eBus-High Power Charging Solutions from Siemens
Siemens eBus infrastructure
Introduction

"eBus infrastructure" part of urban transport within Mobility Division

Global HQ in Vienna

Three core eBus solutions
1. Fast DC high power charging for mass transit (HPC)
2. eBus for airports
3. DC source with onboard pantograph

Complete solution portfolio for eBus

Compliant with international standards

Passenger service reference projects
Siemens role for eBus infrastructure

Electric bus is a stranded asset without connection to the power grid

As a technology provider and integrator, Siemens can offer:

- Charging solutions
  - Power engineering
  - System installation
  - Service and maintenance
  - Asset management
  - Energy services

Cities
- Eliminate particulates
- Lower emissions
- Reduce noise
- Improve quality
- Avoid penalties
- Raise profile
- Promote sustainability

Transit operators
- Maintain service
- Reduce costs
- Create efficiencies
- Limit infrastructure

Energy suppliers
- Sell electricity
- Secure new customers
- Maintain the grid

Vehicle suppliers
- Sell vehicles
- Sell solutions and service
- Maintain customers

Technology provider and systems integrator
eBus technology options
Influence on infrastructure choices

Continuous charging
- Expensive infrastructure
- Inflexible

Overnight charging
- Heavy vehicles
- Reduced capacity

Opportunity charging

Inductive
- Expensive vehicles
- Magnetic shielding
- Expensive installation
- Low energy transfer efficiency

Conductive
- Low weight vehicle components
- Proven, safe technology
- Lower vehicle cost/complexity
- Fast charging up to 450kW
- Efficient energy transfer

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**eBus deployment**

Need for scalable, real world solutions

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**Fast, reliable, efficient**

One charger – multiple buses per hour

- Low cost onboard components per vehicle
- Automatic operation, highest availability

<table>
<thead>
<tr>
<th>Uses low weight onboard components</th>
<th>Places charging equipment off-board</th>
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</thead>
<tbody>
<tr>
<td>Compliant with EN/SAE EV standards</td>
<td>ISO 15118 wireless communication</td>
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<tr>
<td>Supports multiple bus makes and types</td>
<td>Enables automatic charging operations</td>
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Siemens high power charger

- Grid connection and switching devices
- Isolation transformer
- Core charger and system controller
- Secure, equipment enclosure
- Design mast and covers
- Structural mast for pantograph
- Inversely mounted pantograph
- Wireless communication bus to charger
High power charger
Typical system outline

Up to 5 kW/min

North-bound terminus
• 600 V – 230 V, 3ØAC
• 60 Hz
• HPC, 300 kW
• 450 – 750 VDC

12 miles

6 mins depending on SOC

South-bound terminus
• 600 V – 230 V, 3ØAC
• 60 Hz
• HPC, 300 kW
• 450 – 750 VDC
Operating sequences
Fully automated and safe

1 Approach
Bus arrives at the charging station and stops under the pantograph – wireless communication between charging station and bus is established
Positioning of the bus: Driver stops at parking reference point and activates the parking break
Sensors check position of the bus; system checks if parking break is activated; if "all ok" charging process is initiated
Notification to driver: Charging session "initiated"

2 Contact and charge
Pantograph is lowered down on the bus rails until the required pressure is detected and confirmed
System checks via 4 pole approach on positive earthing and safe isolation – if "all ok" the main circuit of the HPC is switched on
System sends message to the bus "all ok/all safe" – bus closes the isolation circuit to the battery system
Charging started with continuous isolation and power monitoring

3 Charge and release
Charging and battery status are being transmitted to the driver via visual display in the bus cockpit
At "battery status 100 %" or at any point, the driver can release the parking break and by that, initiate the termination of the charging process
The charger lowers the current and opens the charging circuit, switching off the main circuit – charging process terminated
The pantograph is raised to "full raised up" position; the bus leaves the station
High power charger
Communication, safety and standards

Communication is established wirelessly via WiFi patch antennas mounted on the mast and bus roof

The HPC takes advantage of the Combined Charging System (CCS) with ISO/IEC15118 control interface standard

Siemens and Volvo have developed a wireless version of the control interface standard for pantograph charging

- Continuous protective earth (PE) continuity checks as per EN61851-23
- Isolation monitoring as per EN61851-23 to detect pole to earth isolation faults
- The isolation monitor is set to 75kOhms, which is equivalent to 10mA leakage current to earth (less than hazardous DC current) at maximum voltage

EN/IEC 61851-1
EN/IEC 61851-23
ISO/IEC 15118
Complete solutions for eBus roll out

Core charger
Isolated transformer
Operation centre functions
Onboard charging components

Inverted pantograph

System dimensioning
Service & maintenance

Installation and project management

Equipment enclosure
Mast covers

Wireless communications

Design masts for onstreet installations

Operation centre functions

System dimensioning
Service & maintenance

Installation and project management

Equipment enclosure
Mast covers

Wireless communications
High power charger
Reference projects

- Hamburg | Germany
  4 x 300 kW HPC

- Stockholm | Sweden
  2 x 150 kW HPC

- Gothenburg | Sweden
  3 x 300 kW HPC

- Hallerad | Sweden
  1 x 300 kW HPC

- Wroclaw | Poland
  1 x 300 kW HPC

- Montreal | Canada
  1 x 450 kW HPC
Siemens’s off-board high power charging solution for Hamburg’s Hochbahn

### Project information
- Off-board charging at start/end-point of line
- Start of passenger service: December 18, 2014
- Innovation Line 109 (route 9.3 km; 6-8 min charging)

### Project organization
- Siemens and Volvo (Lead) consortium
- Project duration <24 months

### Technical information

**Siemens**
- 4 Siemens 300 kW high power chargers
- Grid access 10 kV via Hamburg Metro

**Volvo**
- 3 Volvo 7900 H electric hybrid 12 meter buses (32+1)
- Lithium-ion battery with 19 kW/h
- eDrive 150 kW; diesel 250 PS

### Sustainability
- Reduced local emissions (CO₂, noise)
- More energy efficiency (electric drives, auxiliaries, etc.)
- Utilization of renewable energy
- Air condition and heating are fully electric

### Maintenance
- Reduced maintenance due to fewer mechanical parts
Bottom line

- Develop a concept to integrate eBus services in standard operating conditions
- Use already present infrastructure intelligently
- Use suitable battery sizes
- Make vehicles practicable and financially viable
Siemens eBus infrastructure summary

- **Input voltage:** 3AC, 230 V +/-10%
- **Maximum output current:** 600 A
- **Output voltage:** 450 – 750 VDC, 300 kW @ 750 VDC
- **150 – 450 kW DC fast charging**
- **LV or MV grid connection**
- **Automatic operation**
- **Isolation monitoring and PE checks**
- **System dimensioning and street design**
- **Installation and project management**
- **Onboard components and integration**
Thanks for your attention!

Efficient and integrated mobility