VECTOR CSM
TECHDAY
2023 GRAZ

Mobile Leistungs- und Wirkungsgradmessungen in der Fahrzeugerprobung von E-Fahrzeugen

VECTOR

Agenda

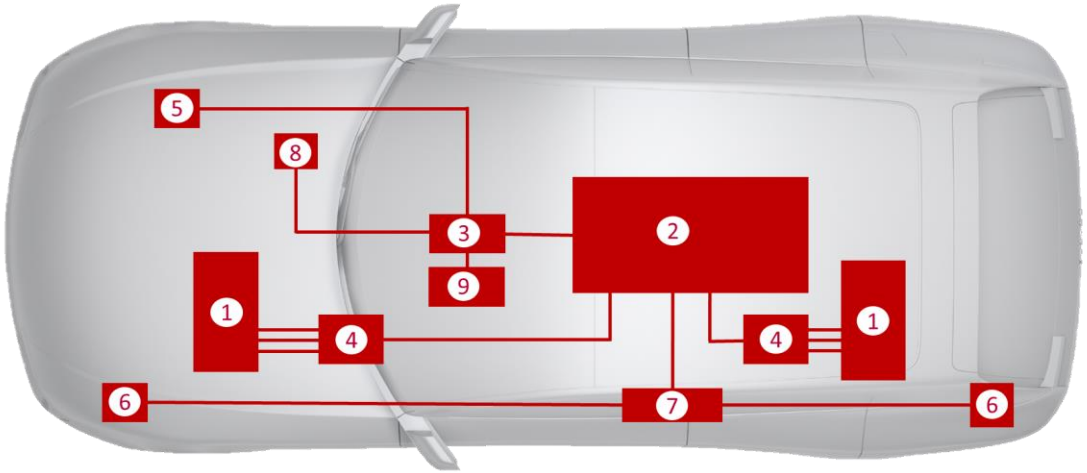
- **Challenges in Development of Electrical Driven Vehicles**

  Analysis of Electrical Power and Efficiency

  Laboratory Power Analyser

  Vector-CSM eMobility Measurement System

Design Goals and Challenges



Design Goals

- Develop a vehicle that sells
  - > Great looks
  - > Even better image
  - ✔ Technical superior
  - ✔ Drive experience
- Ultimately, with profit
  - > Material cost
  - ✔ Time
  - ✔ Manpower
  - ✔ Resources, e.g. testbenches

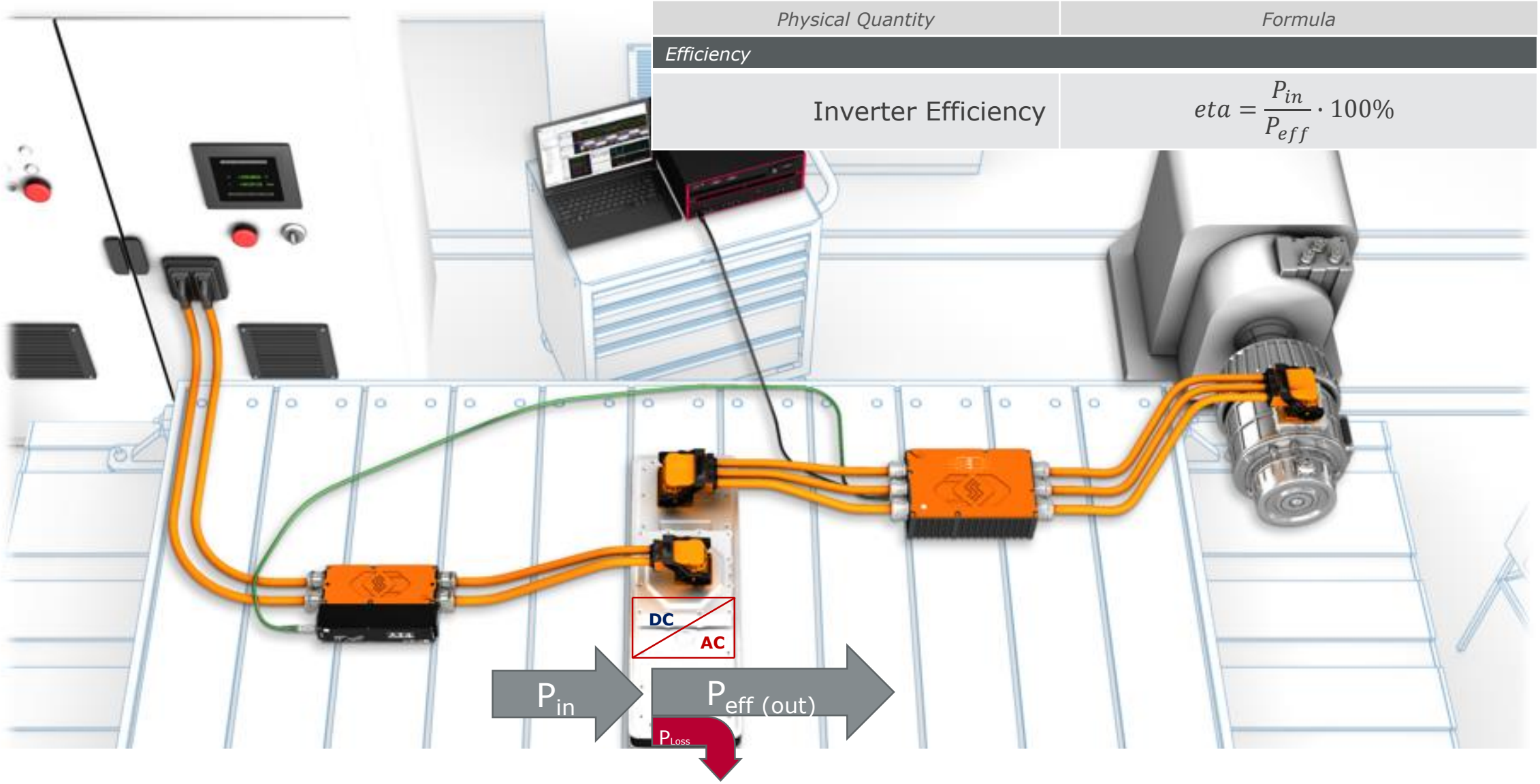
New Challenges

- Efficiency
- Charging
- Safety and Robustness
- Noise Vibration Harshness

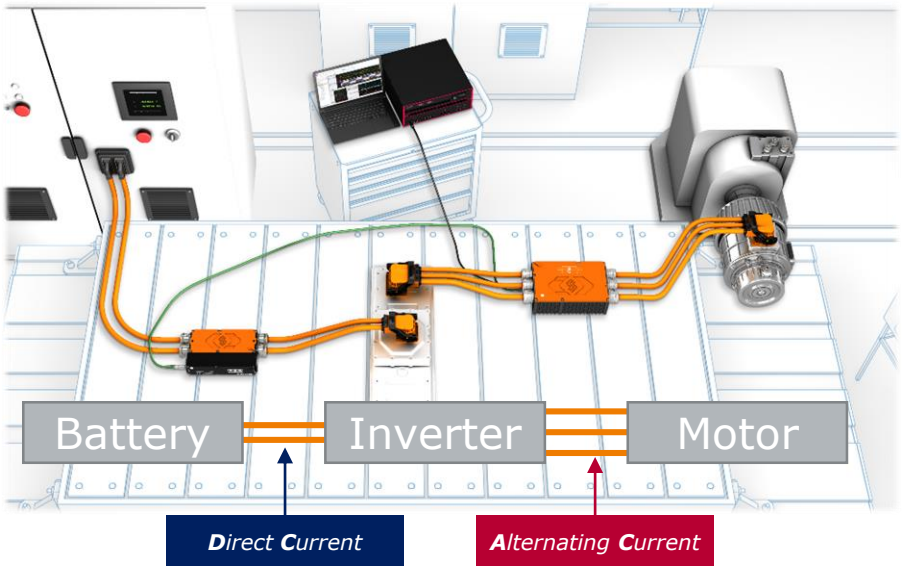
VECTOR & CSM have solutions for your eMobility challenges

Efficiency is the Ratio of Input vs. Output Power

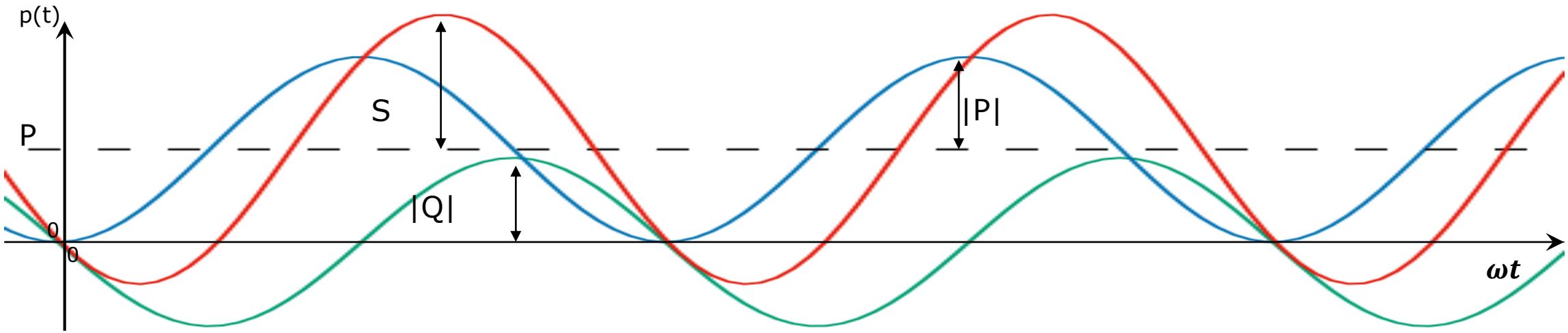
Physical Quantity	*Formula*
Efficiency	
Inverter Efficiency	$eta = \frac{P_{in}}{P_{eff}} \cdot 100\%$



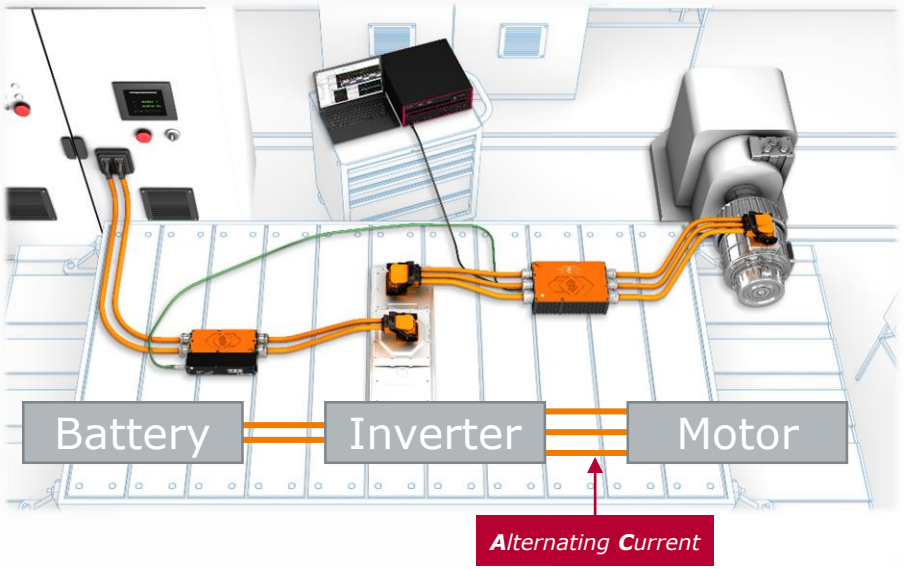
Indirect Power Measurement by Current and Voltage Measurement

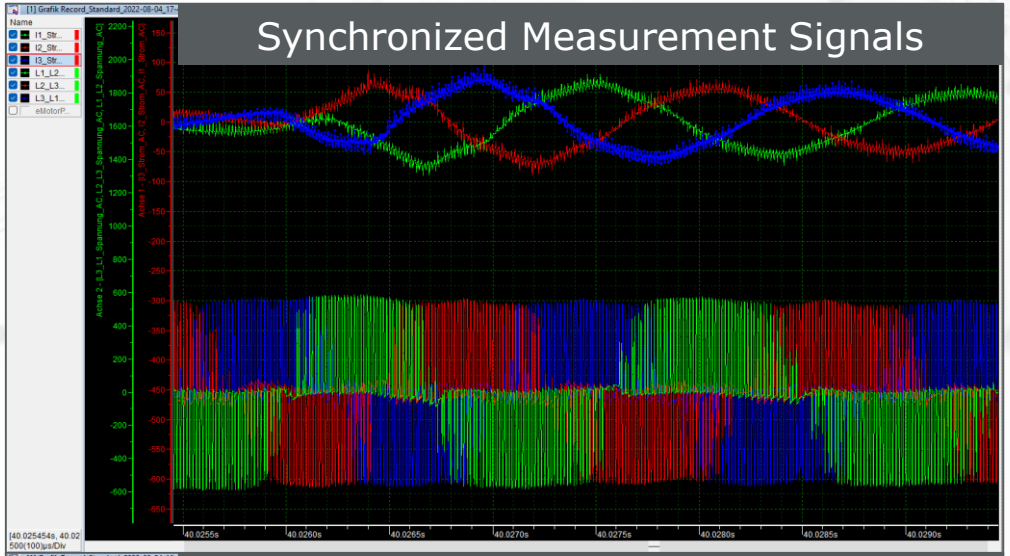


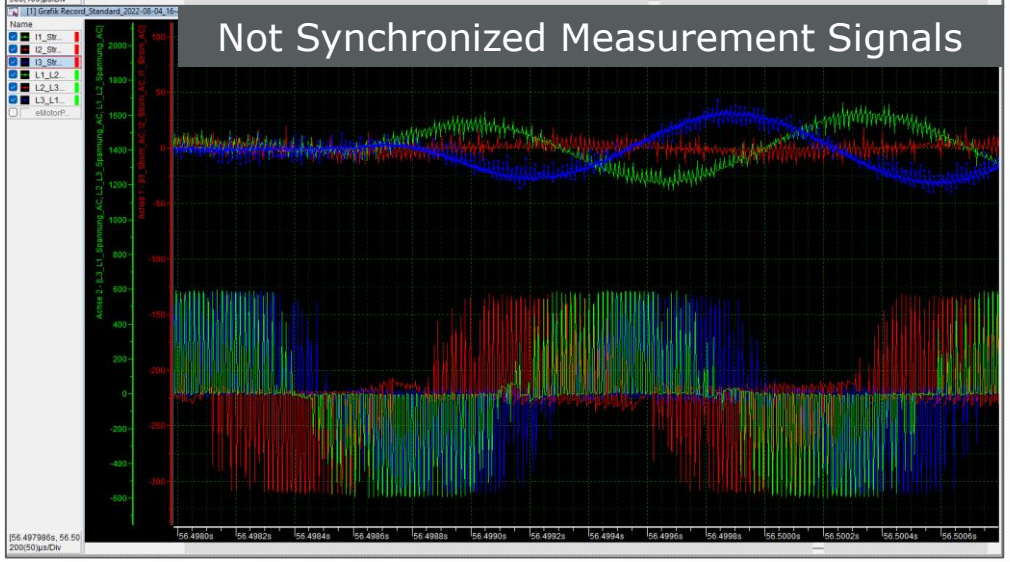
Physical Quantity	Formula
Direct Current	
Power	$\boldsymbol{P = \mathbf{V} \cdot I}$
Alternating Current	
Complex Power	$\boldsymbol{S = \sqrt{P^2 + Q^2}}$
Active Power	$\boldsymbol{P = \hat{V} \cdot \hat{I} \cdot cos(\varphi) = \frac{1}{T} \int_{t_0}^{t_0+T} v_{(t)} \times i_{(t)}\, dt}$
Reactive Power	$\boldsymbol{Q = \mathbf{V} \cdot I \cdot \lvert \sin \varphi \rvert}$
3-Phase Effective Power	$\boldsymbol{P_{eff} = P_1 + P_2 + P_3}$



Challenges at AC Power Measurement – Synchronization





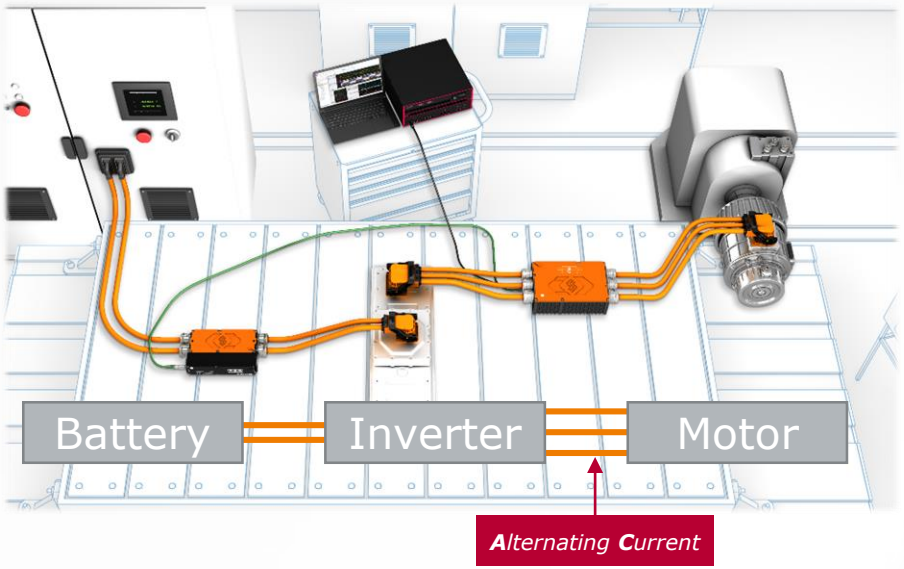


The phase angle φ must be accurately measured so requirements to time synchronous acquisition are very high to avoid

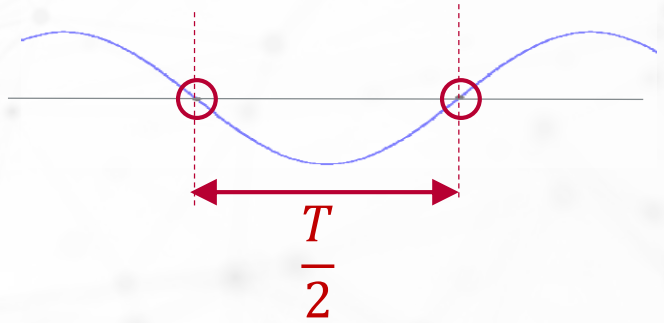
- shifts by time inaccuracy
- any variation in system latency on the different signals acquisition path's

- Precise Synchronization of current and voltage measurement is a MUST for power calculations

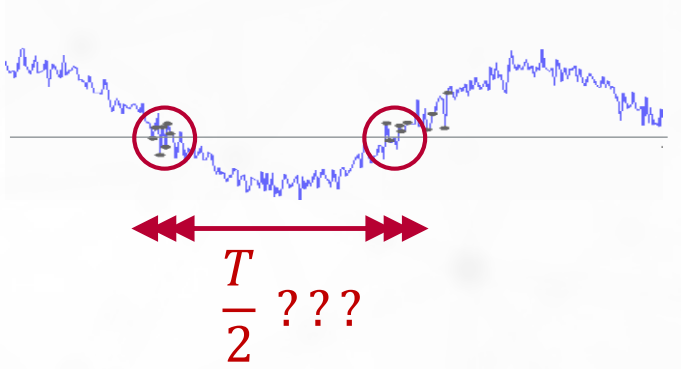
Challenges at AC Power Measurement – Frequency Detection



Ideal Sinusoidal Signal

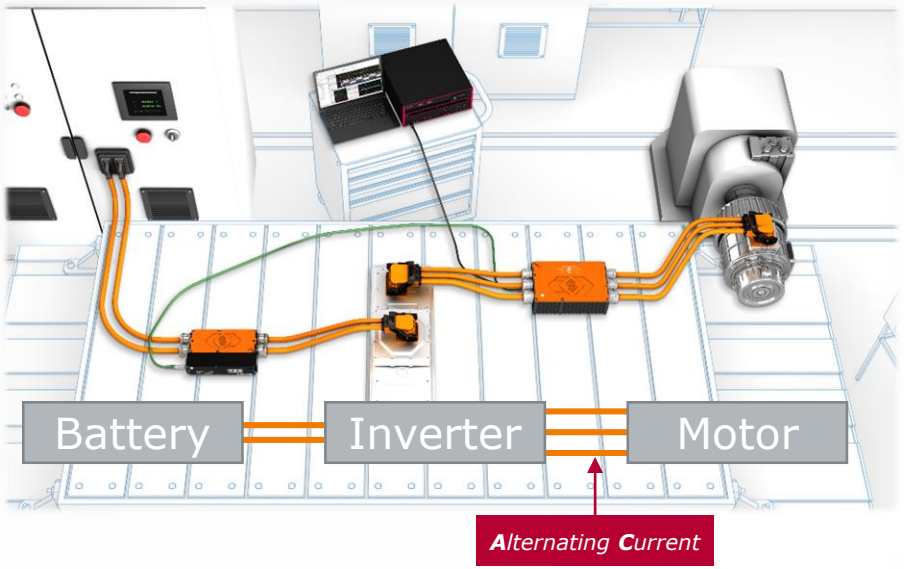


Real Noisy Measurement Signal

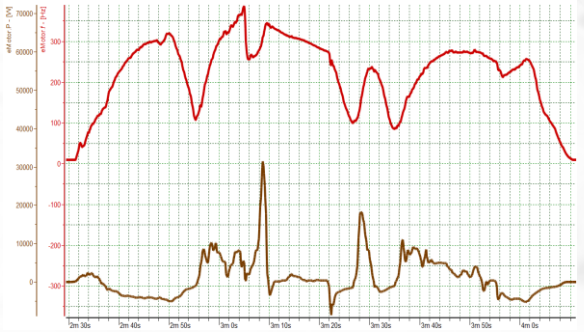


- The frequency f by period time T detection ($f = \frac{1}{T}$)
- Detection of T in noisy signals is a challenge
  - Zero crossing difficult to determine
- Sophisticated statistical algorithms are required to determine period time / frequency

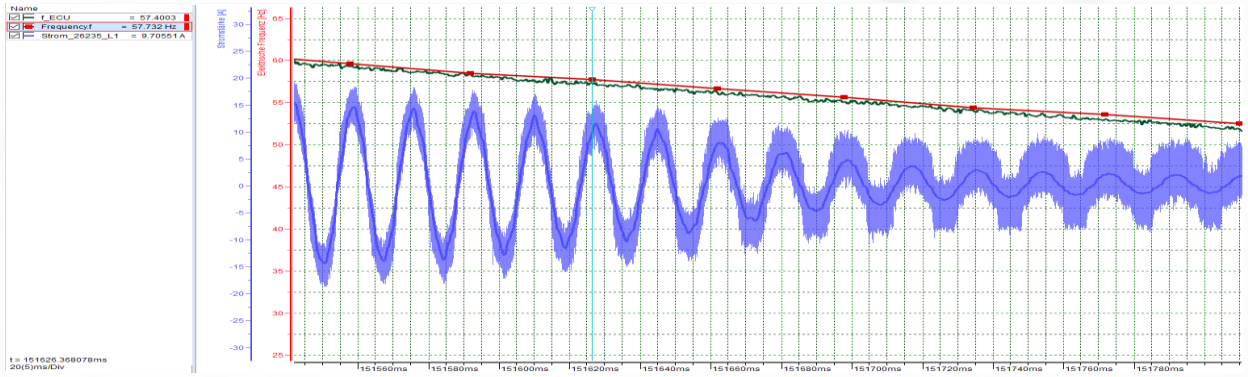
Challenges at AC Power Measurement – Highly Dynamic Frequency Changes



- Very **dynamic** vehicle **operation conditions** continuously changes
  - Acceleration
  - Breaking
  - Recuperation
  - Load changes
  - Direction changes
  - Force feed back from road, …

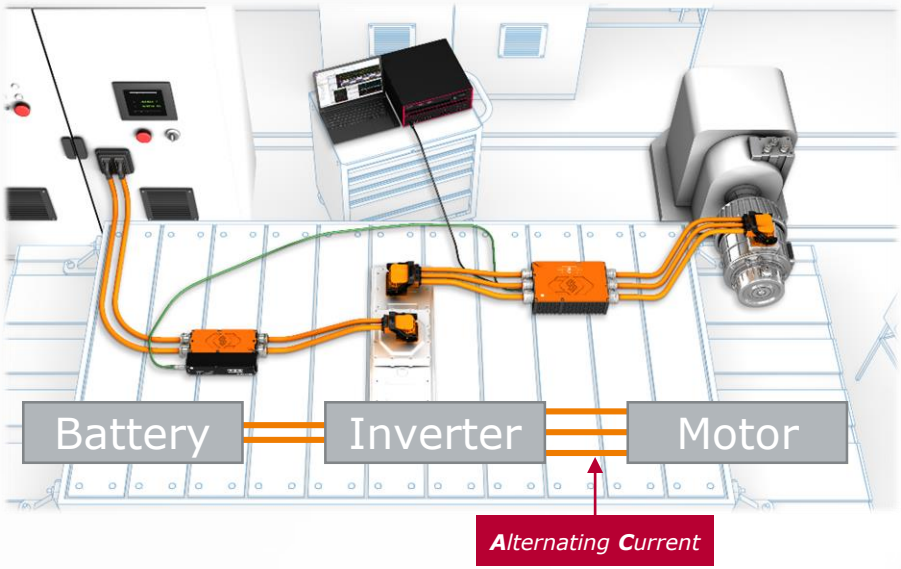


- **Frequency and Amplitudes** are not steady state, they are **changing** very **dynamically** by load and speed

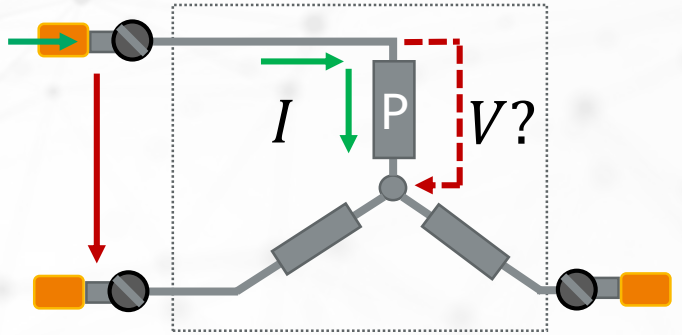


- Frequency detection must be stable/fast enough to follow highly dynamic changes

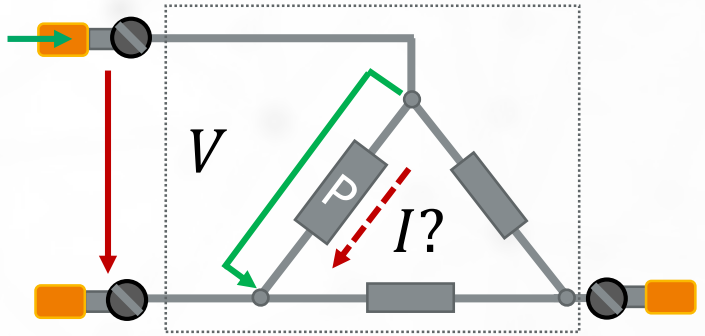
Challenge eMotor Power Analysis



Star Motor



Delta Motor



Accessible measurement points for current and voltage measurement cannot be used directly for power calculation.

- The Y-delta transformation or its inverse required to calculate the respective currents and voltages of windings

Conventional Tools for Power Analysis

- Power analyzer are typically
  - Very precise
  - Made for In-lab usage
  - Limited synchronization to further signal sources
    - ECUs
    - Vehicle Bus Signals
    - …
  - Missing context information
  - Challenging offline analysis

Power Analysis with Vector-CSM eMobility Measurement System

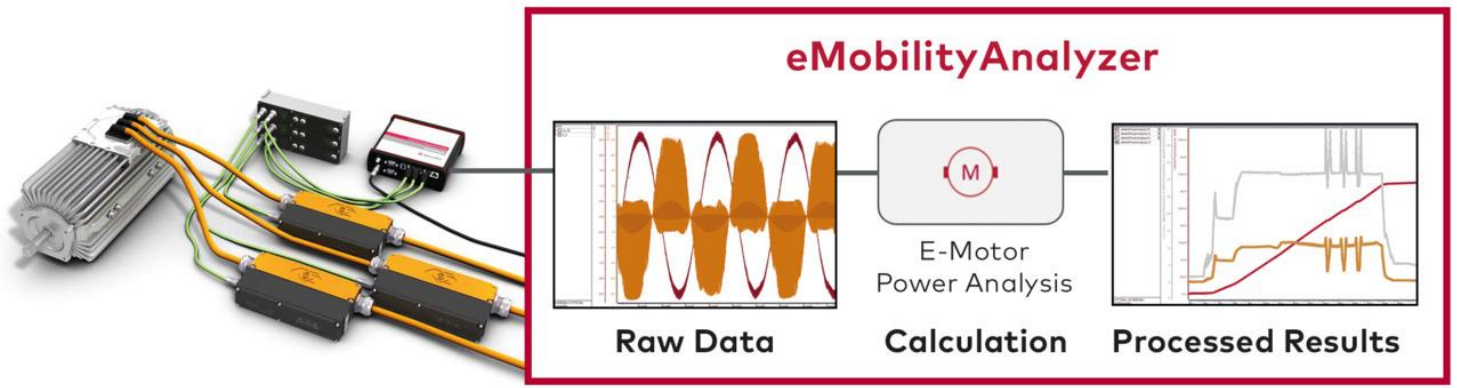
CSM offers an extensive range of **rugged measurement technology** made **for on road testing**

- Measure voltages, currents, temperatures, strain gauges,…
- Measurement sample rates up to 2 MHz per channel
- Safe operation in HV environments

Power Analysis with Vector-CSM eMobility Measurement System

Vector completes the measurement system with data acquisition systems providing the

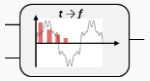
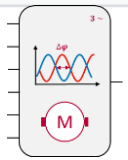
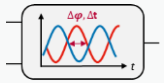
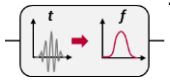
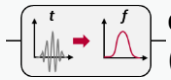
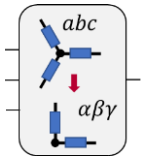
- **eMobilityAnalyzer** fast function library **with Power Analyzer functionality**



- Available in **CANape**, **vMeasure**, **vSignalizer**
  - Measure power along with
    - Signals from ECUs, vehicle bus, all kinds of further analog sensors
    - Context information like GPS, video
- All precisely synchronized and stored to the same measurement file

- eMobilityAnalyzer
  - ✔ DCAnalysis
  - ✔ eMotorPowerAnalysis
  - ✔ eMotorYdelta
  - ✔ DCEfficiency
  - ✔ ChargerEfficiency
  - ✔ Ripple
  - ✔ ShaftPower
  - ✔ AxlePower
  - ✔ LinearMean
  - ✔ TrueRMS
  - ✔ Slope
  - ✔ Harmonics
  - …

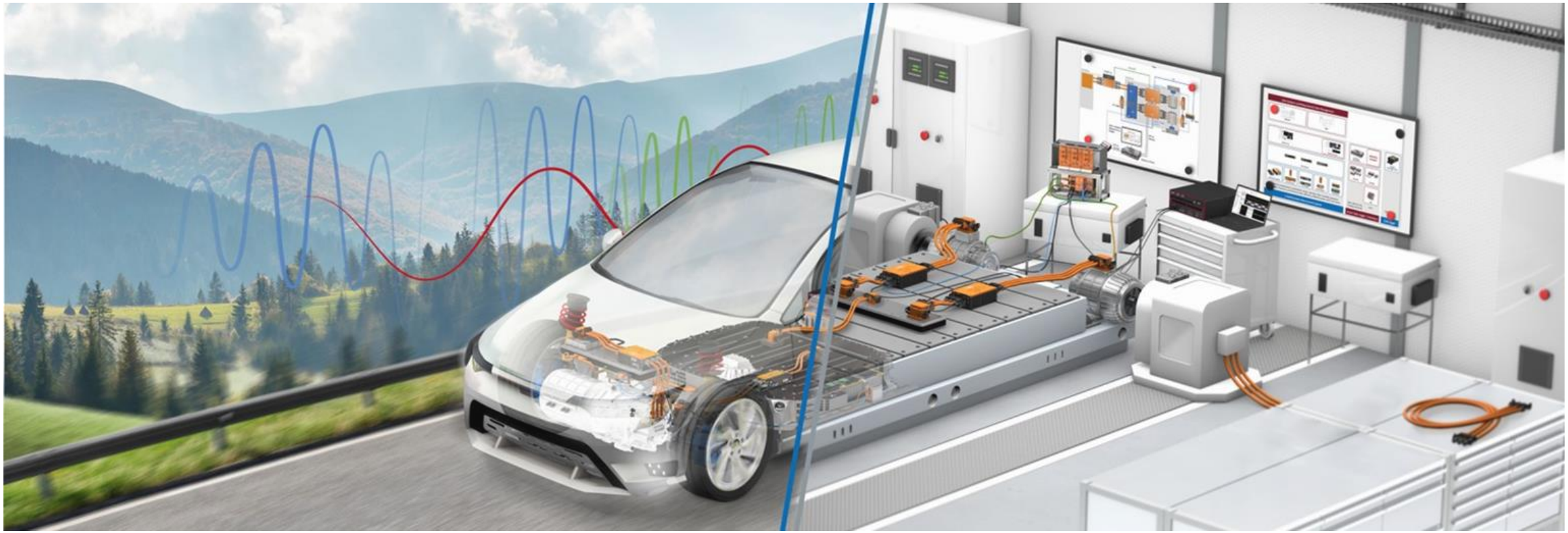
New Functions in eMobilityAnalyzer 1.0.4

Function		Short Description	eMobilityAnalyzer
HarmonicPower		HarmonicPower is an extension to the HarmonicAnalysis function for calculation of the active power of the fundamental and higher harmonics.	1.0.3
eMotorPhaseAnalysis		This function analyses the phase angles between voltages and currents in a 3-phase electric motor. It also calculates the root-mean-square values of the fundamentals.	1.0.4
PhaseAnalysis		Phase angle and time shift between two periodic signals are analyzed based on their fundamental oscillations. The root-mean-square-values of the fundamentals are also calculated.	1.0.4
Frequency		The fundamental frequency of a periodic signal and its changing rate are calculated by this function.	1.0.4
SingleFrequencyAnalysis		This function conducts a Fourier analysis for a single prescribed frequency. It corresponds to the calculation of a single bin in a discrete Fourier transform (DFT). The function offers windowing and calculates root-mean-square-values and levels.	1.0.4
AlphaBeta		This function conducts a Clarke transformation of three-phase quantities, also including calculation of the zero-sequence component, so that the quantities do not need to be balanced.	1.0.4

Extensible Fast Function Framework

- Further Fast Functions will be released with next Release CANape 22 / vMeasure 8
  - FFT
  - …
- Extensibility with Customer Specific Functions
  - We can offer you to implement your special customer functions on demand
  - These can be added to the framework at any time,
    no dependency on release cycles of CANape/vMeasure

Power Analysis with Vector-CSM eMobility Measurement System



- All equipment is capable for On-Road Vehicle Trials and Laboratory use cases
- **Vector Smart Logger** can run the measurements fully automated in On-Road Tests
- And automated Data Analysis and Reporting can be realized with Vectors Measurement Data Management Tool **vMDM**

For more information about Vector and our products please visit

www.vector.com
www.vector.com/emobilityanalyzer
www.vector.com/csm

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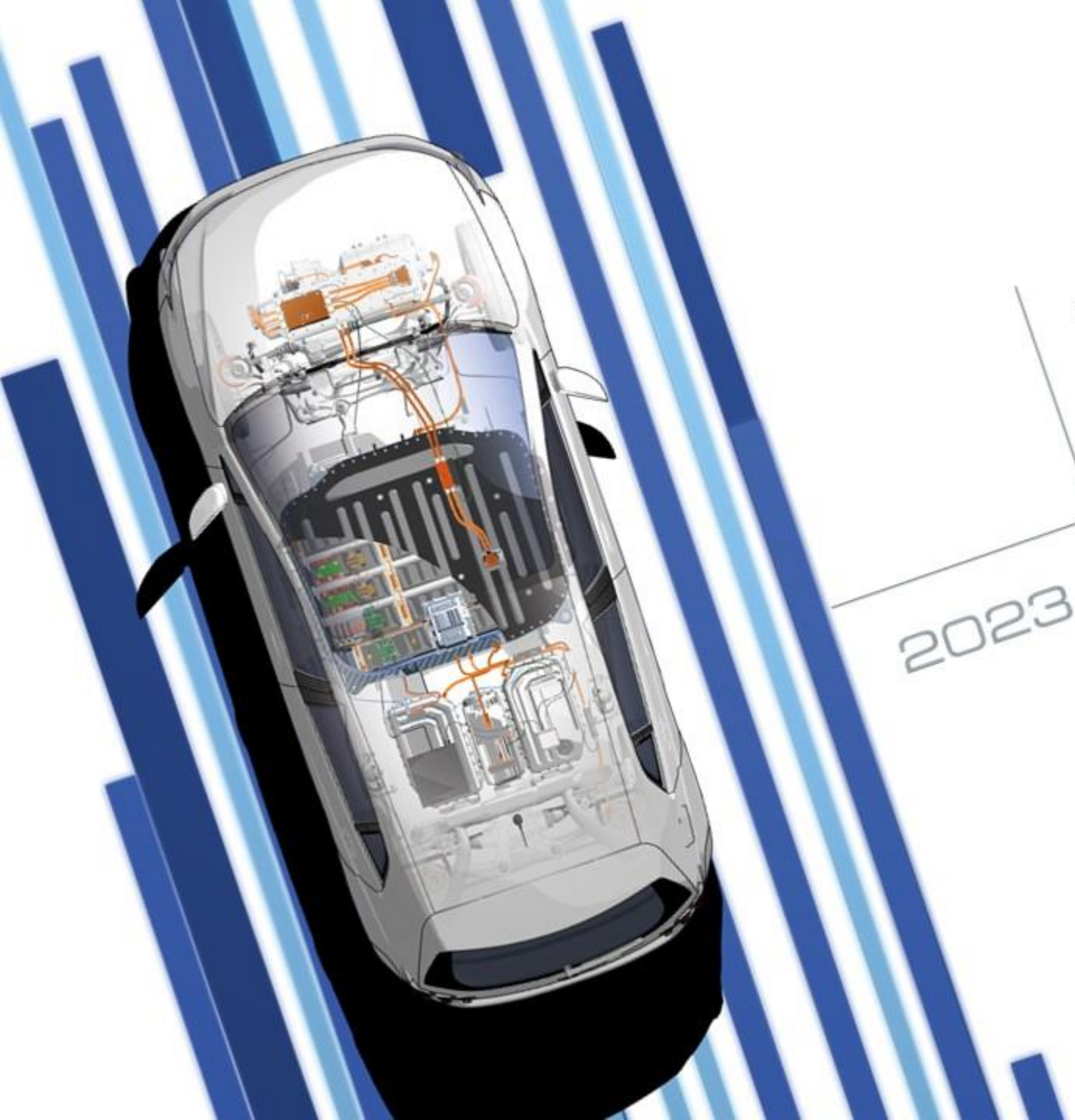

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SPECIAL CABLES SAB

AXON systems