VECTOR CSM
TECHDAY
2023 GRAZ

Strom-, Spannungs- und Leistungsmessung

CSM

Solutions for Safe Measurements of

Temperature

- Thermocouples
- High precision RTD sensors

Physical signals with standard sensors

- Humidity, pressure, acceleration, vibration, strain

Voltage and current

- V up to ±20 V for sensors, ±90 V for cells
- V up to 1 kV working voltage and
  up to 2 kV for spikes/transients
- I with precise Hall effect sensors or flux gates or
  CSM HV BM up to ±1 kA nominal and ±2 kA for spikes

CSM's HV-safe voltage measurements

Examples 1

HV AD4 XW1000

- To measure up to 4x U
- Up to ±1000 V,
  ±2000 V for spikes
- ECAT up to 1 MS/s

HV AD2 IF20

- To measure up to 2x U
- up to ±20 V
- + sensor supply voltage
- CAN up to 20 kS/s

CSM's HV-safe voltage measurements

Examples 2

HV AD4 XW4000

- To measure up to 4x U
- up to ±1000 V,
  ±2000 V for spikes
- XCPoE up to 4 MS/s

HV AD8 OW20

- To measure up to 8x U
- up to ±90 V
- CAN up to 20 kS/s

CSM's Current Clamp

CSM Current Clamp

- To measure one current
- ±20 A .. ±1000 A
  - Analogue output ±2 V
  - DC-supply 10 V .. 30 V

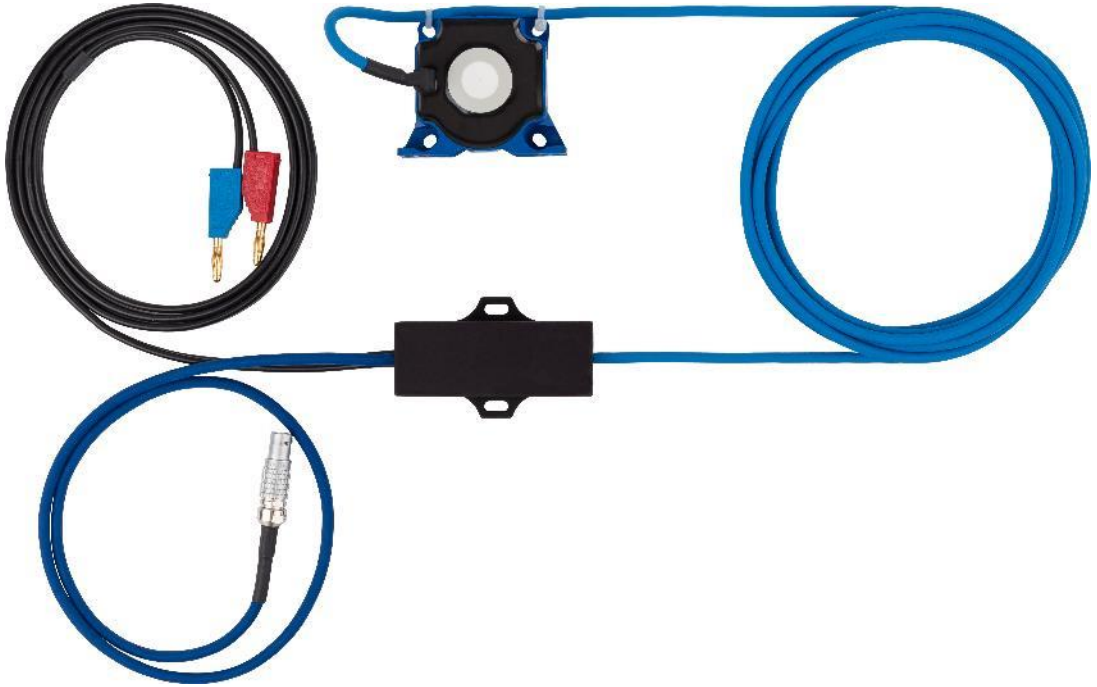
AD4 IG1000

- To measure 1 .. 4 voltages

CSM's LEM Sensor Package

LEM Sensor Package

- To measure one current
- ±5 A .. ±1250 A
  - Analogue output ±5 V
  - DC-supply 9 V .. 36 V
- Loop is potted



AD4 IG1000

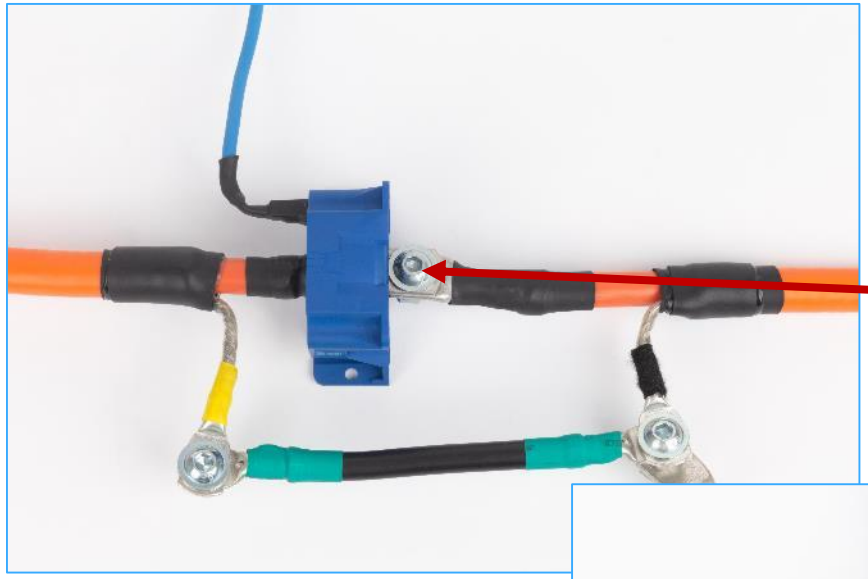
- To measure 1 .. 4 voltages

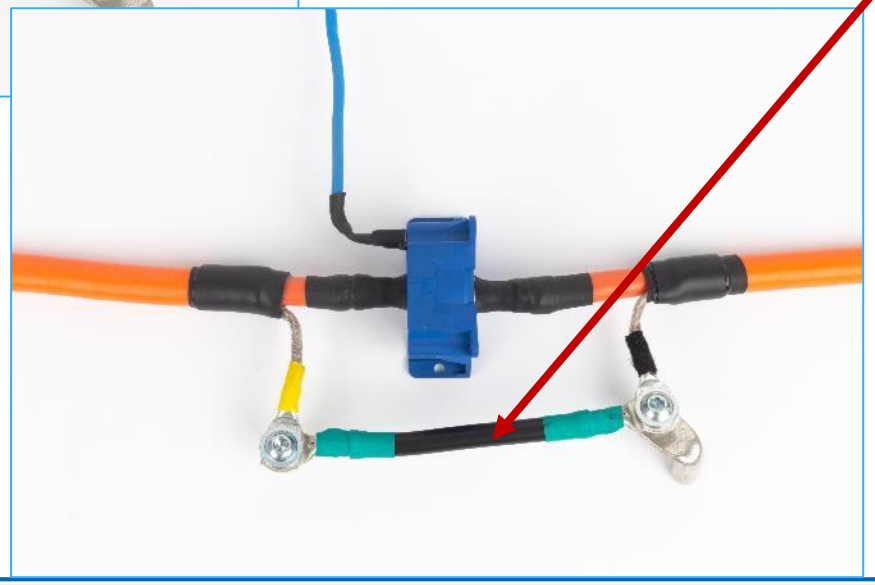
Installation of a closed loop sensor on an HV-cable

Shielded Cable

- Sensor measures the sum of the inner current and the shield current
- Shield has to be routed around the sensor
- Cable should be centered
- Set-up should be in enclosure

Installation of a closed loop sensor on an HV-cable





Shielded Cable, connector too big

- Connector does not fit through closed loop
- Joint needs to be in cable
- Shield has to be routed around the sensor

CSM HV Measurement Modules - active Breakout Modules

HV Breakout Modules (BM) for in vehicle testing and dynamometer measurements

- Safe measurement of voltages up to ±2 kV
- Safe measurement of currents up to ±2 kA
- CAN and ECAT output, up to 1 MHz
- Comprising 1 or 3 shunts

HV BM 3.1

HV BM 1.1

HV BM 1.2

CSM HV Breakout Modules to measure I and V and to calculate P

Shunts are calibrated inserts

- Adaption to current range
- Calibration data stored on shunt PCB
- Temperature compensation

HV BM 1.1
=
1 shunt
1 gland

CSM HV Measurement Modules - Special Versions

HV Breakout Modules (BM) for in vehicle testing and dynamometer measurements

- HV BM 1.x+ U to measure balance/isolation of battery

  U (HV+ -> HV-)

  U (HV+ -> PA)

  U (HV- -> PA

HV BM 1.1 +U

HV BM 1.2 +U

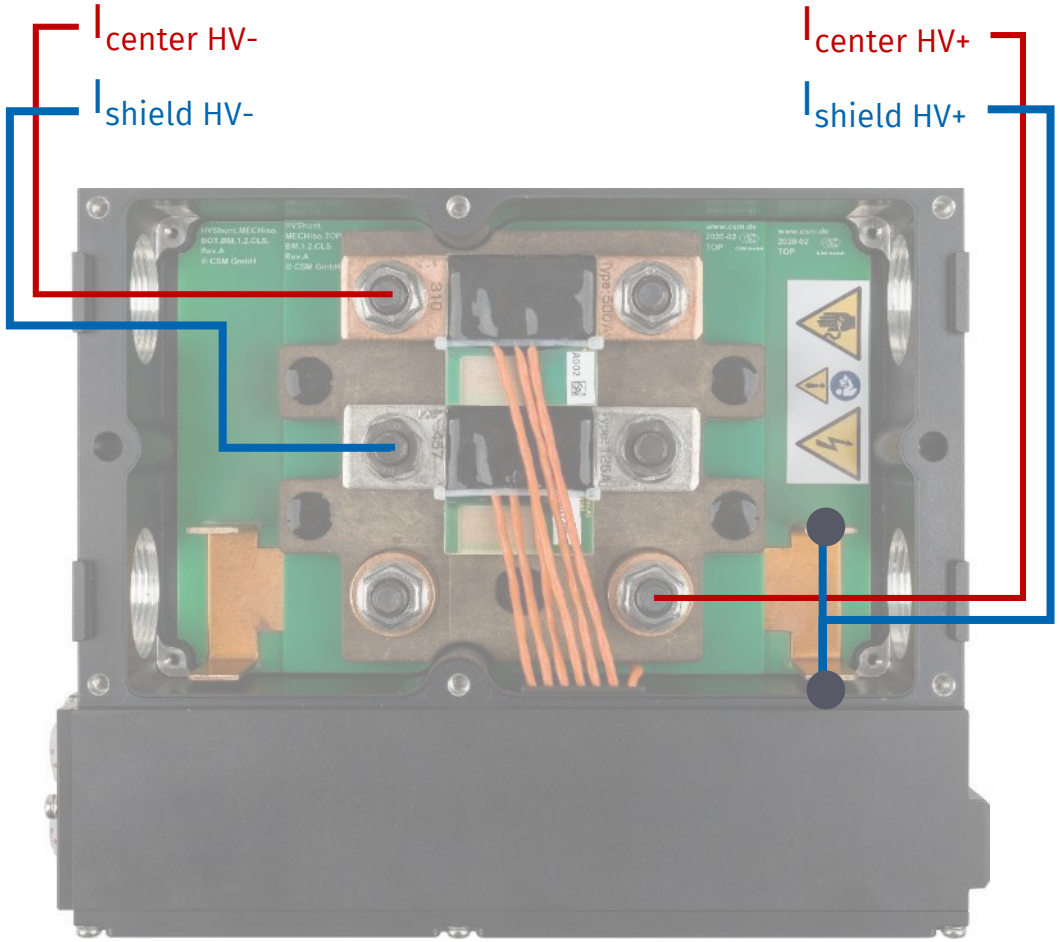
PA / PE

CSM HV Measurement Modules - Active Breakout Modules

HV Breakout Module HV BM 1.2 +S

to measure shield current and center current

- Shield is isolated from enclosure



CSM HV Measurement Modules - Active Breakout Modules

HV BM 3.3 to measure 3 lines simultaneously

- Up to ±1400 A, up to ±2000 V
- 3 voltages -> 3 line voltages

XCP-port and ECAT-port

- Sending rate up to 2 MHz of 3xI + 3xU
- Up to 12 MS/s (6 channels, 2 MHz each)
- Plus 4 MS/s from ECAT

Plus one CAN-port

- Up to 1 Mbit/s for CSM-Modules

HV BM 3.3

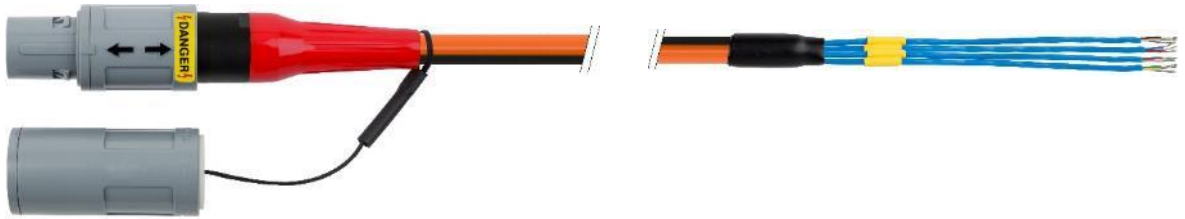
HV BM 3.3C

Accessories for HV measurements of U, I

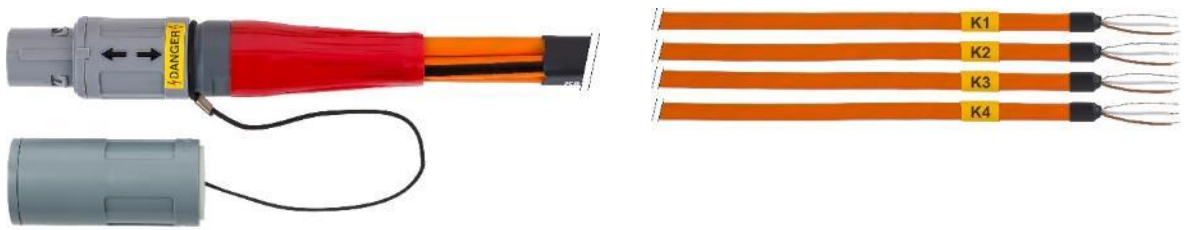
Plug-in solutions for Breakout Modules

HV CA HVR200 + HV BM 1.2 + OEM HV cable

Measure up to 4 voltages in one HV-enclosure, K910



Measure up to 4 voltages in different HV-enclosures, K913



System Setup: HV BM vs CSM's LEM Sensor Package

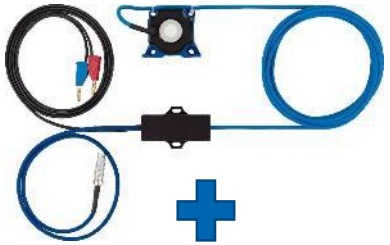
LEM Sensor Package to measure current

- Connector of HV-cable does not fit through the loop
- => Connector has to be disassembled or HV-cable has to be cut
- Shield has to bypass the sensor
- => HV-safe enclosure is needed

HV AD4 XW 1000 to measure voltage

- Tap into HV-cable to get contact
- => HV-safe enclosure is needed

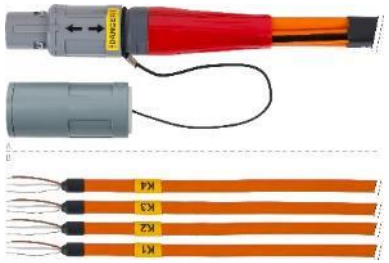
LEM Sensor Package
1 .. 4 pcs => 1 .. 4 x I



AD4 IG1000
1 pce => 1 .. 4 x I

HV AD4 XW 1000
1 pce => 1 .. 4 x U

K913
1 pce => 1 .. 4 x U



System Setup: HV BM vs CSM's LEM Sensor Package

HV BM to measure current and voltage

- Shield is routed internally
- HV-safe enclosure

HV BM 1.2
1 pce => 1 x I, 1 x U

LEM Sensor Package
1 .. 4 pcs => 1 .. 4 x I

AD4 IG1000
1 pce => 1 .. 4 x I

HV AD4 XW 1000
1 pce => 1 .. 4 x U

K913
1 pce => 1 .. 4 x U

LEM Sensor Package vs HV BM measuring shield current

LEM Sensor Package + HV AD4 XW1000

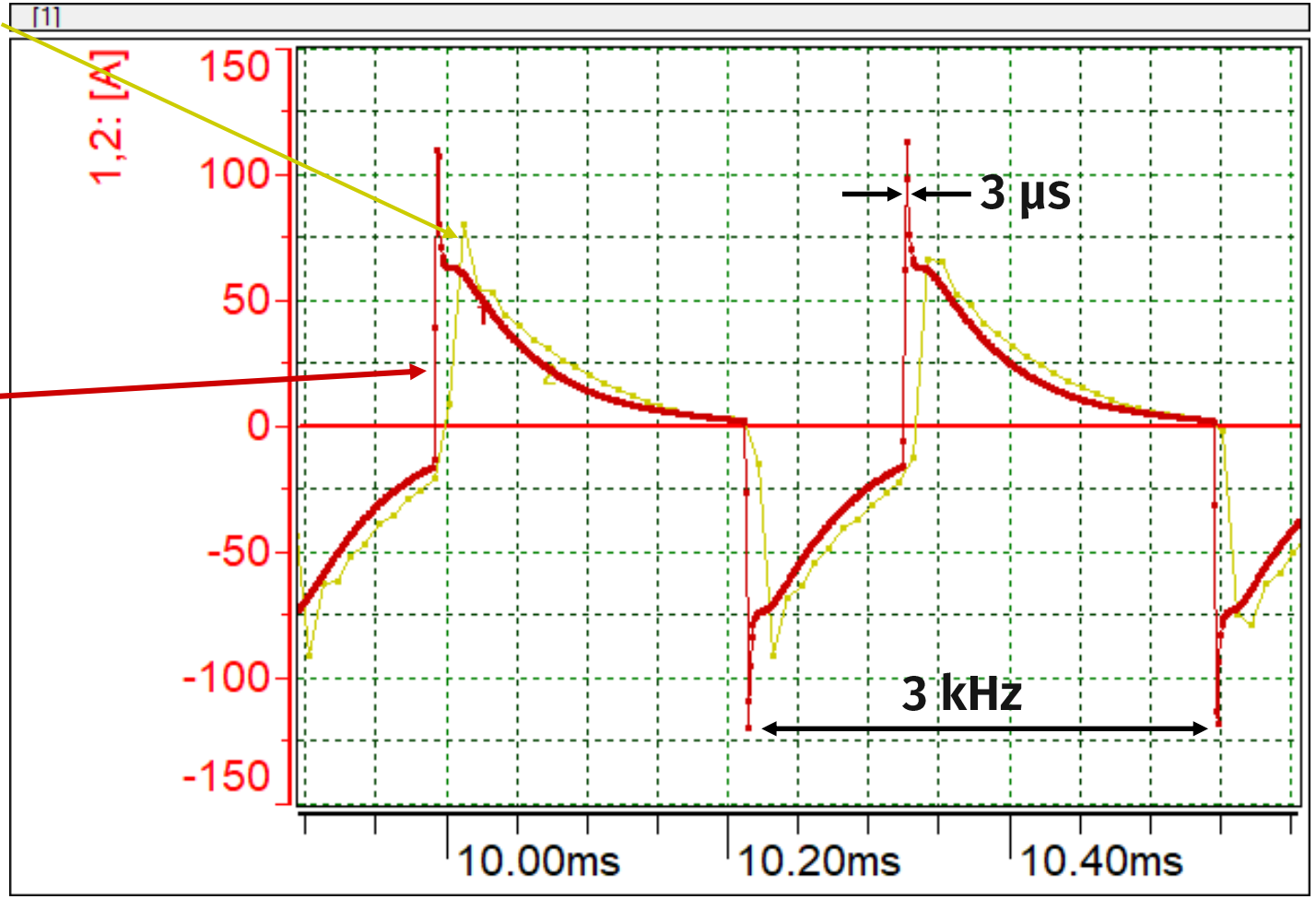
- Bandwidth for U >> 300 kHz
- Bandwidth for I ~ 100 kHz
- Bandwidth of I too small to resolve spikes
- Delayed current signal

HV BM

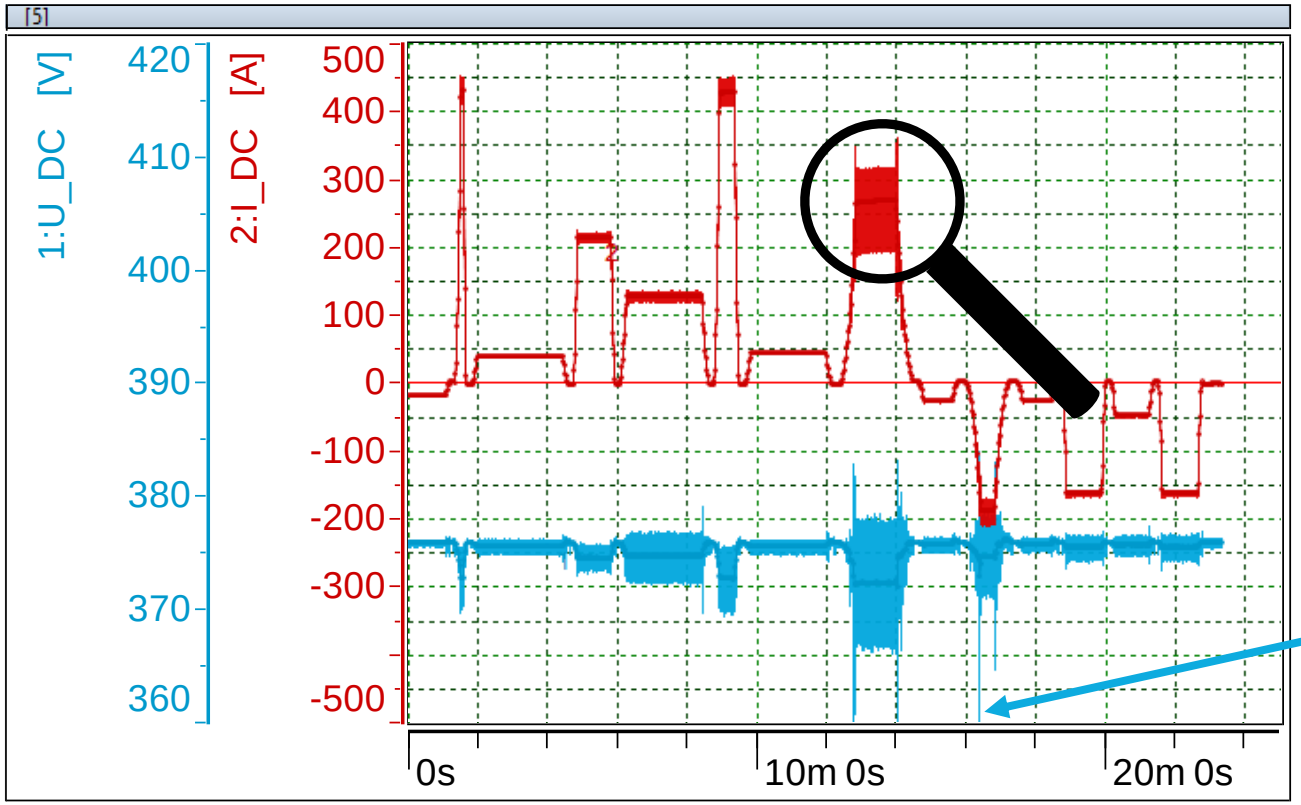
- Bandwidth for I and U > 200 kHz

Measured current maxima on shield:

- I_{min}: LEM = -91 A | HV BM -120 A



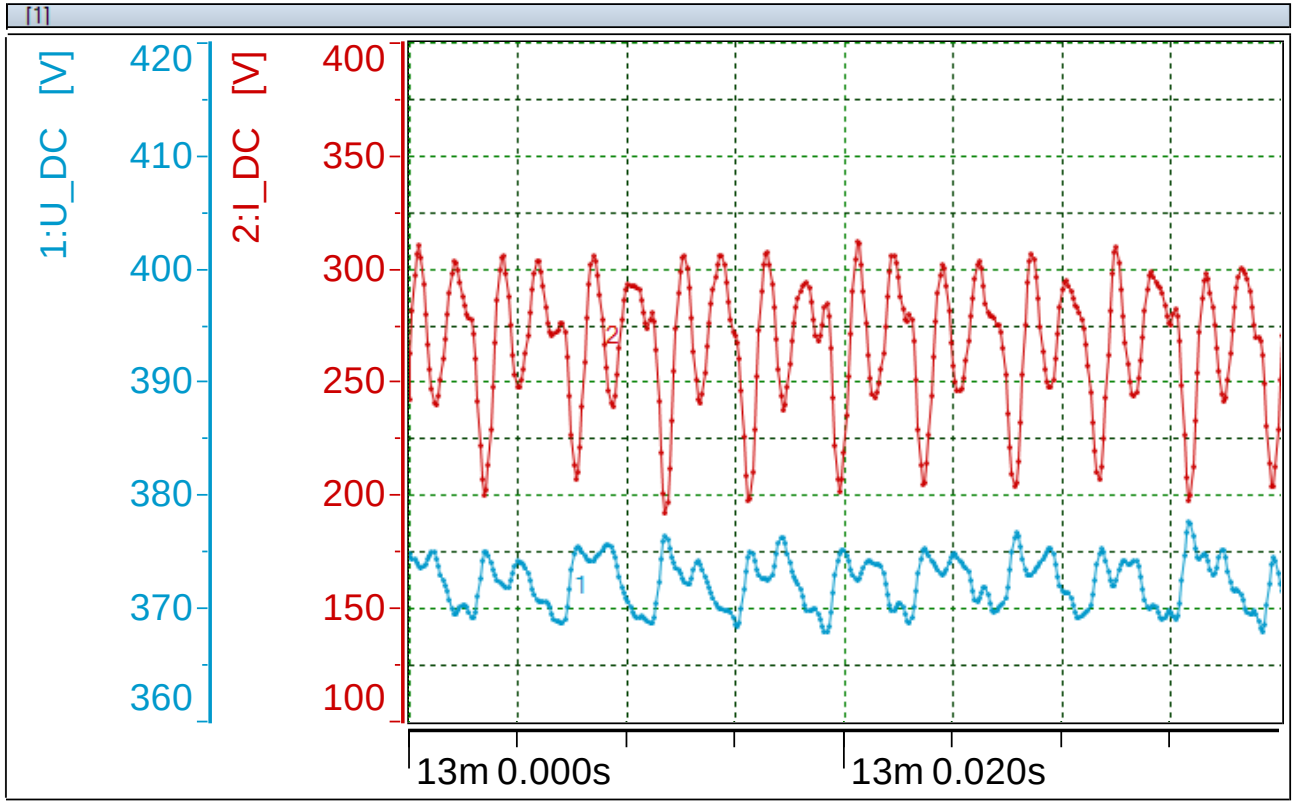
DUT: Electric Axle, HV BM 1.2, Measured Current and Voltage



- Test cycle
- Different load situations
- Driving (I > 0 A)
- Regenerative braking (I < 0 A)

Too large ripple of U_{pp} > 20 V

DUT: Electric Axle, HV BM 1.2, Measured Current and Voltage

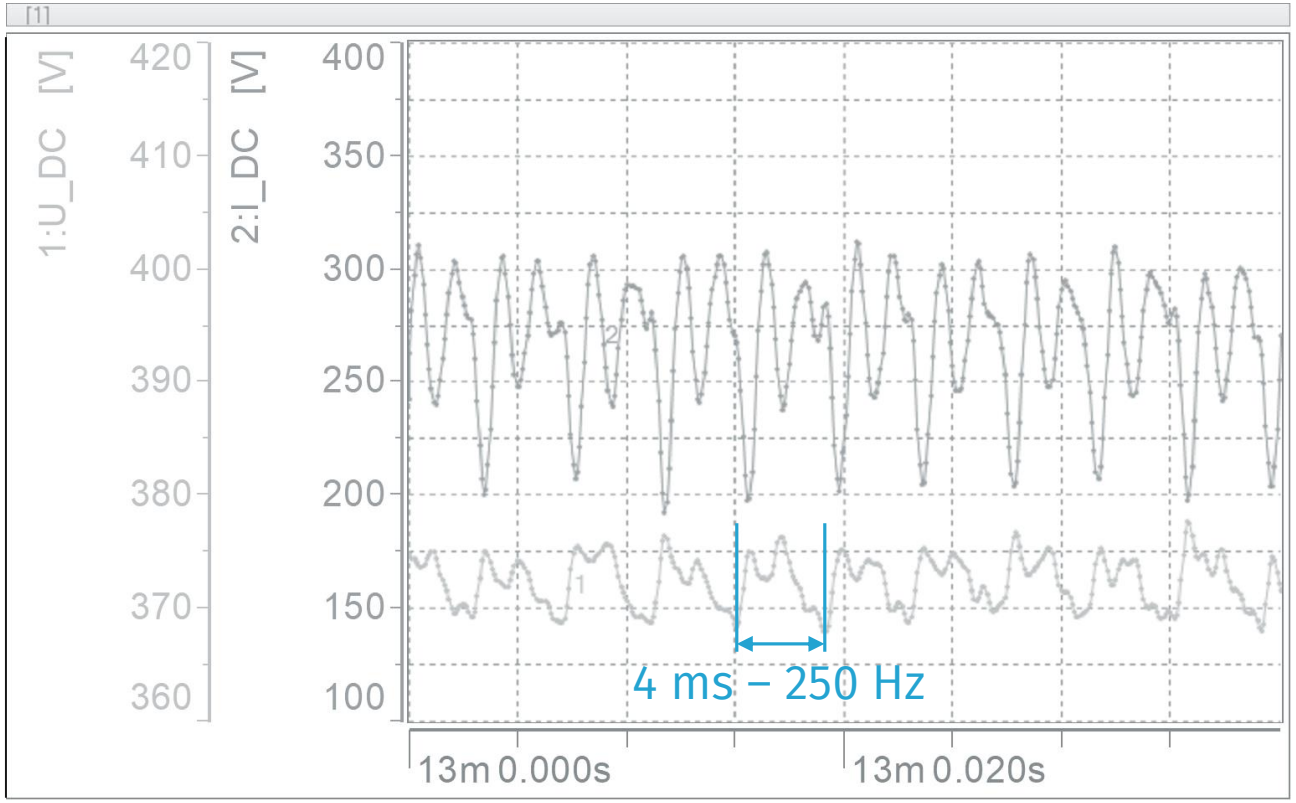


@ P_{el} ~ 100 kW

- Large ripple of I
- Acceptable ripple of U here
  - ISO/DIS 21498-1 and 21498-2

- I_{dc} = 268 A
- I_{min} = 195 A
- I_{max} = 312 A
- I_{pp} = 117 A
- U_{dc} = 372 V
- U_{min} = 368 V
- U_{max} = 377 V
- U_{pp} = 9.5 V

DUT: Electric Axle, HV BM 1.2, Measured Current and Voltage



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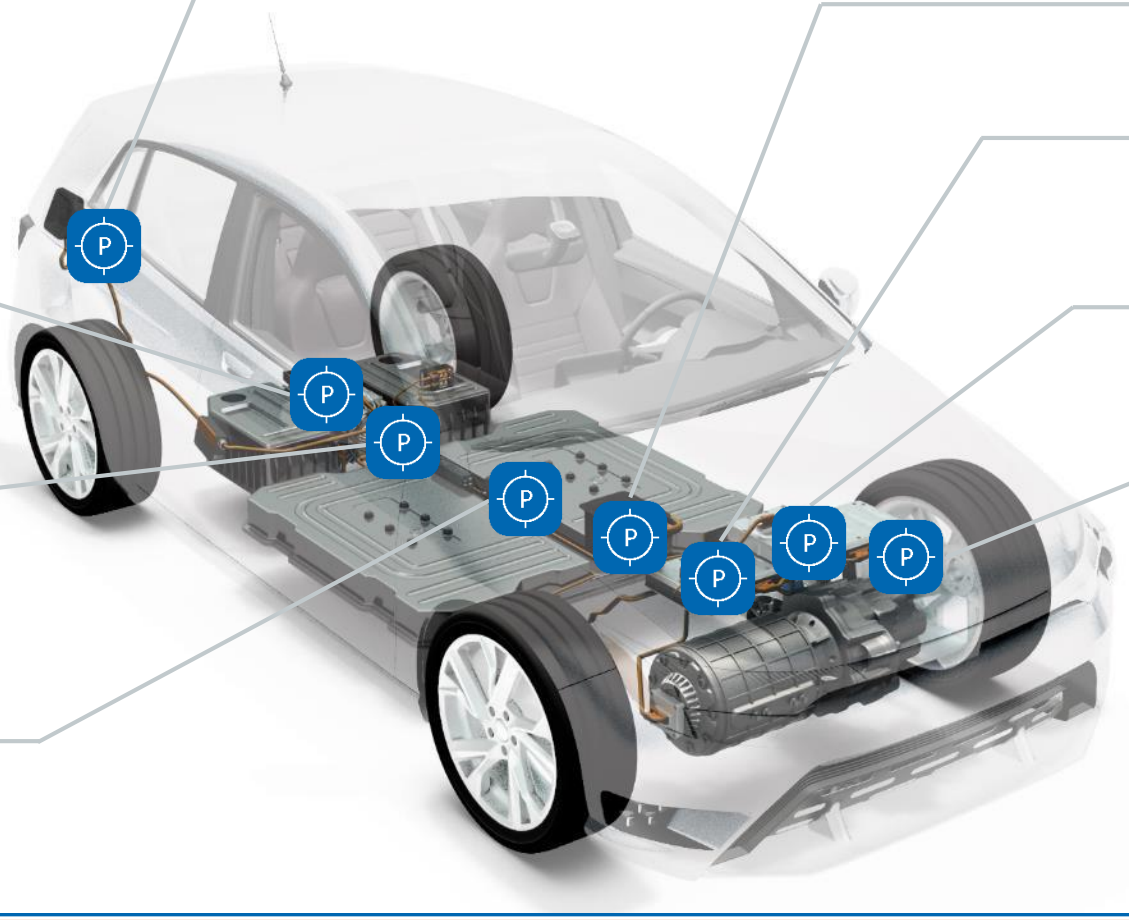
Basics Electrical Power

Electrical power	$P = U \times I$	Direct current (DC)
Instantaneous power	$p(t) = u(t) \times i(t)$	
Active power	$P = \frac{1}{T}\int_0^T u(t) \times i(t)dt$	
Active power	$P = \frac{1}{N}\sum_{n=0}^{N} u_n i_n \Delta t$	
Active power	$P = U_{rms} \times I_{rms} \times \lambda$	Alternating current (AC)
Apparent power	$S = U_{rms} \times I_{rms}$	Total apparent power
Power factor	$\lambda = \frac{\lvert P \rvert}{S}$	Any curve shape
Power factor = Displacement factor	$\cos\varphi = \frac{\lvert P \rvert}{S}$	Sinusoidal signal
Reactive power	$Q = \sqrt{S^2 - P^2}$	Total reactive power

Power measurements



Charging system

HV/LV DC/DC Converter

Powertrain

Electric heater

Electric motor

Electric water pump

DC/AC Inverter

AC Compressor

Additional consumers

HV battery

CSM HV Measurement Modules - active Breakout Modules

HV Breakout Modules (BM) for in vehicle testing and dynamometer measurements

- Safe measurement of voltages up to ±2 kV
- Safe measurement of currents up to ±2 kA
- CAN and ECAT output, up to 1 MHz
- Comprising 1 or 3 shunts

HV BM 3.1

HV BM 1.1

HV BM 1.2

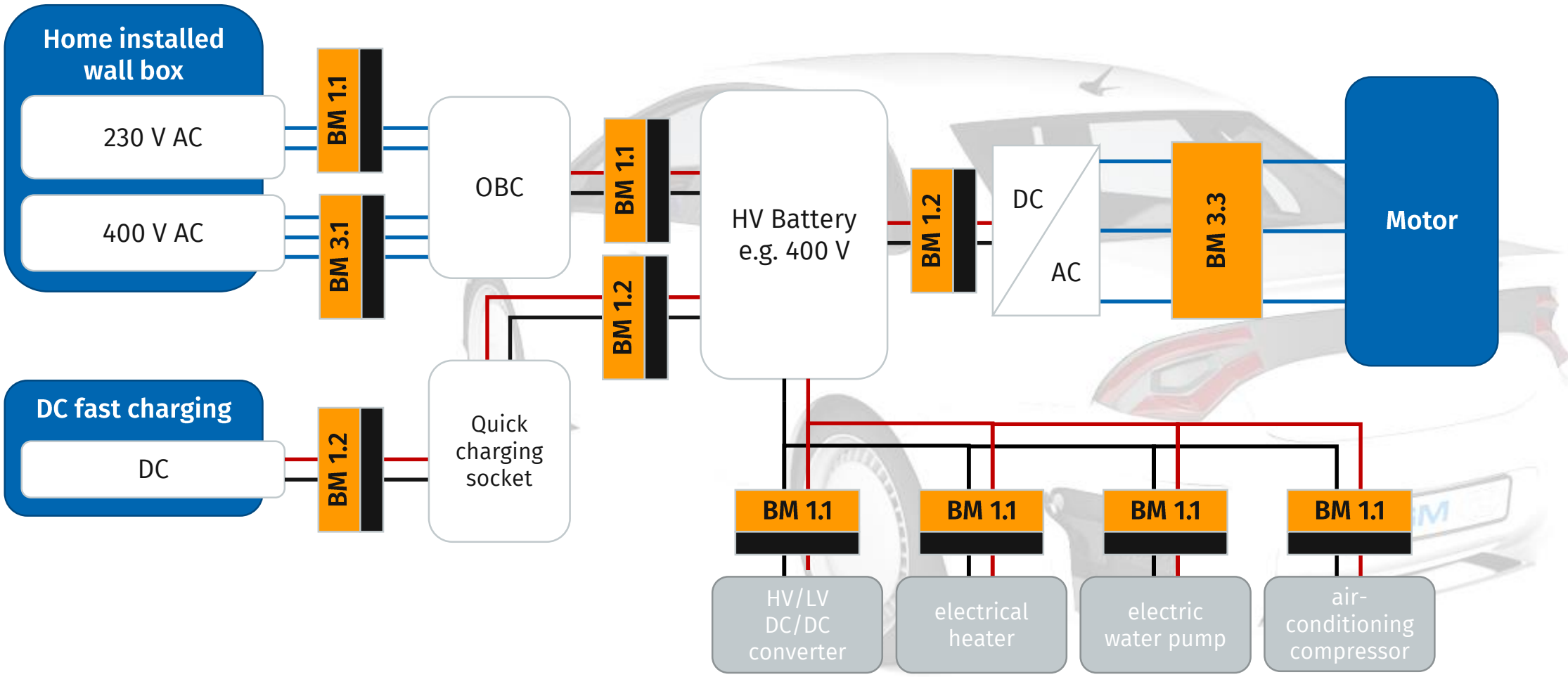
CSM HV Breakout Modules to Measure I and V and to Calculate P

Various breakout modules available

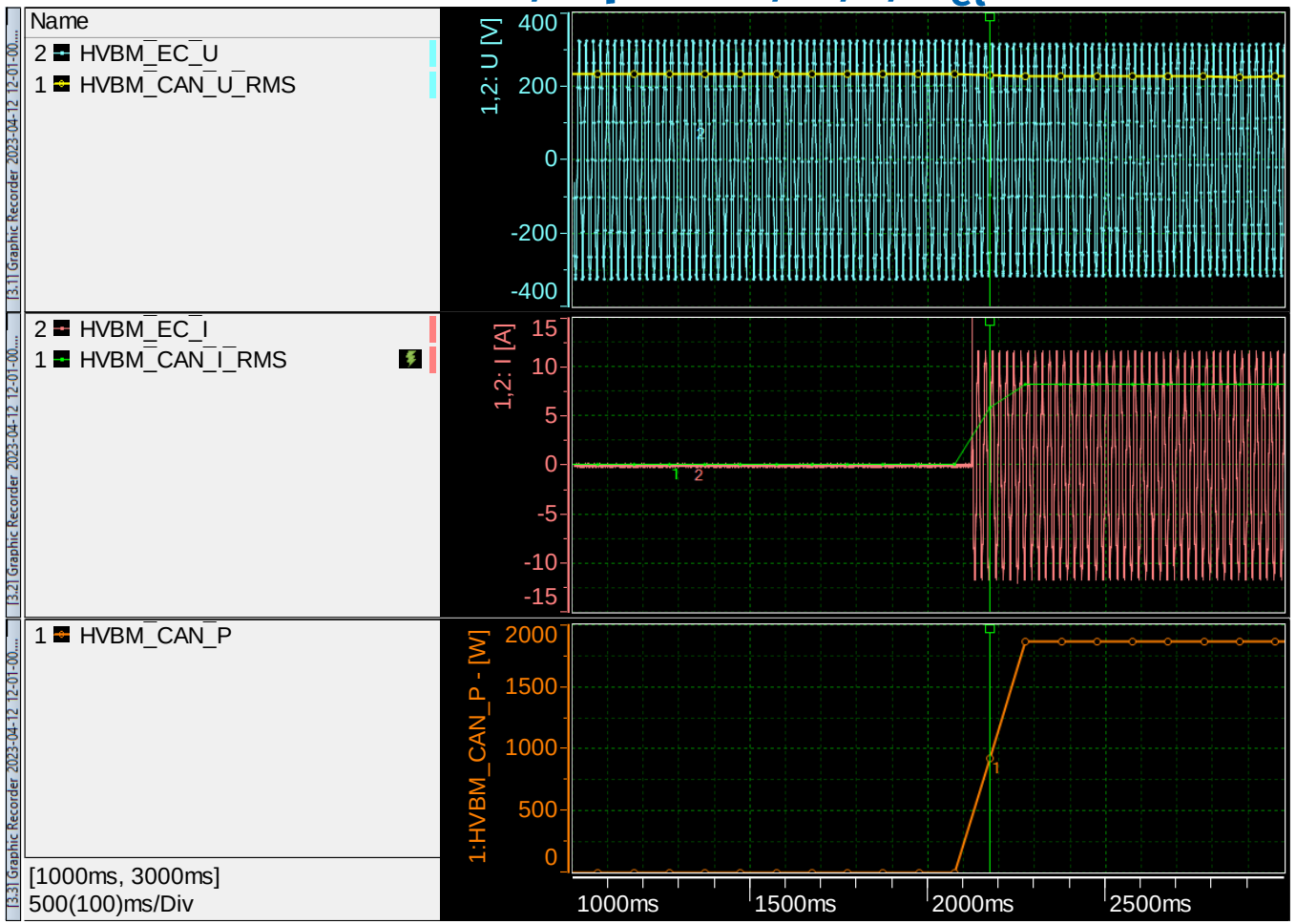
- Single phase measurements of
  - V up to 1 kV working voltage and 2 kV of spikes
  - Inserts, I_{nom} : ±1000 A, ±500 A, ±250 A, ±125 A
  - I_{spike} with shunts up to ±2000 A
- EtherCAT output up to 1 MHz per channel
- Optional CAN output for data loggers
- **Calculation of RMS-values and power**

HV BM 1.2
=
1 phase
2 glands

Power Measurements in HV Electrical Systems with HV BM's (Breakout Modules)



DUT: Electric kettle, 1 phase, U, I, P_{el}

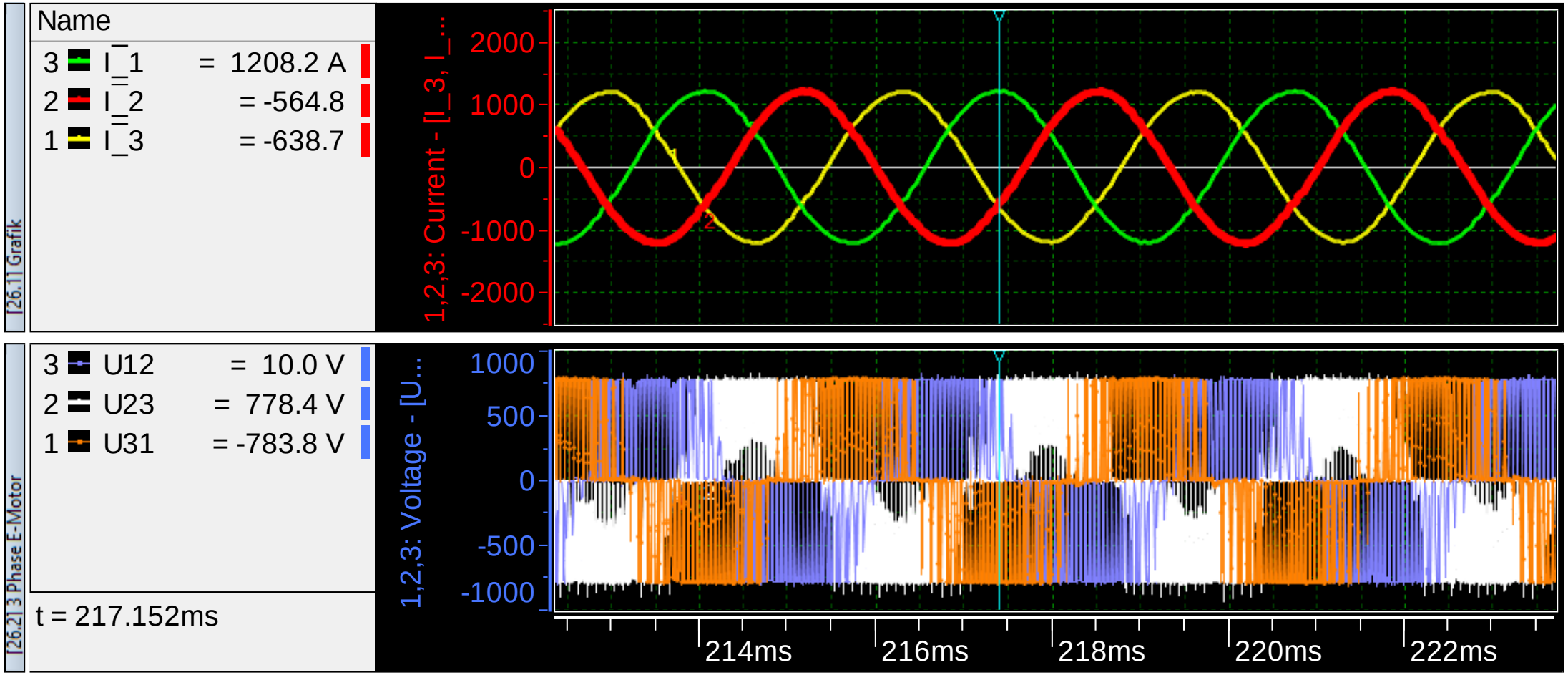


HV BM 1.2 with option Calc.

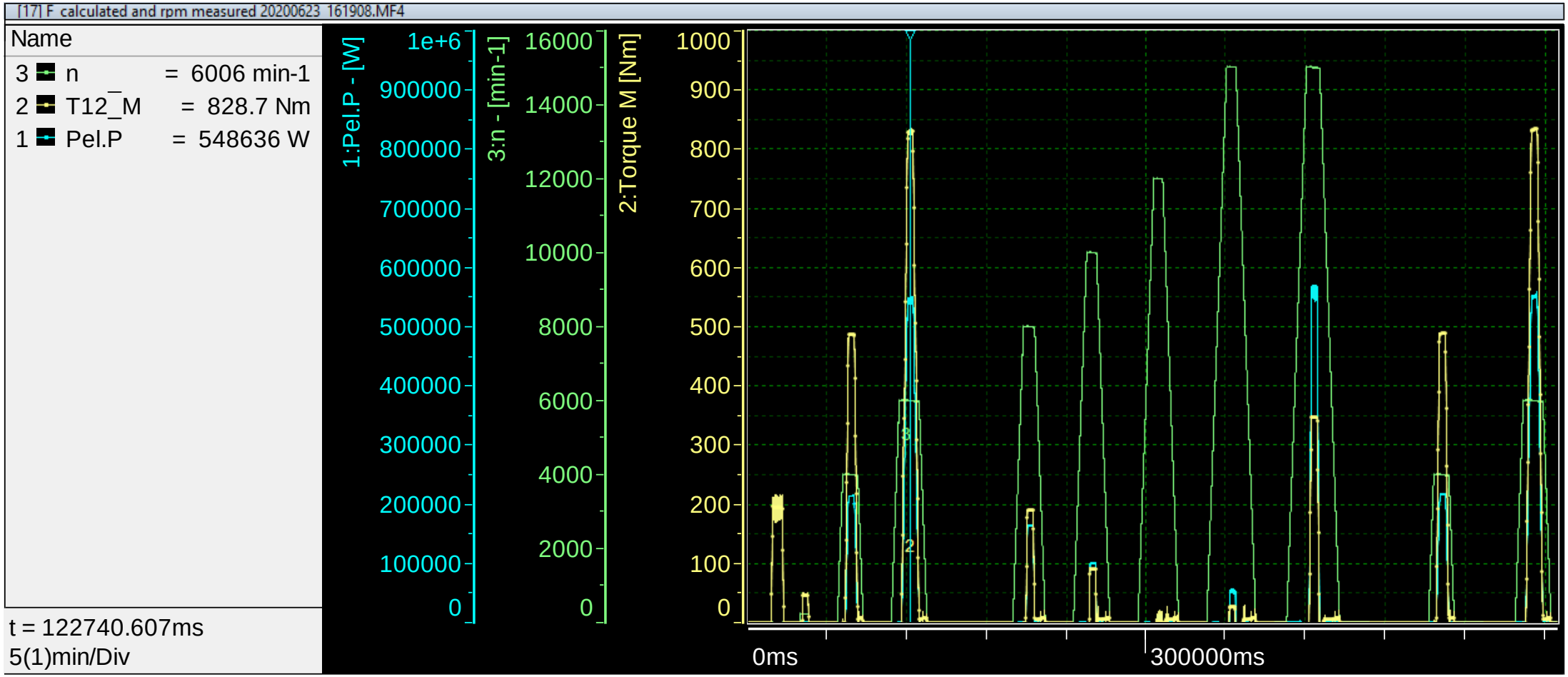
- To measure U, I
- To calculate P, U_rms, I_rms
- To save CPU load on PC
- To save SSD on PC

DUT: Electric Motor, 3 phases, U, I, P, ...

DUT: Electric Motor, 3 phases, U, I, I_rms up to 860 A



DUT: Electric Motor, 3 phases, P_{el} and mechanical data



After Sales Support – HV Isolation Testing Station

Proper function of HV isolation of modules should be monitored during lifetime

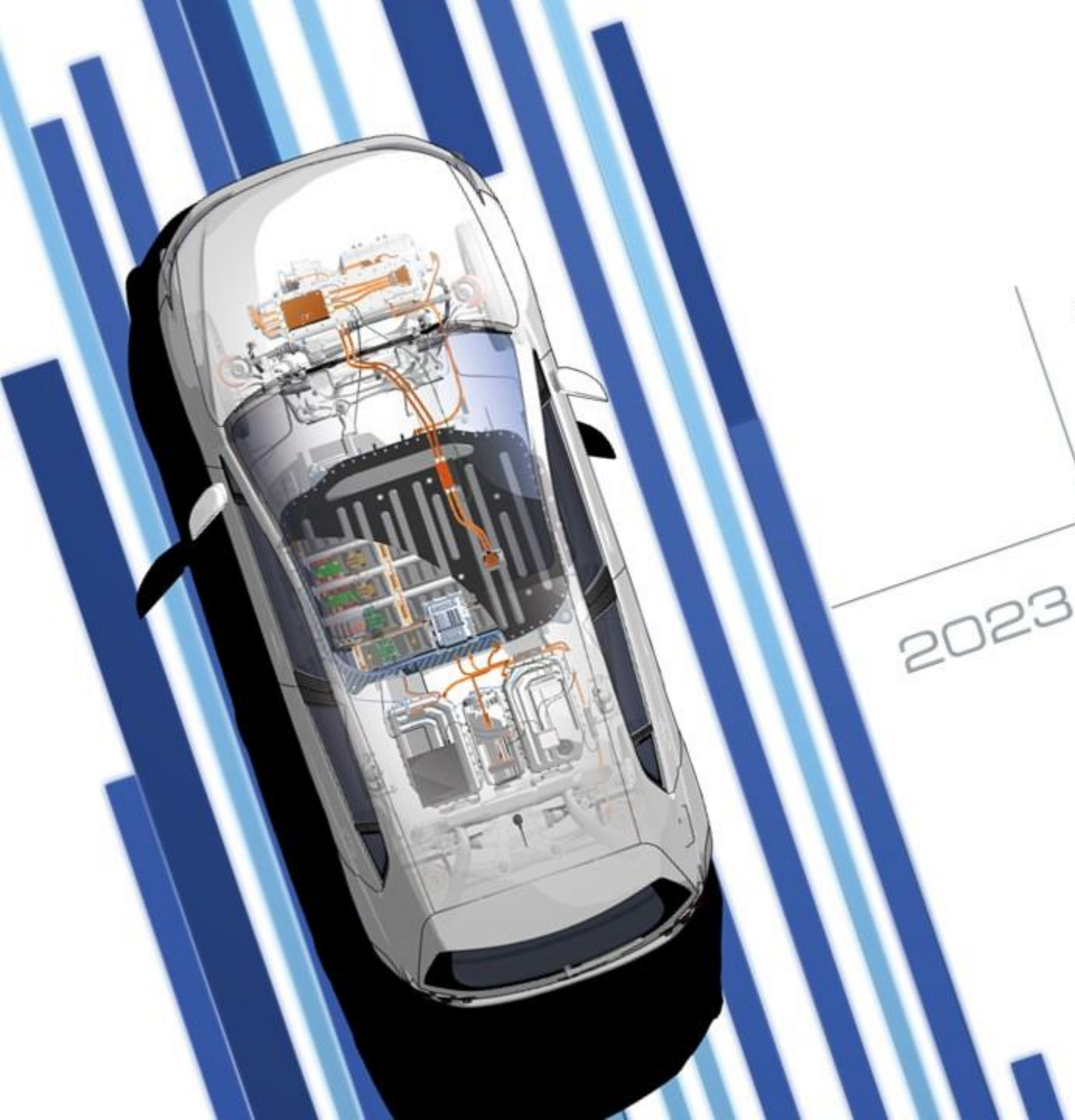
- Recommend yearly and after dedicated incidents
- CSM HV Isolation Testing Station:
  - PC based Isolation Test Software to execute Isolation Test automatically
  - Self-Test Adapters
  - All necessary accessories
  - High potential tester (optional)

More detailed Information requested?

Refer to

- Datasheets of CSM HV Modules and Accessories
- Technical Information: Operation of CSM HV Modules

- Our Website: www.csm.de



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MÜLLER-BBM
VibroAkustik Systeme

SPECIAL CABLES SAB

AXON systems