INL/EXT-13-30929

Results from the Operational Testing of the General Electric Smart Grid Capable Electric Vehicle Supply Equipment (EVSE)

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December 2013

Idaho National Laboratory

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Results from the Operational Testing of the General Electric Smart Grid Capable Electric Vehicle Supply Equipment

1. INTRODUCTION

The Idaho National Laboratory conducted testing and analysis of the General Electric (GE) smart grid capable electric vehicle supply equipment (EVSE), which was a deliverable from GE for the U.S. Department of Energy FOA-554. The Idaho National Laboratory has extensive knowledge and experience in testing advanced conductive and wireless charging systems though INL's support of the U.S. Department of Energy's Advanced Vehicle Testing Activity. This document details the findings from the EVSE operational testing conducted at the Idaho National Laboratory on the GE smart grid capable EVSE (Figure 1). The testing conducted on the EVSE included energy efficiency testing, SAE J1772 functionality testing, abnormal conditions testing, and charging of a plug-in vehicle.

Figure 1. GE EVSE and the EVSE front panel display during operation.

1.1 Laboratory Test Setup and Equipment

For laboratory testing of the EVSE, vehicle emulation equipment was utilized, including a control pilot emulation module and a programmable AC load bank. The control pilot emulation module contained multiple resistors and a National Instruments relay module that was controlled to provide the proper resistance to the control pilot during testing to request the desired operation state. To draw power from the EVSE, a programmable AC load bank, which is capable of up to 9.0 kW, was utilized (Figure 2).

Figure 2. Programmable AC load bank (up to 9.0 kW).

Two pieces of calibrated measurement equipment (Figure 3) were used to measure voltage, current, and energy at multiple nodes during testing. A Hioki 3390 power meter was used to measure the input node, output node, and control pilot signal of the EVSE. An Eaton IQ 250 watt hour meter, with a GE CTM-0C current transformer, also was used to measure the output node of the EVSE.

Figure 3. Hioki 3390 power meter and Eaton IQ 250 watt hour meter with GE CTM-0C current transformer.

A schematic of the test setup is shown in Figure 4. The input voltage of 208 VAC was supplied from a single 40-A circuit breaker to a safety stop (i.e., E-stop) module that contained two contactors (one per line) and a status light. The voltage output from the E-stop module was connected to both EVSE input connectors. The chosen EVSE output (Plug 1 or Plug 2) was connected to an enclosure that housed the Eaton IQ250 watt hour meter. The control pilot emulation module was connected next in the series to provide the appropriate resistance for the desired J1772 state. Finally, the power was absorbed by the AC programmable load. The Hioki voltage taps and current clamps were located as shown in Figure 4 and detailed in Table 1.

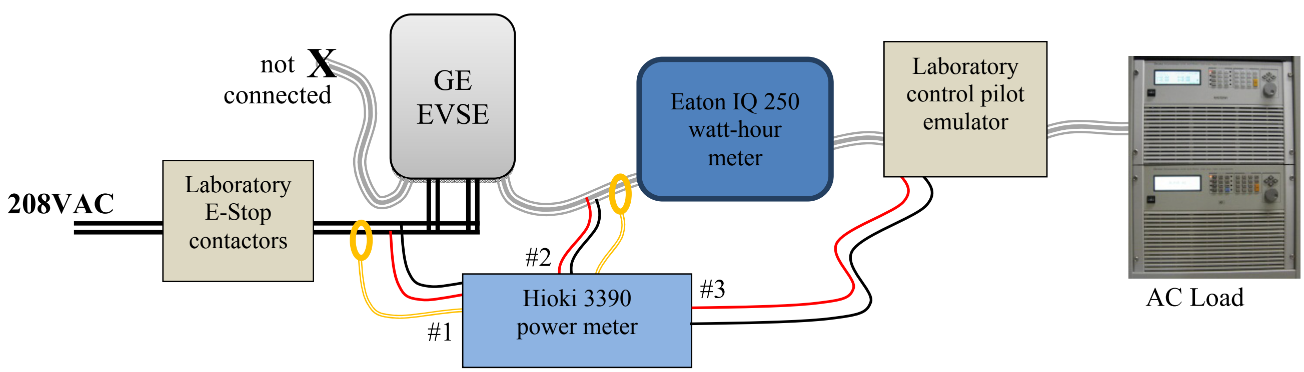

Figure 4. Schematic drawing of the laboratory test setup.

Table 1. Hioki signal channel node locations.

Hioki Channel	Voltage Node	Current Node
Channel 1	Combined input to EVSE	Combined input to EVSE
Channel 2	Output from selected J1772 connector	Output from selected J1772 connector
Channel 3	Control pilot signal	Open
Channel 4	Open	Open

2. ENERGY EFFICIENCY TESTING

EVSE testing was conducted in the laboratory for both the left and right J1772 plug (i.e., Plug 1 and Plug 2). Energy testing was done at four EVSE output power levels (i.e., 0.05 kW, 1.1 kW, 3.3 kW, and 6.5 kW), where each power level was tested for 10 minutes. EVSE standby power consumption also was tested to determine the amount of energy the EVSE uses while in a passive, non-charging state. Various power levels were chosen because they represent typical charge rates for a wide range of plug-in vehicles such as Level 1 and Level 2. The highest output power tested was limited to 6.5 kW, because of the 32-amp input continuous current limit of the 40-amp circuit breaker with 20% safety factor. The nominal input voltage was 208 VAC. Details from the energy efficiency testing are described in the following subsections.

2.1 Electric Vehicle Supply Equipment Standby Power Consumption

EVSE standby power consumption was tested for the following J1772 states: State B, State C, and State D. In State B, the EVSE was connected to a vehicle, but the vehicle was not ready to charge; therefore, the contactor in the EVSE was open. In State C and State D, the EVSE was connected to a vehicle and the vehicle had communicated to the EVSE that it was ready to charge; therefore, the contactor in the EVSE was closed if all conditions are correct.

The results from these tests are summarized in Table 2. As seen in Table 2, the behavior of the two plugs is almost identical for the various J1772 states. In addition, the standby power of State C is about 2 watts greater than the standby power of State B. This is likely due to the power required to keep the contactors closed in State C. Finally, no standby power was recorded for State D because the contactor did not close due to the soft fault, “Fan Required to Charge”. Since there is no fan available for operation (if required by a vehicle), the soft fault is an appropriate response. This soft fault prevents the charging of a vehicle that requires ventilation fan operation in a condition where a fan is not available.

Table 2. EVSE standby power in watts.

J1712 State	Left Plug (Plug #1)	Right Plug (Plug #2)
State B	17.7 Watts	17.8 Watts
State C	19.8 Watts	19.9 Watts
State D	NA	NA

2.2 Electric Vehicle Supply Equipment Efficiency

The EVSE efficiency as measured by the Hioki 3390 power meter for Plug #1 and Plug #2 can be found in Tables 3 and 4. Of the four power levels measured, the efficiency is the best when 3.3 kW is being drawn from the EVSE. The efficiency at very low power levels (i.e., 50 watts) is lower because the EVSE standby power is large compared to the output power drawn from the EVSE. The efficiency also drops slightly at high power levels (i.e., 6.5 kW) due to the resistive losses caused by the large currents at high power levels. Comparing the results from the two plugs, the results are almost identical at the measured power levels.

Table 3. Left plug (Plug #1) EVSE efficiency testing.

Test Condition	Average EVSE Efficiency (Output Power/Input Power)
50 watts	71.9%
1.1 kW	97.8%
3.3 kW	98.7%
6.5 kW	98.5%

Table 4. Right plug (Plug #2) EVSE efficiency testing.

Test Condition	Average EVSE Efficiency (Output Power/Input Power)
50 watts	71.5%
1.1 kW	97.9%
3.3 kW	98.7%
6.5 kW	98.4%

2.3 Electric Vehicle Supply Equipment Energy Measurement

The final energy measurements of each test obtained from the Hioki 3390 power meter, the IQ 250 watt hour meter, and the EVSE front panel display are listed in Tables 5 and 6. The final energy measurements from the Hioki power meter and the IQ 250 watt hour meter are nearly identical. When EVSE Plug #1 was tested, the energy measurement from the EVSE always indicated zero (no energy was recorded). This may be due to unknown damage during shipment of the EVSE to the test location. This issue is being addressed by GE engineering staff. When the EVSE Plug #2 was tested, the EVSE front panel kWh display was fairly close to the energy measurements of the Hioki power meter and the IQ 250 watt hour meter.

Table 5. Left plug (Plug #1) energy efficiency testing: final kilowatt hour test measurement.

Test Condition	Hioki Power Meter	IQ 250 Watt Hour Meter	GE EVSE kWh Display
50 watts	0.01 kWh	0.01 kWh	0.0 kWh
1.1 kW	0.18 kWh	0.18 kWh	0.0 kWh
3.3 kW	0.54 kWh	0.54 kWh	0.0 kWh
6.5 kW	1.06 kWh	1.06 kWh	0.0 kWh

Table 6. Right plug (Plug #2) energy efficiency testing: final kilowatt hour test measurement.

Test Condition	Hioki Power Meter	IQ 250 Watt Hour Meter	GE EVSE kWh display
50 watts	0.01 kWh	0.01 kWh	0.0 kWh
1.1 kW	0.15 kWh	0.15 kWh	0.2 kWh
3.3 kW	0.55 kWh	0.55 kWh	0.6 kWh
6.5 kW	1.15 kWh	1.15 kWh	1.2 kWh

The energy measurements discussed above are compared through time in Figure 5. The EVSE output power measured by the Hioki power meter and the IQ 250 watt hour meter are very close (red and yellow lines). The purple dots indicate the energy measurement displayed on the EVSE front panel. This curve looks like stairs rather than a straight line because it appears that the measurement display is rounded to the nearest 100 watt hours (0.1 kWh).

3. SAE J1772 FUNCTIONALITY TESTING

EVSE functionality testing was conducted on each cord set individually. A Grid Test EVE-100L Lab Test Unit was used as shown in Figure 6; it measured the voltage, frequency, and duty cycle in each control pilot state and measured the transition times from state to state. The EVE-100L unit also provided a pass or fail indication based on SAE J1772 (January 2010). Figure 7 shows the table of results for the

Plug 2 (“Righty”) cord set. Figure 8 shows the table of results for the Plug 1 (“Lefty”) cord set. For both Plug 1 and Plug 2, all tested parameters were measured to be within the expected bounds per SAE J1772.

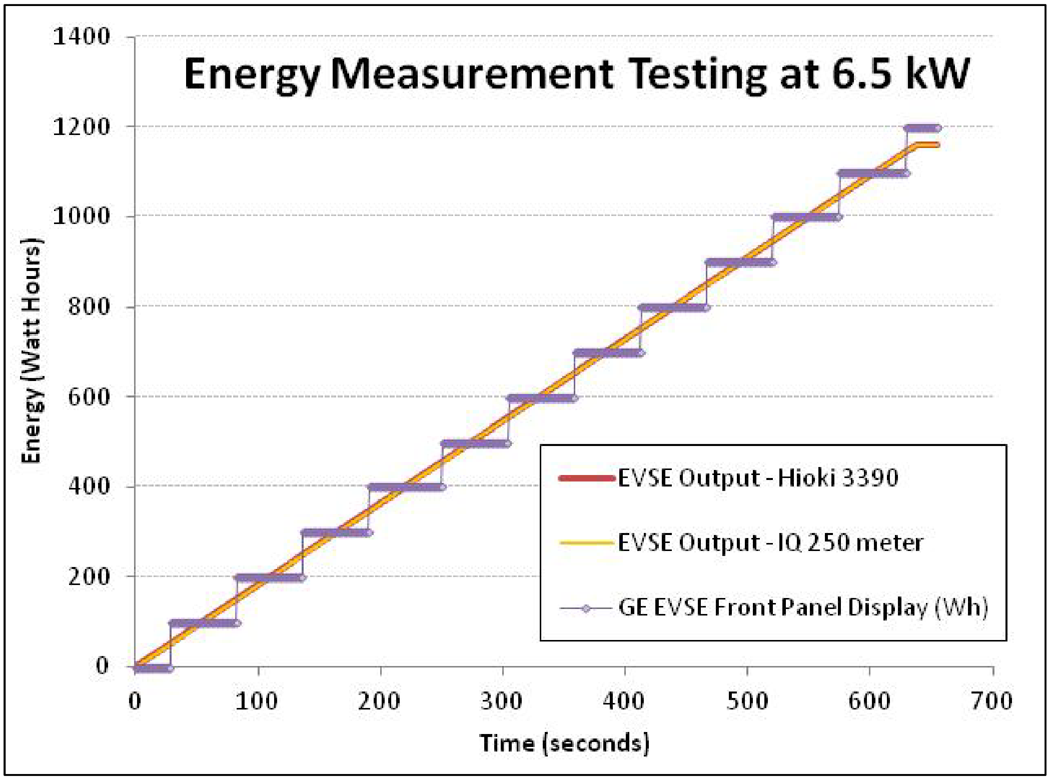

Figure 5. Energy measurement during 6.5-kW power transfer.

Figure 6. Grid Test EVE-100L Lab Test Unit.

Gridtest® Test Report					Copyright © 2011-2012 Gridtest Systems, Inc.							
Test Suite	SAE J1772											
Standard	SAE J1772™ JAN2010											
EVSE Identity	RIGHT											
Customer Identity	GE											
Date of Validation	12/5/2013 12:09											
Electrician/Engineer												
EV Emulator	EVE-100L Lab Test Unit	10000582	1.10.0.090	8								
Test Suite	Test	Validation	LastTestTimestamp	Result	Notes	Units	Expected Low Value	Expected Warning Low	Expected Nominal Value	Expected Warning High	Expected High Value	**Measured Value**
SAE J1772	State A	Pilot Voltage	12/5/2013 12:09	Pass		V	11	11.4	12	12.6	13	**11.76**
SAE J1772	State A	Pilot Frequency	12/5/2013 12:09	Pass		Hz		0		0		**0**
SAE J1772	J1772 State B	Pilot Voltage	12/5/2013 12:10	Pass		V	8	8.35	9	9.56	10	**8.97**
SAE J1772	J1772 State B	Pilot Frequency	12/5/2013 12:10	Pass		Hz	980		1000		1020	**1004**
SAE J1772	J1772 State B	Duty Cycle	12/5/2013 12:10	Pass		%	8				96	**54.21**
SAE J1772	J1772 State B	Available Current	12/5/2013 12:10	Pass		A	6				80	**32.53**
SAE J1772	J1772 State B	Glitch Voltage	12/5/2013 12:10	Pass		V				42.4		**0**
SAE J1772	J1772 State C	Pilot Voltage	12/5/2013 12:10	Pass		V	5	5.48	6	6.49	7	**6.01**
SAE J1772	J1772 State C	Pilot Frequency	12/5/2013 12:10	Pass		Hz	980		1000		1020	**1004**
SAE J1772	J1772 State C	Duty Cycle	12/5/2013 12:10	Pass		%	8				96	**54.41**
SAE J1772	J1772 State C	Available Current	12/5/2013 12:10	Pass		A	6				80	**32.64**
SAE J1772	J1772 State C	Timing Power	12/5/2013 12:10	Pass		ms	0				3000	**2700.3**
SAE J1772	State C to State B	Pilot Voltage	12/5/2013 12:10	Pass		V	8	8.35	9	9.56	10	**8.97**
SAE J1772	State C to State B	Pilot Frequency	12/5/2013 12:10	Pass		Hz	980		1000		1020	**1004**
SAE J1772	State C to State B	Duty Cycle	12/5/2013 12:10	Pass		%	8				96	**54.22**
SAE J1772	State C to State B	Available Current	12/5/2013 12:10	Pass		A	6				80	**32.53**
SAE J1772	State C to State B	Transition Time	12/5/2013 12:10	Pass		ms	0				3000	**499**
SAE J1772	J1772 State C	Pilot Voltage	12/5/2013 12:10	Pass		V	5	5.48	6	6.49	7	**6.02**
SAE J1772	J1772 State C	Pilot Frequency	12/5/2013 12:11	Pass		Hz	980		1000		1020	**1004**
SAE J1772	J1772 State C	Duty Cycle	12/5/2013 12:11	Pass		%	8				96	**54.41**
SAE J1772	J1772 State C	Available Current	12/5/2013 12:11	Pass		A	6				80	**32.64**
SAE J1772	J1772 State C	Timing Power	12/5/2013 12:11	Pass		ms	0				3000	**2605.8**
SAE J1772	GFI 20mA	Contact Line Voltage Before GFI	12/5/2013 12:11	Pass		V	97		120		264	**210.5**
SAE J1772	GFI 20mA	Contact Line Voltage After GFI	12/5/2013 12:11	Pass		V	0				10	**0**
SAE J1772	GFI 20mA	GFI TRIP CURRENT	12/5/2013 12:11	Pass		mA	5				25	**20**
SAE J1772	OVERALL	OVERALL	12/5/2013 12:11	PASS								

Figure 7. Plug 2 (“Righty”) test results from the Grid Test EVE-100L Lab Test Unit.

Gridtest® Test Report					Copyright © 2011-2012 Gridtest Systems, Inc.							
Test Suite	SAE J1772											
Standard	SAE J1772™ JAN2010											
EVSE Identity	LEFT											
Customer Identity	GE											
Date of Validation	12/5/2013 12:13											
Electrician/Engineer												
EV Emulator	EVE-100L Lab Test Unit	10000582	1.10.0.090	8								
Test Suite	Test	Validation	LastTestTimestamp	Result	Notes	Units	Expected Low Value	Expected Warning Low	Expected Nominal Value	Expected Warning High	Expected High Value	**Measured Value**
SAE J1772	State A	Pilot Voltage	12/5/2013 12:13	Pass		V	11	11.4	12	12.6	13	**11.75**
SAE J1772	State A	Pilot Frequency	12/5/2013 12:13	Pass		Hz		0		0		**0**
SAE J1772	J1772 State B	Pilot Voltage	12/5/2013 12:13	Pass		V	8	8.35	9	9.56	10	**8.94**
SAE J1772	J1772 State B	Pilot Frequency	12/5/2013 12:13	Pass		Hz	980		1000		1020	**1004**
SAE J1772	J1772 State B	Duty Cycle	12/5/2013 12:13	Pass		%	8				96	**54.27**
SAE J1772	J1772 State B	Available Current	12/5/2013 12:13	Pass		A	6				80	**32.55**
SAE J1772	J1772 State B	Glitch Voltage	12/5/2013 12:13	Pass		V				42.4		**0**
SAE J1772	J1772 State C	Pilot Voltage	12/5/2013 12:13	Pass		V	5	5.48	6	6.49	7	**6**
SAE J1772	J1772 State C	Pilot Frequency	12/5/2013 12:14	Pass		Hz	980		1000		1020	**1003.9**
SAE J1772	J1772 State C	Duty Cycle	12/5/2013 12:14	Pass		%	8				96	**54.46**
SAE J1772	J1772 State C	Available Current	12/5/2013 12:14	Pass		A	6				80	**32.67**
SAE J1772	J1772 State C	Timing Power	12/5/2013 12:14	Pass		ms	0				3000	**2626**
SAE J1772	State C to State B	Pilot Voltage	12/5/2013 12:14	Pass		V	8	8.35	9	9.56	10	**8.94**
SAE J1772	State C to State B	Pilot Frequency	12/5/2013 12:14	Pass		Hz	980		1000		1020	**1003.9**
SAE J1772	State C to State B	Duty Cycle	12/5/2013 12:14	Pass		%	8				96	**54.26**
SAE J1772	State C to State B	Available Current	12/5/2013 12:14	Pass		A	6				80	**32.56**
SAE J1772	State C to State B	Transition Time	12/5/2013 12:14	Pass		ms	0				3000	**479.4**
SAE J1772	J1772 State C	Pilot Voltage	12/5/2013 12:14	Pass		V	5	5.48	6	6.49	7	**6.01**
SAE J1772	J1772 State C	Pilot Frequency	12/5/2013 12:14	Pass		Hz	980		1000		1020	**1004**
SAE J1772	J1772 State C	Duty Cycle	12/5/2013 12:14	Pass		%	8				96	**54.46**
SAE J1772	J1772 State C	Available Current	12/5/2013 12:14	Pass		A	6				80	**32.67**
SAE J1772	J1772 State C	Timing Power	12/5/2013 12:14	Pass		ms	0				3000	**2675.6**
SAE J1772	GFI 20mA	Contact Line Voltage Before GFI	12/5/2013 12:14	Pass		V	97		120		264	**210.43**
SAE J1772	GFI 20mA	Contact Line Voltage After GFI	12/5/2013 12:14	Pass		V	0				10	**0**
SAE J1772	GFI 20mA	GFI TRIP CURRENT	12/5/2013 12:14	Pass		mA	5				25	**20**
SAE J1772	OVERALL	OVERALL	12/5/2013 12:15	PASS								

Figure 8. Plug 1 (“Lefty”) test results from the Grid Test EVE-100L Lab Test Unit.

4. ABNORMAL CONDITIONS TESTING

In addition to the previously described testing at normal conditions, testing was also conducted to determine the response of the EVSE to abnormal input conditions.

4.1 Electric Vehicle Supply Equipment Response to Abnormal Control Pilot Voltage

Previously, each of the control pilot states was tested (State A, B, C, and D). Additionally, testing was conducted at control pilot voltages that are outside of the voltages specified by SAE J1772 for each control pilot state. Figure 9 shows the SAE J1772 recommended practices for the EVSE manufacturer for state determination from the control pilot voltage.

	Minimum	Nominal	Maximum
Positive Voltage, State A	11.40	12.00	12.60
Positive Voltage, State B	8.36	9.00	9.56
Positive Voltage, State C	5.48	6.00	6.49
Positive Voltage, State D	2.62	3.00	3.25
Negative Voltage - States B, C, D, and F	-11.40	-12.00	-12.60

Figure 9. SAE J1772 (version 2010) recommended practice of control pilot voltage range for each state.

Two control pilot voltage conditions were tested: Control Pilot = 7.2 V (between State B and C) and Control Pilot = 4.8 V (between State C and D). For both Plug 1 and Plug 2, the contactors closed at the tested control pilot voltage as shown in Table 7.

Table 7. EVSE response to abnormal control pilot voltage.

Test Condition	CP Voltage Peak+	Between States (per J1772)	GE EVSE Response
Plug 1 (“Lefty”)	7.2 V	B and C	Contactors closed
Plug 1 (“Lefty”)	4.8 V	C and D	Contactors closed
Plug 2 (“Righty”)	7.2 V	B and C	Contactors closed
Plug 2 (“Righty”)	4.8 V	C and D	Contactors closed

4.2 Electric Vehicle Supply Equipment Response to Abnormal Input Voltage Condition

Testing was conducted to identify EVSE functionality when only a single input to the EVSE is supplied with 208VAC as compared to when both inputs powered from 208 VAC.

When Plug #1 (Lefty) was connected and Plug#2 (Righty) was not connected, the LCD display was not lit (completely dark). The EVSE was successfully able to provide charge power (i.e., contactors closed in State C). EVSE Plug #1 was observed to be “online” when pinged from the GE Watt Station Connect software. Plug #2 was observed to be “offline.”

When Plug #2 (Righty) was connected and Plug#1 (Lefty) was not connected, the LCD display was backlit, but no information was displayed. The EVSE had no functionality besides the LCD display merely being backlit. The control pilot did not pulse width modulate and the contactors did not close in State C; therefore, the EVSE was unable to supply power to charge to a vehicle. EVSE Plug #2 (as well as Plug #1) was observed to be “offline” when pinged from the GE Watt Station Connect software.

5. VEHICLE CHARGING TESTING (CHEVY VOLT)

A vehicle charging test was performed with a 2012 Chevrolet Volt (Figure 10), which is an extended range electric vehicle, to observe EVSE operation during real-world charging. Under these conditions, the efficiency, standby loads, and watt-hour meter of the EVSE were observed and measured. Secondary observations included charge ramp up and ramp down as dictated by the vehicles onboard charger.

The Volt was driven before each test to deplete the battery pack until charge sustaining mode was reached and the combustion engine was running. A full charge event was then initiated, monitored, and recorded using the Hioki 3390 power analyzer.

Figure 10. The 2012 Chevrolet Volt used for EVSE testing.

A mobile, in-line breakout box (Figure 11) was constructed to enable the safe and easy connection of current and voltage measurements without the need to modify the EVSE or the vehicle. The breakout box contained two independent sections that each contained conductor loops and voltage taps to which the Hioki current clamps and voltage taps were connected. The two sections were housed within one enclosure for ease of transport. The first section was a pass-through of grid power to the EVSE. The second section was the EVSE J1772 output power, which was passed through to another J1772 connector that was plugged into the vehicle J1772 charge port.

Figure 11. Mobile breakout box showing plugs, receptacles, current loops, and voltage taps.

Figure 12 shows the connection schematic for the breakout box and the Hioki 3390 power meter for vehicle testing. Measurement at the input of the EVSE is node #1 and measurement at the SAE J1772 output connector of the EVSE is node #2 as shown in Figure 12.

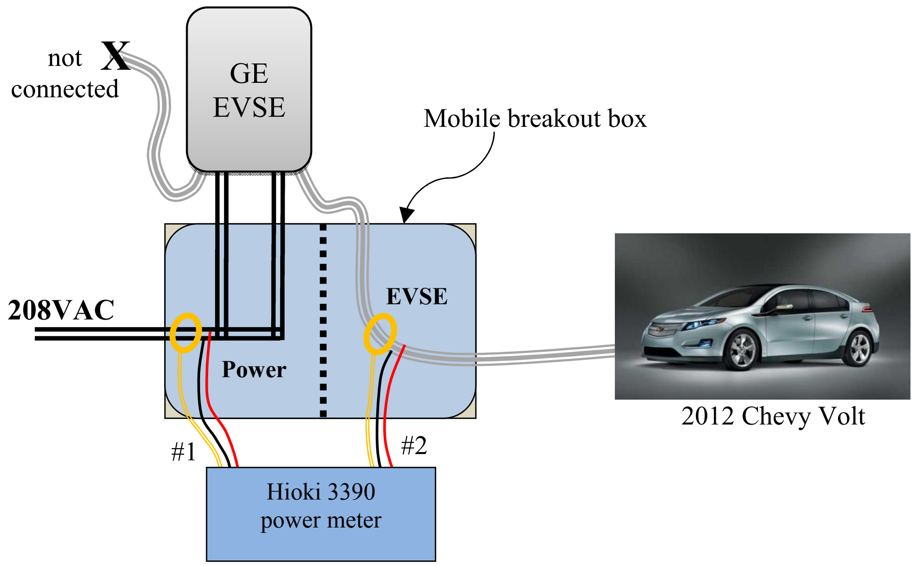

Figure 12. Schematic drawing of the vehicle test setup.

5.1 Electric Vehicle Supply Equipment Energy Efficiency

The EVSE energy transfer was measured throughout a full charge event for the Chevy Volt. This charge event was approximately 4.5 hours in duration and nominal power transfer was 3.1 kW as controlled by the vehicle's battery management system. From the cumulative measured energy delivered to the vehicle and the cumulative energy supplied to the EVSE from the grid, the efficiency of the EVSE can be determined over the entire charge event. Tables 8 and 9 show the energy efficiency of the EVSE for Plug #1 and Plug #2. Energy efficiency is defined as the total energy output from the EVSE divided by the total energy input to the EVSE over the entire duration of the charge event. The EVSE efficiency was measured to be 98.8% for both plugs. This is nearly the same as the 98.7% results as shown in table 4 in section 2.2 measured during laboratory testing at the slightly higher 3.3 kW power level.

Table 8. Left plug (Plug #1) energy efficiency testing: EVSE efficiency over charge event.

Test Condition	EVSE Efficiency (Total Output Energy/Total Input Energy)
Vehicle Full Charge Event	98.86%

Table 9. Right plug (Plug #2) energy efficiency testing: EVSE efficiency over charge event.

Test Condition	EVSE efficiency (Total Output Energy/Total Input Energy)
Vehicle Full Charge Event	98.82%

5.2 Electric Vehicle Supply Equipment Energy Measurement

The vehicle testing also compared the measured energy values of both Plug #1 and Plug #2 over the full charge event. As previously seen in laboratory testing, the Plug #1 energy reading on the EVSE front panel display does not increment up during vehicle testing charge event (Figure 13). The front panel reading is 0.0 kWh throughout the entire test. As previously stated in section 2.3, this issue may be due to unknown damage during shipping to the test location. GE engineering staff is working to resolve the issue. Conversely, the energy reading on the front panel display for Plug #2 closely matches the Hioki cumulative energy measurement (Figure 14). The final energy measurements are shown in Tables 10 and 11 for Plug #1 and Plug #2, respectively.

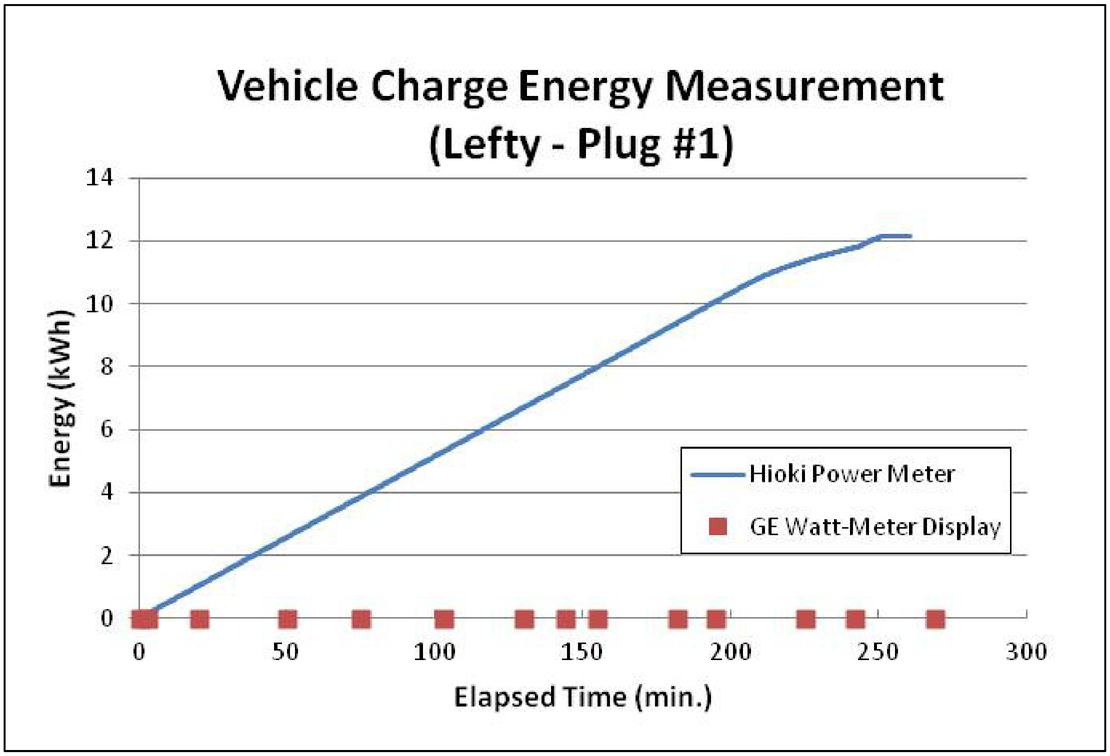

Figure 13. Hioki cumulative energy measurement and GE watt-hour display (lefty – Plug #1).

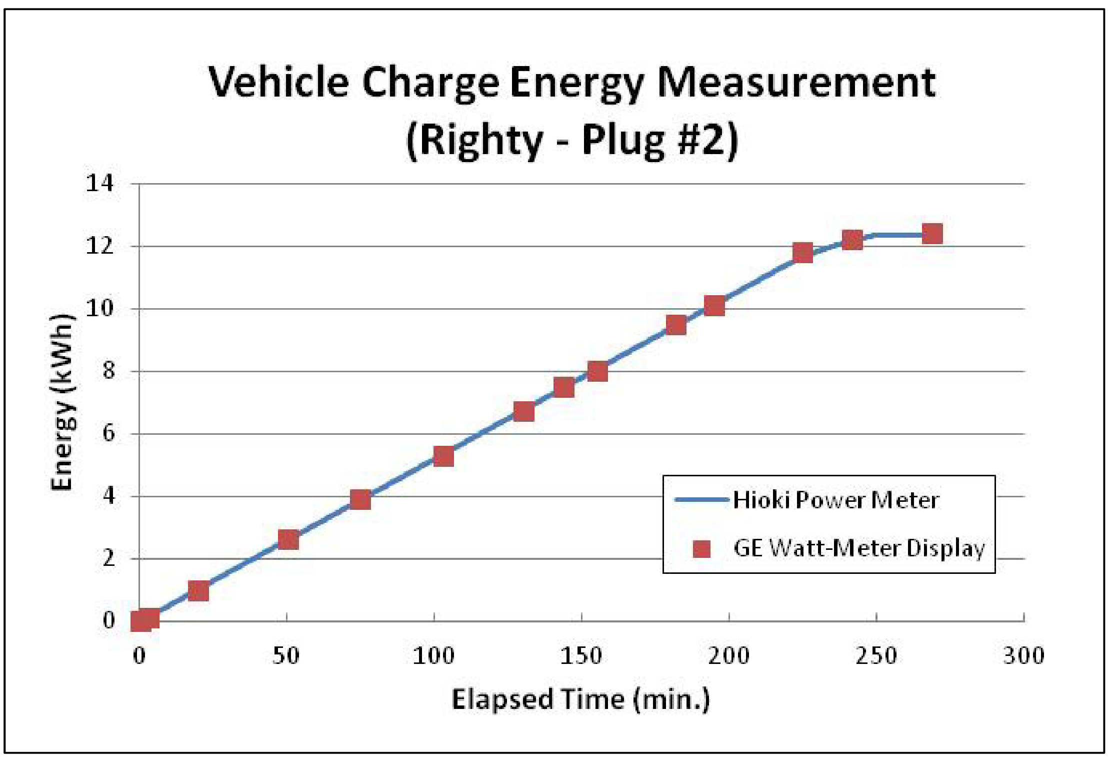

Figure 14. Hioki cumulative energy measurement and GE watt-hour display (righty – Plug #2).

Table 10. Left plug (Plug #1) vehicle testing: final watt hour test measurement.

Test Condition	Hioki Power Meter (kWh)	GE Watt-Meter Display (kWh)
Full Vehicle Charge Event	12.18	0.0

Table 11. Right plug (Plug #2) vehicle testing: final watt hour test measurement.

Test Condition	Hioki Power Meter (kWh)	GE Watt-Meter Display (kWh)
Full Vehicle Charge Event	12.30	12.4

5.3 Electric Vehicle Supply Equipment Response to Interrupted Grid Power

Testing was conducted on the EVSE to identify the EVSE response to a grid power outage. This testing was conducted using the Chevy Volt vehicle testing protocols described above. A vehicle charging event was initiated and nominal charge power was reached and monitored for approximately one minute to ensure proper steady state operation. Grid power (208 VAC) was then interrupted simultaneously for both EVSE inputs. The EVSE ceased to function or provide charge power to the vehicle as expected. Grid power was restored after approximately 5 seconds; the EVSE rebooted. The EVSE then reinitiated the charge event without the need from outside intervention. The charge event continued as expected.

6. SUMMARY

The Idaho National Laboratory tested the GE smart grid capable EVSE in support of the U.S. Department of Energy FOA-554. Energy efficiency, stand-by power consumption, and functionality per SAE J1772 were tested. The EVSE also was used to charge a 2012 Chevy Volt to verify full functionality with a production plug-in vehicle.

The test results of the GE EVSE showed the nominal operating efficiency for both Plug #1 and Plug #2 is >98% during Level 2 charging. The standby power consumption was measured to be 17.7 watts in State B (vehicle connected but not ready to charge) and 19.8 watts in State C (vehicle connected and ready to charge). The EVSE displays the cumulative energy that is delivered to a vehicle during a charge event. Plug #2 energy display value closely matched the calibrated measurement equipment during testing. Plug #1 energy display was not functional under all test conditions which might be due to unknown damage during shipping to the test facility. GE engineering staff is actively working to resolve this issue. The GE smart grid capable EVSE successfully charged a production Plug-In vehicle from both Plug #1 and Plug #2.