DC Fast Charger Fact Sheet: ABB Terra 53 CJ charging a 2015 Nissan Leaf

Description
Testing of the ABB DC fast charger was conducted to quantify its steady-state operational performance characteristics during a single charge of a 2015 Nissan Leaf using the CHAdeMO connector.

DC Fast Charger Specifications

Input Power
- 480 VAC 3φ +/- 10%
- 50 or 60 Hz
- 75A RMS maximum

Output Power
- CHAdeMO connector
  - 50 kW maximum
  - 120 A DC maximum
  - 10' cable length
- J1772 - CCS connector
  - 50 kW maximum
  - 125 A DC maximum
  - 10' cable length

Interfaces
- Touch screen Interface
- GSM / CDMA modem
- 10/100Base-T Ethernet

Vehicle Specifications
2015 Nissan Leaf
equipped with CHAdeMO DC fast charge inlet
For more information go to https://avt.inl.gov/vehicle-make/nissan

Testing Information
Electrical Measurement Points
- AC Input: DC Fast Charger 3-phase inputs measured at input terminal block
- DC Output: DC Fast Charger DC output measured at the CHAdeMO vehicle inlet
- Power Meter: Hioki 3390

Source Power Characteristics During Charge
- Nominal frequency: 60 Hz
- Nominal voltage magnitude: 480 VAC 3φ
- Max. deviation from nominal frequency: 0.09%
- Max. deviation from nominal voltage magnitude: 1.37%
- Max. voltage total harmonic distortion (THD): 2.28%
- Max. voltage phase unbalance: 0.30%
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Test Results: Standby Power

Standby Power Operation

- AC power prior to charging: 99 watts
- AC power at charge completion: 150 watts (cooling fan operating)
- AC power 5 minutes after charge completion: 110 watts

Test Results: Vehicle DC Fast Charging

Total energy transferred during charge event:
- AC Input: 20.1 kWh
- DC Output: 18.5 kWh

Maximum measured power:
- Maximum DC input: 49.7 kW
- Maximum DC output: 45.9 kW

Maximum measured current:
- Maximum A RMS: 64.4 A
- Maximum DC current: 116.5 A

Constant Current Mode

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC current</td>
<td>115.4 A</td>
</tr>
<tr>
<td>Average AC to DC Efficiency</td>
<td>92.3%</td>
</tr>
<tr>
<td>Avg. Power Factor</td>
<td>-0.984</td>
</tr>
<tr>
<td>Avg. Current THD</td>
<td>11.0%</td>
</tr>
<tr>
<td>Avg. Phase Current Unbalance</td>
<td>6.1%</td>
</tr>
</tbody>
</table>

Constant Voltage Mode

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC voltage</td>
<td>397 V DC</td>
</tr>
<tr>
<td>Range of Efficiency</td>
<td>79.8% to 92.8%</td>
</tr>
<tr>
<td>Range of Power Factor</td>
<td>-0.50 to -0.990</td>
</tr>
<tr>
<td>Range of Current THD</td>
<td>9.3% to 30.7%</td>
</tr>
<tr>
<td>Range of Current Unbalance</td>
<td>0.02% to 2.1%</td>
</tr>
</tbody>
</table>

Fast Charge Event

Unbalance: 3-phase Input Current and 3-phase Input Voltage
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Total System Efficiency

Power Factor

Input Current Total Harmonic Distortion (THD)
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Input Current and Input Voltage Phase Unbalance

- Input Current Phase Unbalance
- Input Voltage Phase Unbalance

Input Current Harmonics: at 50kW 3-phase Input Power

Input Current Harmonics: at 11kW 3-phase Input Power
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Definitions:

**Efficiency** - Efficiency is the useful power output divided by the total power input. In order to minimize the total amount of energy needed to complete a given task it is desirable for the efficiency to be as close to 100% as possible.

**Power Factor** - In the presence of a stiff voltage source, power factor is a measure of how much of the current is being utilized to perform work. Since the electrical infrastructure is limited in the amount of current it can deliver, power factor is a way to determine how efficiently the electrical infrastructure is being utilized. Ideally the power factor should be as close to 1 as possible.

**Total Harmonic Distortion (THD)** - In power systems, the voltage and current waveforms are both 60 Hz sinusoidal waveforms. The total harmonic distortion (THD) is a measure of the amount of distortion that is present in the sinusoidal wave form. Excessive amounts of THD in current wave forms can cause many problems in a power system such as overheating transformers, motors, and capacitors among other things. Ideally the THD should be as close to zero as possible.

**Phase Unbalance** - In a balanced three phase system the individual phases of a three phase voltage or current source have the same magnitude and are 120 degrees out of phase with each other. When a system is not balanced it is said to be unbalanced. The voltage and current unbalance in these test results were calculated using the following equations (from the Hioki 3390 Power Analyzer Instruction Manual).

\[
\text{Current Unbalance} \quad I_{unb_{123}} = \frac{1 - \sqrt{3} - 6\beta}{1 + \sqrt{3} - 6\beta} \times 100
\]

\[
\beta = \frac{I_{12}^4 + I_{23}^4 + I_{31}^4}{(I_{12}^2 + I_{23}^2 + I_{31}^2)^2}
\]

\[
\text{Voltage Unbalance} \quad U_{unb_{123}} = \sqrt{1 - \frac{1 - \sqrt{3} - 6\beta}{1 + \sqrt{3} - 6\beta}} \times 100
\]

\[
\beta = \frac{U_{12}^4 + U_{23}^4 + U_{31}^4}{(U_{12}^2 + U_{23}^2 + U_{31}^2)^2}
\]

\(I_{12}, I_{23}, \text{ and } I_{31}\) are fundamental rms currents (between lines)

\(U_{12}, U_{23}, \text{ and } U_{31}\) are fundamental rms voltages (between lines)