Steady State Vehicle Charging Fact Sheet: 2012 Chevrolet Volt

Description

The steady state charging behavior of a 2012 Chevrolet Volt was tested at many different charge rates. Testing measured the efficiency and power quality of the vehicle charging. Vehicle charging is considered to be in steady state when the RMS current magnitude is not changing and the voltage source is close to nominal. Testing was done for both 120 volt Level 1 charging and 208 volt Level 2 charging.

Key Insights from Testing

- Chevrolet Volt charging is most efficient and has the best power quality when charged at the maximum charge rate.
- When reducing the charging of a group of Chevrolet Volts, it is better to charge a subset of the vehicles at the maximum charge rate than to continue to charge all of the vehicles at a reduced charge rate.[1]

Vehicle Specifications

Vehicle Type: Extended range electric vehicle
Class: Compact
Battery: Lithium-ion
Battery Capacity: 16 kWh
Usable Battery Capacity: 12 kWh
Charge Port: J1772 compatible
DC Fast Charge: No

Electrical Measurement Points[2]

- AC Input: EVSE Output
- DC Output: On Board Charge Module Output

Source Characteristics[3]

Nominal Frequency	60 Hz
Nominal Voltages	120 V / 208 V
Max Deviation from Nominal Frequency	0.08%
Max Deviation from Nominal Voltage Magnitude	2.48%
Max Voltage Total Harmonic Distortion (THD)[4]	2.26%

Load Characteristics

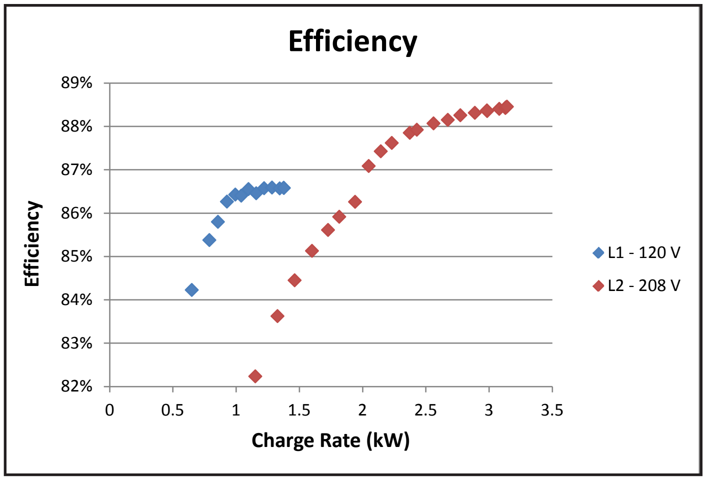
Level 1 - 120 V Test

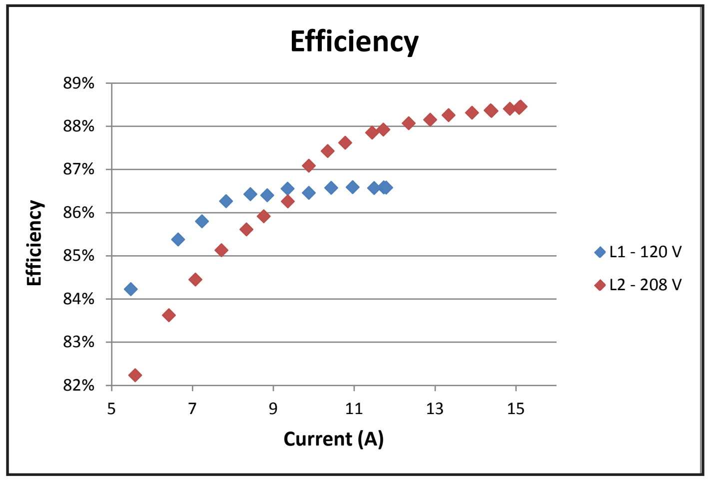
	Min Charge Rate	Max Charge Rate
Charge Rate	0.65 kW	1.38 kW
Current[5]	5.48 A	11.79 A
Efficiency[6]	84.2%	86.6%
Power Factor[7]	0.990	0.997
Current THD[4]	14.41%	7.88%

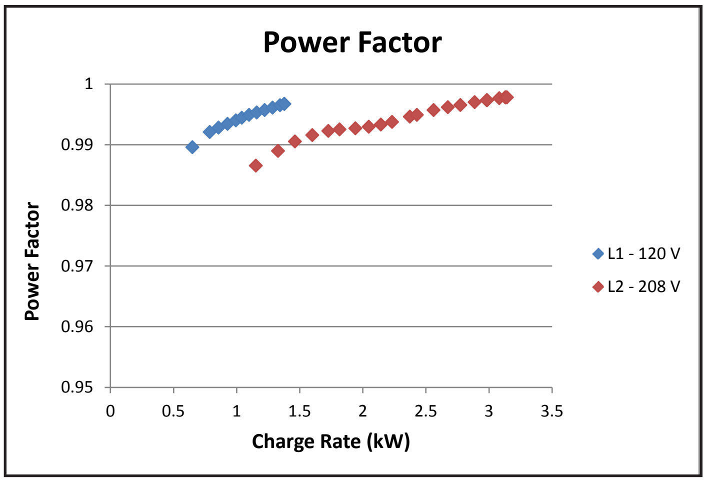
Level 2 - 208 V Test

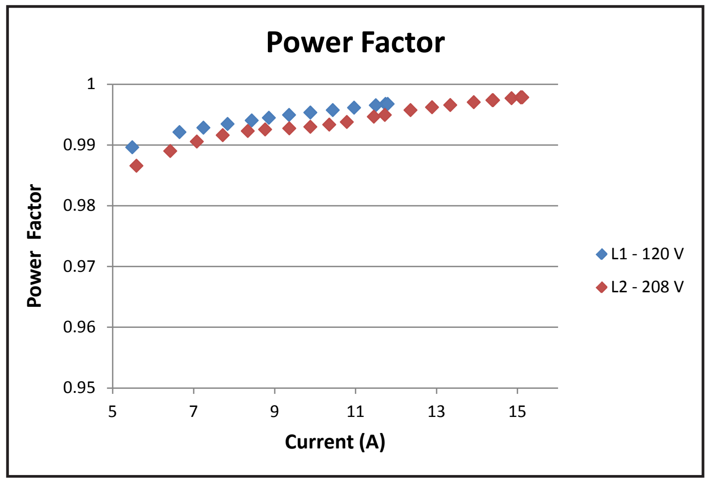
	Min Charge Rate	Max Charge Rate
Charge Rate	1.15 kW	3.14 kW
Current[5]	5.59 A	15.12 A
Efficiency[6]	82.2%	88.5%
Power Factor[7]	0.987	0.998
Current THD[4]	13.73%	6.04%

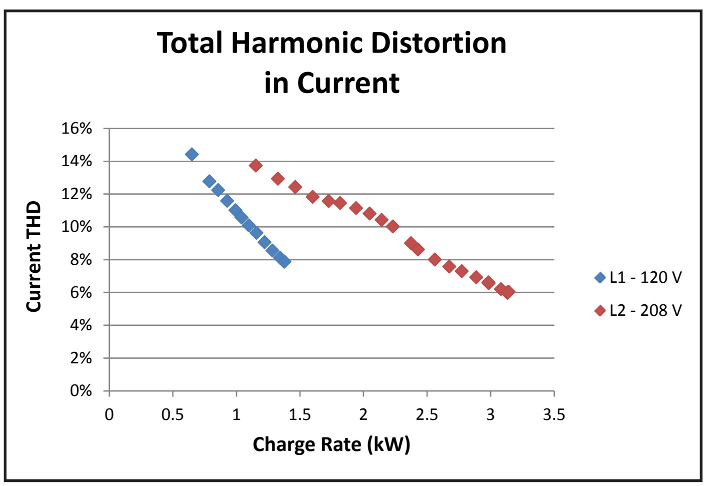
1. See Example A on page 3
2. The DC output electrical measurement point was only used to calculate efficiency
3. The voltage source was close to nominal during the testing
4. See definition of total harmonic distortion on page 3
5. Current magnitudes are given in RMS values
6. See definition of efficiency on page 3
7. See definition of power factor on page 3

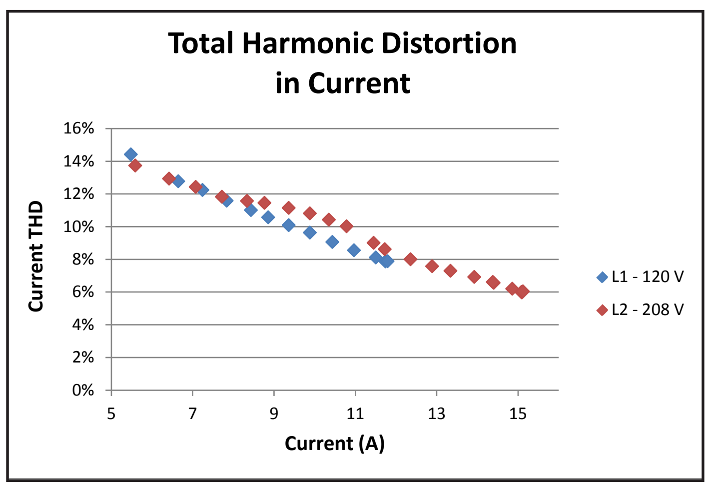












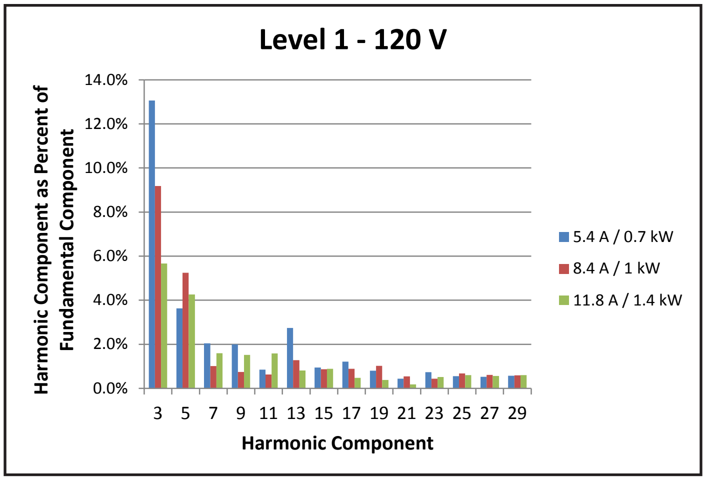
As the vehicle charge rate decreases, efficiency decreases, power factor decreases, and total harmonic distortion increases. The decrease in power factor is negligible, but the decrease in efficiency and increase in total harmonic distortion is not negligible and should be avoided when possible.

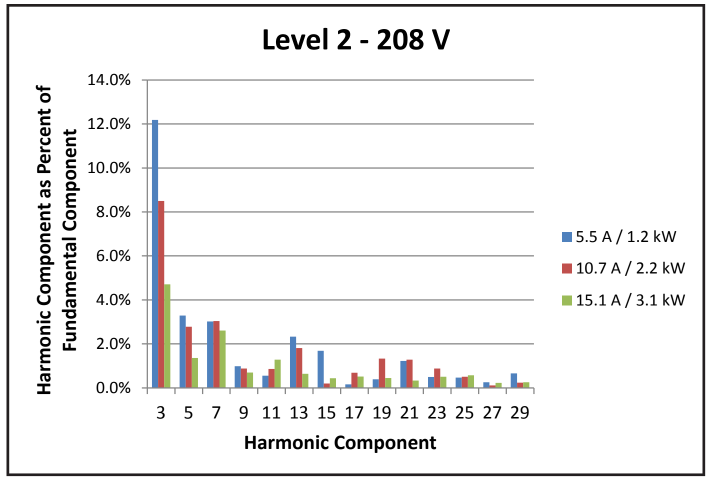
NOTES:

See the definitions for efficiency, power factor and total harmonic distortion on page 3

All current magnitudes are given as RMS values

L1 = Level 1 charging, L2 = Level 2 charging





The harmonic components for three different charge rates are displayed in the charts above for both the Level 1 and Level 2 tests. For each test, the minimum charge rate (blue), maximum charge rate (green), and a charge rate halfway between the minimum and maximum (red) were selected. In all cases, the third harmonic is the dominant harmonic component.

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. A power factor of 1 signifies that all of the current is delivering useful work, a power factor of 0.5 means that only half of the current delivering useful work. 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.

Examples

Example A:

The following example uses the charts on page 2 to demonstrate why it is better to charge a subset of Chevrolet Volts at the maximum charge rate than to continue charging all of the vehicles at a reduced charge rate. If there are 20 Chevrolet Volts Level 2 charging that are collectively drawing 60 kW, the power being drawn could be reduced to 30 kW by reducing the charge rate of all 20 vehicles to 1.5 kW. In this case, the collective efficiency would be about 84.5% and the THD would be about 12%. Alternatively, if the power being drawn is reduced to 30 kW by interrupting the charging of 10 vehicles and continuing to charge the remaining 10 vehicles at the maximum charge rate, then the collective efficiency would be about 88.5% and the THD would be about 6%. In this example, the vehicle charging is 4% more efficient and the current THD is reduced by half, when charging a subset of the vehicles at the maximum charge rate instead of charging all of the vehicles at a reduced charge rate.