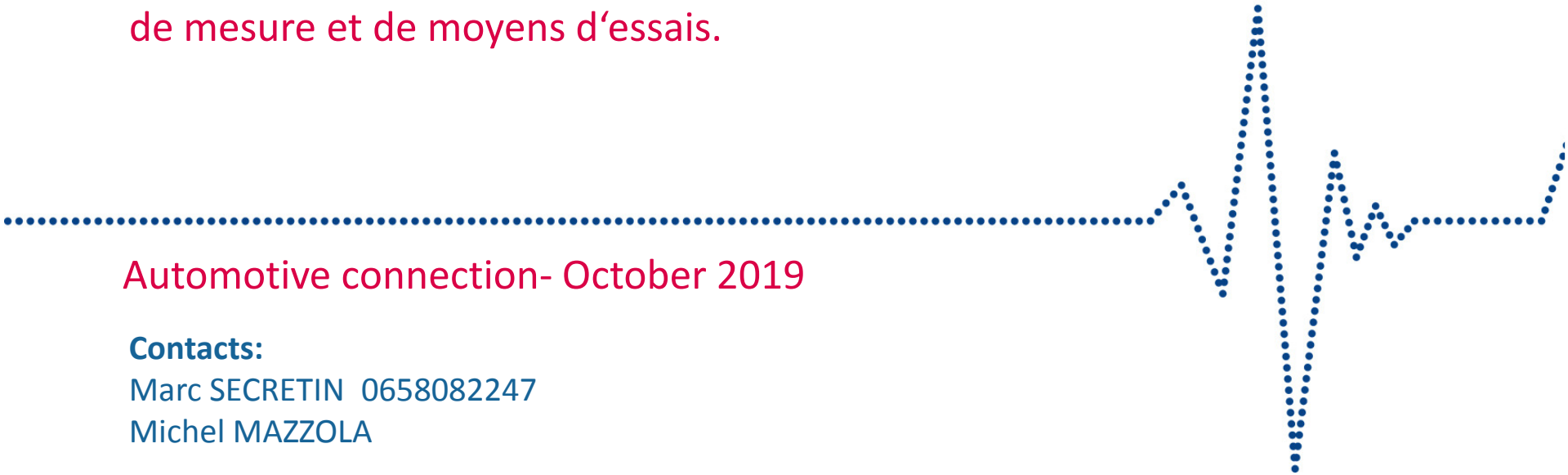
E-Mobility Solutions

Comment améliorer les échanges emotor-batterie, l‘optimisation des rendements et l‘éfficacité des véhicules grace à des solutions innovantes de mesure et de moyens d‘essais.



Automotive connection- October 2019

Contacts:
Marc SECRETIN 0658082247
Michel MAZZOLA

Facts

imc Test & Measurement GmbH

- Founded in 1988
- Head office and production in Berlin, Germany
- Subsidiaries in China, Austria, Switzerland, France, Benelux and USA
- Approximately 200 employees (thereof ca. 60% developers and engineers)
- Cooperation with 25 companies in 28 countries
- More than 100 patents

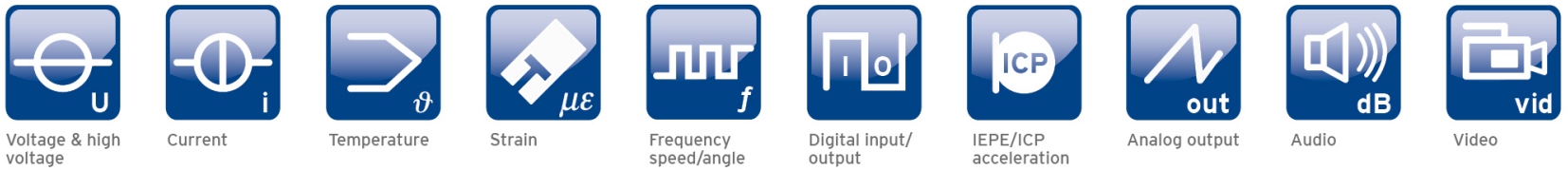
Management: imc Berlin & Frankfurt

What is our business?

imc solutions

From the sensor -> data acquisition system -> analyses -> results -> report

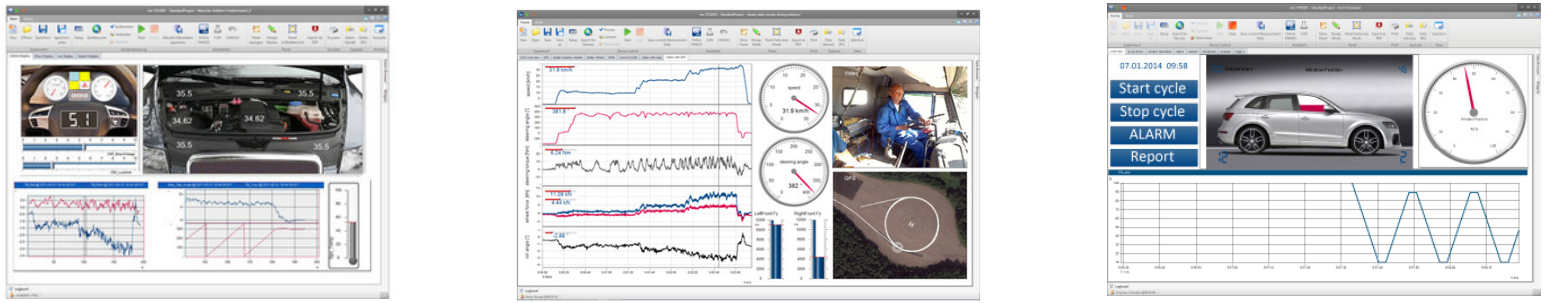
Sensor



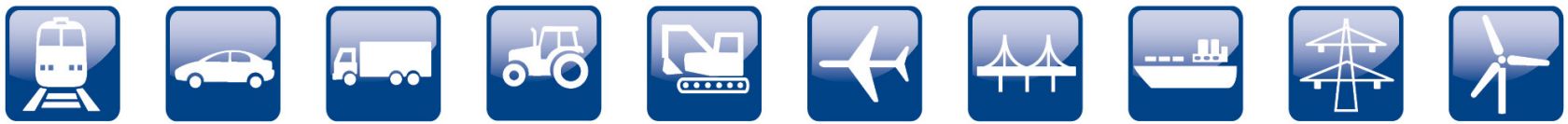
Voltage & high voltage | Current | Temperature | Strain | Frequency speed/angle | Digital input/ output | IEPE/ICP acceleration | Analog output | Audio | Video

Data acquisition system

Data analyze



Your application

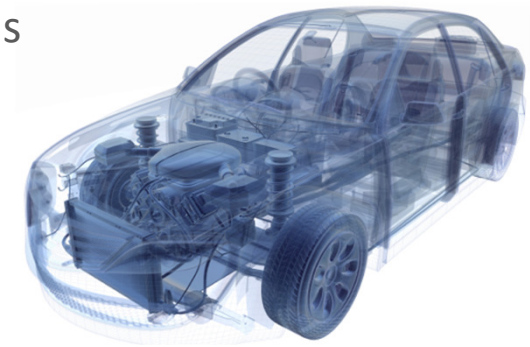


eMobility

New Tasks: ***the application's view***

Classical testing tasks

- Brake performance
  Chassis systems (ABS, ESP)
- Handling / vehicle dynamics
- Durability, endurance
- HVAC
  (Heating, Ventilation, Air Condition)
- Driving performance, torque
- Fuel consumption
- NVH (Noise Vibration Harshness)
- Exhaust emissions
- …



New tasks with eMobility

- Interplay with charging infrastructure
- Battery performance and safety
- Cooling and heating of electrical sub-systems
- Power converter performance
- eMotor performance
- Interplay with drive battery
- Interplay of mechanical and electrical brakes, recuperation
- Electrical energy consumption
- Subjective human experience
  (drive comfort)
- …

eMobility Issues

New questions: ***Tasks and applications for test and measurement***

Temperature measurement

- Battery systems, drives, power electronics, connectors, …
- Temperature is relevant for stress and wear, performance, efficiency, heat management, overload,…
- High channel count, robustness, HV environment

State of charge, efficiency, Energy flow

- Charging performance, charge gauge, balance, efficiency – as a function of temperature
- Charging stations with connectors, cables, metering, DC/DC converters…
- DC intermediate Power bus, recuperation, hybrid concepts
- Voltage, current, DC power

Current measurement in vehicle electrical systems

- Current transducers, LEM-transducers, Shunts, AC/DC mode
- From Leakage to full power, range dynamics, energy consumption of ECUs and sub systems
- IHR Autoranging

eMobility Issues

New questions: ***Tasks and applications for test and measurement***

Power

- AC and high frequency: Power converter (Inverter), DC/DC, drives
- Mechanical vs. electrical power – efficiency
- Active and reactive power

E-Drives test bench

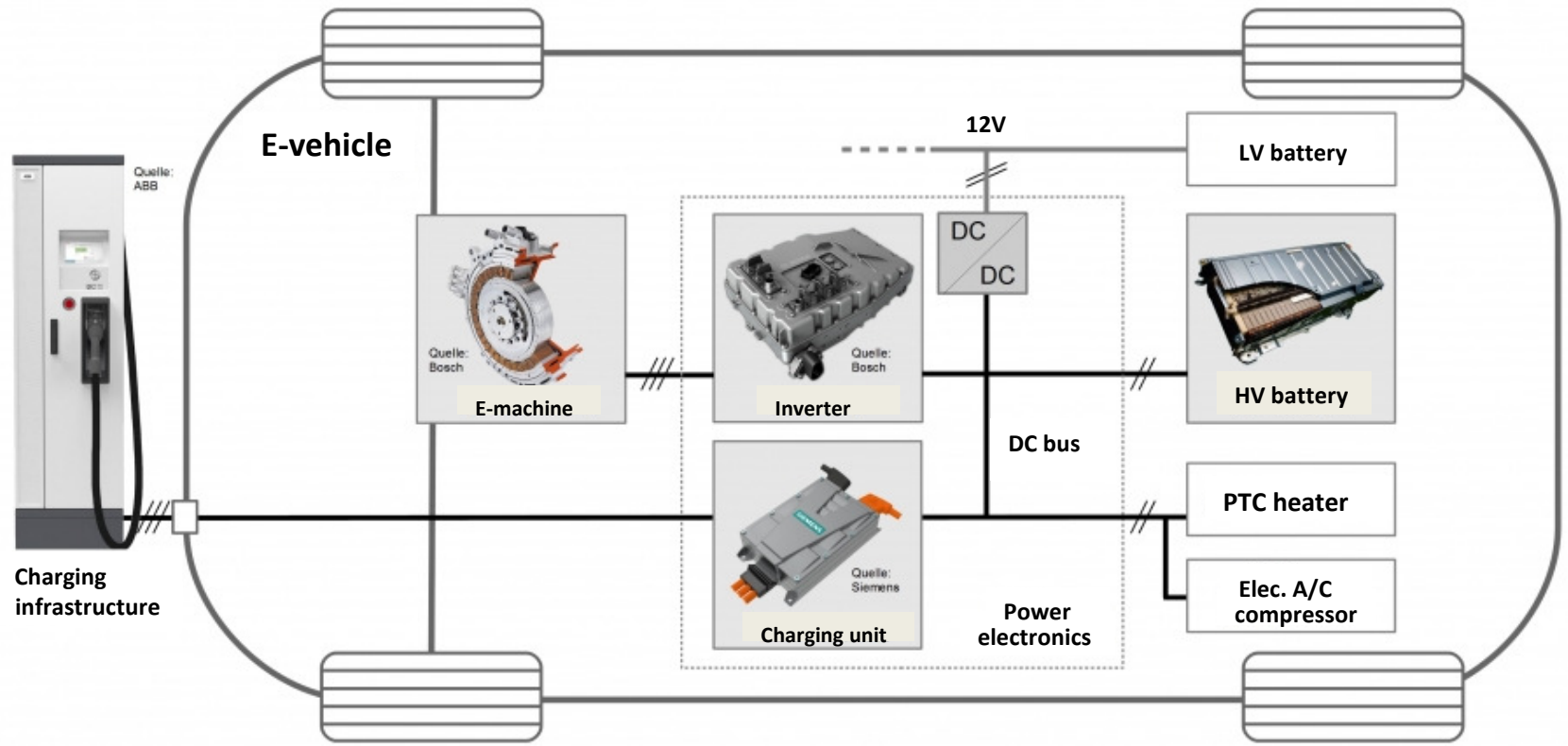
- eMotor test, BLDC, Parameter Identification (PI-method)
- EoL test stands
- Development test stands for systematic analysis and optimization

Telemetry

- Rotating parts / shafts and inaccessible components
- Radio / Fiber-Optic and battery based solutions
- Mechanical power
- Integration into multi-channel multi-domain data acquisition (analog, digital, fieldbus…)

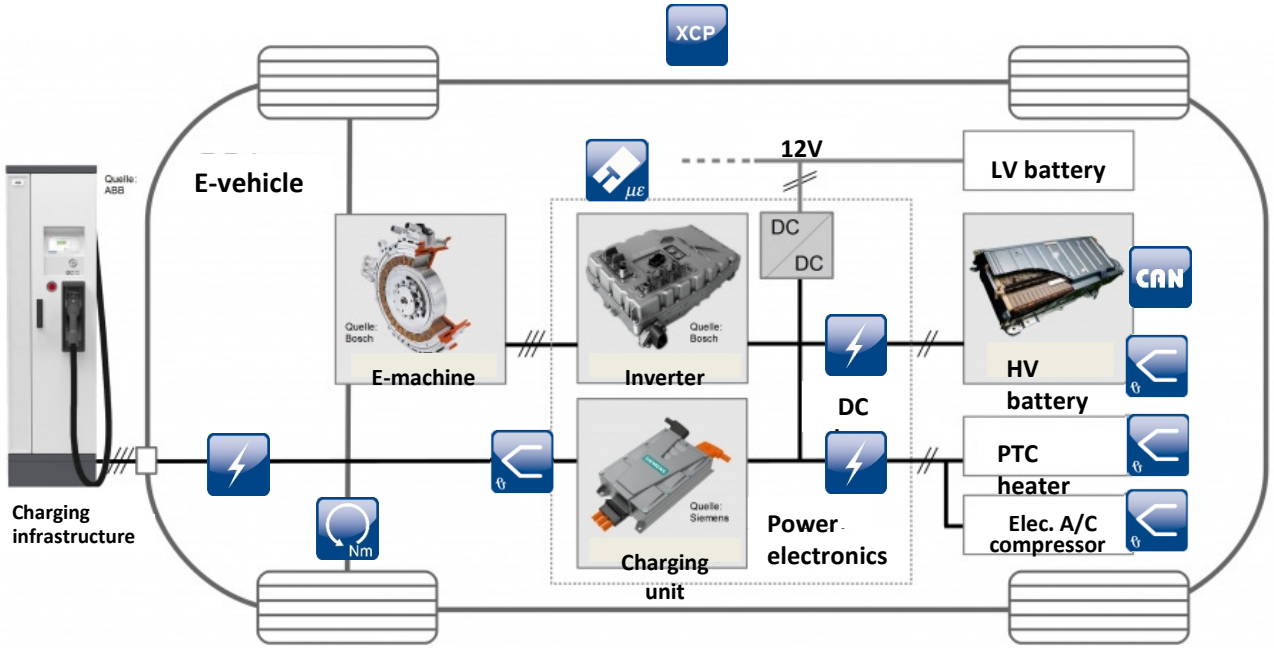
Typical Full Electrical Vehicle

Sub-Systems and functional units



Measurement Tasks

Electrical and hybrid vehicles

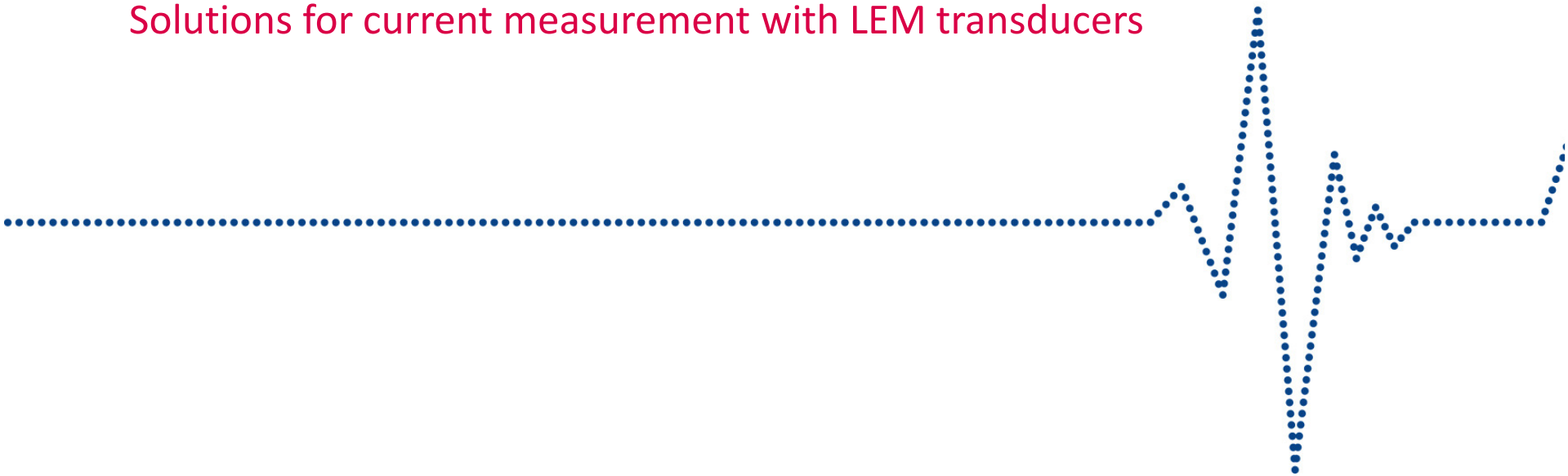


Tasks:

- Electrical power
- Mechanical power
- Temperature measurement
- Additional physical quantities
- ECUs
- Automation & Application systems

E-Mobility Solutions

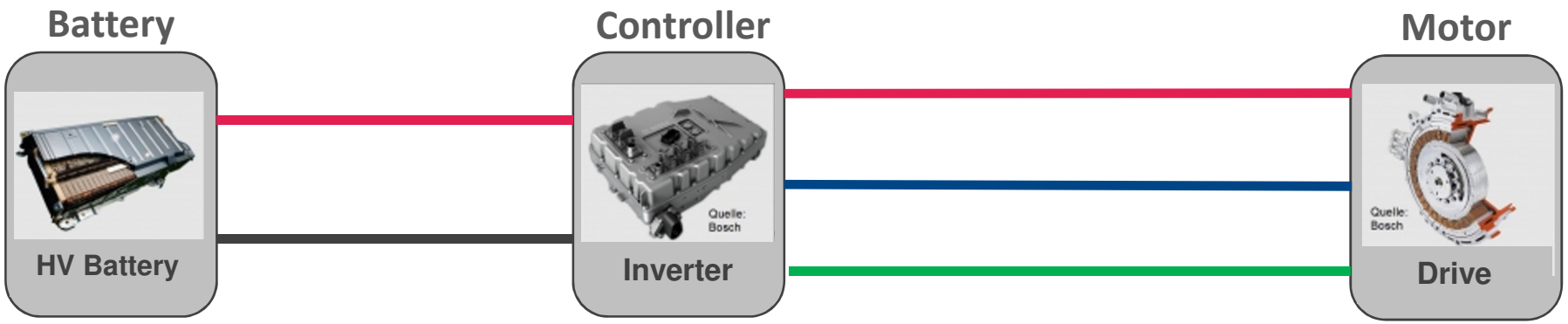
Solutions for current measurement with LEM transducers



eMobility: Current and Power Measurement

Typical application with vehicle testing

Power budgets and energy flow



1 Phase

DC Bus bar

- **DC with high frequency ripple**
  stability/precision & high bandwidth

3 Phase

Motor currents (Inverter)

- some 100 Hz + 30 kHz PWM,
  high bandwidth

New requirements and challenges

Driven by technological changes

DC accuracy and general precision

- improved efficiency
- Challenging fraction of % improvements… → ppm precision and stability

Bandwidth

- modern *Wide-Bandgap* power semiconductors SiC/GaN
- increasing PWM frequencies → >= 30 kHz

Large current ranges

- Larger hybrid- (HEV) and fill electric vehicles (FEV): SUV, bus, truck
  → up to 500A / 1000 A

Robustness

- Field testing, competitor product analysis … → compact, wide operating temperature range

Current: with flux gate transducers

Ring type transducers and current clamps based on flux gate technology

Modern flux gate transducers

Ring type transducer (“pass-through”)

- Compact installation
- **Test stand** applications

Current clamp transducer

- **No breaking of load circuit** required for installation
- E.g. examination of standard mass product specimen (**competitor vehicles** etc.)
- More expensive than ring type

Both types

- **High-End**: High bandwidth and extreme precision
- Active transducers that require **+/-15V supply @significant power**

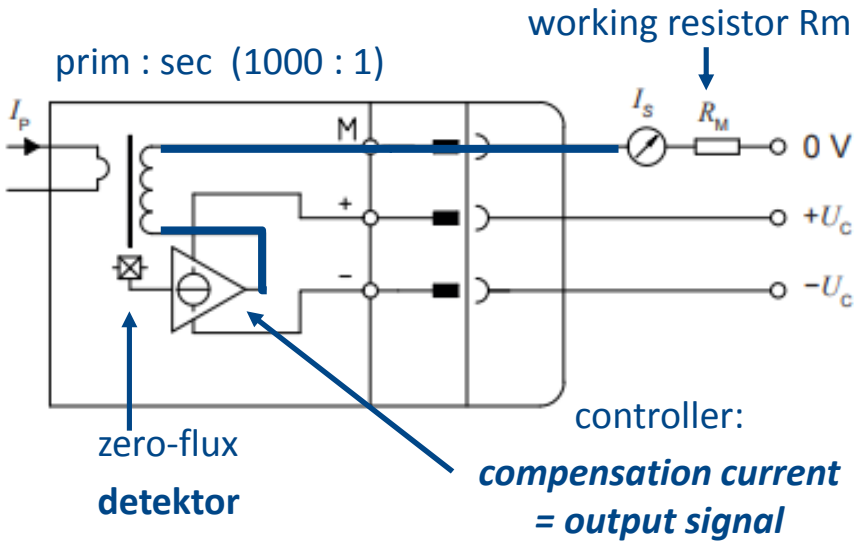
LEM Ultrastab

HIOKI

Working principle of flux gate transducers

Compensation type transducers: **Hall vs. high end flux gate**

Compensation current transducer



Principle

- Magnetic flux differential: Primary current – compensation
- Controller forces flux → 0 : **zero-flux compensation**
- **Output signal: compensation current * working resistor**
- Controller compensates non-linearities of flux sensor

Hall compensation transducer (established)

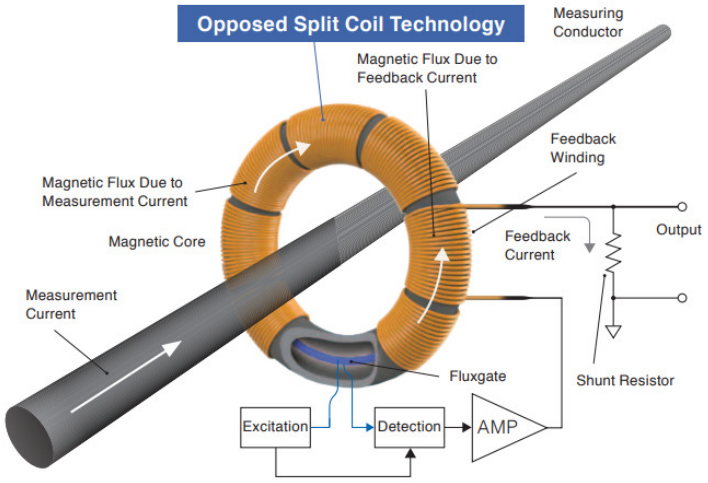
- **Hall sensor** as flux detector

➢ Limited bandwidth, DC stability and drift

Flux gate transducer (“new”)

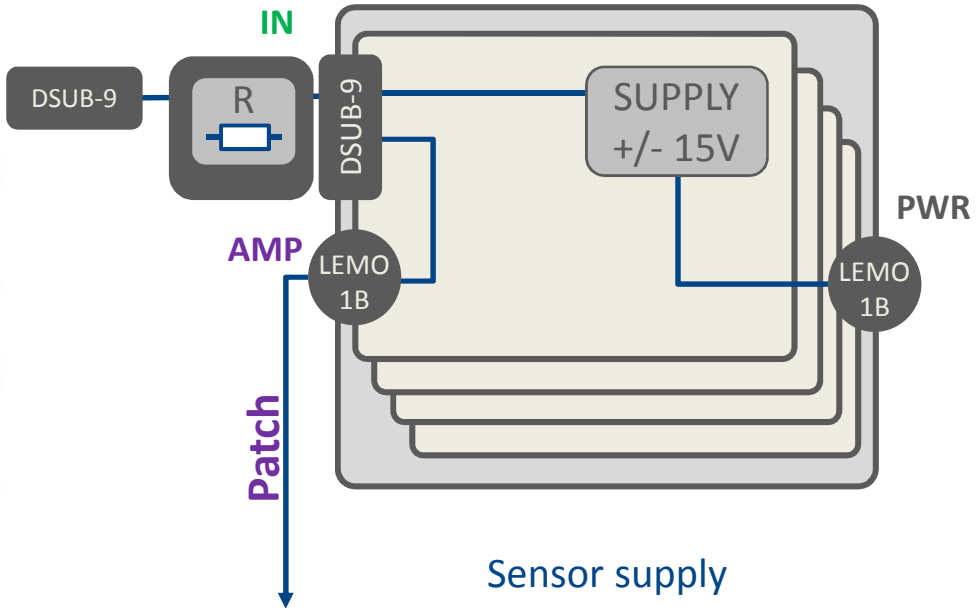
- **Flux gate** used as detector

➢ **Bandwidth up to 1 MHz, extreme precision and stability (ppm)**

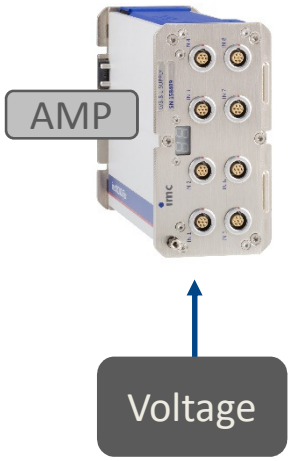


Supply for LEM and current clamps

CRFX/SEN-SUPPLY-4: Current and power measurement (U/I/P)



CRFX/SEN-SUPPLY-4



Sensor supply

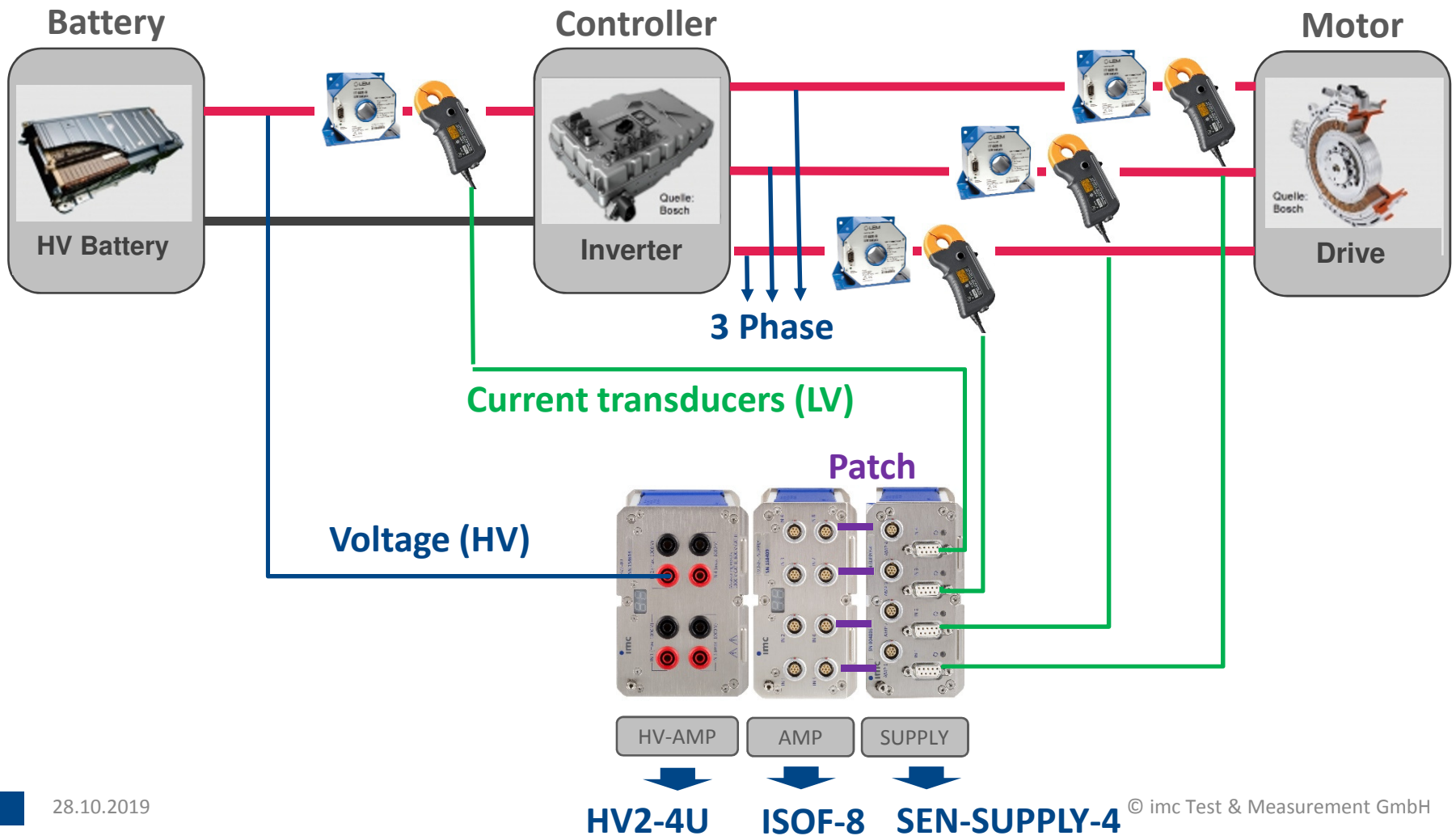
- **R=10 Ω … 1 Ω flexible: DSUB-9 Plug** easily adaptable
- +/-15V supply, max. 4 x 10W = **40W**
- **Click module (CRFX),** also applicable **Stand-Alone**
- extra Power-IN: LEMO.1B **: 20-50V DC → not via click connector**
- Compatible with POWER-HANDLE (10..50V wide range input & UPS): via AUX cable!

Separate measurement amplifier (voltage)

- **flexible: any device series**
- LEMO out (AMP connected via patch cable)

eMobility: Current and Power Measurement

imc solution with CRFX/SEN-SUPPLY-4: supply of LEM and current clamps



HV voltage probe transducer

Example: LEM DVL 750

MR1

Alternative solution instead of native HV amp

HV voltage probe

- HV isolation
- Conversion to low voltage (+/-10V)

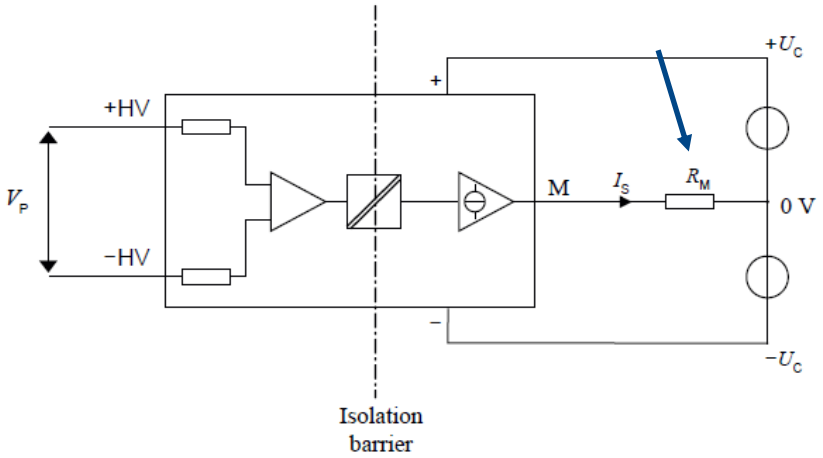
Interfacing

- ***Equivalent to LEM current transducers***
- +/- 15V (3 W) Supply
- 75 mA out, 50..100 Ω load resistor
- ***Acquisition with non-isolated LV amp***

Key specs

- 1125 V (iso testing with 8.5 kV)
- 8 kHz (-1 dB)
- 0.5 % accuracy

Load resistor Rm



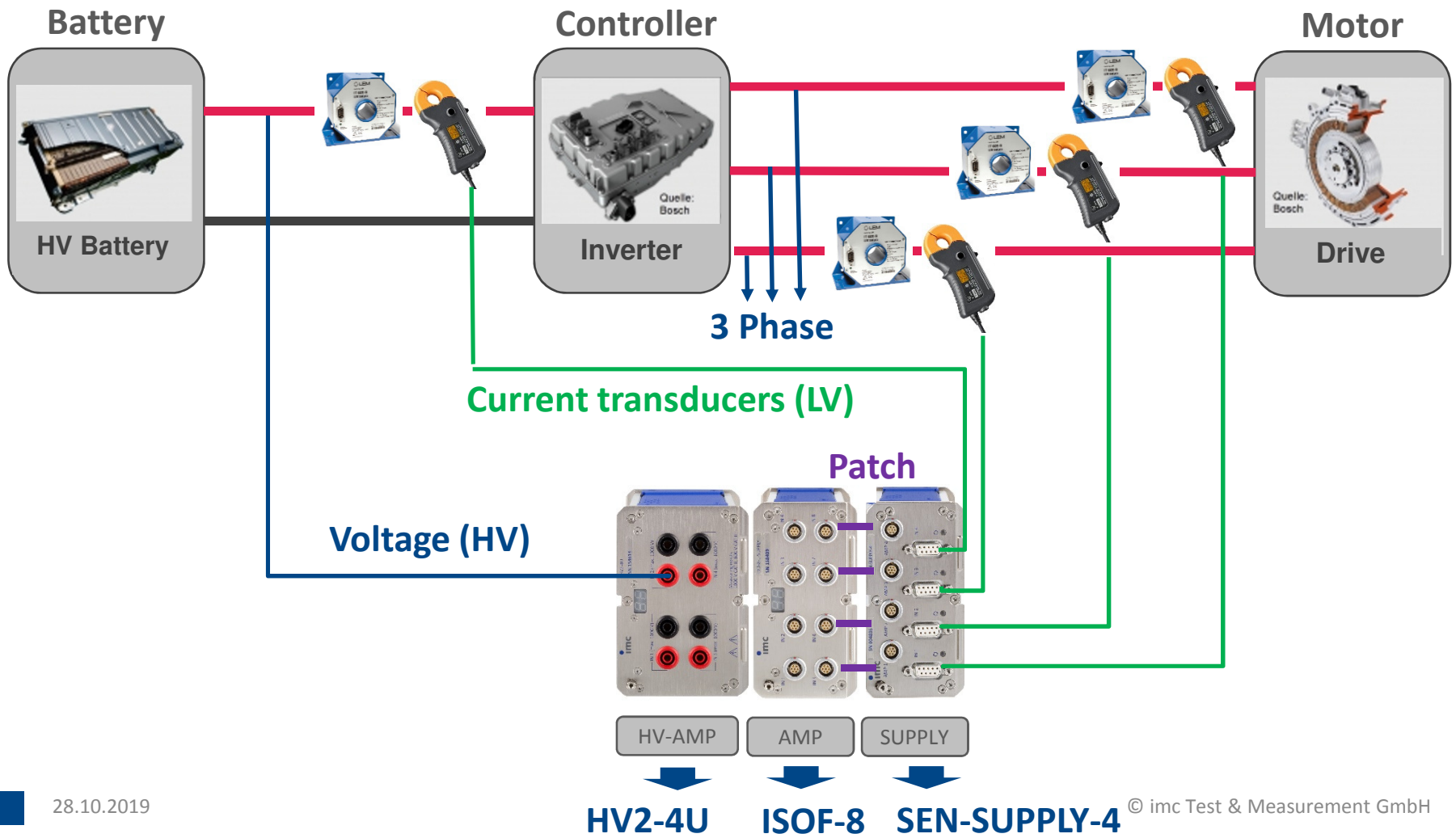
+/- 15 V Supply
I_out (100mA)

Diapositive 17

MR1 Martin Riedel; 27/08/2018

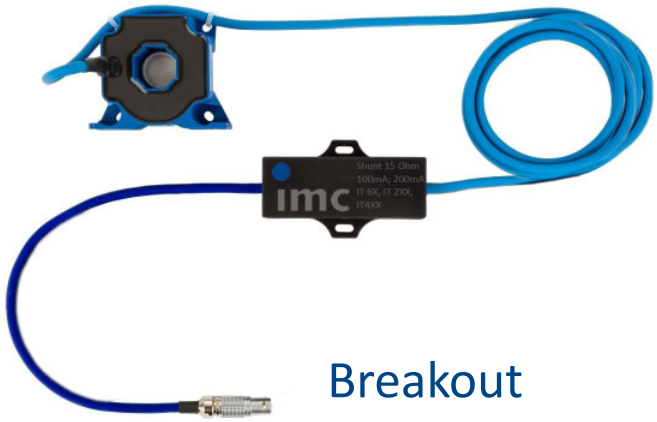
eMobility: Current and Power Measurement

imc solution with CRFX/SEN-SUPPLY-4: supply of LEM and current clamps



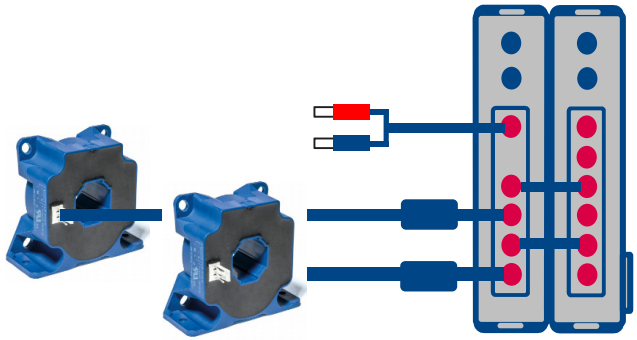
Solutions for LEM-Interface (Supply)

Single-channel / multi-channel / stand-alone / incl. amp



Breakout

- Single-channel
- Any device series



CANSAS*fit*

- Clickable

CRONOS*flex*

- 4-channel, 60W, clickable
- with / without amplifier

Electric system testing by using breadboard car

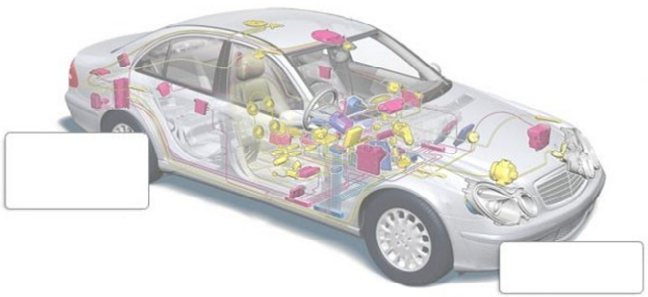
The imc IHR module

APP PREVIEW

Test of electrical systems on automotive dashboard

Modern vehicles are integrating more and more electrical systems.
Current measurement is necessary to optimize these electrical systems

- Quiescent current
- Nominal current
- Intelligent energy management when waking up components
- Powering sequences



Goal

Test of electrical systems on automotive dashboard

- DC current measurement in low voltage
- Handling of very low (50 nA) and very high (50 A) current in a single measurement Need for a very large dynamic range of measurement
- Exact measurement of peak values during switching events
- Accurate measurement of the event triggering this switching
- Low impedance needed to minimize influence
- Possibility to connect small and large diameter wires

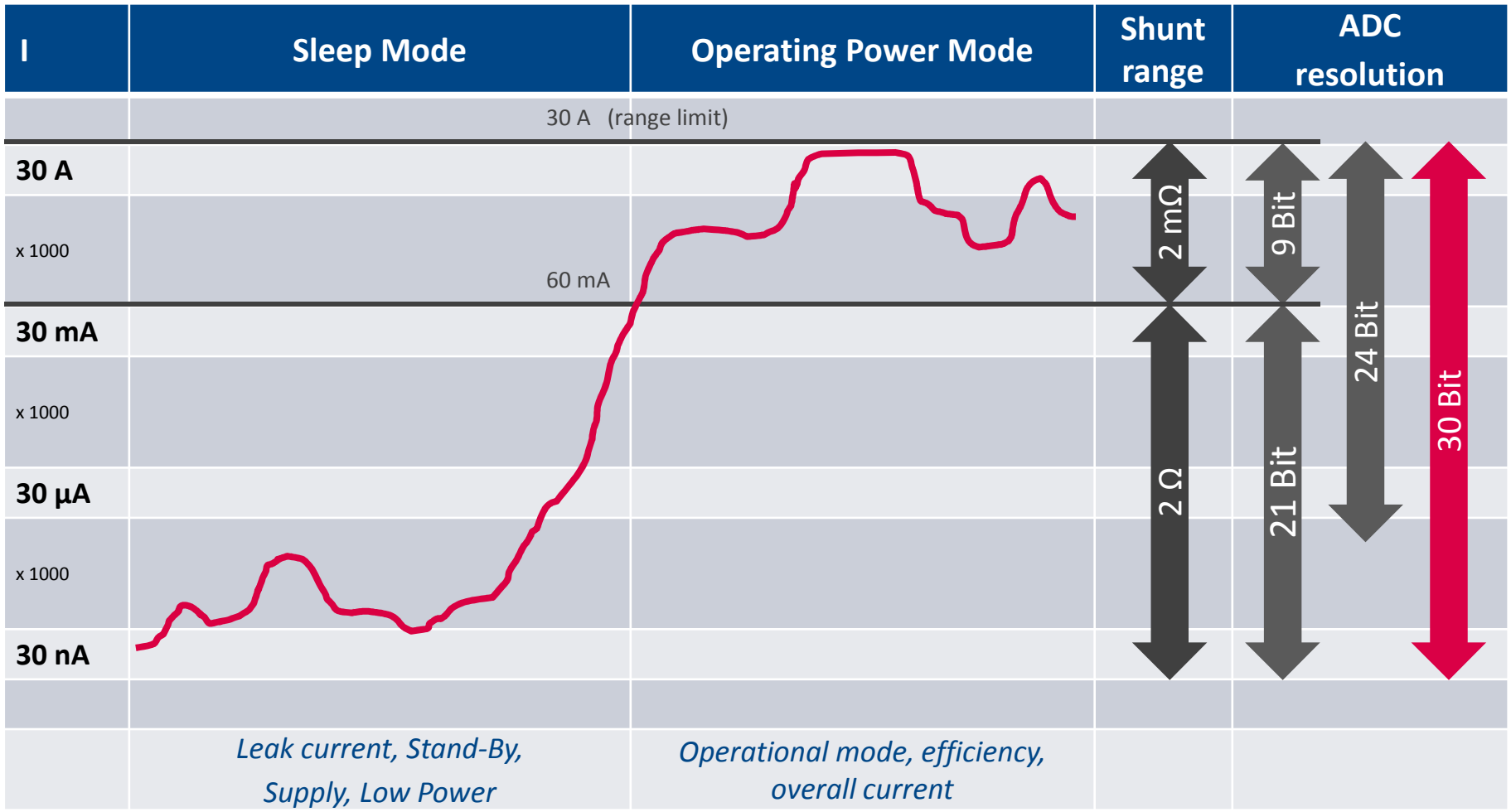
Summary

imc IHR

- Slides on a backplane in 19” rack
- Backplane has high-current terminals (solder or spring)
- Output on CAN bus → integration into any measurement/control system easy
- Output rate 1 Hz or 10 Hz
- Internal sampling rate 30 kHz
- Shunt switching within 1 µs / 1 ms
- Max. current slope 10 A/µs
- Output information:
  - Average of each interval
  - Min & max in each interval
  - Location of peaks in interval

Realizing high dynamic range

30 nA … 30 A → 180 dB / 30 bit



E-Mobility Solutions

Solutions with telemetry

eMobility and Telemetry

What particular issues can be solved with telemetry?

Difficult access

- Inaccessible locations and objects
- Rotating parts

HV Isolation

- Autarkic solutions: “island HV-Zone”
- Can avoid expensive HV-suited equipment (sensors & devices)

Typ. examples

- Mechanical power of rotating shafts
- Autarkic battery-powered units
- Radio and Fiber-optic transmission
- Intelligent sensor subsystems based on telemetry: Wheelforce-Transducer

D^x digital multi-channel telemetry

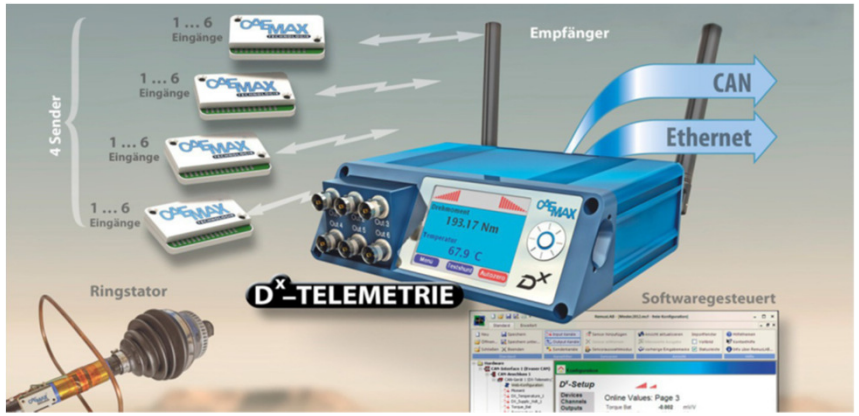
D^x telemetry

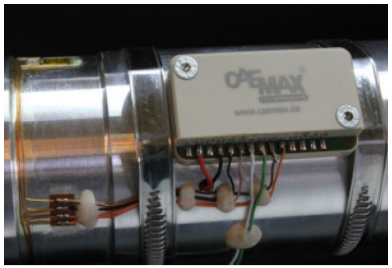
Technical data

- Up to 4 transmitters
- 16-Bit digitized signals
- 868 MHz- or 2.4 GHz-Band
- Analog outputs or CAN bus
- Power supplies:
  Inductive, battery or rechargeable
- Up to 6 channels per transmitter:
  Strain gauge, temperature, acceleration
- Sampling rate SCT summary:
  Max. 4.6 kHz (868 MHz)
  Max. 5 kHz (2.4 GHz)
- Sampling rate RCI summary:
  Max. 7.2 kHz (868 MHz)
  Max. 8 kHz (2.4 GHz)

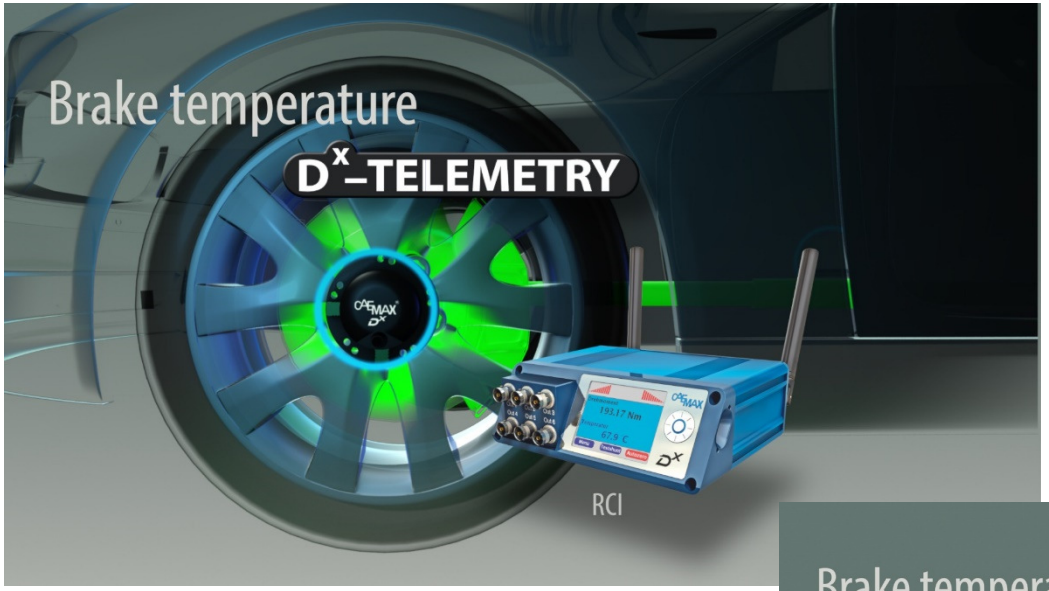
Connection to imc:

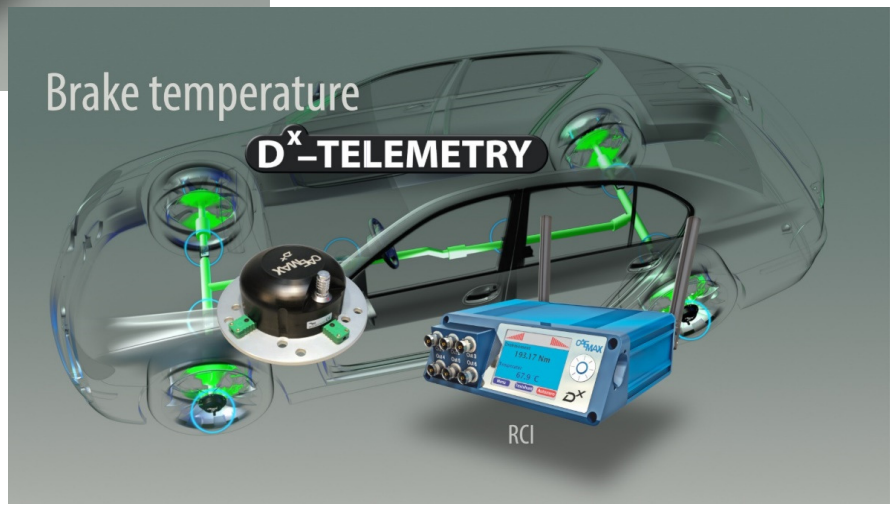
- CAN bus
- Analog output





D^x digital multi-channel telemetry





D^x digital multi-channel telemetry

Temperature measurements at the wheel

Temperature at the wheel

- Measure brake disc temperature
- Measure tire temperatures

Technical data

- Up to 4 wheels can be synchronously acquired
- Temperature acquisition integrated in proven wheel holder
- Remotely triggered sensor breakage detection
- 3 or 4 thermocouples per wheel, differential acquisition with integrated thermal reference point
- Type K or Type J thermocouples standard (others by request)
- Universally applicable. Mountable on all wheel bolts.
- Measuring time with integrated battery approx. 50 hours

Connection to imc:

- CAN bus
- Analog output

D^x digital multi-channel telemetry

Aquaplane recognition at the wheel

Speed detection at the wheel

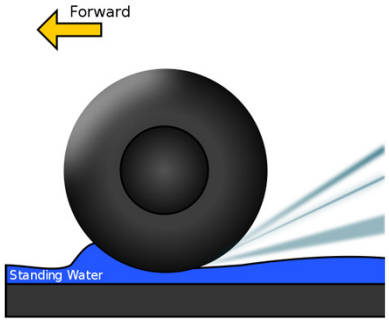
- When the wheel is floating, the rotation rate changes
- With this change of rate, the exact time of aquaplaning is recognized

Technical data

- Up to 4 wheels can be synchronously acquired
- Speed acquisition integrated in proven wheel holder
- Speed measurement by MEMS-based rotation rate sensor
- Up to 7,200 rpm
- Shock resistant up to 10,000 g
- Accuracy 0.5% of measured value from 500 rpm, below < 2.5 rpm
- “Older” SCTs retrofittable

Connection to imc:

- CAN bus
- Analog output



Source: Wikipedia

- Stator mounting on wheel not necessary
- No annoying cables necessary (time saving and safety)
- Small size, quickly mounted
- Universally applicable. Mountable on all wheel bolts.
- Minimum 8 h running time with integrated battery
- IP 68
- Bandwidth 16 Hz per channel (output)

D^x digital multi-channel telemetry

Power measurements on drivetrains

Power measurement on axles

Technical data

- up to 4 units can be synchronously acquired
- Synchronous acquisition of speed and torque integrated in proven half-shell housing
- Internal power processing in RCI
- RPM measurement by MEMS-based rotation rate sensor
- Up to 7,200 rpm
- Shock resistant up to 10,000 g
- Accuracy 0.5% of measured value from 500 rpm, below < 2.5 rpm
- “Older” SCTs retrofittable

Connection to imc:

- CAN bus
- Analog output

$$P = 2\pi \cdot n \cdot M$$

P = Power
n = RPM
M = Torque

eMobility and Telemetry

Efficiency of drive trains

Efficiency

$$\eta = \frac{P_{out}}{P_{in}} \qquad = \frac{P_{mechanic}}{P_{electric}} \qquad = \frac{2\,\pi\;\; n\;\; * M}{U\;\; * I}$$

- $P_{electric}$ Power meter (LV, HV)
- $P_{mechanic}$ torque (DMS), rpm

P = 2π · n · M

P = Power
n = rpm
M = torque

rpm assessment

- Classic solution: incremental encoder / pulse counter
- alternative: acceleration (no stator required!)

Telemetric solution with caemax Dx

- Telemetry on rotating shaft
- Integrated solution for torque (STRG) und ***rotation rate (MEMS based yaw gyro)***
- ***fully synchronous, internal power calculation***

D^x digital multi-channel telemetry

Power measurements on drivetrains

Benefits of the caemax Dx solution for test stand and mobile testing

- Fully synchronous, online ***power calculation in telemetry receive***r
- ***No stator involved*** for rotation sensor, no fixed points
- Insensitive to shock, vibration and lateral acceleration
- MEMS Gyro (**M**icro **E**lectro-**M**echanical **S**ystem)
  based on Coriolis force, comp structure, capacitance variation…
- Up to +/- 7200 rpm, accuracy 0.5 %, -40 … +85°C, IP67
- Power supply inductive or battery
- Mounting: ***no changes to original shaft component***!

robust and sealed half shell case

Thanks for your attention!

More information: www.imc-france.com