Acceleration measurements in e-mobility

CSM Web Seminars

Innovative Measurement and Data Technology

Acceleration measurements in e-mobility

Supplier components

Specifications

Battery housing

Safety (drop test)

Test bench iteration

Battery housing

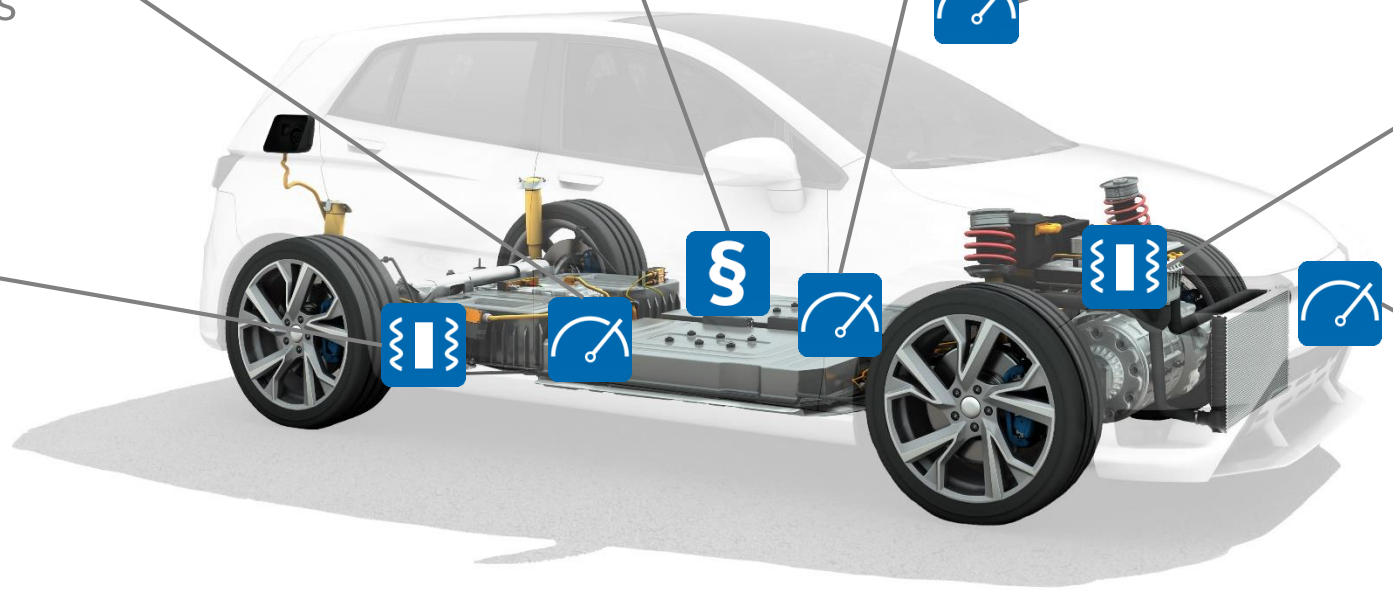
Verify calculations

Bracket / damper

Load profiles

Busbar

Vibration
transmission rate



Crash test

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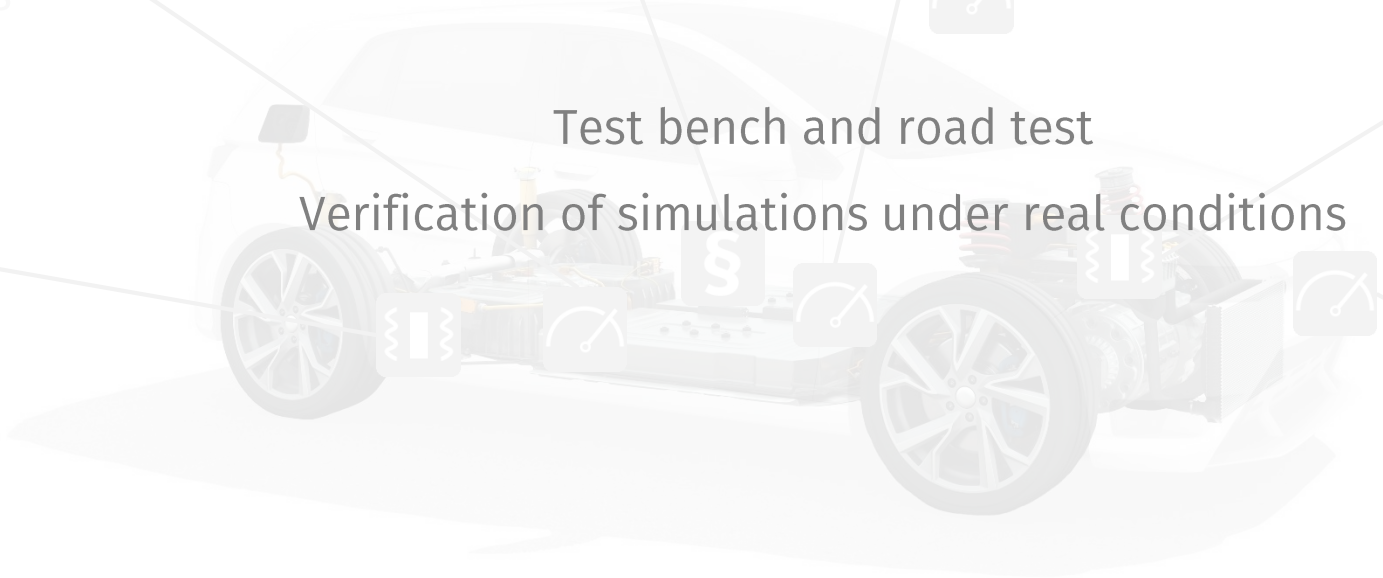


Ensuring safety

Test bench and road test

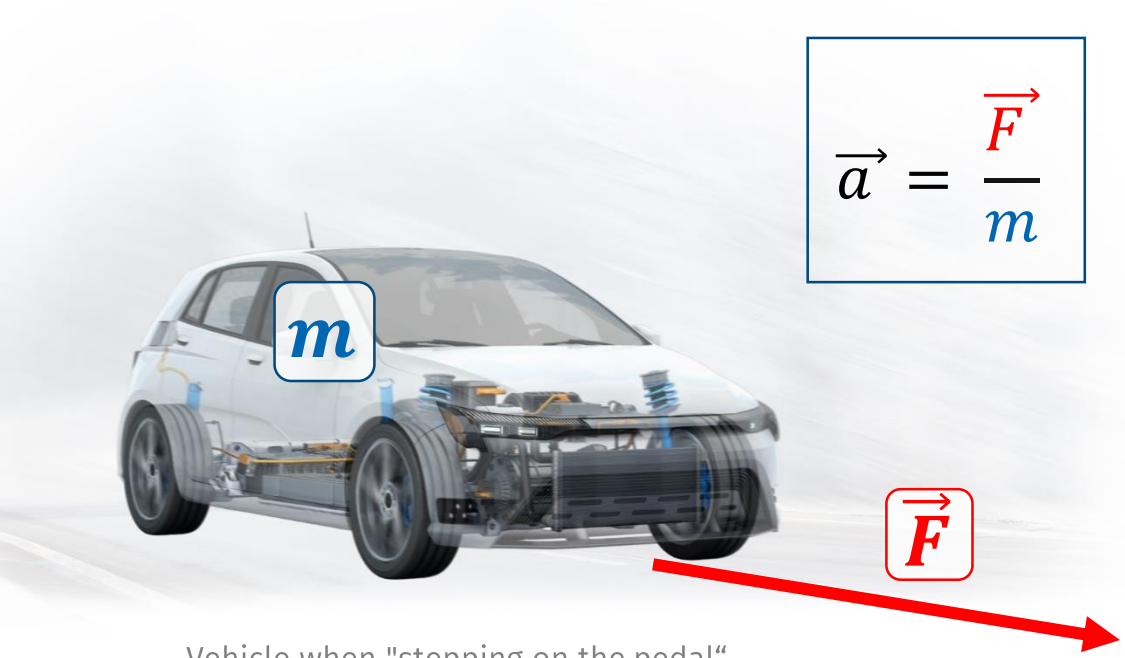
Verification of simulations under real conditions

Acceleration

Acceleration (a) is defined as the change in the state of motion of a body.

- **Amount of change of the velocity**

$$\vec{a} = \frac{\vec{F}}{m}$$



Vehicle when "stepping on the pedal“

Acceleration

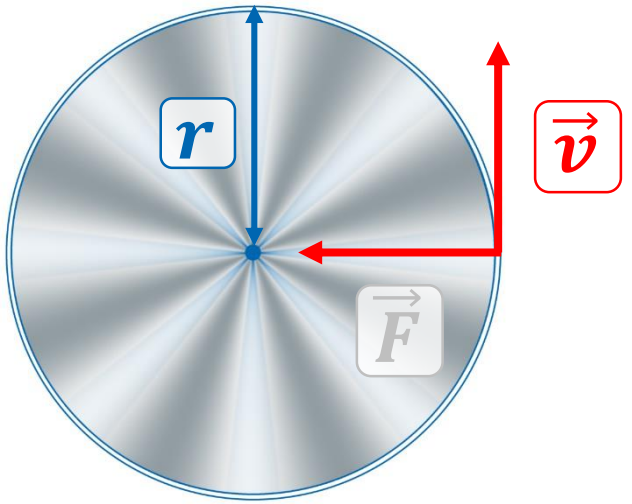
Acceleration (a) is defined as the change in the state of motion of a body.

- Amount change of the velocity
- **Change of the direction of the velocity**

$$\vec{a} = \frac{\vec{F}}{m}$$

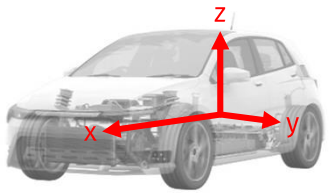
Vehicle when "stepping on the pedal“

$$\vec{a} = \frac{\vec{v}^2}{r}$$



Carousel from the top

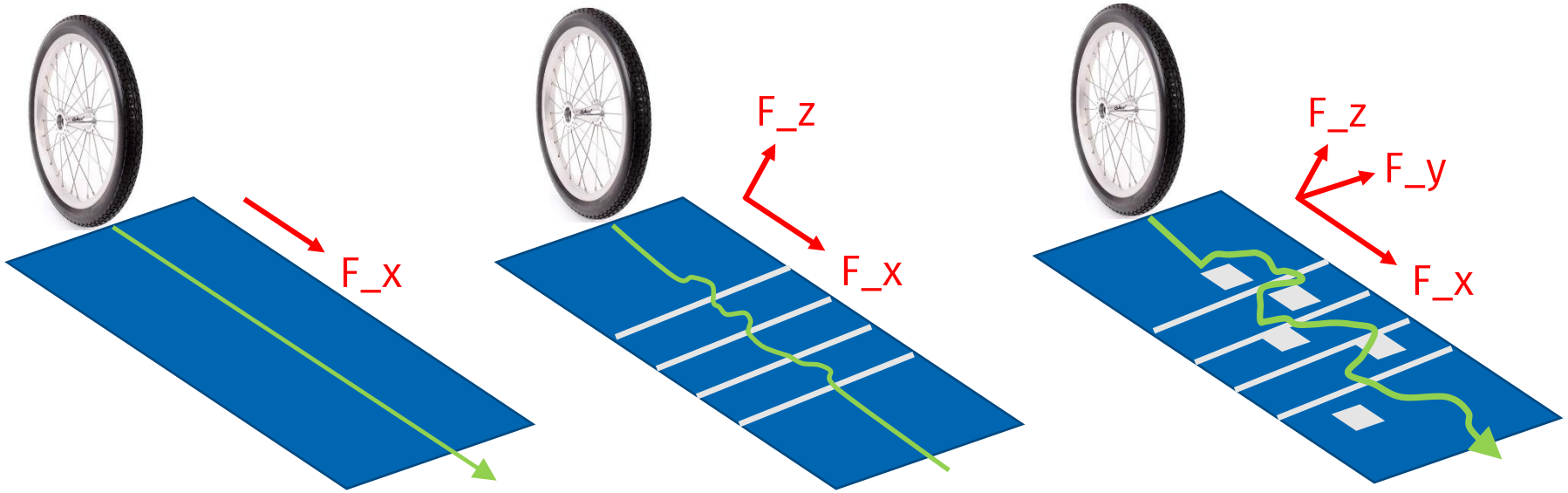
Acceleration



Combined acceleration

- Accelerations often occur simultaneously with different directions

Important for the selection of the right sensors



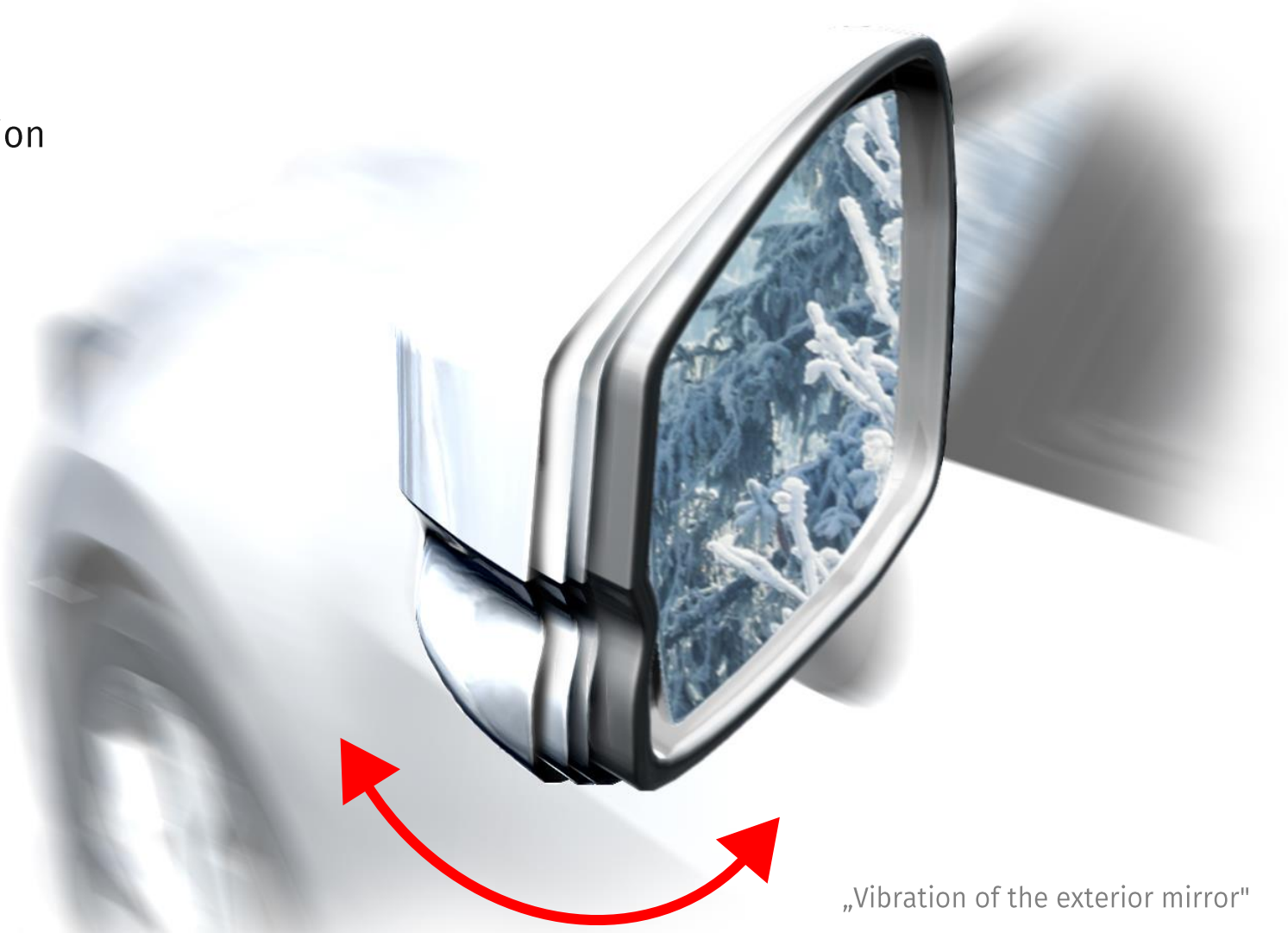
Acceleration

Acceleration is given in **g**, or in **m/s^2 (SI)**.

Motion	Approx. amount of acceleration
Bicycle ride	0.1 – 0.2 g
Driving a car	0.3 – 0.5 g
1,000 km above the earth's surface	0.74 g
100 km above the earth's surface	0.97 g
Mean value for the earth's surface	1 g
Racing car	3 – 4 g
Washing machine spin cycle	600 g
Sewing machine needle	Up to 6,000 g

Vibration

- In this case:
  - Repeated, persistent changes of direction



„Vibration of the exterior mirror"

What do I have to consider when measuring?

- The acceleration of a body can be measured with an accelerometer.
- How fast do I measure (selection of the correct measurement data rate)?

Investigation	Frequency
Vibrations e.g. printed circuit board	3 Hz – 2,000Hz
Structure-borne sound investigations	5 Hz – 30,000 Hz
Durability testing	0 Hz - 500 Hz
Airborne sound	20 Hz – 30,000 Hz

Sensor types for acceleration measurement

Typical values	Capacitive sensors
Measurement range	±50 g
Signal output	±2 V
Bandwidth	**0 Hz – 300 Hz**
Sensor power supply	10 V supply (4-6 wires)

Measurement of accelerations on vehicle parts

- Acceleration in a curve (Sustained constant lateral acceleration)
- Slow linear acceleration (Train, vehicle)
- Static angle determination (Tilting process)
- Force applied to a body (e.g. 800 liter tank of a truck attached to the frame)

Sensor types for acceleration measurement

Typical values	Capacitive sensors	Piezoresistive sensors
Measurement range	±50 g	±200 g
Signal output	±2 V	±1 mV
Bandwidth	0 Hz – 300 Hz	**0 Hz – 1,000 Hz**
Sensor power supply	10 V supply (4-6 wires)	5 V supply (4-6 wires)

Measurement of relative movements on vehicle parts

- Inside a module (e.g. bars in a battery)
- Chrash behavior of individual components (Position calculation)
- Force applied to a body (Dummy)

Sensor types for acceleration measurement

Typical values	Capacitive sensors	Piezoresistive sensors	IEPE - Sensors
Measurement range	±50 g	±200 g	±500 g
Signal output	±2 V	±1 mV	±100 mV ... ± 5 V
Bandwidth	0 Hz – 300 Hz	0 Hz – 1,000 Hz	**2 Hz – 20,000 Hz**
Sensor power supply	10 V supply (4-6 wires)	5 V supply (4-6 wires)	Power supply (2-wire)

Measurement of vibration frequencies

- Structure-borne sound (Sound radiation from the surface of a body)
- Airborne sound (Microphone)
- Vibrations (Vibration excitation)
- Natural frequencies (Printed circuit board, busbar, bracket)
- Shock (Knock sensor, contact)
- Contact stroke (Break-in, frame collision with component)
- Modal analysis (Model matching, damage analysis)

Which measurement device do I use?

▶ How fast do I have to measure?	Typical data rate 1 Hz... 100 kHz, max. 1 MHz
▶ How big is my signal voltage?	Measurement range ±3 mV... ±5 V
▶ Which sensor do I use?	IEPE, capacitive, piezoresistive
▶ Low voltage / High voltage	Limits : 60 V DC / 30 V AC
▶ Who may install and measure?	Observe regulations!

For voltages above 60 V DC and 30 V AC: **Observe HV regulations!**

Measurement chain for acceleration measurement (in environments up to 60 V)

- Each accelerometer requires a supply voltage

Suitable accelerometer

Sensor cable e.g. CSM K645
for IEPE sensors
with integrated TEDS

Measuring device

ECAT Measurement Modules on www.csm.de

Suitable measuring devices for accelerations (in environments up to 60 V)

Example: CSM CAN and ECAT measurement modules

- Various module types
  - Analog signal voltage (mV or V -range)
  - IEPE
  - Sensor supply
  - TEDS
- Sampling rates: up to 100 kHz (max. 1 MHz)
- Operating temperature range: -40 °C to +125 °C
- IP67

CAN measurement module
AD4 pro MC10

ECAT (EtherCAT®) measurement module
AD4 IE100

*Example measurement modules

Measurement chain for acceleration measurement (in environments up to 60 V)

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Suitable accelerometer

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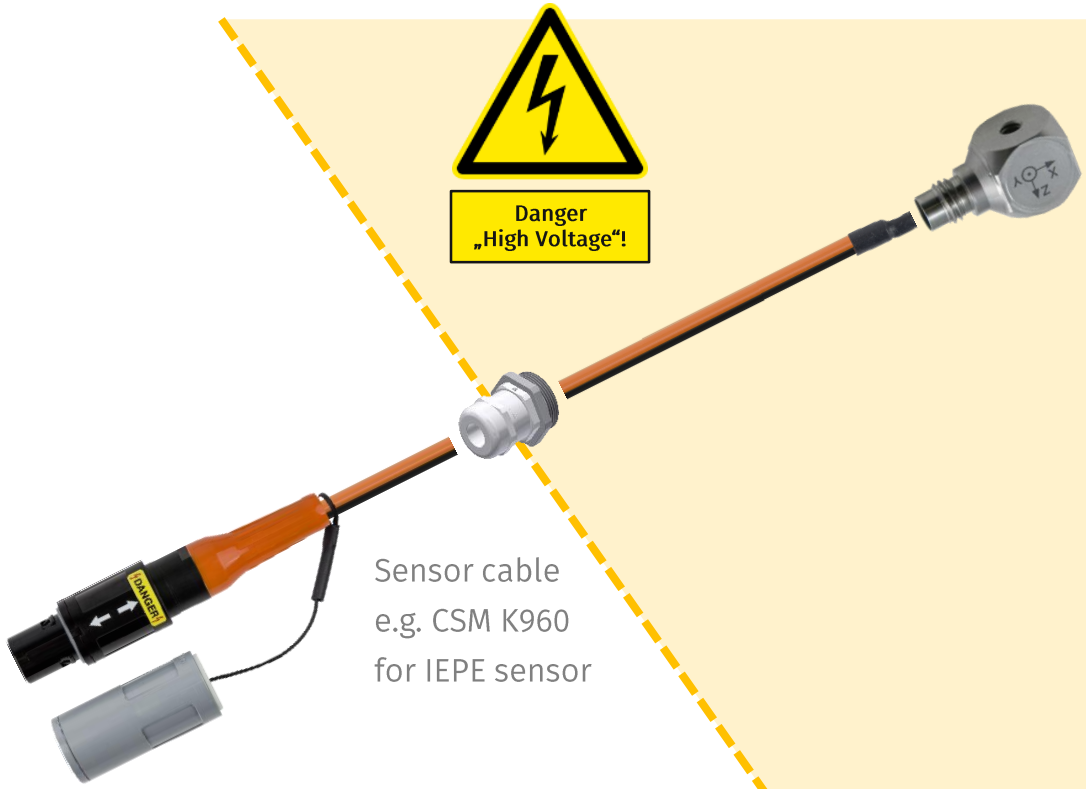
ECAT (EtherCAT®) measurement module
AD4 IE100

Measurement chain for acceleration measurement (in environments up to 1,000 V)

- Each accelerometer requires a supply voltage



Suitable accelerometer

Sensor cable
e.g. CSM K960
for IEPE sensor

Measuring device

HV safe Measurement Modules on www.csm.de

Suitable measuring devices for accelerations (in environments up to 1,000 V)

Example: CSM HV CAN and HV ECAT AD measurement modules

- Signal voltages from µV to V
- Sampling rates: up to 100 kHz
- Operating temperature range: -40 °C to +125 °C
- IP67
- TEDS

HV ECAT measurement module
HV STG4 pro BS20

HV ECAT measurement module
HV IEPE3 FL100

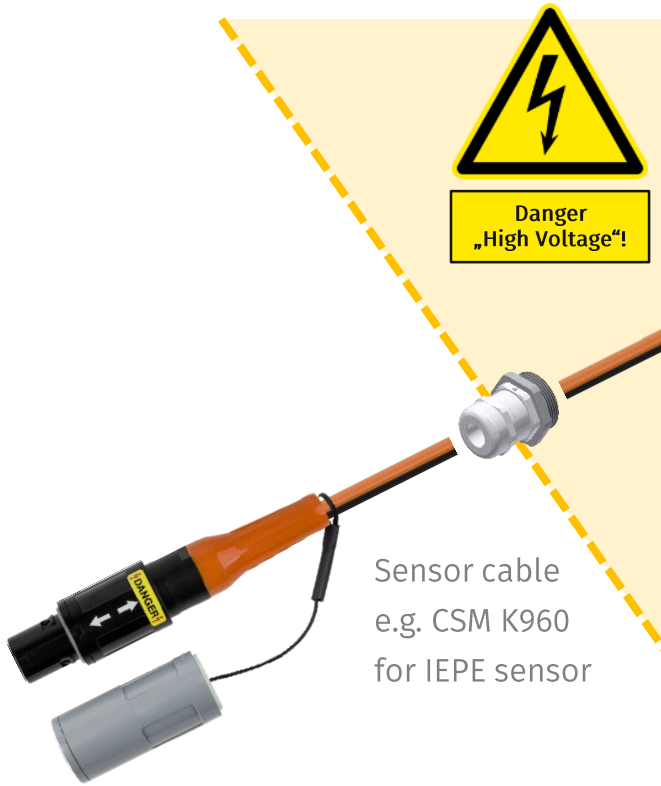
- HV-safe connector
- Mechanical connector guide for tightness and bend protection
- Reinforced insulation
- Type-tested according to safety standard EN61010 by accredited test laboratory
- Unit test with certificate
  - 3,100 V ramp 5 sec each

*Example measurement modules

Measurement chain for acceleration measurement (in environments up to 1,000 V)

- Each accelerometer requires a supply voltage

HV ECAT measurement module
HV IEPE3 FL100



Sensor cable
e.g. CSM K960
for IEPE sensor

Suitable accelerometer

HV-safe use of sensors from the low-voltage environment in HV environments.

Applications: Vibration measurement on busbars

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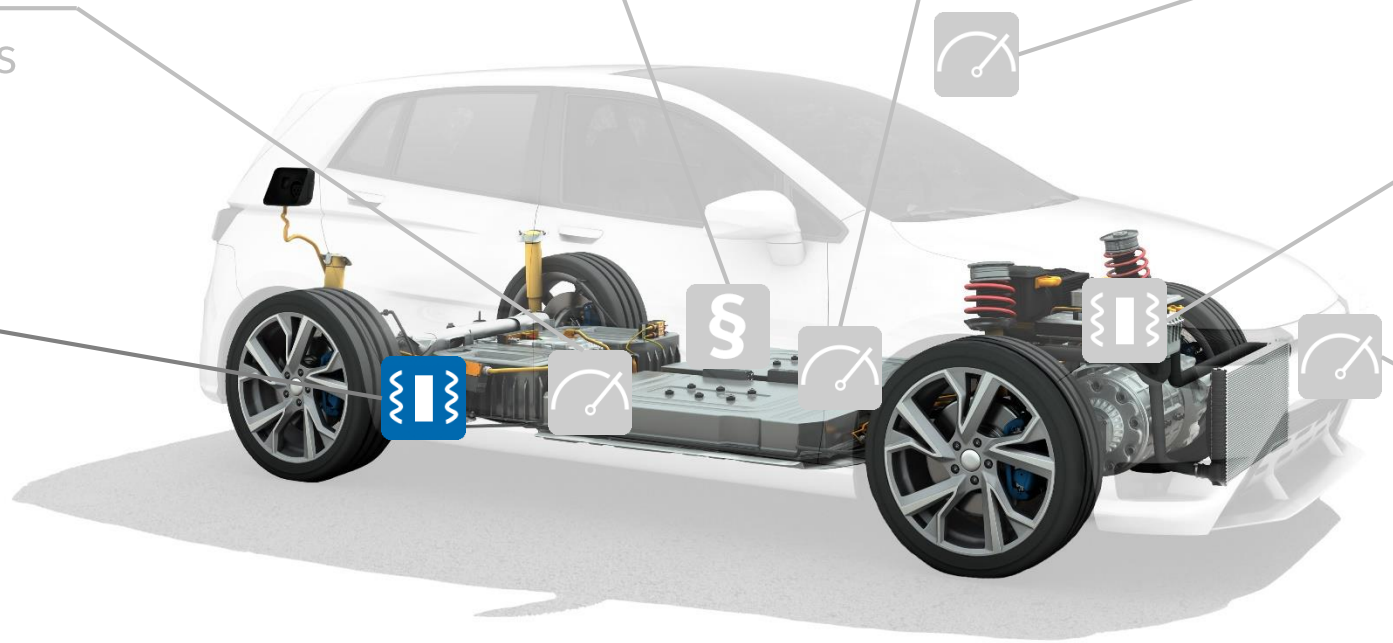

Crash test

Applications: Vibration measurement on busbars

- Battery modules are mounted individually and have a **relative movement to each other**.
- The busbar is thus subject to corresponding vibrations.
- In extreme cases, these can lead to a crack in the busbar and thus to a failure of the battery.

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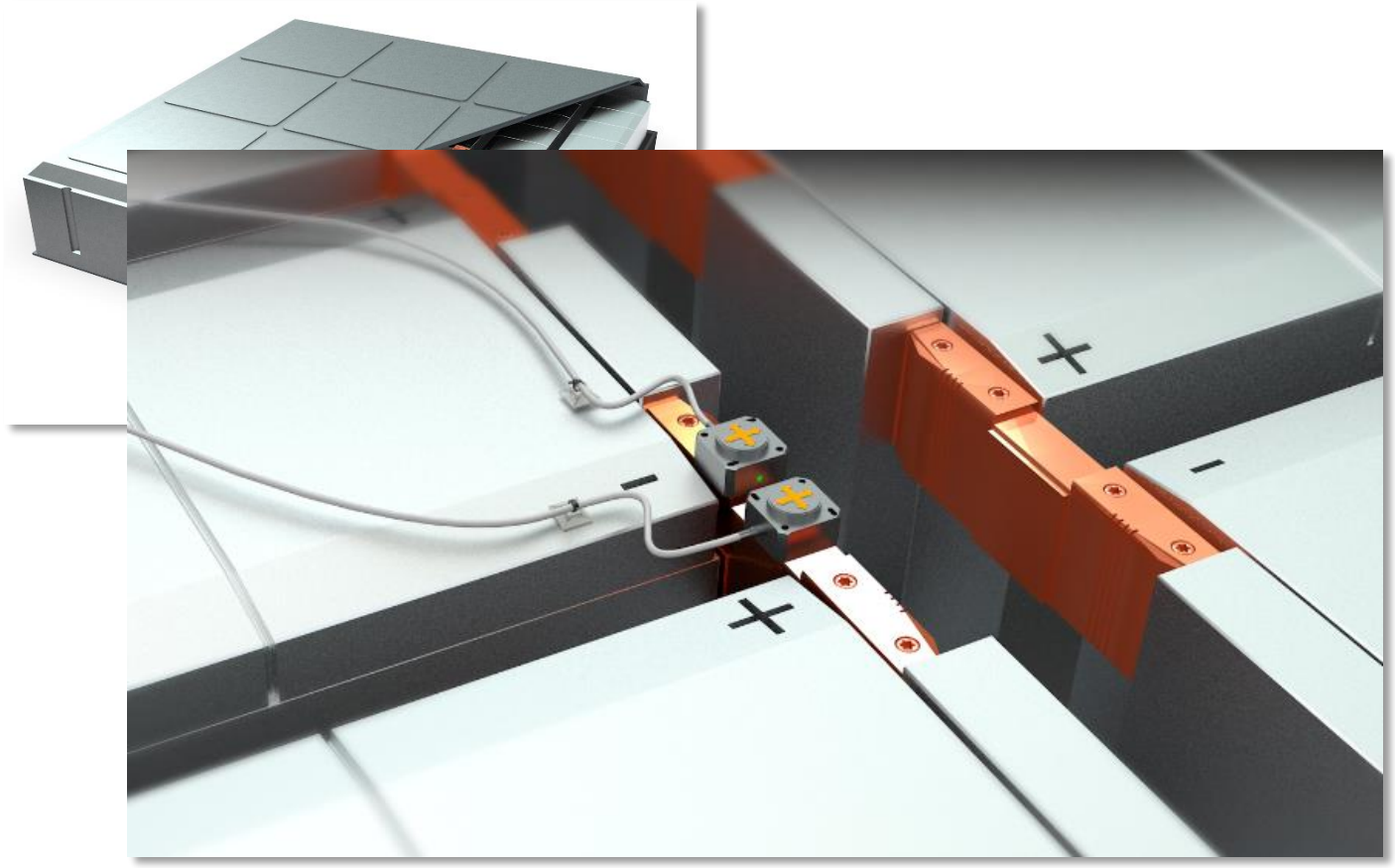
- **HV-safe acceleration measurement required.**



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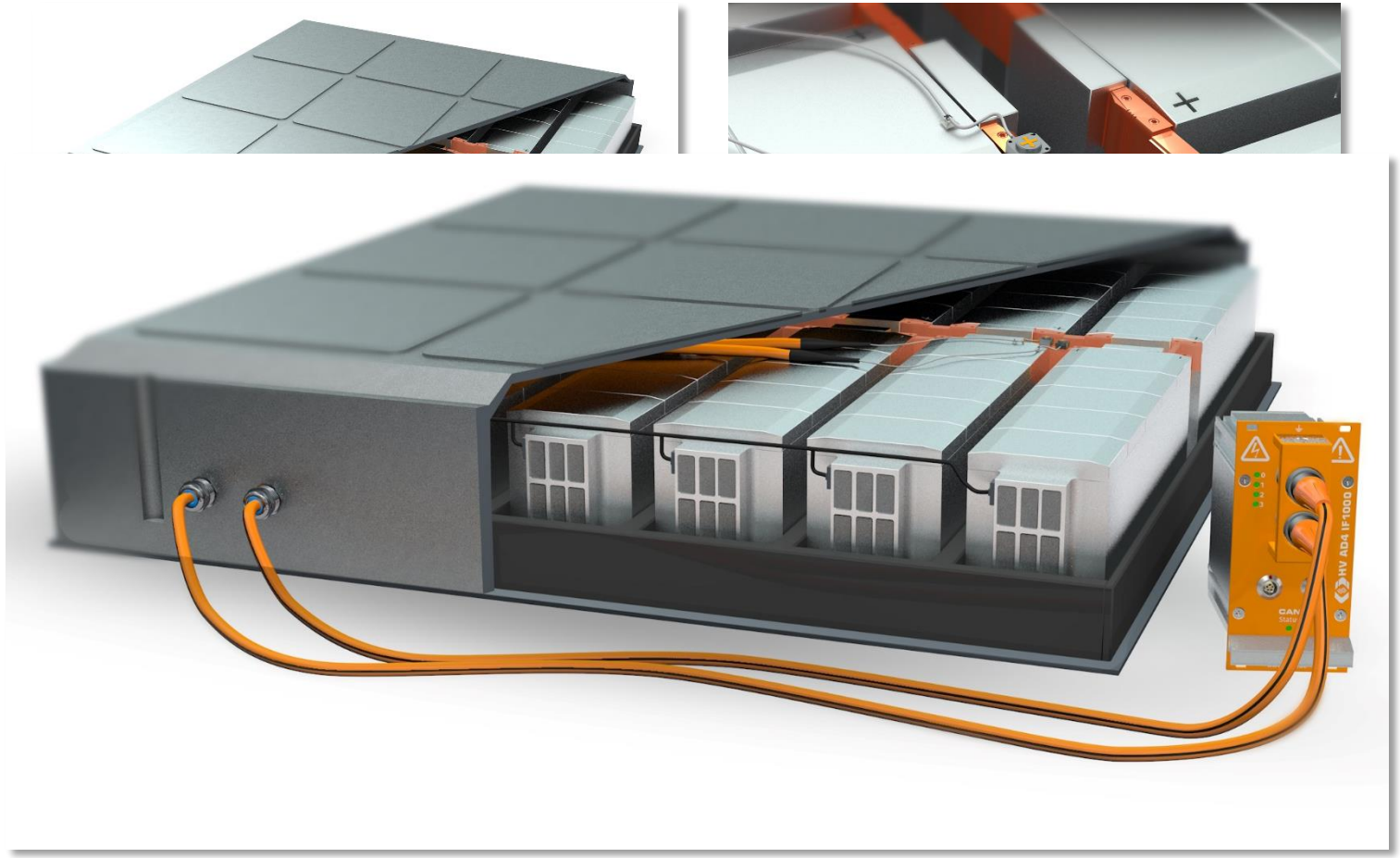

Applications: Vehicle on the bad road

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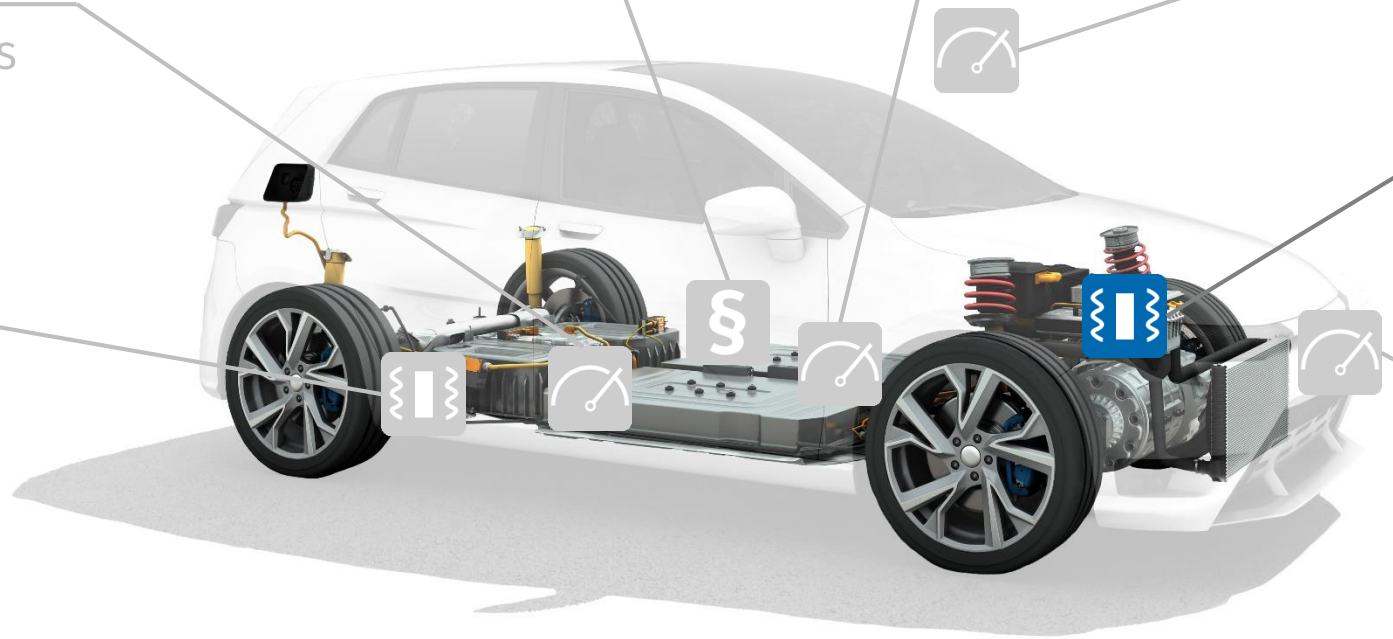
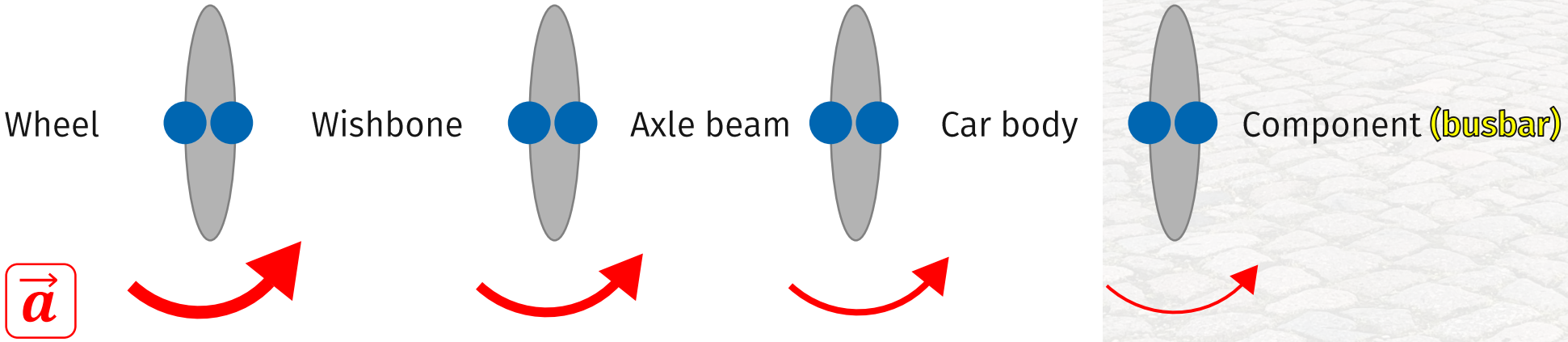


Applications: Vehicle on the bad road

- Bad road driving
- Measurement of vibration transmission paths from the wheel to the busbar



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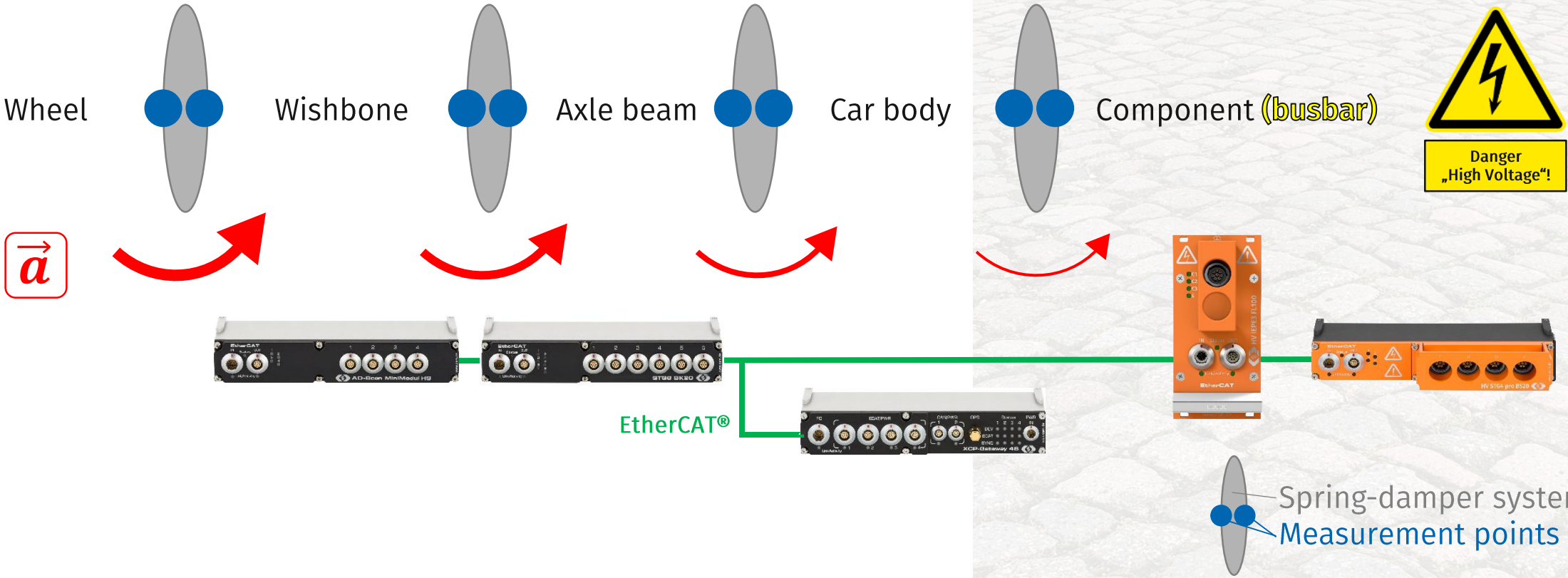

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- Bad road driving
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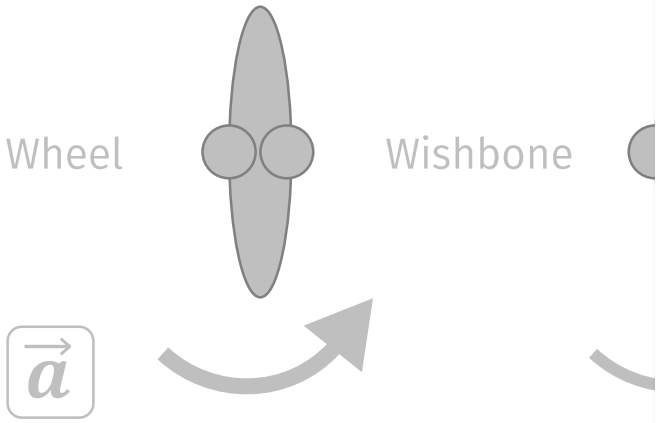
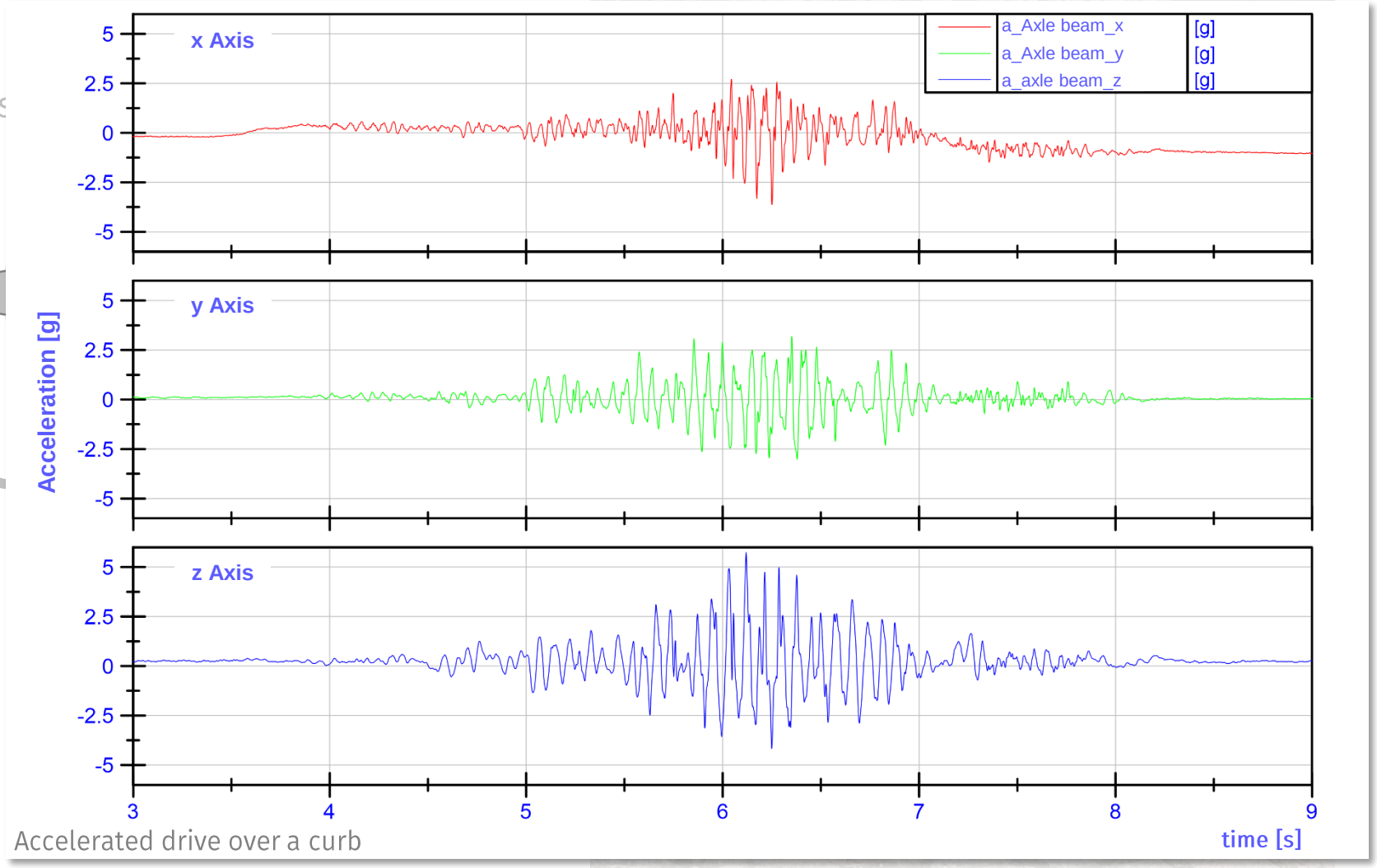
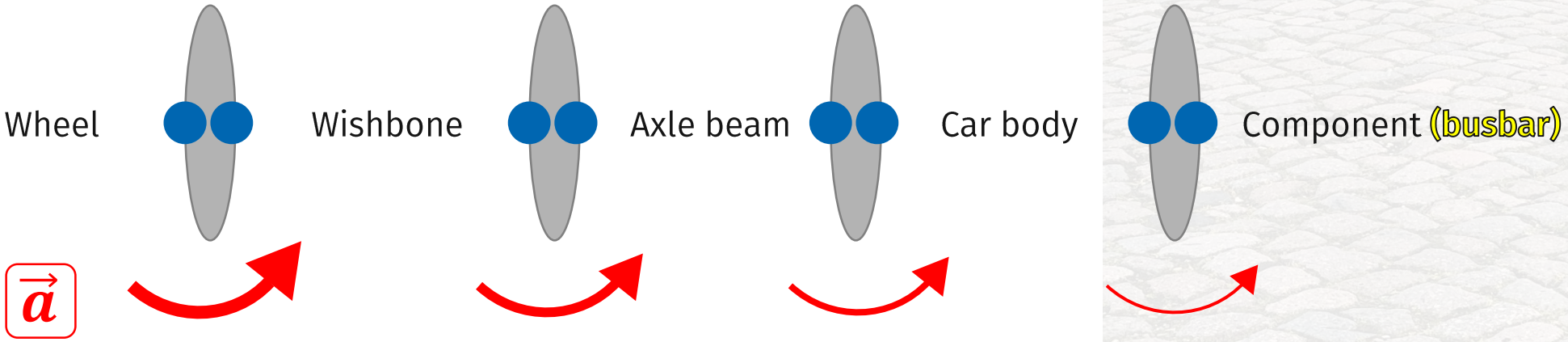




Accelerated drive over a curb

Applications: Vehicle on the bad road

- Bad road driving
- Measurement of vibration transmission paths from the wheel to the busbar



- **Gathering of a load level**

Applications: HV battery drop test

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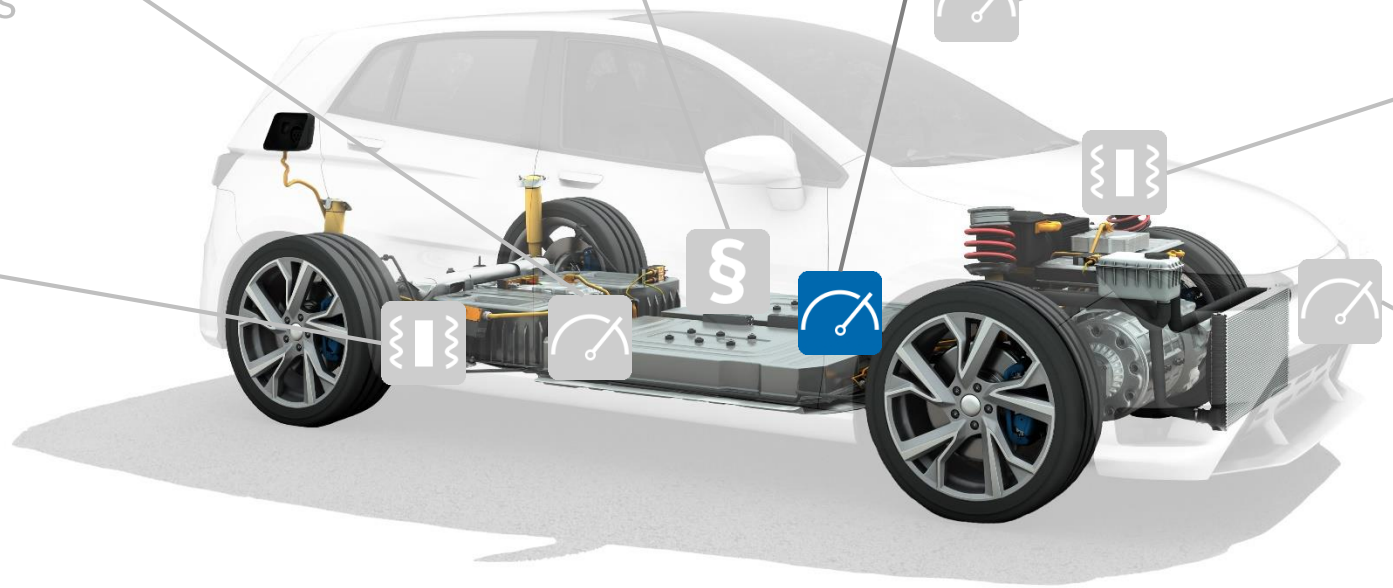


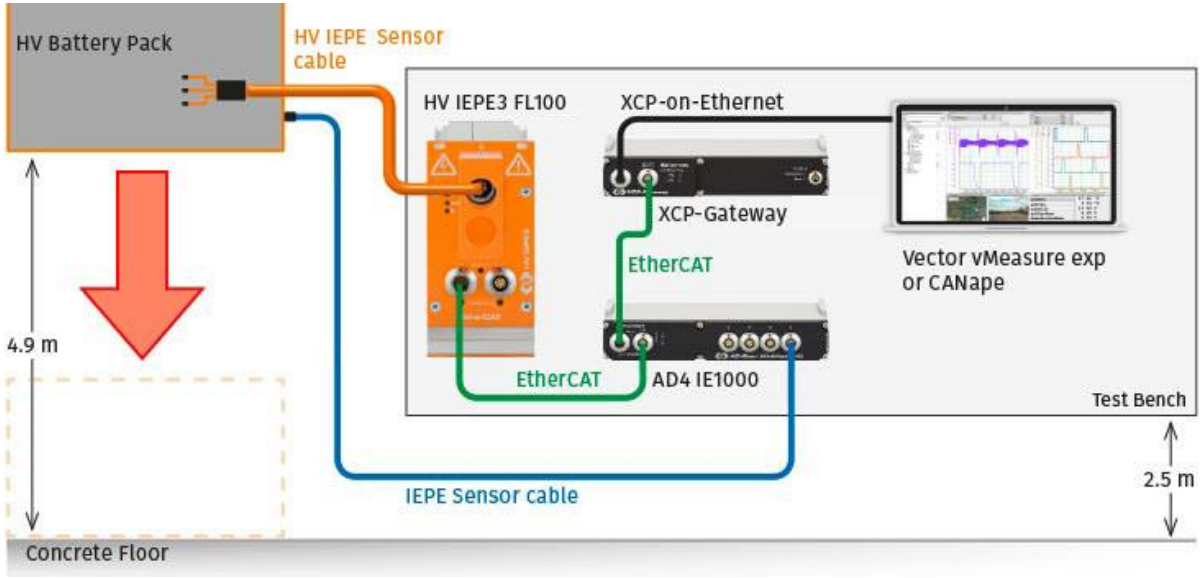
Application Example on www.csm.de

Applications: HV battery drop test

"Korea Motor Vehicle Safety Standard" (KMVSS)

This standard requires that the battery pack (with a state of charge of 80%) hits a concrete floor from a height of 4.90 meters.

A combined measurement with sensors inside and outside the HV environment is necessary.



Acceleration measurements in e-mobility

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Signal output	±2 V	±1 mV	±100 mV ... ±5 V
Bandwidth	**0 Hz – 300 Hz**	**0 Hz – 1,000 Hz**	**2 Hz – 20,000 Hz**
Sensor power supply	10 V supply (4-6 wires)	5 V supply (4-6 wires)	Power supply (2-wire)

Suitable measurement technology for different sensor types:

Conventional and HV-safe.

About CSM

CSM has been setting technological standards for decentralized measurement technology in vehicle development for over 35 years. Our CAN bus and EtherCAT® measurement devices support worldwide renowned vehicle manufacturers, suppliers and service providers in their developments.

Continuous innovation and long-term satisfied customers are our guarantee for success. Together with our partner Vector Informatik, we have developed an easily scalable and powerful E-Mobility Measurement System for hybrid and electric vehicles and are constantly expanding the areas of application. With our high-voltage safe measurement systems designed for fast and synchronous measurements and power analyses, we actively accompany the change to E-Mobility.

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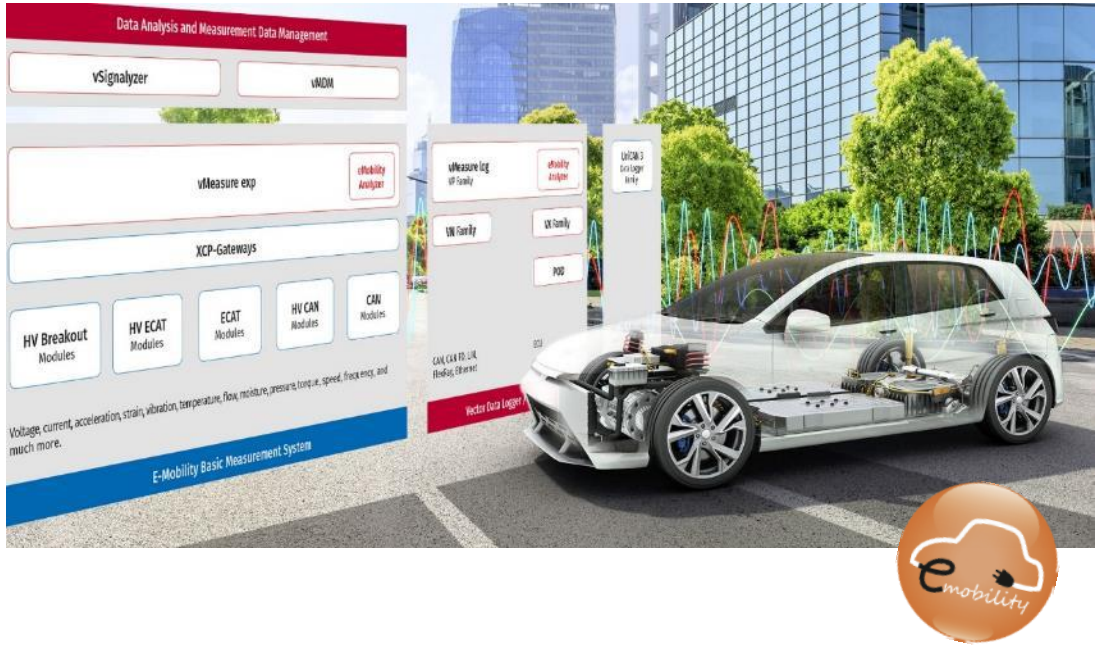

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