# CSM Measurement Technology in the Formula E

Case study, August 2015

in collaboration with ABT Sportsline GmbH – Author: Jens Häberle, Technical Manager E-Mobility

# Introduction

ABT operates four race cars in the all-electric racing series FIA Formula E in cooperation with Audi and Schaeffler Automotive. At the official manufacturer tests for the second season, ABT relies on measurement technology from CSM. Measurement modules from CSM are applied in stationary test benches such as dynamic suspension tests and powertrain endurance tests, as well as in racetrack tests.

## What significance does Formula E have for Audi Sport ABT?

ABT Sportsline is the only German team in the FIA Formula E, which stages its races with all-electric driven Formula cars. The second season, which will kick off on 17 October 2015 in Beijing (China), will mark the launch of an in-house designed vehicle of the Kempten-based company. The new generation named "ABT Schaeffler FE 01" has already completed its maiden voyage in southern Germany in mid-June 2015. More test drives are to follow in Italy, Hungary, Germany and the UK. At about the same time, four spare chassis will be constructed at the premises of ABT in Kempten.

ABT Sportsline is once again competing with Daniel Abt (22) and Lucas di Grassi (30). The German-Brazilian duo was already more than once the cause for a sensation in the premiere season 2014/2015 and was at the end ranked third in the team standings. Lucas di Grassi fought for the title until the very last race and was ranked third in the final standings.

ABT Sportsline has been approved by the FIA as one of eight manufacturers for the Formula E. As the exclusive technology partner of the team, Schaeffler Automotive has developed an electric motor and co-designed the entire drive system of the race car consisting of motor and transmission. In season 2015/2016, the team will compete under the name "Audi Sport ABT Schaeffler". At the official test drives for the second season, ABT relies on the measurement technology from CSM.


Paddock of the ABT Formula-E Team // Picture: ABT Sportsline GmbH


# Measurement system: requirements

Requirements to be fulfilled:

- Operating temperature range 0 °C to +65 °C
- Acceleration in z axis direction up to 5 g
- Splash-water proof
- Easy mounting and dismounting
- Measurement data transmission via CAN
- Adaptability of the CAN matrix

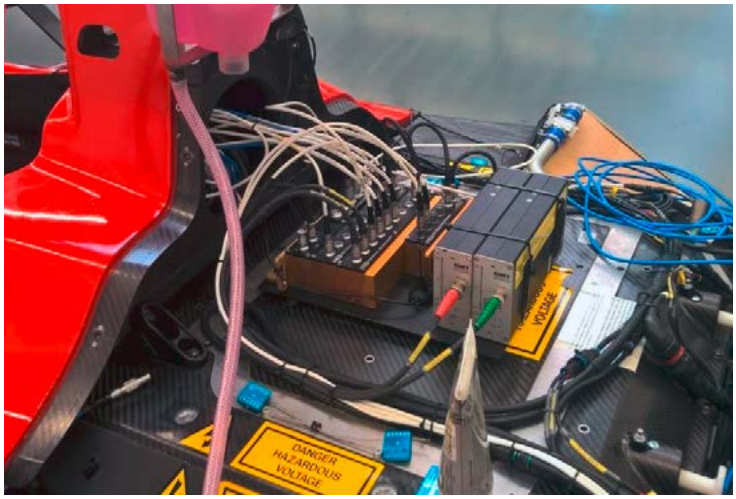
Sensors to be integrated:

- 4 × pushrod loads (strain gauge) 1 kHz
- 2 × driveshaft torque (strain gauge) 1 kHz
- 6 × acceleration in Y axis 500 Hz
- 2 × current (low-volt)
- 6 × Ridehight laser
- 1 × water flow
- 1 × Pitot pressure
- 4 × temperature

Race in Buenos Aires // Picture: ABT Sportsline GmbH

# Where the modules are mounted

The MiniModules are mounted on the carbon housing of the high-voltage traction battery by means of easy-to-use mounting brackets. The picture on the right shows the measurement setup installed on the test vehicle.




CSM MiniModules mounted for test operation
Pictures: ABT Sportsline GmbH


MiniModules (left to right):

- CAN PTMM 4
- CAN AD8 pro MC2
- CAN AD8 pro MC2
- CAN STGMM 6 pro HS

# Linkage to the logging system

There are two different application cases:

- Data logging in the vehicle on the race track
- Data logging at the test bench

In the vehicle, the recording of measurement data is performed entirely via the vehicle's own control unit from McLaren, the TAG400i. This ECU ensures an offset-free data logging among all the high-frequency signal channels and control signals.

At the test bench, the data logging is performed directly via the CSM UniCAN 2 Professional data logger. Only a single CAN cable (which includes the power supply line) is needed to connect all the sensors with minimal cabling efforts to the vehicle system / data logger via CSM's measurement modules.

McLaren Control Unit
Picture: ABT Sportsline GmbH


The figures on the right show the channel assignments of the individual CSM Mini-Modules. For the individual test drives, the number of measurement channels is either expanded or reduced. Measurement values are used to confirm values assumed in the design phase. Also, measurement values are used to determine and implement the settings for the individual race setups (chassis, engine, controller, etc.).

CAN STGMM 6 pro HS


Push rod rear 1 | Push rod rear 2 | Push rod front 3 | Push rod front 4

### STGMM

| | Sensor designation | Sampling rate |
|---|---|---|
| 1 | Push rod rear 1 | 1000 Hz |
| 2 | Push rod rear 2 | 1000 Hz |
| 3 | Push rod front 3 | 1000 Hz |
| 4 | Push rod front 4 | 1000 Hz |

4 strain gauge sensors, full bridge, sensitivity 0.048098 µV/V/N, signal range +/- 416 kN

CAN AD8 pro MC2


Laser 1 | Laser 2 | Laser 3 | Laser 4 | Laser 5 | Laser 6 | Flow sensor | Pitot

### AD8 pro MC2 1

| | Sensor designation | Sampling rate |
|---|---|---|
| 1 | Laser 1 | 500 Hz |
| 2 | Laser 2 | 500 Hz |
| 3 | Laser 3 | 500 Hz |
| 4 | Laser 4 | 500 Hz |
| 5 | Laser 5 | 500 Hz |
| 6 | Laser 6 | 500 Hz |
| 7 | Flow sensor | 500 Hz |
| 8 | Pitot | 500 Hz |

CAN AD8 pro MC2


Drive Shaft 1 | Drive Shaft 2 | Acc_Rear_Axle | Acc_Front_Axle

### AD8 pro MC2 2

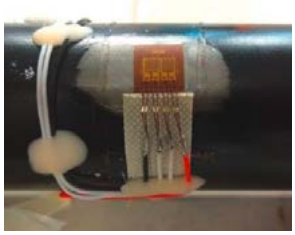
| | Sensor designation | Sampling rate |
|---|---|---|
| 1 | Drive Shaft1 | 500 Hz |
| 2 | Drive Shaft2 | 500 Hz |
| 3 | Acc_Rear_Axle | 500 Hz |
| 4 | Acc_Front_Axle | 500 Hz |

CAN PTMM 4


PT 1000 | PT 1000 | PT 1000 | PT 1000

### PTMM

| | Sensor designation | Sampling rate |
|---|---|---|
| 1 | Drive Shaft1 | 10 Hz |
| 2 | Drive Shaft2 | 10 Hz |
| 3 | Acc_Rear_Axle | 10 Hz |
| 4 | Acc_Front_Axle | 10 Hz |

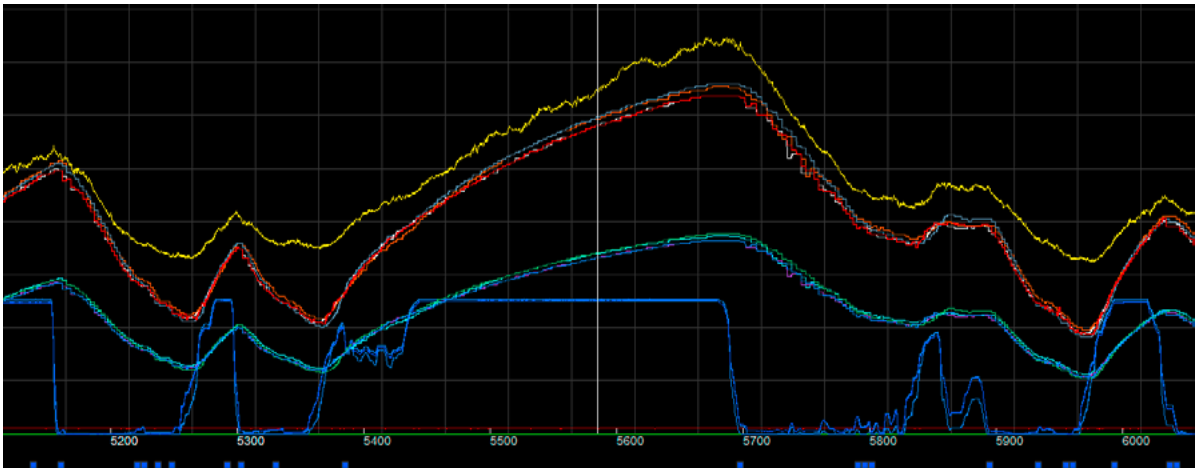


Strain gauge application
Picture: ABT Sportsline GmbH

# Experience in the field

CSM's hardware has been integrated into the already existing data acquisition system. Due to the scalability, new sensors could be integrated very quickly and easily. Neither existing wiring harnesses nor the software needed to be modified during the test phase in June and July. Support via phone and email was smoothly rendered and feedback on requests for information (RFIs) from the race track in Hungary (Hungaroring) went without a hitch.

Despite the extremely harsh operating conditions during the entire test period, no outage of the measurement technology or of the individual measurement channels was recorded!




Graphs of measurement data recorded during a test run // Picture: ABT Sportsline GmbH

# CSM measurement technology - advantages

In addition to the excellent support and product quality, the following advantages deserve particular attention from a motorsport point of view:

- Easy mechanical mountability thanks to "Plug & Play" mounting brackets. This is essential as the vehicle often needs to be completely disassembled.
- Straightforward extension of the setup simply by adding further measurement modules
- Easy integration of a wide variety of analog sensors into a CAN network
- Easy electrical connection via standard cables

CSM would like to thank ABT Sportsline GmbH and Jens Häberle for their support in drawing up this case study. We are very happy to support the development of ABT Schaeffler FE 01 with our measurement equipment and we wish the ABT Schaeffler Audi Sport team all the best for the Formula E season.

Pictures on cover / back page and page headers courtesy of ABT Sportsline GmbH


# About us

## CSM Computer-Systeme-Messtechnik GmbH

CSM is a leading and innovative manufacturer of mobile measurement equipment and data acquisition systems. For over 30 years, we set technological standards in the field of measurement technology. Our products are successfully and reliably in use worldwide, in the case of virtually all known manufacturers of automobiles and commercial vehicles as well as their suppliers and service providers.

Permanent innovation in conjunction with long-term satisfied customers constitute our guarantee for success, also in the future. We constantly address new challenges, such as the need for high-voltage-safe as well as synchronous high-speed measurement technology for the test and trial of electric and hybrid vehicles.

The close cooperation with Vector Informatik allows us now to offer complete solutions consisting of hardware and software from one source, which is an ideal addition to our measurement technology product range.

## Products and data: all Information at a glance


www.csm.de

Find all information on CSM measurement modules and data loggers on our new website **www.csm.de**. Make use of our solutions for the development and testing of cars, construction and agricultural machinery, cranes, commercial vehicles, trains, aircraft, boats, wind turbines, etc.

- Introduction to our product portfolio
- Examples of application
- Available for download: the latest CSM software versions
- Fast access to all datasheets and product information

**www.csm.de**

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