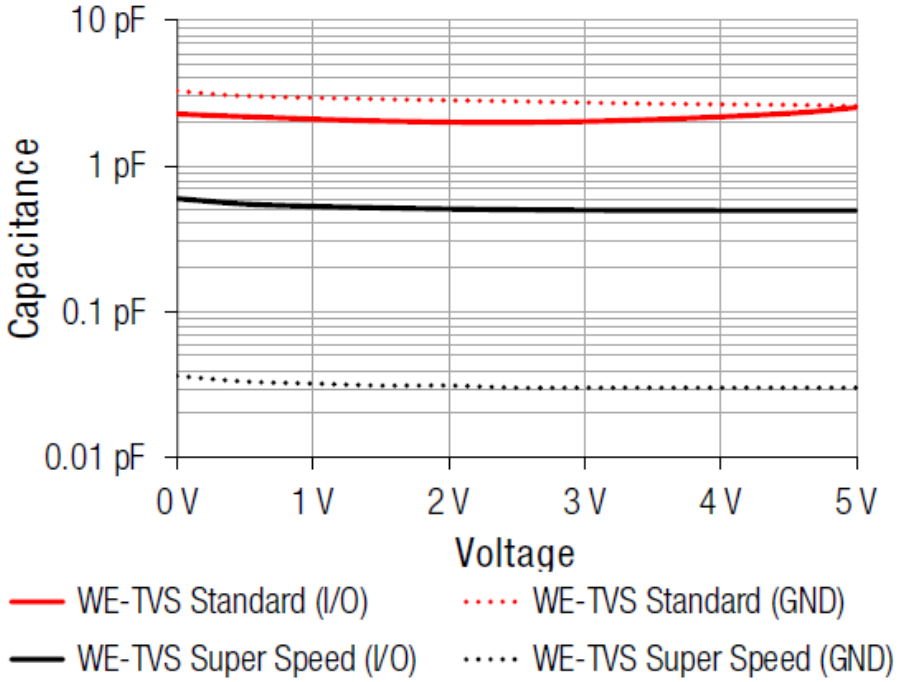
Level	Contact Discharge		Air Discharge	
	Test Voltage kV	Peak Current (A) IEC 61000-4-2	Test Voltage kV	Peak Current (A) IEC 61000-4-2
1	2	7.5	2	7.5
2	4	15	4	15
3	6	22.5	8	30
4	8	30	15	-
X*	Special	Special	Special	Special



WE-TVS selection

- Important selection criteria
  - Nominal voltage
  - Clamping voltage
  - Capacitance





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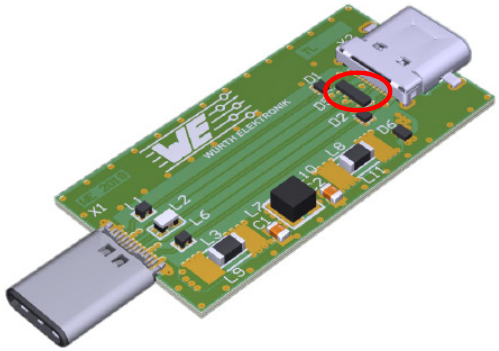
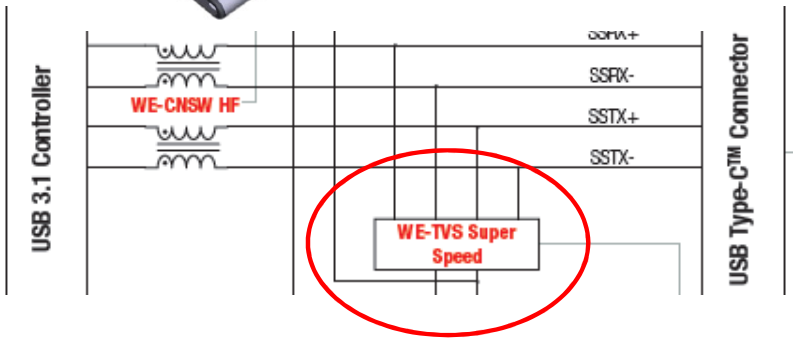
WE-TVS

Electrical Properties:

Properties	Test conditions		Value			Unit
			min.	typ.	max.	
Channel Operating Voltage	I/O to GND	V_{Ch}			5	V
(Reverse) Breakdown Voltage	I_{BR}=1mA; I/O to GND	V_{BR}	6		9	V
Channel (Reverse) Leackage Current	$V_{I/O}$=V_{DC}; V_{GND}=0V	$I_{Ch\ Leak}$			1	µA
Forward Voltage	I_F=15mA; GND to I/O	V_F		0.9	1.2	V
(Channel) Input Capacitance	V_{GND}=0V $V_{I/O}$=2.5V, f=1MHz, I/O to GND	C_{Ch}		0.5	0.65	pF
Channel to Channel Input Capacitance	V_{GND}=0V $V_{I/O}$=2.5V, f=1MHz, between I/O pins	C_{Cross}		0.03	0.08	pF
Channel ESD Clamping Voltage	IEC 61000-4-2 +8kV (TLP=16A) Contact Mode, I/O to GND	$V_{Ch\ Clamp\ ESD}$		10.5		V





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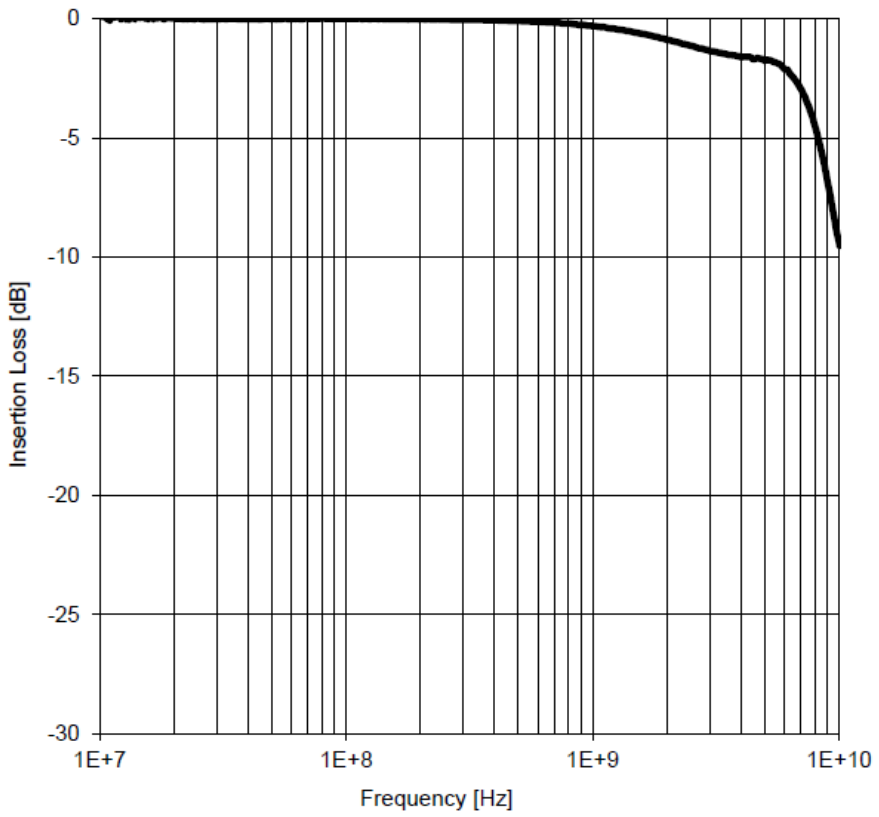
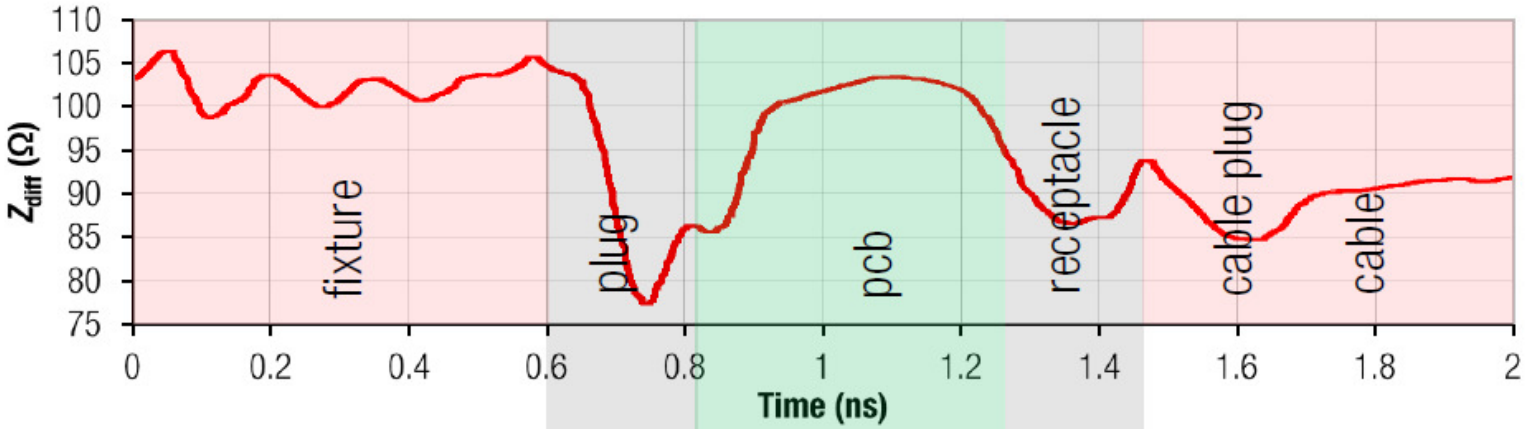
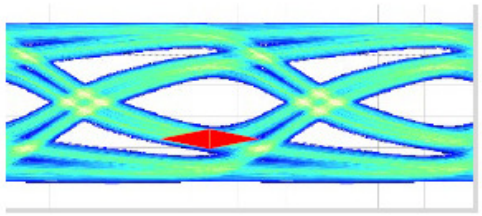
WE-TVS

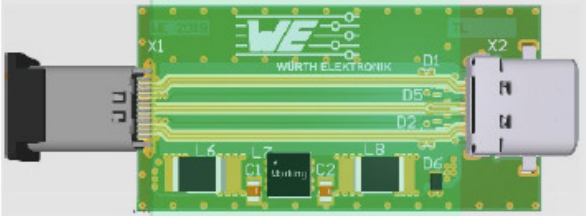
Insertion Loss SDD21 (I/O to GND):



Measurements







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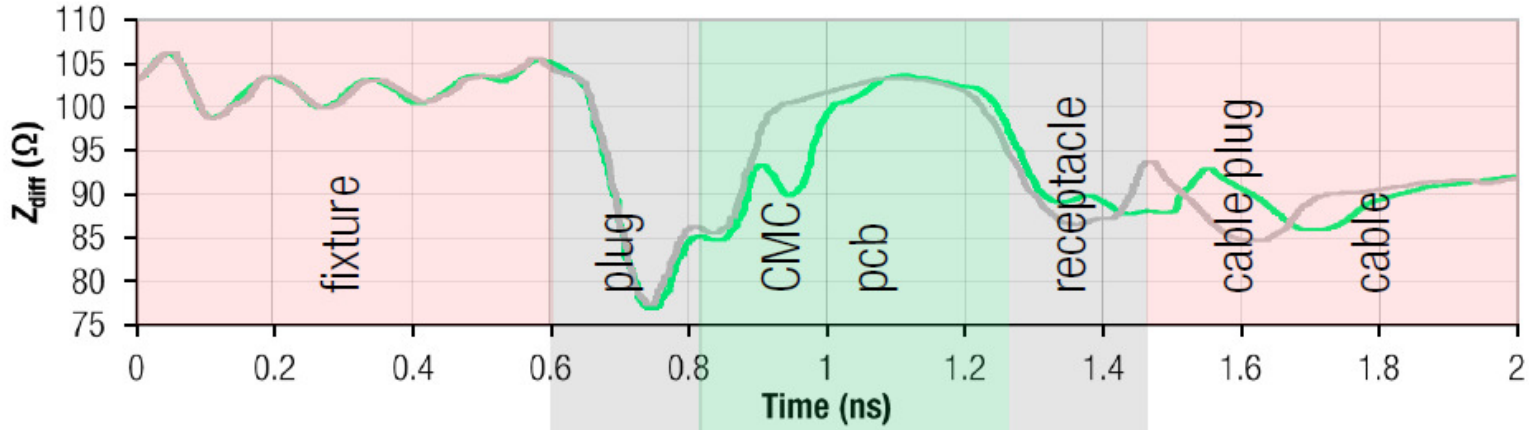

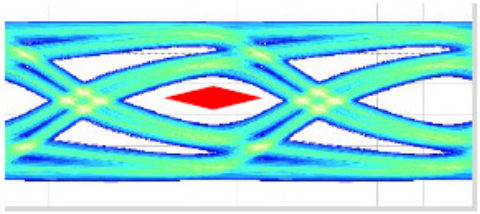

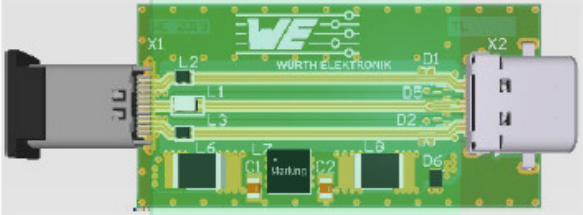

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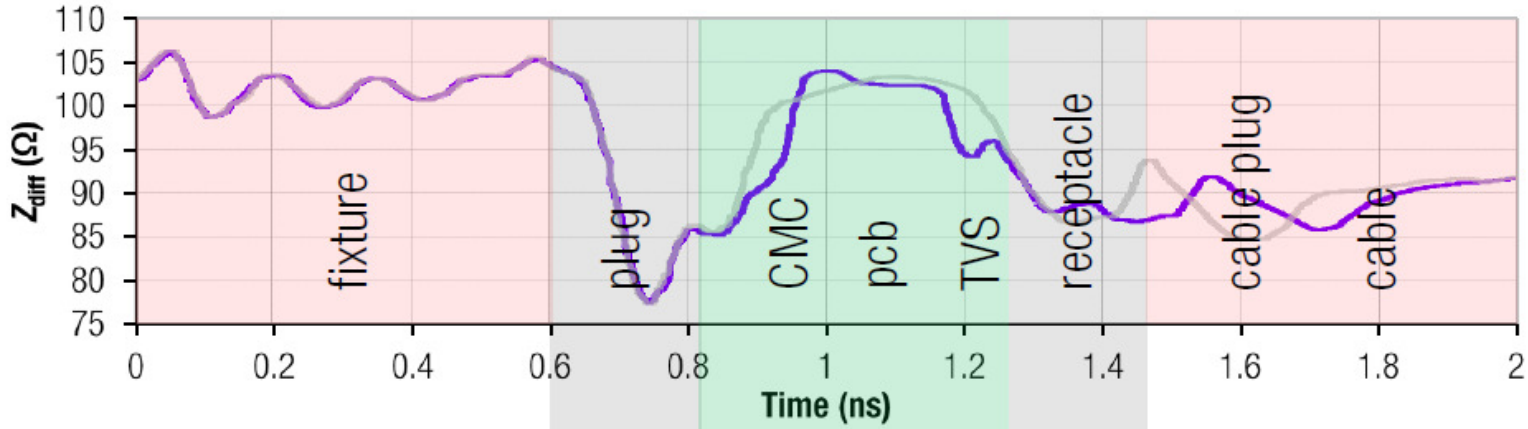

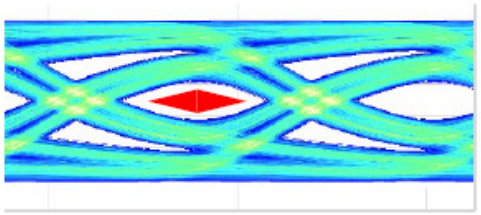

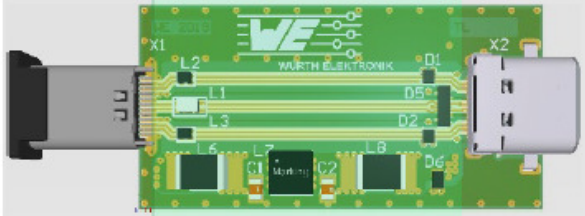

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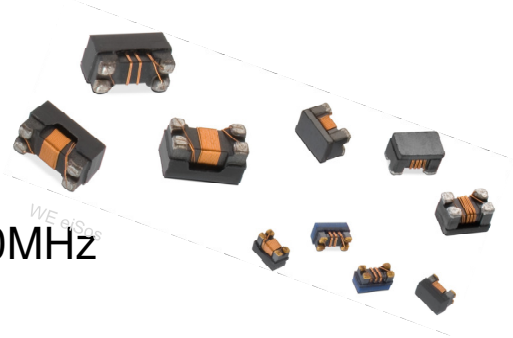
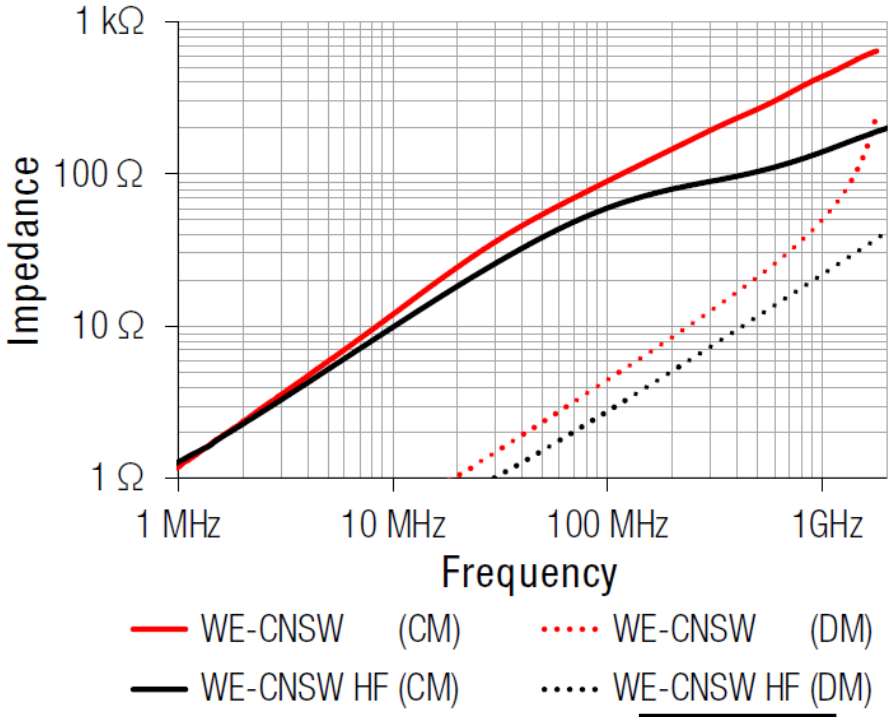
Example Common mode Choke

High frequency signals



- WE-CNSW
  - 90 Ω CM @ 100MHz
  - 0603
- WE-CNSW HF
  - 60 Ω CM @ 100MHz
  - 0504



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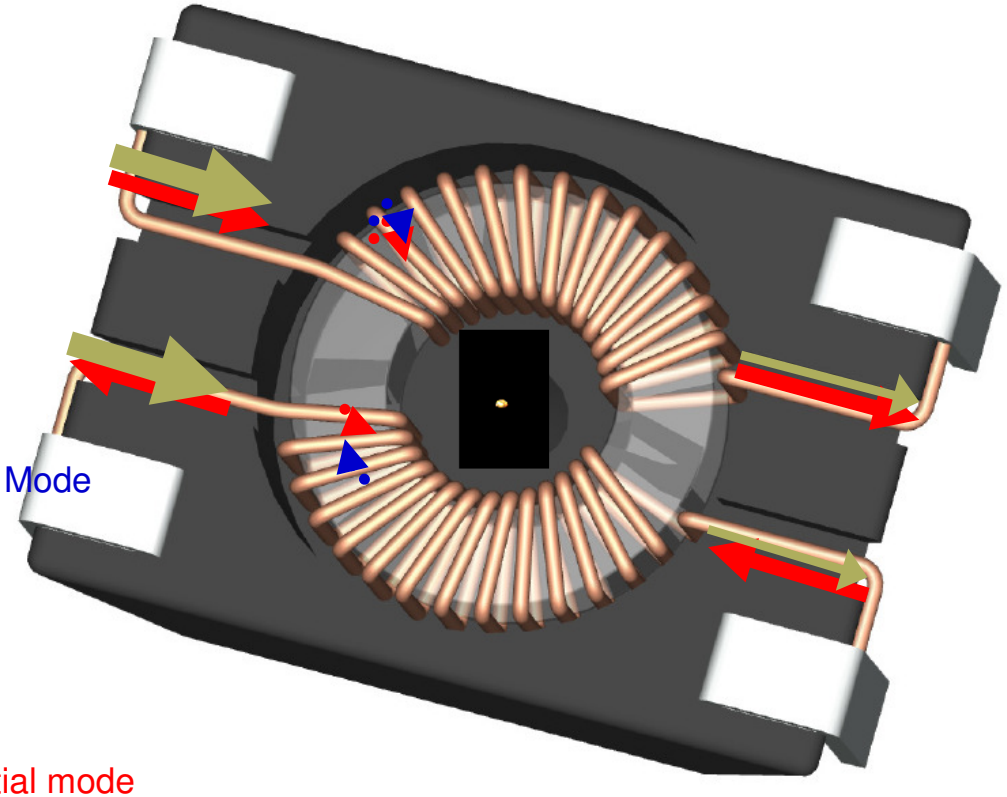
Common Mode Filter – How it works

It is a Bi-directional filter

- From device to outside environment
- From outside environment to inside device

Intended Signal - Differential mode

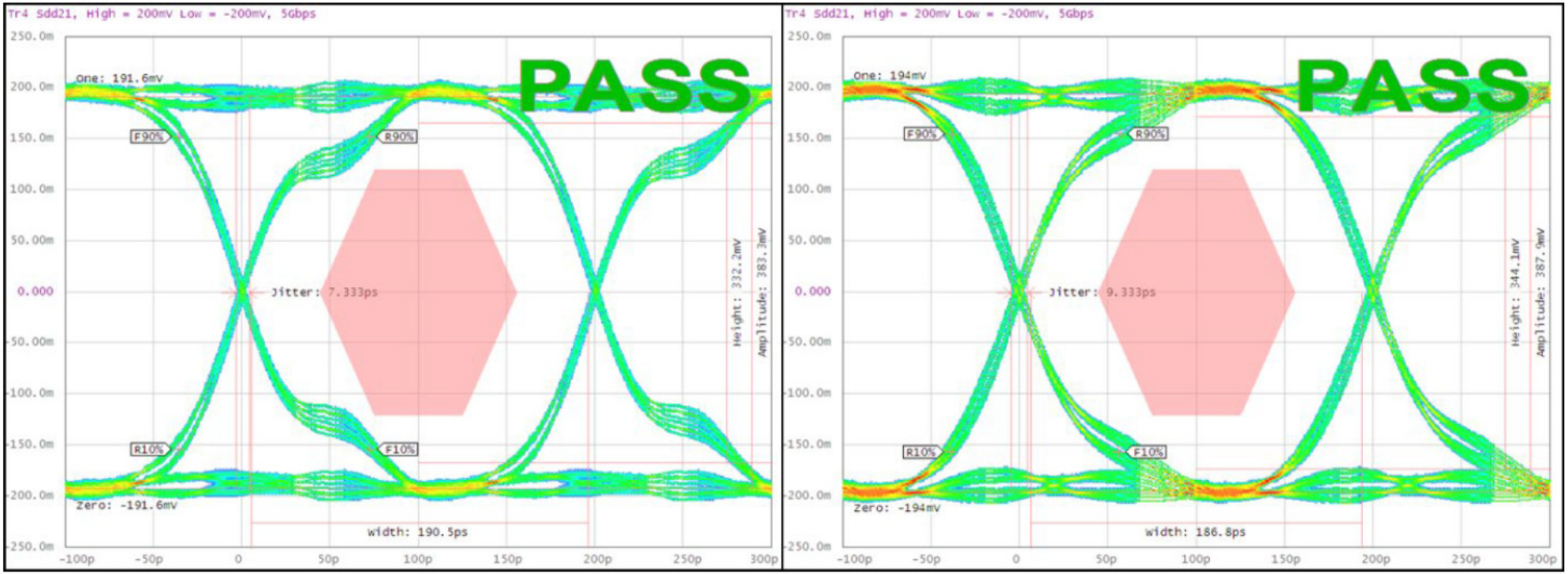
Interference Signal (noise) – Common Mode



Conclusion:

- “almost” no affect the signal - Differential mode
- high attenuation to the interference signal (noise) – Common Mode

USB 3.1 – Signal Integrity



Eye diagram with the WE-CNSW filter (left) and the WE-CNSW HF filter (right) at 5 GBit/s

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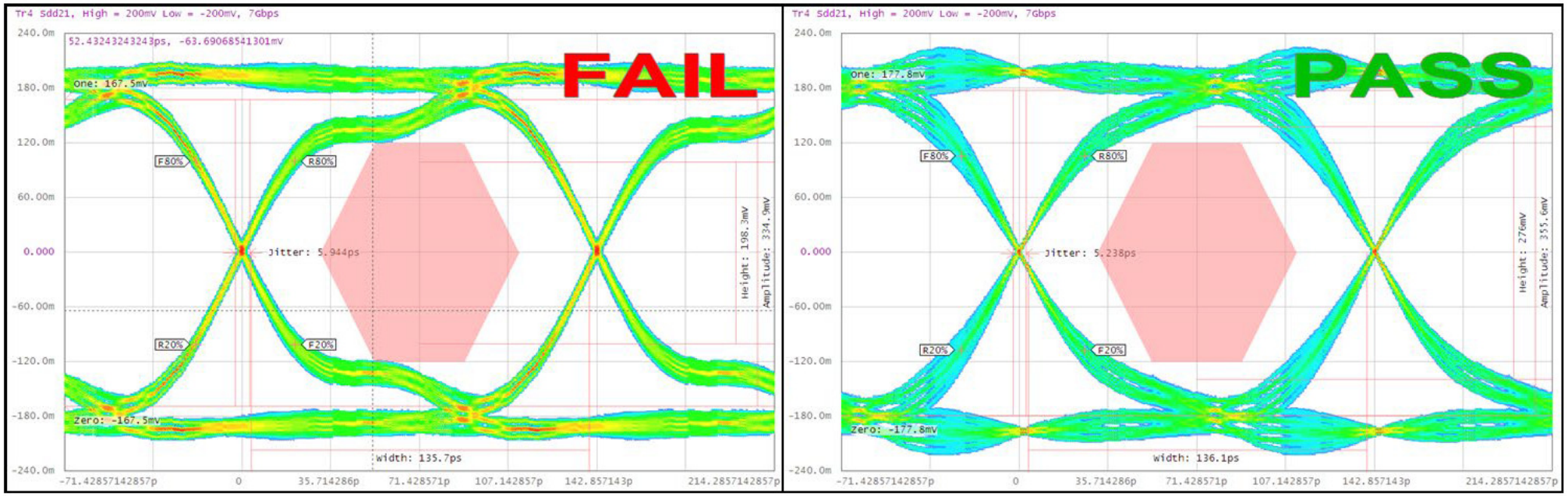
USB 3.1 – Signal Integrity



Eye diagram with the WE-CNSW filter (left) and the WE-CNSW HF filter (right) at 7 GBit/s

Appnote www.we-online.com/ANP007

Summary

- USB 3.1 interface is susceptible for:
  - Noise (common mode and differential mode)
  - Transients
- Goal: Attenuate unwanted signals while maintaining speed and integrity of data transfer
- Built in ESD protection is often not sufficient
- ESD can go up to 30kV
- Important selection criteria for TVS:
  - Nominal voltage
  - Clamping voltage
  - Capacitance
- By using the right components, the useful signal is not influenced

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Thank you for your attention!

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