Power Quality Benchmarking and Evaluation of Vehicle On-Board Chargers

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Introduction

- The purpose of power quality benchmarking is to:
  - Ensure PEV charging does not negatively impact the grid.
  - Ensure that undesirable grid conditions do not negatively impact PEV charging.
  - Populate PEV charging models in grid simulation software.
  - Support standards development
    - SAE J2894 “Power Quality Requirements for Plug-in Electric Vehicle Chargers”.

Evaluation of PEV On-Board Chargers

- PEV Chargers Evaluated
  - 2012 Nissan Leaf
  - 2012 Chevrolet Volt
  - 2014 BMW i3
  - 2015 Nissan Leaf

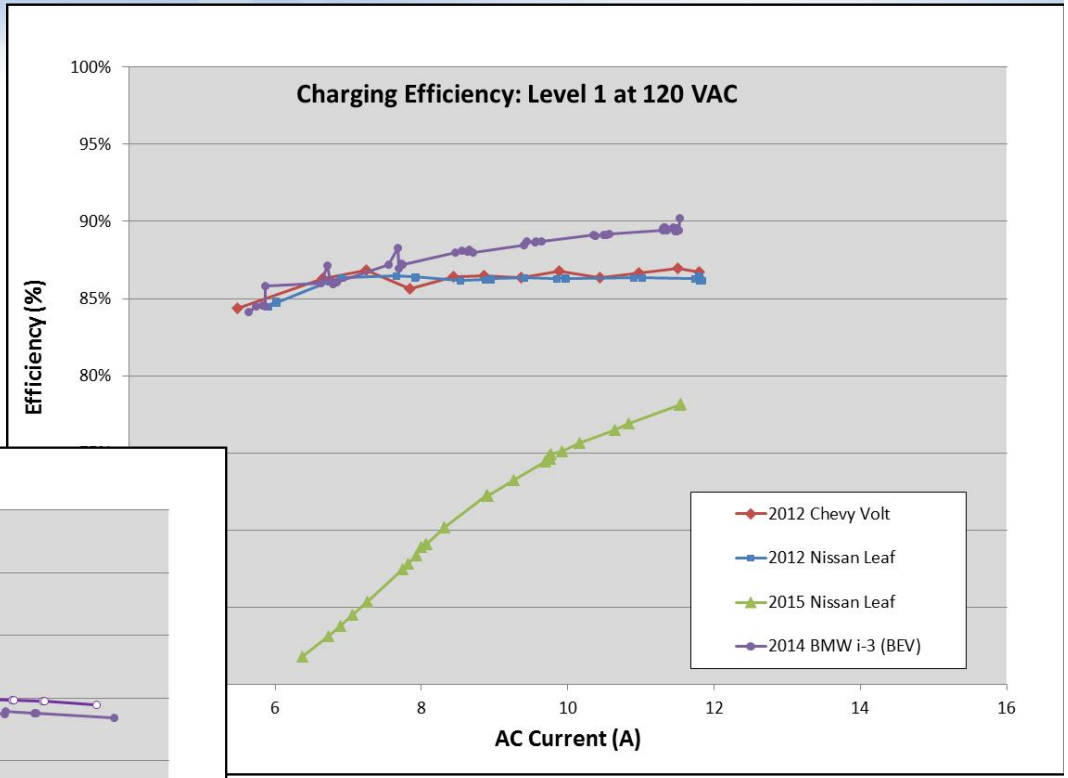
- Charging Metrics:
  - Charge Efficiency
  - Power Factor
  - Total Harmonic Distortion in input current

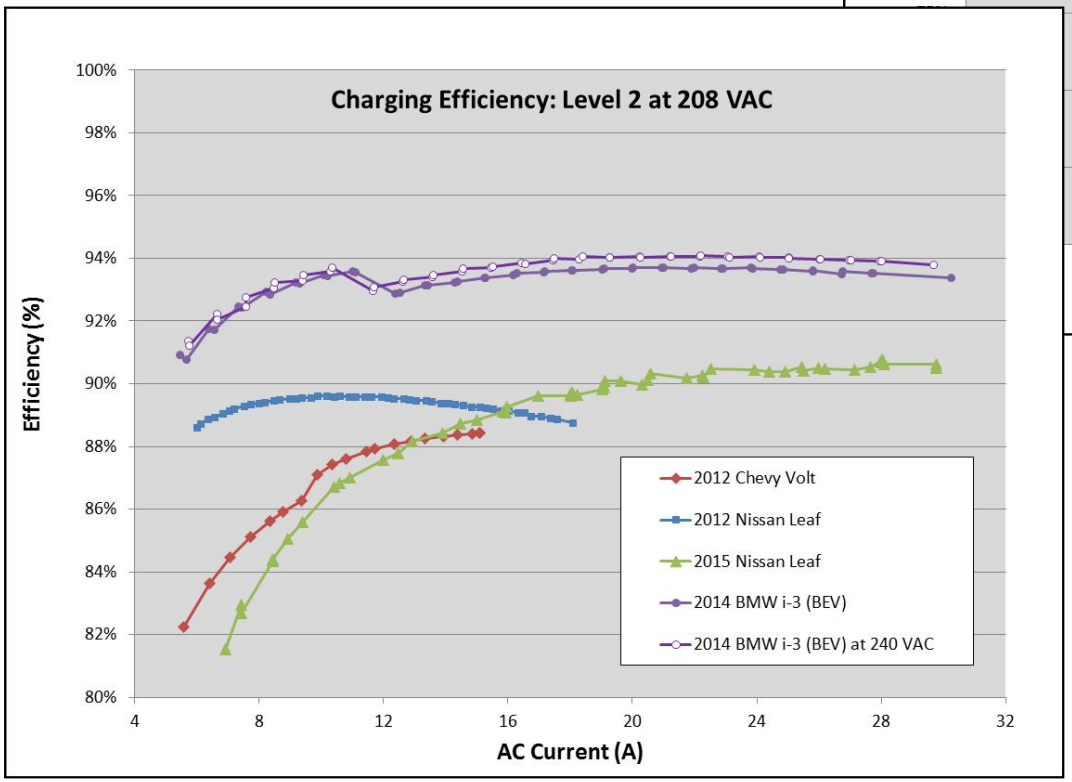
Evaluation of PEV On-Board Chargers

- **Efficiency** - Efficiency is the useful power output divided by the total power input. 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 a sinusoidal wave form. Excessive amounts of THD in current wave forms can cause overheating of transformers, motors, and capacitors among other things. Ideally the THD should be as close to zero as possible.

Charging Efficiency

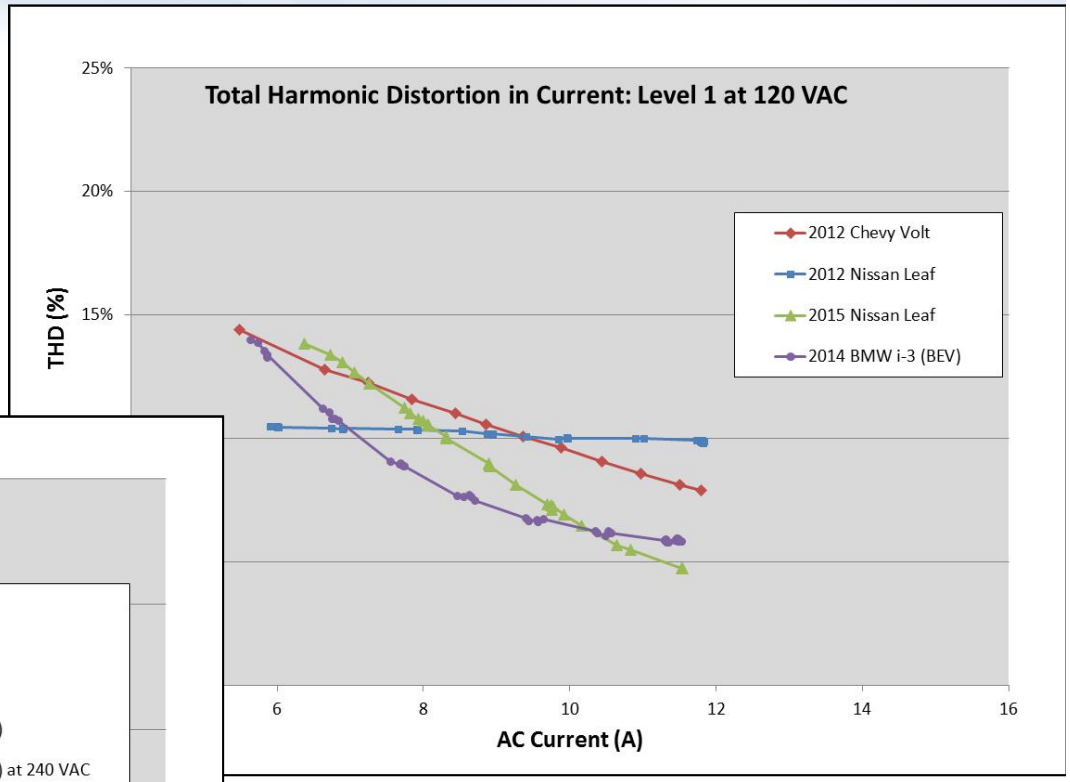
- Level 1 and Level 2

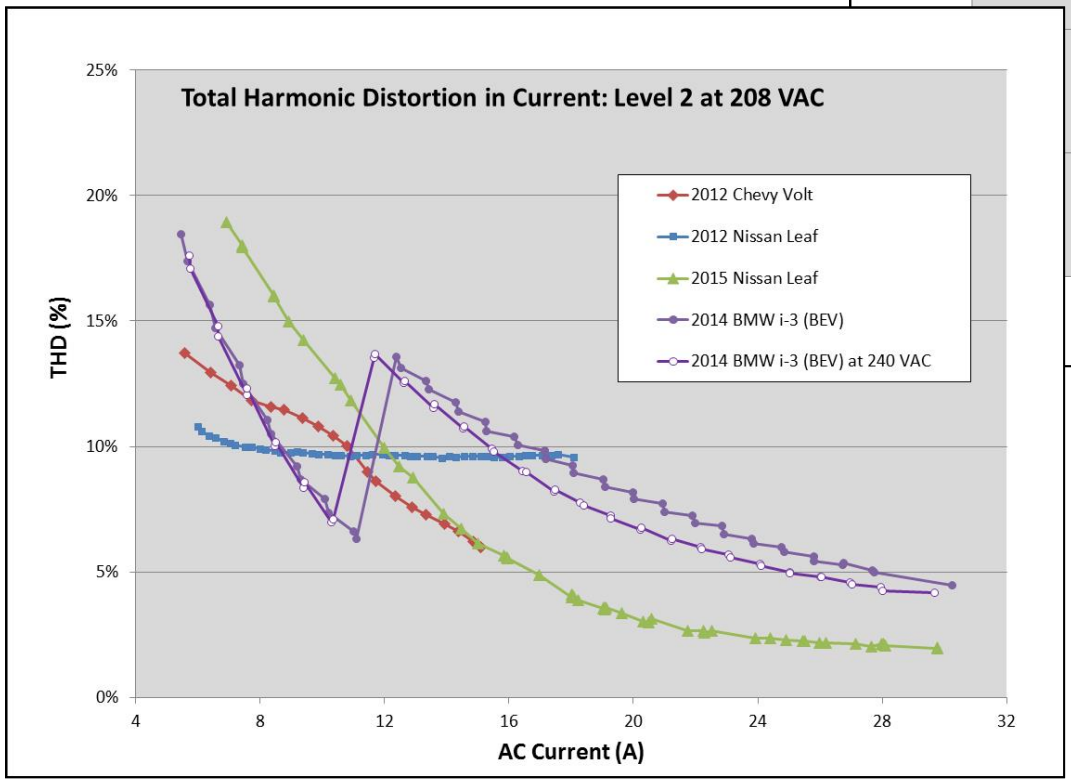




Total Harmonic Distortion on Input Current

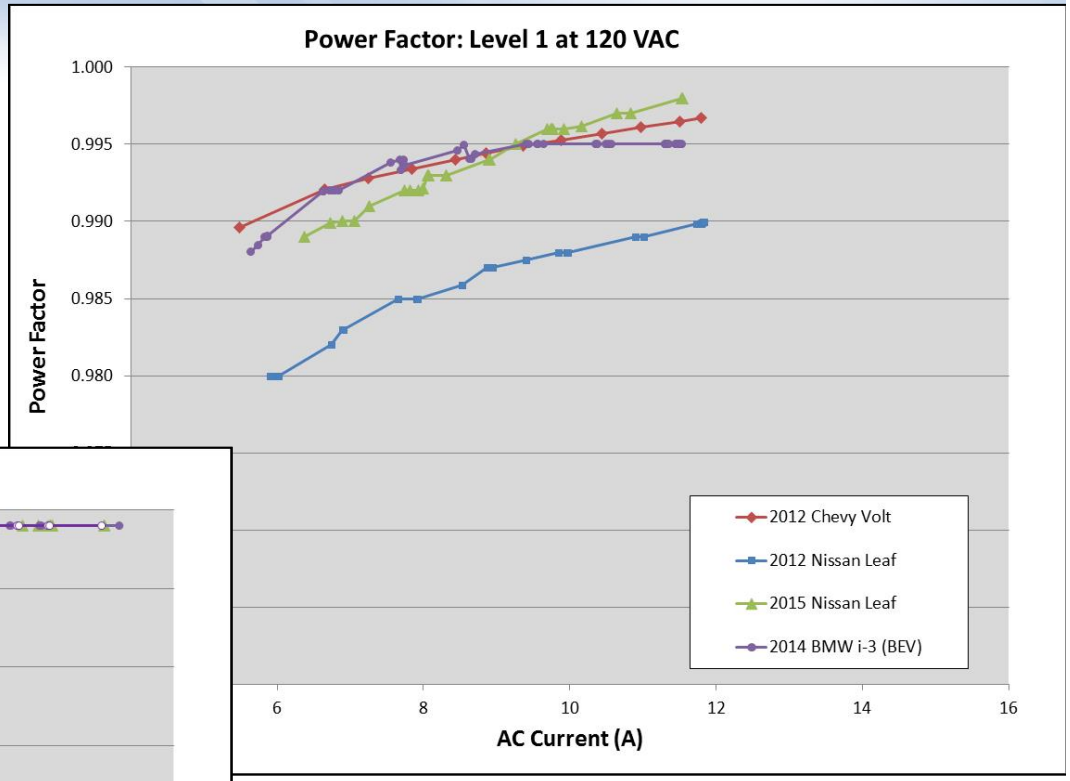
- Level 1 and Level 2

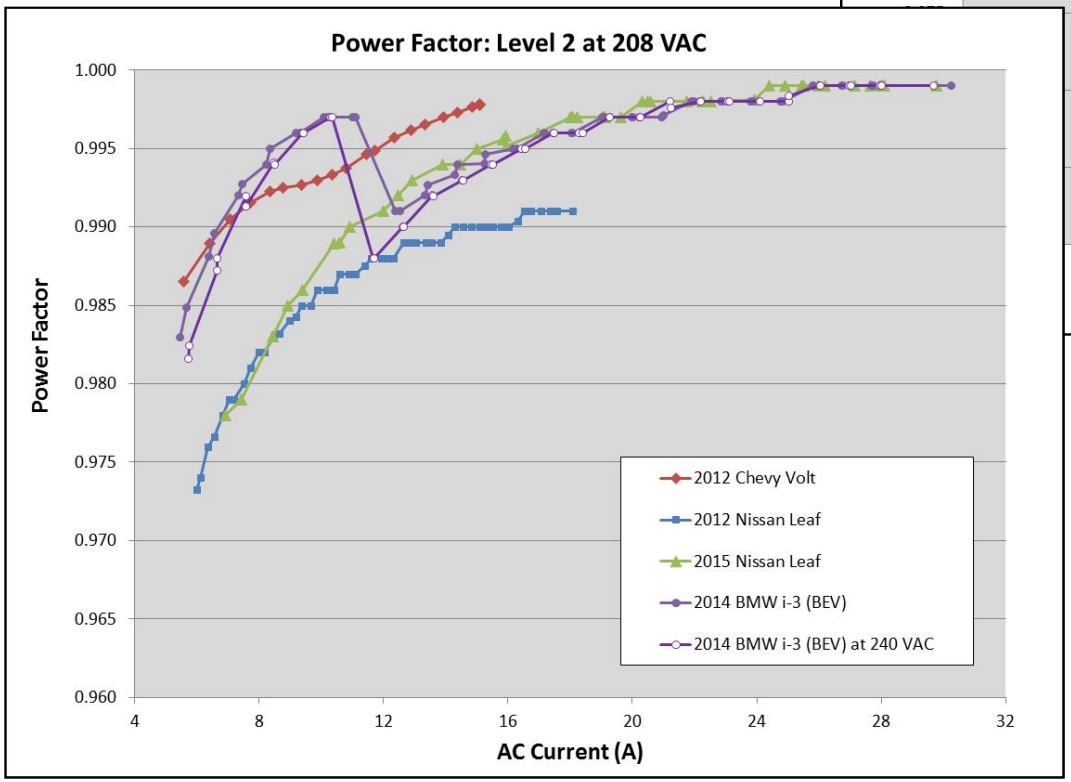




Power Factor

- Level 1 and Level 2

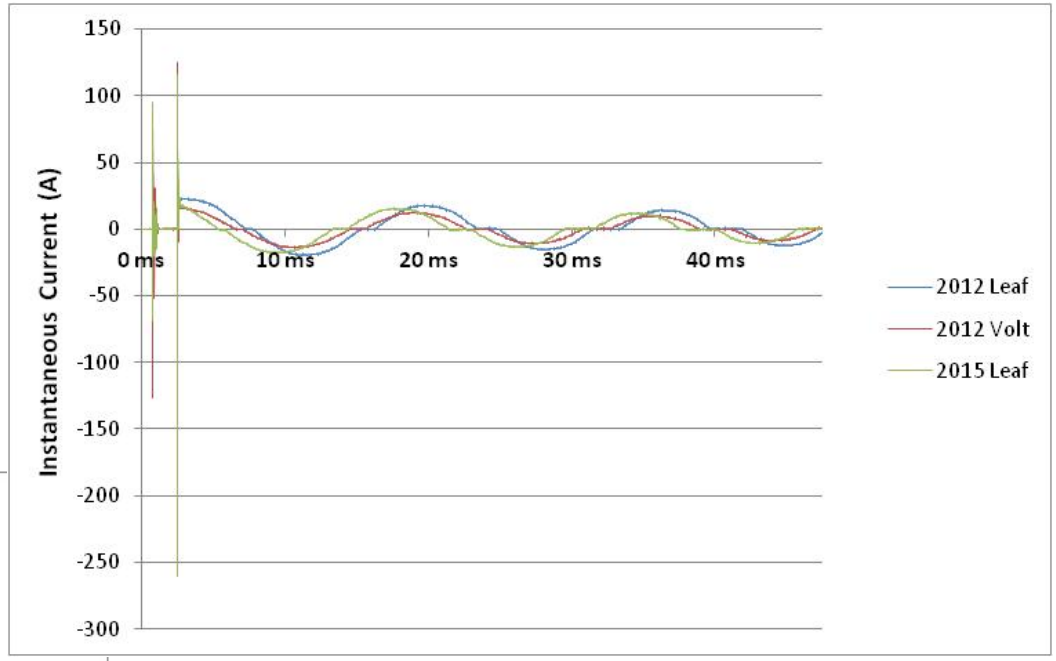


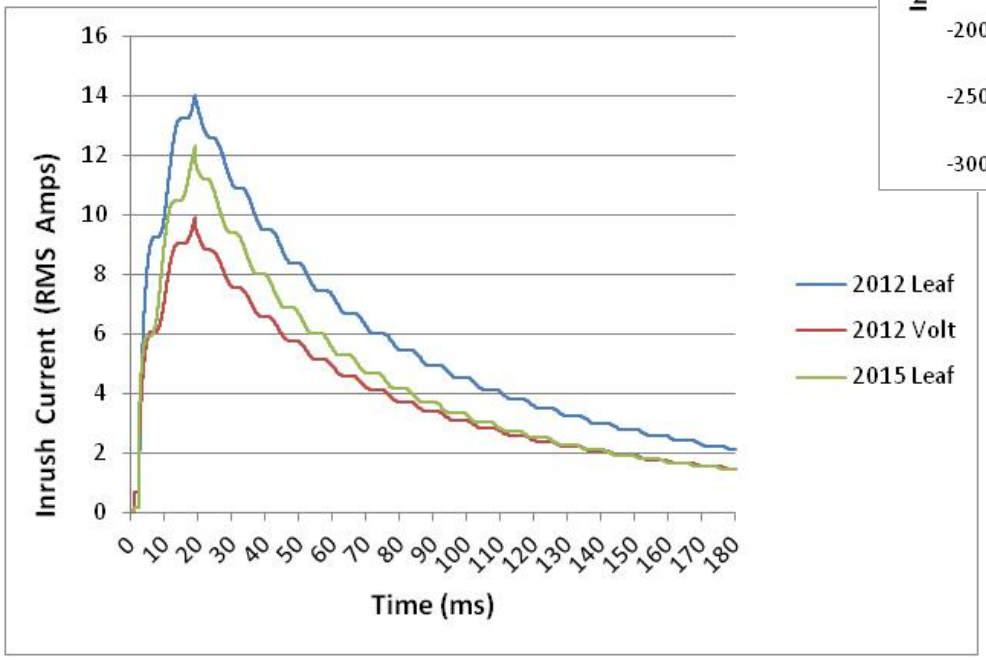


Highlights

- No two PEV chargers have identical charging behavior.
  - Important to test many different PEV chargers to assess possible grid impacts.
- Most PEV on board chargers are designed to operate at their maximum charge rate.
  - Most Efficient
  - Best Power Quality
- PEV chargers should be operated at this point when practical.
  - This is not always possible.
    - PEV charge rate is intentionally reduced by active charge control (currently not common).
    - PEV is charging on an electric circuit that can't supply the PEVs max charge rate (common).

Inrush Current Testing





Questions