Bus Traffic

Fraunhofer Institute for
Transportation and Infrastructure Systems IVI

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PARTNERS

- HOPPECKE Advanced Battery Technology GmbH
- M&P motion control & power electronics GmbH
- Schunk Bahn- und Industrietechnik GmbH
- Vossloh Kiepe GmbH
- Dresdner Verkehrsbetriebe (DVB) AG

TECHNICAL DATA

Vehicle length	12,000 mm
Bottom edge of contact head above ground	4,500 mm
Passenger capacity	58
Weight of battery storage system (incl. cooling system)	1,300 kg
Weight of on-board re-charging system	85 kg
(Permanent) power of the central propulsion (ASM)	145 kW
Effective energy content of fast charging	30 kWh
Medium energy demand in regular operation	1.2 kWh
Time required for re-charging (fast charging)	20 s/km
Time required for re-charging (pulse charging) 9 s/km	9 s/km
Time required for contact closure until start of energy transfer	< 1 s

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... For Urban

E-Power ...

Fast-Charging Electric Bus

IDEA AND VEHICLE

The Fraunhofer IVI has been working towards the implementation of fully electric bus operation following the »DockingPrinciple« for over ten years now. The term »DockingPrinciple« stands for a new electric propulsion concept for public transport vehicles, in which an on-board energy storage unit serves as the sole source of energy for the vehicle. The storage unit takes in energy from fast-charging wayside stations and releases it on demand to the vehicle propulsion or the electric auxiliaries.

For the implementation and testing of these components under near-regular operating conditions, a consortium consisting of industry partners, transport providers and the Fraunhofer IVI has been formed. Within the SEB-subproject EDDA-Bus, funded by the Federal Ministry of Education and Research (BMBF), the necessary key technologies were developed and integrated into a city bus. The »DockingPrinciple« has been demonstrated in passenger service with the Dresdner Verkehrsbetriebe (DVB) AG.

Since November 2010, the Fraunhofer IVI owns a serial hybrid bus, which has been re-equipped during the course of the project by integrating an 86 kWh lithium-ion battery storage and an on-board high-current contact system for fully electric operation with fast charging.

KEY TECHNOLOGIES

There are currently two suitable types of wayside installations for energy supply to enable re-charging of the vehicle's energy storage. The requirements for pulse charging (15 seconds with 700 kilowatts) at bus stops and fast charging (approx. 6 minutes with 250 kilowatts) designed for terminal stations differ considerably from each other with regard to supplying power from a net resource.

M&P motion control and power electronics developed two charging stations that offer both pulse charging and fast charging. Power can be supplied from a low voltage grid, a 20 kilovolt medium-voltage grid or the tram network power supply. For pulse charging, a supercapacitor integrated into the charging station is pre-charged for several minutes from a low voltage grid with 35 kilowatts. During fast charging, energy is transferred directly from the net resource without intermediate storage.

HOPPECKE Advanced Battery Technology GmbH developed the battery storage, which is suitable for the uptake of high charging currents. From the overall energy content of 86 kWh, 30 kWh can be utilized for driving.

CONTACT SYSTEM

The contact system, developed in the EDDA-Bus project in cooperation with Schunk Bahn- und Industrietechnik GmbH, not only meets the normative requirements (number of poles and contact sequence) but also the specific demands of city bus operation. This includes a generous positioning tolerance as well as the option to transfer high currents without damaging the contact system.

In combination with the automation solution by the Fraunhofer IVI, energy can be transferred safely and reliably between the charging station and the vehicle without any interaction by the driver. Based on an extensive risk analysis, the TÜV Rheinland certified the overall system of battery of bus and re-charging system, including the wayside charging infrastructure, and released it for passenger operation.

Vossloh Kiepe GmbH provided the traction equipment, which has been modified for fast charging and fully electric operation.

FIELD TEST IN REGULAR OPERATION

The vehicle was tested in regular operation for the first time from November 2014 until January 2015 in Dresden. The fast charging process after each cycle as well as the pulse charging were carried out at the bus depot in Dresden-Gruna using the medium-voltage power grid. The bus operated on a 14.4 km-long segment (round trip) of a highly frequented city bus line. Compared to standard operation with conventional vehicles, the key technologies developed within project EDDA-Bus proved themselves extremely reliable in the field test. On a total of 9,400 kilometers, the average energy demand from the contact system amounted to 1.19 kWh/km. To even out the energy balance of the vehicle energy storage, an average 4.5 minutes of re-charging time were required after each turnaround with an average transmission efficiency of 94.7 percent. Following the highly successful outcomes, the field test was extended, demonstrating an overall availability of 94 percent even on a highly demanding route with a steep slope. With a stable energy demand of 1.19 kWh/km, the average time required to even out the energy balance was 6.5 minutes.

Since May 2016, the vehicle has been used in regular operation in the city of Leipzig at the Leipziger Verkehrsbetriebe (LVB) GmbH bus line 89. The batteries are recharged after each cycle during the bus's regular turnaround times. The special feature of this operation is the energy supply: The charging takes place with electric energy via the Leipzig tramway traction network, thus keeping the infrastructure expenditures at a minimum. Due to the many route sections with low average speed and high passenger figures on this line, the energy demand increased to 1.3 kWh/km.