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“Fuel Cell Systems for FCE buses”

Bosch Engineering GmbH

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Agenda

- Bosch Engineering Overview
- Fuel Cell Control Unit
- Project Giantleap
- Further Bosch Engineering Fuel Cell Range Extender projects
Bosch Engineering
Locations

Abstatt | Holzkirchen | Weissach | Ingolstadt | Braunschweig

Farmington Hills | Palo Alto

Curitiba | Campinas

Coventry

Paris (Saint Ouen)

Turin

Wien

Shanghai | Suzhou

Yokohama
Fuel Cell Engineering Services

- **System design**: requirements management, topology definition, sizing of fuel cell/ battery/ hydrogen tank capacity
- **Simulation**: use case analysis, load profiles
- **Selection of components**: component specification and benchmarking of suppliers
- **Control software**: development of operating strategy and implementation on BEG fuel cell control unit (FCCU)
- **Functional safety**: Consideration of relevant safety aspects and standards
- **System testing**: subsystem/ system testing and validation on BEG test benches
- **Vehicle integration**: packaging, construction, installation and commissioning
Agenda

▶ Bosch Engineering Overview

▶ Fuel Cell Control Unit
  ▶ Overview
  ▶ The System
  ▶ Platform Software Benefits

▶ Project Giantleap

▶ Further Bosch Engineering Fuel Cell Range Extender projects
Fuel Cell Control Unit

- A wide range of analog and digital interfaces enable flexible integration into a fuel cell system
- The Fuel Cell Control Unit is characterized by its robust design
- The FCCU meets the international functional safety standard. Safety-relevant functions are monitored via redundant software levels. Diagnostics and maintenance can be carried out remotely via the usual wireless interfaces.
- The FCCU guarantees safe operation in all circumstances and offers sophisticated fail-safe strategies
- Using established calibration methods, tolerances can be compensated without software changes.
Fuel Cell Control Unit – The System
Fuel Cell Control Unit - Platform Software Benefits

- **EG79/2009**
  - Safety of hydrogen-bearing Parts

- **ISO26262**
  - Road vehicles – Functional safety

- **ISO 13849**
  - Safety of machinery - Safety-related parts of control systems

- **DIN EN 62282-4**
  - Fuel Cell Power Systems For Propulsion Other Than Road Vehicles And Auxiliary Power Units - Fuel Cell Power Systems For Industrial Electrically Driven Forklift Trucks - Safety
Fuel Cell Control Unit - Platform Software Benefits

- **Operational**
  operation strategy, hydrogen, air and thermal control available

- **Adaptable**
  adapt the SW to your system demands without changing code

- **Diagnoseable**
  define error behaviour, find failure root cause in service station

- **Safety oriented**
  redundant ECU HW and SW check to fulfill safety requirements

- **Future proof**
  customer specific Add On’s and future requirements can be realised
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- Bosch Engineering Overview
- Fuel Cell Control Unit
- Project Giantleap
  - Project Organization
  - Project Objectives
  - Fuel Cell System Overview
- Further Bosch Engineering Fuel Cell Range Extender projects
**Giantleap Project Organization**

- Fuel Cells and Hydrogen Joint Undertaking (FCH-JU)  
  Belgium  
  Lead Partner
- Stiftelsen SINTEF (SINTEF)  
  Norway  
  Project Organization
- Sveuciliste u Splitu –  
  Fakultet Elektrotehnike, Strojarstva i Brodogranje (FESB)  
  Croatia  
  Degradation mechanisms
- Universite de Franchecompte (UFC)  
  France  
  Lifetime prognostics
- BOSCH Engineering GmbH (BEG)  
  Germany  
  System development
- Elring Klinger AG (EK)  
  Germany  
  Stack manufacturer
- VDL Bus & Coach BV (VDL)  
  Netherlands  
  Bus manufacturer

![Giantleap Project Organization logos]
Giantleap Project Objective

- Design and build of a fuel cell range extender system for battery electric city buses
- Reduction of system cost by use of production components
  - Aim: System cost < 500 €/kW for the FC system
  - TCO for a FC-REx city bus within the range of a Diesel powered bus
- Increase of lifetime and availability of the fuel cell system
- Development of algorithms for modelling remaining lifetime
  - State of Health und diagnostic functions
  - Prediction of remaining useful life
  - Operation and control strategy optimized für maximum lifetime
Fuel Cell Range-Extender for Intercity bus

- Electrified bus with a rated power of 210-240 kW, lithium-ion battery with a usable capacity of 60-120 kWh and rated voltage of 700 V
- PEM fuel cell system providing 60 kW net power in range-extender mode
- Tank capacity of 32 kg hydrogen (diesel energy equivalent of 108 l) with a tank pressure of 350 bar. Maximum driving range of 450 km.
- Suitable system for low ambient temperatures during winter
Fuel Cell Power Train Topology
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Project InnoROBE

- Fuel cell range extender airport baggage tow truck
- Project founded by German government (NOW)
- Development of fuel cell system by Bosch Engineering GmbH
- First demonstrator project done within Bosch Group

**Technical Data**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
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<tr>
<td>Load Capacity</td>
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<tr>
<td>Vehicle Speed</td>
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<tr>
<td>Powertrain</td>
<td>30 kW</td>
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<tr>
<td>Battery</td>
<td>6 kWh @ 80 V</td>
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<td>Fuel Cell System</td>
<td>15 kW net power</td>
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<td>Total Range</td>
<td>8 hours airport transport</td>
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Project Bosch eCityBus Demonstrator Vehicle

- Fuel cell range extender midi bus based on Iveco Daily Tourys
- Bosch FCCU platform (software and hardware)
- Powertrain with Bosch SMG Gen2 electric motor
- Bosch VCU platform (software and hardware)

**Technical Data**

<table>
<thead>
<tr>
<th>Feature</th>
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<td>Load Capacity</td>
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<tr>
<td>Vehicle Speed</td>
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<td>Powertrain</td>
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<td>Battery</td>
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<td>Total Range</td>
<td>max. 580 km</td>
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Nikola Motor, Type One and Two

- Fuel cell range extender class 8 heavy truck for US market
- Co-operation between Nikola Motor Corp. and Robert Bosch GmbH
- Development of powertrain by Robert Bosch GmbH
- Development of fuel cell system by Bosch Engineering GmbH

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<td>Load Capacity</td>
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<td>Vehicle Speed</td>
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<td>Powertrain</td>
<td>1,000 bhp</td>
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<td>Battery</td>
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<td>Fuel Cell System</td>
<td>300 kW net power</td>
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<td>Total Range</td>
<td>max. 1,000 mls</td>
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Giant Leap

Giant Leap Improves Automation of Non-polluting Transportation with Lifetime Extension of Automotive PEM fuel cells

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