Electric Vehicle Supply Equipment Basics Review

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What’s What? Understanding Terminology

Hybrid Electric Vehicle

Plug-in Hybrid Electric Vehicle

Electric Vehicle
Here come the EV’s.....
Total Electrified Vehicle Sales, World Markets: 2010 - 2015

Source: Pike Research, Published 3Q 2010
Annual EV Charging Equipment Sales, United States: 2011-2015

Source: Pike Research, Published 3Q 2010
Government Support

• Federal Government
  • Tax credits
    • EV or Plug-in Hybrid (with minimum 4kWH batteries) up to $7,500
    • Alternative Fuel Vehicle Refueling Property
      • 30% up to $30,000 for businesses
      • 30% up to $1,000 for residences
  • Check your local and state government incentives. Many were set to end in 2011
Electric Vehicle Supply Equipment (EVSE)

• EVSE
  • Electric Vehicle Supply Equipment
  • General term used for all of the equipment used to supply electricity to the car
  • In most cases, the battery charger resides in the vehicle. EV Supply Equipment is simply regulating the flow of AC power to vehicle charger
  • Only in DC charging is the EVSE equipment directly charging the batteries
How does EVSE work?

**AC Charging**
Direct charge to the car’s onboard battery charger

**DC Charging**
Direct charge to the car’s battery

- EVSE
- Electric Vehicle
- Battery Charger
Level Terminology – NEC 2011

• **Article 625 – Electric Vehicle Charging System**

  • **Level 1**
    • 120Vac, 12-16A (up to 2 kW)
    • 15amp or 20amp receptacle

  • **Level 2**
    • 208 or 240Vac, 30-80A (up to 20 kW)

  • **Level 3**
    • DC (undefined)
    • Power requirements specified by equipment manufacturer
Level Terminology – Society of Automotive Engineers (SAE)

- **AC Level 1 – 120V**
  - Single Phase 2kW
- **AC Level 2 – 240V**
  - Single Phase ~20kW
- **AC Level 3 – Undefined**
  - Single or 3 Phase
- **DC Level 1 – 200-450V**
  - ≤ 20kW
- **DC Level 2 – 200-450V**
  - ~80kW
- **DC Level 3 – 200-450V**
  - ~120kW
EVSE Overview
Eaton Pow-R-Station™ EVSE Family

Level 1 AC
16amp Receptacle
12 - 18 Hours

Level 1 & 2 AC
16 & 30amp
4 - 8 Hours

Level 2 AC
30-75amp
4 - 8 Hours

DC Quick Charger
(Level 2)
20 - 30 Minutes

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Codes and Standards

- **UL 2594, UL 2231-1, UL2231-2, UL 1998**
- **NFPA NEC Article 625** – Electric Vehicle Charging System
  - Defines the Electrical Code and Requirements around the installation of Electric Vehicle Supply Equipment
  - Considered “continuous loads”
- **SAE J1772™** – Conductive Charging Connector
  - Society of Automotive Engineers J1772 Standards defines the physical medium by which the connection between the EVSE and vehicle is established
  - Defines the details of how the vehicle and EVSE interact during a charging sequence
- **SAE J2836 / J2847 / J2931** – Electric Vehicle Communication
  - Defines communication and messaging between the vehicle and EVSE
  - Theses standards are in the beginning phases of being drafted
- **CHAdeMO**
  - Association formed by The Tokyo Electric Power Company, Nissan, Mitsubishi and Fuji Heavy Industries; later joined by Toyota using a standard connector for DC quick charging
Lithium-Ion Battery Basics

• They are lighter. Typical lithium-ion battery can store 150 watt-hours of electricity in 1 kilogram of battery. (6 times as much as Lead Acid and 2x as much as Nickel-metal Hydride (NiMH)
• They hold their charge. A lithium-ion battery pack loses only about 5 percent of its charge per month, compared to a 20 percent loss per month for NiMH batteries.
• They have no memory effect, which means that you do not have to completely discharge them before recharging, as with some other battery chemistries
• Lithium-ion batteries can handle hundreds of charge/discharge
SAE J1772™ Connector
SAE J1772 Handshake – High Level - How Does It Work?

- **Step 1**: Driver plugs J1772™ connector into the inlet located on EV
- **Step 2**: EVSE confirms that it is a car by waking it up through one of the pins in the connector
  - Note: Five pins on the connector have no AC power to them at this point - safe to touch
- **Step 3**: EV tests to make sure it is connected to an EVSE, and then tells the EVSE whether the battery needs ventilation
  - Note: Ventilation in most cases is not necessary
- **Step 4**: EVSE responds by telling the EV the EVSE’s available line current (ALC)
  - Note: Maximum current that the EV is allowed to draw
- **Step 5**: EV’s onboard battery charger uses this information to compare to its own maximum current to find the lesser of the two
- **Step 6**: Power is turned on by the EVSE to the connector
AC Level 2 EVSE Overview

- Protection and Control Board
  - Handles hand-shaking with the EV
  - Monitors, stops/starts flow of electricity
  - Protects from over/under current, ground fault, breakaway, etc
- SAE J1772 Compliant
- Electrically operated Contactor sends power to the EV
AC Level 2

Wall-Mount

Pedestal
## Understanding the User Interface

<table>
<thead>
<tr>
<th>Blink Description</th>
<th>Steady Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Power Symbol" /></td>
<td><img src="image" alt="Power Symbol" /></td>
</tr>
<tr>
<td>Payment / Authorization Needed</td>
<td>Unit Ready for Charge Session</td>
</tr>
<tr>
<td><img src="image" alt="Battery Symbol" /></td>
<td><img src="image" alt="Battery Symbol" /></td>
</tr>
<tr>
<td>Vehicle Connected, EVSE Ready, Waiting on Vehicle</td>
<td>Vehicle Charging</td>
</tr>
<tr>
<td><img src="image" alt="Checkmark" /></td>
<td><img src="image" alt="Checkmark" /></td>
</tr>
<tr>
<td>N/A</td>
<td>Vehicle Has Ended Charge (May begin again at anytime)</td>
</tr>
<tr>
<td><img src="image" alt="Clock Symbol" /></td>
<td><img src="image" alt="Clock Symbol" /></td>
</tr>
<tr>
<td>Rate of Charge Controlled Remotely and Charging Set to INACTIVE</td>
<td>Rate of Charge Controlled Remotely and Charging ACTIVE</td>
</tr>
<tr>
<td><img src="image" alt="Exclamation Mark" /></td>
<td><img src="image" alt="Exclamation Mark" /></td>
</tr>
<tr>
<td>Temporary Fault. (Usually vehicle related) Press the reset button on the bottom right of the interface to retry charge session</td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Wrench Symbol" /></td>
<td><img src="image" alt="Wrench Symbol" /></td>
</tr>
<tr>
<td>Internal Charging Station Error. Discontinue Use</td>
<td></td>
</tr>
</tbody>
</table>
Level 2 DC – Commercial / Fleet

• CHAdeMO protocol
• Output: 50 kW, 400 VDC at 125 ADC
• Can charge a 16kWh battery to 80% capacity in 20 minutes
• Outdoor rated cable
• Compatible with LEAF and i-Miev
• GM and Ford do not have a DC inlet as of yet
Power Flow with 208 VAC Input

- 208 VAC 3ph 156 Amps
- 225 A UL Circuit Breaker
- 50 kW
- 400 VDC
- 125 ADC
Power Requirements

Eaton’s 50kW DC Quick Charger

Recommended:
Disconnect switch rated 125% of nameplate

<table>
<thead>
<tr>
<th>Voltage 3-phase</th>
<th>Phase Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>198</td>
<td>164</td>
</tr>
<tr>
<td>200</td>
<td>162</td>
</tr>
<tr>
<td>208</td>
<td>156</td>
</tr>
<tr>
<td>480</td>
<td>68</td>
</tr>
</tbody>
</table>

Step-down Transformer

450 VAC 3ph 67 Amps

200 VAC 3ph 161 Amps

208 VAC 3ph 154 Amps

50 kW 400 VDC 125 ADC

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CHAdemo Quick DC Charge Connector

- Sequence Circuit
- Hard-wired control signals
- Power connections
- CAN connections
CHAdeMO Overview

- JARI-specified connector and system
- TEPCO-specified communications and system requirements
- 125A and 500V (60kW)
- 10-pin connector
  - 2 power pins
  - 2 communication pins (CAN-bus)
  - 2 charger start/stop pins (EV Contactor Control)
  - 1 proximity detection pin
  - 1 charging enable/disable pin
  - 1 ground reference pin
  - 1 unused pin
How CHAdeMO charger works:

- **EV computer unit decides** charging speed based on BMS observation.
- Charging current signal is sent to charger using CAN bus.
- Charger supplies DC current following the request from EV.
CHAdeMO is More Than a Connector Specification

- Includes basic electrical safety and structure
- Safety interlock to avoid energizing the connector before it's safe (similar to SAE J1772)
- EV transmits battery parameters to the charging station:
  - voltage at which to stop charging
  - target voltage
  - total battery capacity
  - while charging the station has to vary its output current according to signaling from the car

- 50 kW peak
- Roughly 5 miles per minute of charge in the first 10 minutes of charge
- 6 kWh delivered in the first 10 min; 5 kWh in the remaining 13 minutes
Electric Vehicles with CHAdeMO Interfaces

- **SUBARU Plug-in Stella**
  - Passengers: 4
  - Weight: 1010kg
  - Driving range: 90km (10-15 mode)
  - Battery: 9.2kWh

- **Mitsubishi i-MiEV**
  - Passengers: 4
  - Weight: 1100kg
  - Driving range: 150km (10-15 mode)
  - Battery: 16kWh

- **Protoscar LAMPO2**
  - Passengers: 2
  - Weight: 1580kg
  - Driving range: 200km
  - Battery: 32kWh

- **Peugeot iON**
  - Passengers: 4
  - Weight: 1100kg
  - Driving range: 160km (10-15 mode)
  - Battery: 16kWh

- **Nissan LEAF**
  - Passengers: 5
  - Weight: 1520kg
  - Driving range: 200km (JC08 mode)
  - Battery: 24kWh
TEPCO Shows DCQC Connector Proposals at CHAdeMO Meeting

Main topic of IEC62196-3 and IEC61851-24

**Type of coupler (62196-3)**

<table>
<thead>
<tr>
<th>Japan</th>
<th>US</th>
<th>Germany</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHAdeMO</td>
<td>COMBO of AC type 1</td>
<td>COMBO of AC type 2</td>
<td>DC dedicated</td>
</tr>
</tbody>
</table>

**Communication method and protocol (IEC 61851-24)**

<table>
<thead>
<tr>
<th>Japan</th>
<th>US/Europe</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN</td>
<td>PLC</td>
<td>In-band CAN</td>
</tr>
</tbody>
</table>

• There are four different proposals of connector shape.
• There are four different proposals of communication protocol, however the U.S. is also considering CAN.
• Only CHAdeMO is available in the market. Other proposals are just design/prototype, not existing.
EVSE Revenue and Fleet Management

Wide Variety of Implementation Schemes

Credit Card Processing
Basic RFID – lock & key access
User Authentication with RFID
Synchronous code generation keypad – stored codes, time based codes, pay by phone service
Pow-R-Station™ Network Manager Software

Web Portals for:

- User Authentication
- Fleet, EVSE & Load Management
- Network Provisioning
- Real Time Reporting & Monitoring

Deploy your network to:

- Increase System Uptime
- Reduce energy costs
- Maximize charger reliability
Questions?

Website

www.eaton.com/plugin