SURFACE VEHICLE RECOMMENDED PRACTICE

J2953/2	JAN2014
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Test Procedures for the Plug-In Electric Vehicle (PEV) Interoperability with Electric Vehicle Supply Equipment (EVSE)

RATIONALE

This SAE Recommended Practice SAE J2953/2 is intended to define the test procedures for levels of compatibility between the PEV and EVSE of different vendors outlined in SAE J2953/1. By using the AC Level1, AC Level2, and DC Level1, DC Level2 charging with a cord set and an in cable EVSE, a AC charging station with both analogue and digital communications and a DC off board charger, if equipped.

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TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
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1. SCOPE

This SAE Recommended Practice SAE J2953/2 establishes the test procedures to ensure the interoperability of Plug-In Vehicles (PEV) and Electric Vehicle Supply Equipment (EVSE) for multiple suppliers.

1.1 Purpose

This document establishes the test procedures used for multiple levels of interoperability as described in SAE J2953/1. It provides support for charging systems which are developed according the SAE J1772™ and implement the digital communication requirements within J2836 and J2847 standards. There is also support for J2931 which identifies the vehicle to grid requirements and protocols as various options are available to the consumer and utility.

The test results and findings are intended to function as tools for documenting interoperability issues and standards gaps that can be communicated to standards committees.

1.2 Revision Information:

This first revision addresses interoperability test procedures for AC Level1 und AC Level 2 charging systems.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

J1772™ SAE Electric Vehicle Conductive Charge Coupler (Surface Vehicle Recommended Practice).

J2836/1™ Use Cases for Communication between Plug-in Vehicles and the Utility Grid (Surface Vehicle Information Report).

J2836/2™ Use Cases for Communication between Plug-in Vehicles and the Supply Equipment (EVSE) (Surface Vehicle Information Report).

J2836/3™ Use Cases for Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow (Surface Vehicle Information Report).

J2836/4™ Use Cases for Diagnostic Communication for Plug-in Vehicles (Surface Vehicle Information Report).

J2836/5™ Use Cases for Communication between Plug-in Vehicles and their customers (Surface Vehicle Information Report).

J2931/1 Requirements for digital communication between the PHEV and a EVSE or a DC off board charger

J2847/1 Communication between Plug-in Vehicles and the Utility Grid (Surface Vehicle Recommended Practice).

J2847/2 Communication between Plug-in Vehicles and the Supply Equipment (EVSE) (Surface Vehicle Recommended Practice).

J2847/3 Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow (Surface Vehicle Recommended Practice).

J2894/1 Power Quality Requirements for Plug-In Electric Vehicle Chargers (Surface Vehicle Recommended Practice).

J2953/1 Plug-In Electric Vehicle (PEV) Interoperability with Electric Vehicle Supply Equipment (EVSE)

2.1.2 Related Publications (Optional)

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

ReleaseCandidate2 DIN SPEC 70121 Electromobility - Digital communication between a D.C EV charging station and an electric vehicle for control of D.C. charging in the Combined Charging System

3. DEFINITIONS

3.1 AC LEVEL 1 CHARGING

A method that allows an EV/PHEV to be connected to the most common grounded electrical receptacles (NEMA 5-15R and NEMA 5-20R). The vehicle shall be fitted with an on-board charger capable of accepting energy from the existing single phase alternating current (AC) supply network. The maximum power supplied for AC Level 1 charging shall conform to the values in Table 1. A cord and plug EVSE with a NEMA 5-15P plug may be used with a NEMA 5-20R receptacle. A cord and plug EVSE with a NEMA 5-20P plug is not compatible with a NEMA 5-15R receptacle.

3.2 AC LEVEL 2 CHARGING

A method that uses dedicated AC EV/PHEV supply equipment in either private or public locations. The vehicle shall be fitted with an on-board charger capable of accepting energy from single phase alternating current (AC) electric vehicle supply equipment. The maximum power supplied for AC Level 2 charging shall conform to the values in Table 1.

3.3 CHARGER

An electrical device that converts alternating current energy to regulated direct current for replenishing the energy of a rechargeable energy storage device (i.e., battery) and may also provide energy for operating other vehicle electrical systems.

3.4 COMPATIBILITY

A statement of design and implementation of a device to standards specifications.

3.5 CONDUCTIVE

Having the ability to transmit electricity through a physical path (conductor).

3.6 CONFORMANCE

A statement of successful measureable verification that a device has implemented a standard as written. A compatible device may claim it conforms to a standard only after comprehensive conformance testing.

3.7 CONNECTOR (Charge)

A conductive device that by insertion into a vehicle inlet establishes an electrical connection to the electric vehicle for the purpose of transferring energy and exchanging information. This is part of the coupler.

3.8 CONTACT (Charge)

A conductive element in a connector that mates with a corresponding element in the vehicle inlet to provide an electrical path.

3.9 CONTROL PILOT

An electrical signal that is sourced by the Electric Vehicle Supply Equipment (EVSE). Control Pilot is the primary control conductor and is connected to the equipment ground through control circuitry on the vehicle and performs the following functions:

a. Verifies that the vehicle is present and connected

b. Permits energization/de-energization of the supply

c. Transmits supply equipment current rating to the vehicle

d. Monitors the presence of the equipment ground

e. Establishes vehicle ventilation requirements

f. Serves as a medium for Power-Line-Communication (PLC), as per SAE J2931

3.10 PROXIMITY

A circuit that defines the state of the charge connector in reference to the vehicle inlet. For AC charging the PEV and coupler contains a proximity circuit that the PEV uses to detect connection to the PEV inlet by the EVSE plug. The proximity circuit is modified for DC charging so that the EVSE can also sense that the cord is plugged into the PEV inlet.

3.11 COUPLER (Charge)

A mating vehicle inlet and connector set.

3.12 DC CHARGING

A method that uses dedicated direct current (DC) EV/PHEV supply equipment to provide energy from an appropriate off-board charger to the EV/PHEV in either private or public locations.

3.13 ELECTRIC VEHICLE (EV)

An automotive type vehicle, intended for highway use, primarily powered by an electric motor that draws from a rechargeable energy storage device. For the purpose of this document the definition in the United States Code of Federal Regulations - Title 40, Part 600, Subchapter Q is used. Specifically, an automobile means:

a. Any four wheeled vehicle propelled by a combustion engine using on-board fuel or by an electric motor drawing current from a rechargeable storage battery or other portable energy devices (rechargeable using energy from a source off the vehicle such as residential electric service).

b. Which is manufactured primarily for use on public streets, roads, and highways.

c. Which is rated not more than 3855.6 kg (8500 lb), which has a curb weight of not more than 2721.6 kg (6000 lb), and which has a basic frontal area of not more than 4.18 m^2 (45 ft^2).

3.14 ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE)

The conductors, including the ungrounded, grounded, and equipment grounding conductors, the electric vehicle connectors, attachment plugs, and all other fittings, devices, power outlets, or apparatuses installed specifically for the purpose of delivering energy from the premises wiring to the electric vehicle. Charging cords with NEMA 5-15P and NEMA 5-20P attachment plugs are considered EVSEs.

3.15 EQUIPMENT GROUND (Grounding Conductor)

A conductor used to connect the non-current carrying metal parts of the EV/PHEV supply equipment to the system grounding conductor, the grounding electrode conductor, or both, at the service equipment.

3.16 EV/PHEV CHARGING SYSTEM

The equipment required to condition and transfer energy from the constant frequency, constant voltage supply network to the direct current, variable voltage EV/PHEV traction battery bus for the purpose of charging the battery and/or operating vehicle electrical systems while connected.

3.17 INTEROPERABILITY

Capability of a standards conforming device to function as intended with other standards conforming devices without special effort by the user.

3.18 ON-BOARD CHARGER

A charger located on the vehicle.

3.19 PLUG IN HYBRID ELECTRIC VEHICLE (PHEV)

A hybrid vehicle with the ability to store and use off-board electrical energy in a rechargeable energy storage device.

3.20 VEHICLE INLET (Charge)

The device on the electric vehicle into which the connector is inserted for the purpose of transferring energy and exchanging information. This is part of the coupler.

3.21 FREQUENCY VARIATION

The normal Range of variation of the AC line frequency.

3.22 MOMENTARY OUTAGE

A complete loss of AC line voltage for a 12 Cycles (200 ms) or more.

3.23 VOLTAGE RANGE

The normal range of variability of the AC line voltage. Voltage Range is generally expressed as a “percent of nominal” of the nominal value of the line voltage varies regionally.

3.24 VOLTAGE SAG

A reduction in the AC line voltage below the normal range of variability, typically of relatively short duration, typically 30 to 120 cycles (500 ms to 2000 ms).

3.25 VOLTAGE SURGE (Transient)

A temporary increase in the AC line voltage far beyond the normal range of variability that is evidenced by a sharp brief discontinuity of the waveform, typically of very short duration (sub-cycle).

3.26 VOLTAGE SWELL

A temporary increase in the AC line voltage of more than 10% of the normal range of variability at the power frequency, typically of relatively short duration of half a cycle to a few seconds (8 ms – 5000 ms).

4. AC INTEROPERABILITY TEST PROCEDURES

4.1 Introduction

The procedures section of this document focuses on testing a specific EVSE-PEV pair to the interoperability requirements in SAE J2953/1. Three tiers of procedures are meant to not only test for interoperability but the degree of interoperability the specific EVSE – PEV pair has. The desired outcomes of the procedures are to show that a set of test articles are interoperable to a measureable degree and/or to show insight on the cause of lack of interoperability.

Table 4.1 Test List breaks down the 3 tiers of interoperability and the tests associated with each tier. It is important to note that Tier 1 tests focus on the basic functionality of the charge system. Tier 2 testing is used to gauge the robustness of the charge system under un-ideal conditions. Finally, Tier 3 tests are used to check non-standard feature functionality.

TABLE 4.1 - SAE J2953/2 TEST LIST

Tier	Test
1	Mechanical Interoperability
	Charge Functionality
	Safety Feature Functionality
2	Indefinite Grid Events
	Dynamic Grid Events
3	Ampacity Control
	Scheduled Charge
	Staggered Scheduled Charge
	Charge Interrupt/Resume

4.2 Guidelines

This section defines the test setup for portions of interoperability testing that will require the use of a breakout fixture to interface EVSE – PEV signaling to data acquisition and logging equipment. Figure 4.1 shows required test setup for interoperability test portions requiring a breakout fixture, specifically for Tier 1and Tier 3 testing. It is recommended but not required that Tier 1 and Tier 3 testing be conducted with a regulated supply. See Figure 4.2 for Tier 1 and Tier 3 configuration with a regulated supply in the place of the programmable supply.

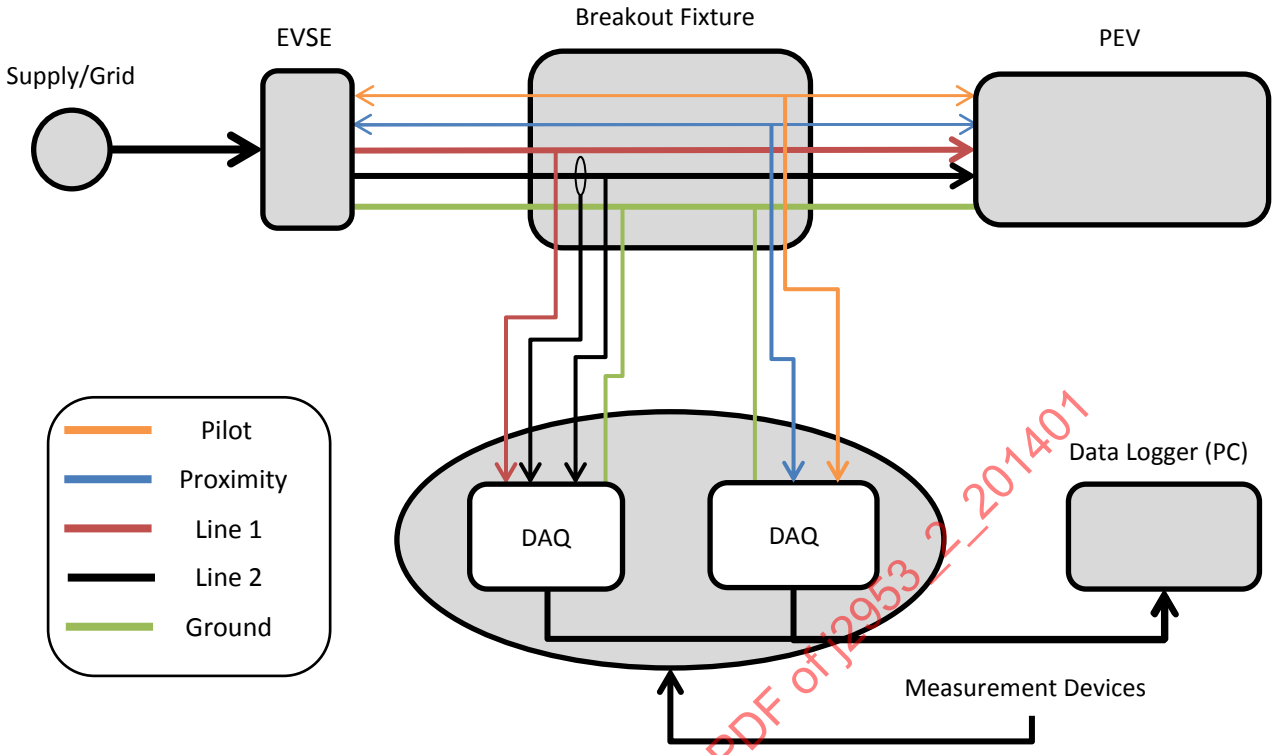

FIGURE 4.1 - TIER 1 AND TIER 3 TESTING CONFIGURATIONS

The Tier 2 test setup must be modified slightly to accommodate a programmable AC power supply. The programmable supply will be used for plausible real-world static and dynamic power modifications to test robustness of the charging system. It is recommended but not required that Tier 1 and Tier 3 testing be conducted in

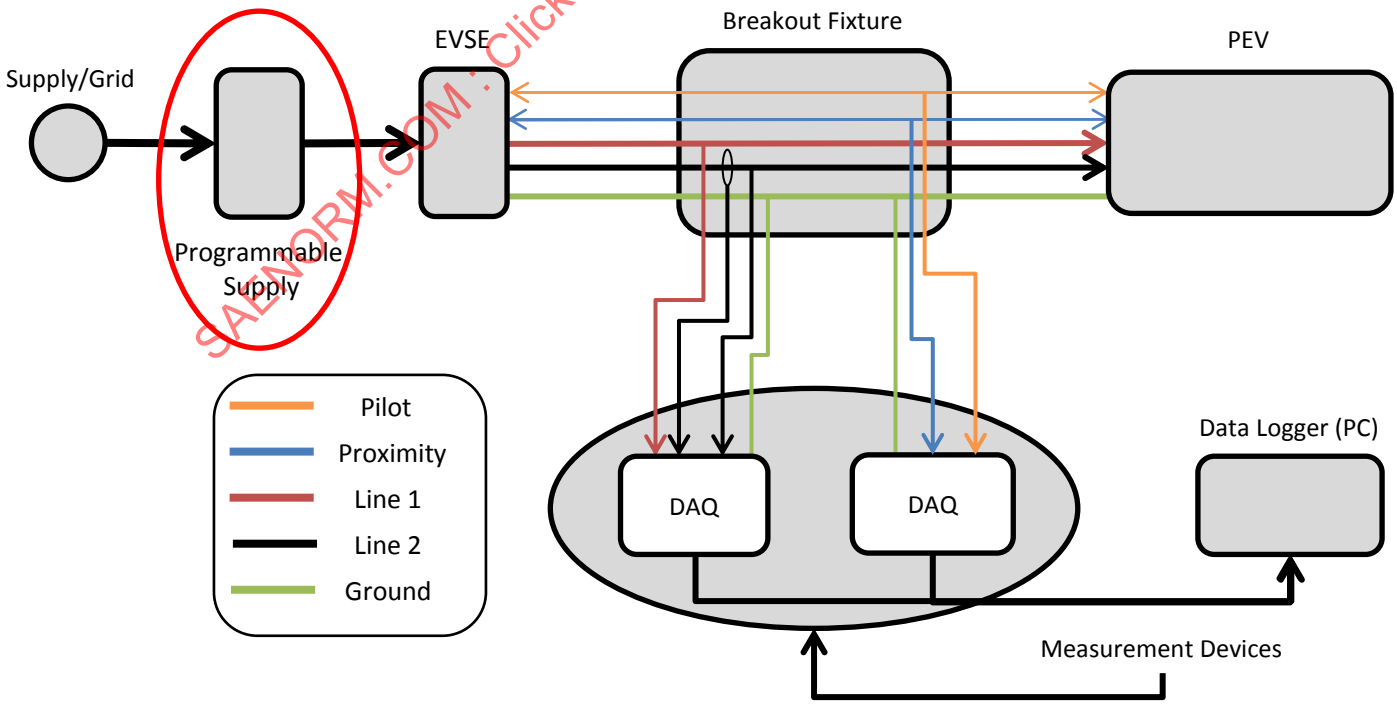

FIGURE 4.2 - TIER 2 TESTING CONFIGURATION

4.3 Test Tools

To properly conduct interoperability testing outlined in this document it is required that proper testing tools are used to insure that test results are accurate and consistent. This section describes the operating requirements of three custom test tools required for testing.

4.3.1 Mechanical Interoperability Test Tool

The purpose of the mechanical interoperability test tool is to test the coupling and decoupling force required during Tier 1 testing. SAE J2953/1 requirement 4.1.7.2 requires that the coupling and de-coupling force of the system coupler be less than 75 newtons.

The basic design of the mechanical interoperability test tool includes an elongated “U”-shaped bracket, an off-the-shelf push-pull force gauge, and a set of adjustable band clamps. As shown in Figure 4.3 the push-pull force gauge is connected to the U-shaped bracket such that the force of the coupler on the bracket can be measured by the push-pull force gauge. The connection is made with a #10 opening on the bracket and a thumbscrew on the gauge sensor. The bracket is then attached around the EVSE connector securely with band clamps such that the force gauge sensor points in the same direction of the lateral coupling movement. With this design it is easy to attach the test tool to many different types of EVSE connectors and obtain true coupling and de-coupling readings.

Figure 4.3 shows the measurement requirements of the custom U-shaped bracket. The push-pull force gauge must be able to record a minimum of 75 newtons of “push” and 75 newtons of “pull” with maximum of 0.5% full scale accuracy. It is optional that the force gauge have a USB or serial output for streaming force measurements that can be plotted over time. Without viewing the USB plot is may be difficult to know whether a maximum measurement is representative of a maximum before fully coupled connector or the effect of additional force after the connector is coupled. Some training and practice by the operator may be required such that the operator inserts the connector without causing binding or continuing to force the connector once coupled.

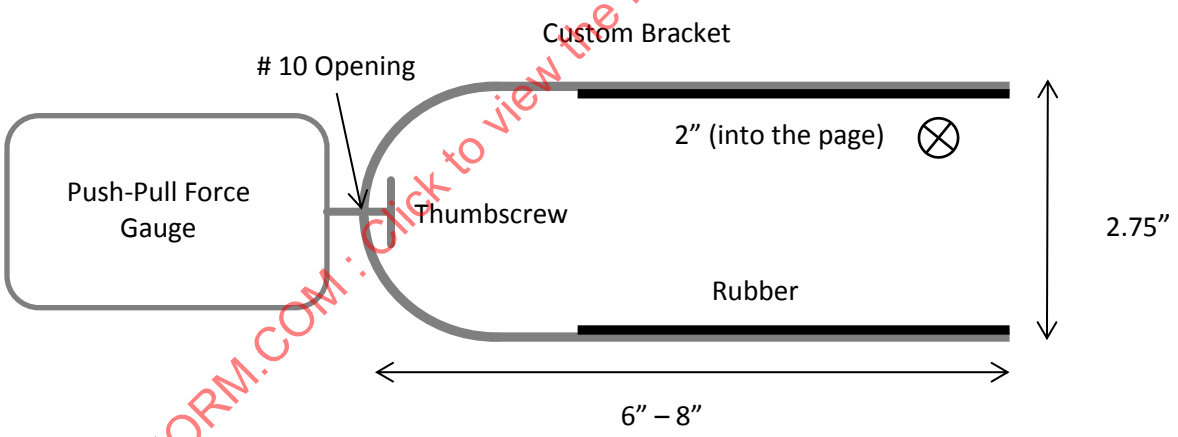

FIGURE 4.3 - MECHANICAL INTEROPERABILITY TOOL

4.3.2 Breakout Fixture

The breakout fixture is a tool used for all tiers of testing. It must be made custom to accommodate measurement devices that will be used by the operator during testing. The tool is designed to pass through all line and signaling conductors between the EVSE and PEV while being able to breakout the conductor nodes for measuring by the data acquisition and data logging system. It is required that the fixture does not break any of the line or signaling circuits to the measurement equipment; i.e. the measurements must be in parallel, not series.

Required features include UL listed SAE J1772 inlet and connector. Inlet, connector and all conductors must be rated for voltage and current limits exceeding the capabilities of all EVSE and PEV articles to be tested. The SAE J1772 connector requires modification such that it does not terminate the proximity circuit, rather it is to pass the proximity conductor through the breakout fixture and ultimately to the EVSE connector for termination.

NOTE: Do not disconnect the breakout fixture connector from the pev inlet when the system is charging. This action may result in arcing which may cause equipment damage.

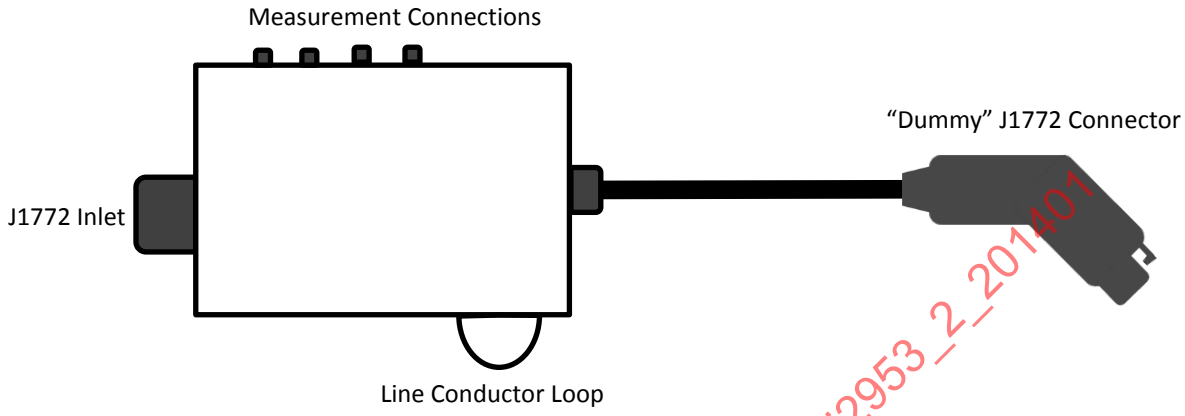

FIGURE 4.4 - SAMPLE BREAKOUT FIXTURE DIAGRAM

The breakout fixture will introduce parallel capacitance to the charging system. This will have a significant effect on the rise, fall, and settling times of the pilot PWM signal. Therefore it is recommended that the breakout fixture be designed to minimize added capacitance. The PEV - EVSE charge system without a breakout fixture has a maximum allowable capacitance of 5500 picoFarad (pF). A target for the breakout fixture capacitance would be 5% the max system capacitance, or 275 pF.

Table 4.2 shows rise, fall, and settling times for all PWM states with and without the addition of a 5% breakout fixture. Matlab scripts in Appendices 2.1.1 and 2.1.2 calculate rise, fall, and settling times. Changing variable "CT" (capacitance total) in the Matlab script from 5500 pF to 5775 pF (5500 pF + 275 pF) yields new rise, fall, and settling times shown in the last column of Table 4.2

TABLE 4.2 - RISE/FALL/SETTLING TIME REQUIREMENTS WITH 5% BREAKOUT FIXTURE

Specification (J2953/1)	Description	Requirement (J2953/1)	Requirement with 5% Breakout Fixture
4.1.3.3	State B Rise Time	≤ 9.624 µs	≤ 10.082 µs
4.1.3.4	State B Fall Time	≤ 12.479 µs	≤ 13.080 µs
4.1.3.5	State C Rise Time	≤ 6.937 µs	≤ 7.257 µs
4.1.3.6	State C Fall Time	≤ 12.508 µs	≤ 13.107 µs
4.1.3.7	State D Rise Time	≤ 4.689 µs	≤ 4.892 µs
4.1.3.8	State D Fall Time	≤ 12.655 µs	≤ 13.257 µs
4.1.3.9	State B Settling Time	≤ 17.660 µs	≤ 18.477 µs
4.1.3.10	State C Settling Time	≤ 13.191 µs	≤ 13.784 µs
4.1.3.11	State D Settling Time	≤ 8.625 µs	≤ 8.989 µs

These new values are to be used for acceptance criteria within interoperability testing when using a 5% or less breakout fixture. In the case that the breakout fixture adds more than 275 pF capacitance to the pilot circuit of the breakout fixture the rise, fall, and settling times must be adjusted. Insert the breakout fixture capacitance value plus 5500 pF into the Matlab scripts found in SAE J2953/1 Appendices 2.1.1 and 2.1.2. The new values may be programmed into the data acquisition system accordingly.

4.3.3 Data Acquisition System

The data acquisition system is used to monitor a test interaction between an EVSE and PEV. The system must sample various signals as outlined below. Table 4.3 shows the minimum sampling requirements for each of the monitored signals. Ultimately these measurements will be reported based upon requirements in Section 4.3.4 Data Logging and Reporting.

TABLE 4.3 - DATA ACQUISITION SAMPLING REQUIREMENTS

Circuit	Parameter	Resolution	Range	Sampling Frequency
Control Pilot	PWM Duty Cycle	0.5 %	0 % - 100 %	1000 Hz[2]
Control Pilot	PWM Frequency	0.5 Hz	900 Hz – 1100Hz	1000 Hz[2]
Control Pilot	PWM State Voltage	10 millivolt	-2.0 V – 15.0 V	20 kHz[1]
Control Pilot	Steady State Voltage	10 millivolt	-2.0 V – 15.0 V	1000 Hz[2]
Control Pilot	PWM Rise/ Fall/ Settling Time	100 nanoseconds	0 µs – 40 µs	10 Hz
Control Pilot	Low-side Voltage	10 millivolt	-15.0 V – 0 V	20 kHz[1]
Proximity Detection	Voltage	10 millivolt	0 V – 6.0 V	1000 Hz[2]
Mains Charge	RMS Line Voltage	0.5 volt	0 VAC – 275 VAC	1000 Hz[2]
Mains Charge	RMS Line Current	0.1 amp	0 A – 80 A	1000 Hz[2]
Mains Charge	Line Frequency	0.1 Hz	0 Hz – 80Hz	1000 Hz[2]

1. Increased sampling frequency is required during Control Pilot PWM.
2. Sampling frequency minimum is required to obtain 1 millisecond transition timing resolution.

Transition Timing:

Excluding PWM Rise/Fall/Settling measurements, all measured signals in Table 4.3 must be measured at 1 millisecond intervals for the purpose of transition detection. Table 4.4 includes a list of transitions that are triggered either in parallel with data capture or post-process.

TABLE 4.4 - TRANSISTION TIMING

J2953/1 Requirement	Specification	Acceptance Criteria	Description	Start Criteria	End Criteria
4.1.1.1	State B1 to State B2	None	Timing from plug-in to PWM oscillator on	Enter State B1	Enter State B2
4.1.1.2	State B2 to C/D	None	Timing from PWM oscillator on to S2 closed	Enter State B2	Enter State C
4.1.1.3	State C/D to mains voltage	≤ 3.0 seconds	Timing from S2 closed to EVSE AC contactors close	Enter State C	Vrms > 10 VAC
4.1.4.1	State C/D to State B2	≤ 3.0 seconds	Timing from AC contactors open in response to S2 open	Enter State B2	Vrms < 10 VAC
4.1.6.1	State X to State A	≤ 100 milliseconds	Timing from plug disconnect to EVSE opening AC contactors	Enter State A	Vrms < 10 VAC
4.1.6.2	State X to State A	≤ 2.0 seconds	Timing from plug disconnect to EVSE oscillator off	Enter State A	PWM duty cycle < 2%
4.1.6.3	State E/F to zero line voltage	≤ 3.0 seconds	Timing from EVSE error state to AC contactor open	Enter State E/F	Vrms < 10 VAC
4.1.6.4	Invalid pilot to State B2	≤ 3.0 seconds	Timing from EVSE invalid pilot frequency to PEV opening S2	Invalid Pilot Frequency	Enter State B2
4.1.6.5	State E/F to zero line current	≤ 5.0 seconds	Timing from EVSE fault state to PEV terminating charge (zero charge current)	Enter State E/F	Charge current < 500 milliamps
4.1.6.6	Duty Cycle change response	≤ 5.0 seconds	Timing from EVSE PWM modification to PEV current draw adjustment	PWM duty cycle ± 5% change within 1 seconds	Charge current ± 2% of PWM ampacity
4.1.6.7	State C/D to State B	≤ 100 milliseconds	Timing from S3 open to PEV terminating charge (zero charge current)	EVSE connected S3 open	Charge current < 500 milliamps

4.3.4 Data Logging and Reporting

Data Logging:

All data signals are to be logged at a rate of once per 100 milliseconds or at 10 Hz. For PWM Rise/Fall/Settling parameters this means that all measurements are logged. For signal parameters that are measured at a higher frequency then 10 Hz all the measurements since the last logged value are averaged to a single value. For example, proximity detection voltage is measured once per millisecond. In order to log at 10 Hz the last 100 measurements are averaged to a single value that becomes the logged value.

Reporting

Logged values must be processed to generate reports that will be used to determine if SAE J2953/1 interoperability requirements are met.

Transition Timing Reporting

All completed transitions are logged. The measured times are binned based upon the transition timing requirement they belong to. Each transition measurement bin is processed into maximum, minimum, and average times. These times are applied to SAE J2953/1 requirements 4.1.1.3, 4.1.4.1, and 4.1.6.1 - 4.1.6.9.

Control Pilot State Voltage Reporting

State voltages are processed the same regardless if logged values were recorded during control pilot oscillation or not. In the case that a state voltage based transition occurs, one voltage value on each side of the transition is excluded from the dataset. State voltages are binned into the following state categories based upon their value. Each control pilot state bin is then processed for maximum value, minimum value, and mean value. These values apply to SAE J2953/1 requirements 4.1.2.1 – 4.1.2.7.

TABLE 4.5 - CONTROL PILOT STATE VOLTAGE REPORTING BINS

Control Pilot State	Bin Voltage Range
State A	15 V ≤ x < 10.5 V
State B	10.5 V ≤ x < 7.5 V
State C	7.5 V ≤ x < 4.5 V
State D	4.5 V ≤ x < 1.5 V
State E	1.5 V ≤ x < -1.5 V
State F	-1.5 V ≤ x < -15 V

Proximity Voltage Reporting

All logged proximity voltages are binned into the following state categories based upon their voltages. In the case that a proximity state transition occurs, one data point on each side of the transition is excluded. These binned values are processed for maximum, minimum, and mean values. The values apply to SAE J2953/1 requirements 4.1.5.1 – 4.1.5.3.

TABLE 4.6 - PROXIMITY DETECTION STATE VOLTAGE REPORTING BINS

Proximity Detection State	Bin Voltage Range
EVSE Unplugged	6.0 V ≤ x < 3.5 V
EVSE Plugged S3 Open	3.5 V ≤ x < 2.0 V
EVSE Plugged S3 Closed	2.0 V ≤ x < 0 V

Control Pilot Waveform Reporting

All logged PWM frequency, PWM duty cycle, state rise times, state fall times, state settling times, and PEV AC current draw measurements are binned into respective categories based upon J2953/1 requirements. These binned values are processed for maximum, minimum, and mean values. The values apply to J2953/1 requirements 4.1.3.1 - 4.1.3.12.

4.4 Testing Prerequisites

It is assumed that a SAE J1772 conformant PEV and EVSE are used for testing. A SAE J1772 conformant EVSE is defined as an EVSE that meets all requirements of SAE J1772 and adequately performs as per the tests described in Appendix H of SAE J1772. A SAE J1772 conformant PEV is defined as a PEV that meets all requirements of SAE J1772.

4.5 Tier 1 Interoperability Test Procedures for AC Level 1 and AC Level 2 Charging

This section addresses the interoperability test procedures of a charge system consisting of a SAE J1772 conforming PEV and SAE J1772 conforming EVSE. Please conduct Tier 1 Interoperability procedure in conjunction with Tier 1 Procedure Test Form. Fill out Section 1 of the test form before proceeding to any of the test sections.

4.5.1 Mechanical Interoperability Test

This test determines if the test article SAE J1772 EVSE connector is interoperable with the test article SAE J1772 PEV inlet. Conduct test in conjunction with Section 2 of Tier 1 test form.

Acceptance Criteria

An EVSE and PEV pair passes this test only when SAE J2953/1 requirements 4.1.7.1 – 4.1.7.5 are met.

Initial Conditions

PEV must not be running; PEV must be in park. EVSE must be disconnected from voltage source. Use of a breakout fixture is not needed for Mechanical Interoperability tests.

Test Steps:

- *Install the mechanical interoperability test tool on the EVSE connector. Set the force gauge to display maximum push and maximum pull forces.*
- *Open the vehicle inlet cover.*
- ***Connection process:** Hold the test tool by the push-pull force gauge in the orientation of insertion, zero the force gauge.*
- *Holding the test tool by the force gauge, slowly insert the connector into the vehicle inlet. Be sure not to cause any binding and be sure not to place pressure on the connector once latched.*
-
- *Once latched, gently press the connector latch button and pull the connector out of the vehicle inlet, still holding by the force gauge.*
- *Once disconnected, record the maximum push force and maximum pull force for the connection iteration.*
- *Repeat the procedure from the "Connection process" step until 4 couple and de-couple iterations occur without binding. This may take numerous iterations depending on the ability of the operator to insert without binding and without forcing beyond the latch process. Fill Section 2.1 of Tier 1 test form with coupling and de-coupling measurements from the 4 successful iterations. Note: All 4 coupling and decoupling measurements must be less than or equal to 75 newtons in order to pass requirement 4.1.7.2.*
- *Remove the mechanical test tool from the EVSE connector.*
- *Insert the EVSE connector into the vehicle inlet with SAE J2953/1 requirements 4.1.7.1 and 4.1.7.3 in mind.*
- *Once connected attempt to de-couple the connector from the inlet without depressing the latch button.*
- *Unplug the EVSE connector from the vehicle inlet with SAE J2953/1 requirements 4.1.7.5 in mind. This is accomplished by ensuring that the latch button is required to be pressed during decoupling. Using a multimeter, verify that depressing and releasing the latch button on the EVSE connector causes a resistance change between the proximity pin and ground.*
- *Place a checkmark next to the corresponding requirements that are met during the previous 2 steps. You may repeat the previous 2 steps multiple times in order to be sure that requirements are met.*
- *If any requirements are not met you may comment and initial in the comments section.*

4.5.2 Charge Functionality Test

This test determines if the EVSE and PEV test articles are capable of starting, maintaining and ending a charge session while holding to requirements of SAE J2953/1. Conduct test in conjunction with Section 4 of Tier 1 Test Form.

Acceptance Criteria

An EVSE and PEV pair passes this test only when a charge session in completed successfully without intervention by the operator. During the charging process the EVSE – PEV pair must meet the following applicable SAE J2953/1 requirements; 4.1.1.3, 4.1.2.1 – 4.1.2.7, 4.1.3.1 – 4.1.3.12, 4.1.4.1, 4.1.5.1 – 4.1.5.3, 4.1.6.3 - 4.1.6.5, 4.1.6.9,

Initial Conditions

PEV must not be running; PEV must be in park. PEV must have a minimum of 10 minutes of charge remaining at max on-board charger current draw. EVSE must be properly connected to branch circuit. It is recommended that the EVSE is powered by a regulated supply to ensure optimal test result. Follow SAE J1772 Table 5.2 Electrical Rating for North America for proper branch circuit ratings. EVSE must not be connected to the PEV and the EVSE must be in a ready state (no faults or busy indicators). Use of a breakout fixture is required for Charge Functionality tests. EVSE connector is disconnected from the PEV and breakout fixture. The breakout fixture connector is disconnected from the PEV.

NOTE: Do not disconnect the breakout fixture connector from the pev inlet when the system is charging. This action may result in arcing which may cause equipment damage.

Test Steps:

- *Power on the EVSE.*
- *Open the vehicle inlet cover.*
- *Setup the breakout fixture to begin data acquisition and logging.*
- *Start data logging.*
- *Insert the EVSE connector to the breakout fixture inlet.*
- *Plug the breakout fixture connector in to the PEV inlet. Make sure that the system begins a charge session.*
- *Wait until the PEV charges completely to ensure a vehicle initiated shutdown.*
- *Wait 1 minute to allow for adequate State B2 PWM and pilot sampling after vehicle initiated shutdown. If the charge system does not enter State B for any reason the operator may press and hold the EVSE connector latch button to open switch S3. This may induce the vehicle to enter the system into State B. Continue to hold the latch button for 1 minute for proper data sampling time. The operator may also wait until the PEV enters State B at a later time; up to 1 hour wait.*
- *Press the EVSE connector latch button for 20 seconds to allow for adequate data sampling while the proximity circuit is connected but unlatched.*
- *Remove the EVSE connector from the breakout fixture inlet, wait 20 seconds to allow for adequate data sampling while the proximity circuit is disconnected.*
- *Stop data logging.*
- *Power down the EVSE and return the charge system to the initial conditions.*

- *Fill Section 3 of Tier 1 Procedure Test Form by conducting post-processing of the data samples.*

4.5.3 Safety Feature Functionality Test

This test determines if the EVSE and PEV test articles are capable of safely ending a user initiated charge session while holding to requirements of SAE J2953/1. Conduct test in conjunction with Section 5 of Tier 1 Test Form.

Acceptance Criteria

An EVSE and PEV pair passes this test successfully only if it meets SAE J2953/1 requirements 4.1.6.1, 4.1.6.2, and 4.1.6.7 when a user initiates the end of a charge session.

Initial Conditions

PEV must not be running; PEV must be in park. PEV must have a minimum of 10 minutes of charge remaining at max on-board charger current draw. EVSE must be properly connected to branch circuit. Follow SAE J1772 Table 5.2 Electrical Rating for North America for proper branch circuit ratings. It is recommended that the EVSE is powered by a regulated supply to ensure optimal test result. EVSE must not be connected to the PEV and the EVSE must be in a ready state (no faults or busy indicators). Use of a breakout fixture is required for Charge Functionality tests. EVSE connector is disconnected from the PEV and breakout fixture. The breakout fixture connector is disconnected from the PEV.

NOTE: Do not disconnect the breakout fixture connector from the pev inlet when the system is charging. This action may result in arcing which may cause equipment damage.

Test Steps:

- *Power on the EVSE.*
- *Open the vehicle inlet cover.*
- *Setup the breakout fixture to begin data acquisition and logging.*
- *Start data logging.*
- *Insert the EVSE connector to the breakout fixture inlet.*
- *Plug the breakout fixture connector in to the PEV inlet. Make sure that the system begins a charge session.*
- *Wait 1 minute to allow for steady charge.*
- *Press latch button (switch S3 open) on EVSE connector and hold open for 1 minute; be sure to maintain connection with the plug and inlet. This step is used to measure the charge current limiting response timing of the PEV in response to the latch button being pressed. If the PEV did not limit charge properly during this step do not perform the remaining procedure steps for 4.5.3. Instead stop data logging, power off the EVSE and return the system back to initial conditions. This step may also be used to meet J2953/1 requirement 4.1.7.5 that may have not been tested during the Mechanical Interoperability Test.*
- *Release the latch switch.*
- *Wait for the charge system to recover and re-establish a charge session.*
- *Once the charge system returns to bulk charge press the EVSE connector latch switch and immediately remove the breakout fixture connector from the PEV inlet. This step may require the coordination of two test operators. This step tests the EVSE's ability to discontinue voltage to the charge pins in the case of connector disconnect during charge.*

- *Wait 30 seconds to allow for data sampling of the EVSE contactors open and oscillator shutdown.*

- *Stop data logging.*

- *Power down the EVSE and return the charge system to the initial conditions.*

- *Fill Section 4 of Tier 1 Procedure Test Form by conducting post-processing of the data samples.*

4.6 Tier 2 Interoperability Test Procedures for AC Level 1 and AC Level 2 Charging

This section addresses the interoperability test procedures of a charge system consisting of a SAE J1772 conforming PEV and SAE J1772 conforming EVSE. Please conduct Tier 2 Interoperability procedures in conjunction with Tier 2 Procedure Test. Fill out Section 1 of the test forms before proceeding to any of the test sections. Notice that each iteration of Tier 2 tests requires a separate test form.

4.6.1 Indefinite Grid Event Test

The following tests check the system's response to various existing conditions on the electric grid. The system should be able to tolerate the conditions specified in SAE J2894/1. Testing cases include 110% and 90% of nominal service voltage and 102% and 98% of nominal service frequency. These will be four separate tests that present to static condition throughout the test session.

Acceptance Criteria

An EVSE and PEV pair passes this test only when a charge session is completed successfully without intervention by the operator. During the charging process the EVSE – PEV pair must meet the following applicable SAE J2953/1 requirements; 4.1.1.3, 4.1.2.1 – 4.1.2.7, 4.1.3.1 – 4.1.3.12, 4.1.4.1, 4.1.5.1 – 4.1.5.3, 4.1.6.3 - 4.1.6.5, 4.1.6.9. EVSE and PEV must not display any fault conditions or interrupt the charge session in any way.

Initial Conditions

PEV must not be running; PEV must be in park. PEV must have a minimum of 10 minutes of charge remaining at max on-board charger current draw. EVSE must be properly connected to branch circuit. Follow SAE J1772 Table 5.2 Electrical Rating for North America for proper branch circuit ratings. EVSE must not be connected to the PEV and the EVSE must be in a ready state (no faults or busy indicators). Use of a breakout fixture is required for Indefinite Grid Event tests. EVSE connector is disconnected from the PEV and breakout fixture. The breakout fixture connector is disconnected from the PEV.

NOTE: Do not disconnect the breakout fixture connector from the pev inlet when the system is charging. This action may result in arcing which may cause equipment damage.

Test Steps:

- *Setup the programmable AC supply for; 90% of nominal voltage, 100% nominal frequency. Fill top portion of Tier 2 Test Form #1 Section 2 with percent of nominal voltage and percent of nominal frequency.*

- *Power on the EVSE.*

- *Open the vehicle inlet cover.*

- *Setup the breakout fixture to begin data acquisition and logging.*

- *Start data logging.*

- *Insert the EVSE connector to the breakout fixture inlet.*

- *Plug the breakout fixture connector in to the PEV inlet. Make sure that the system begins a charge session.*

- *Wait until the PEV charges completely to ensure a vehicle initiated shutdown.*

- *Wait 1 minute to allow for adequate State B2 PWM and pilot sampling after vehicle initiated shutdown. . If the charge system does not enter State B for any reason the operator may press and hold the EVSE connector latch button to open switch S3. This may induce the vehicle to enter the system into State B. Continue to hold the latch button for 1 minute for proper data sampling time. The operator may also wait until the PEV enters State B at a later time; up to 1 hour wait.*

- *Stop data logging.*

- *Fill Section 2 of Tier 2 Test Form #1 by conducting post-processing of the data samples.*

- *Repeat procedure steps 3 times reprogramming AC supply to the following:*
  - *1) 110% nominal voltage, 100% nominal frequency*
  - *2) 100% nominal voltage, 98% nominal frequency*
  - *3) 100% nominal voltage, 102% nominal frequency*

- *Power down the EVSE and return the charge system to the initial conditions.*

4.6.2 Dynamic Grid Event Test

The following test checks the system's response to various events and conditions that may occur on the electric grid. The charging system should be able to tolerate the events and conditions specified in SAE J2894/1. Test cases include; voltage range variation, voltage swell, voltage sag, momentary outage, long term outage, and frequency range variation. Most of these test cases are outlined in more detail in SAE J2894/1 and SAE J2894/2. A charging system is considered adversely affected if, after being subjected to any event or condition, the charging is interrupted and the system fails to re-initiate a new charge sequence. Successful recovery is defined as completing the charging process without manual intervention. These test case events shall be initiated only after a charging pair has entered a stable charge session.

Figures 4.4 – 4.9 are graphical representations of the programmed test cases to be used in this section of testing. Please refer to SAE J2894/1 and J2894/2 for a more expanded definition of these test cases.

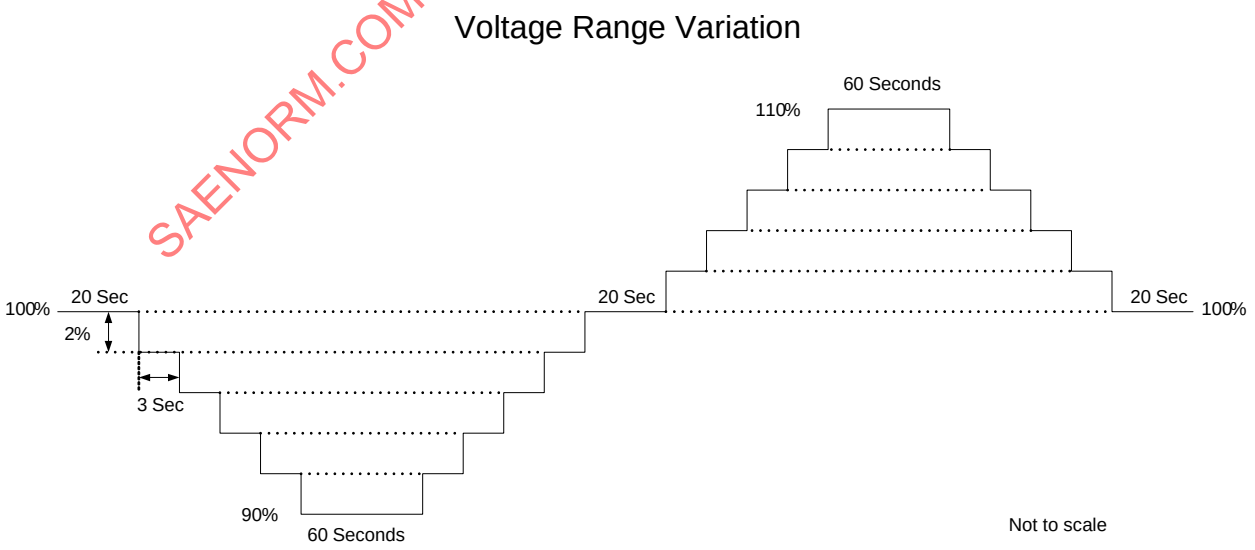

FIGURE 4.5 - VOLTAGE RANGE VARIATION

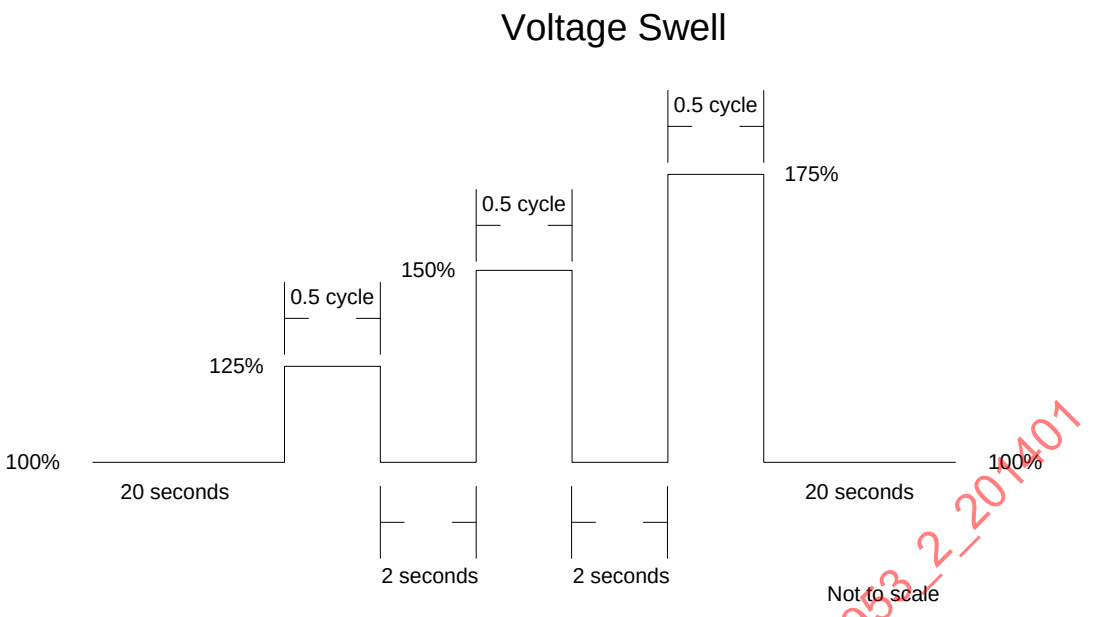

FIGURE 4.6 - VOLTAGE SWELL

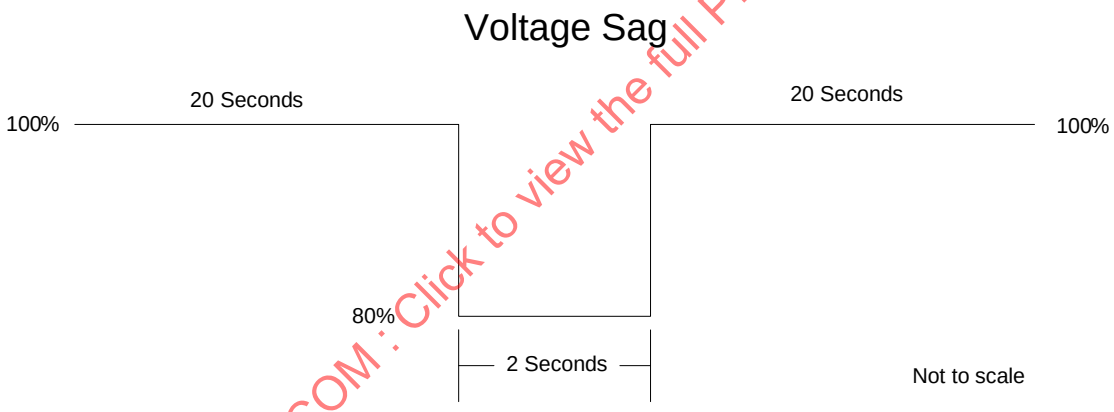

FIGURE 4.7 - VOLTAGEW SAG

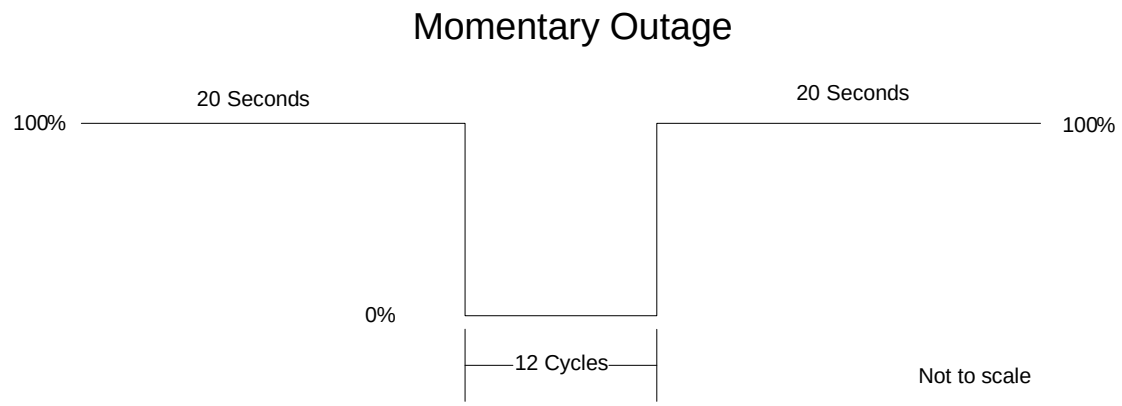

FIGURE 4.8 - MOMENTARY OUTAGE

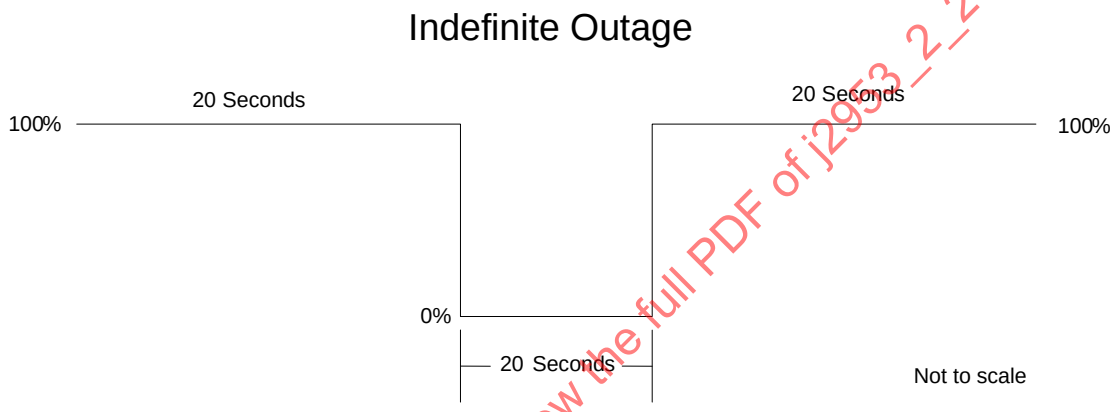

FIGURE 4.9 - INDEFINTE OUTAGE

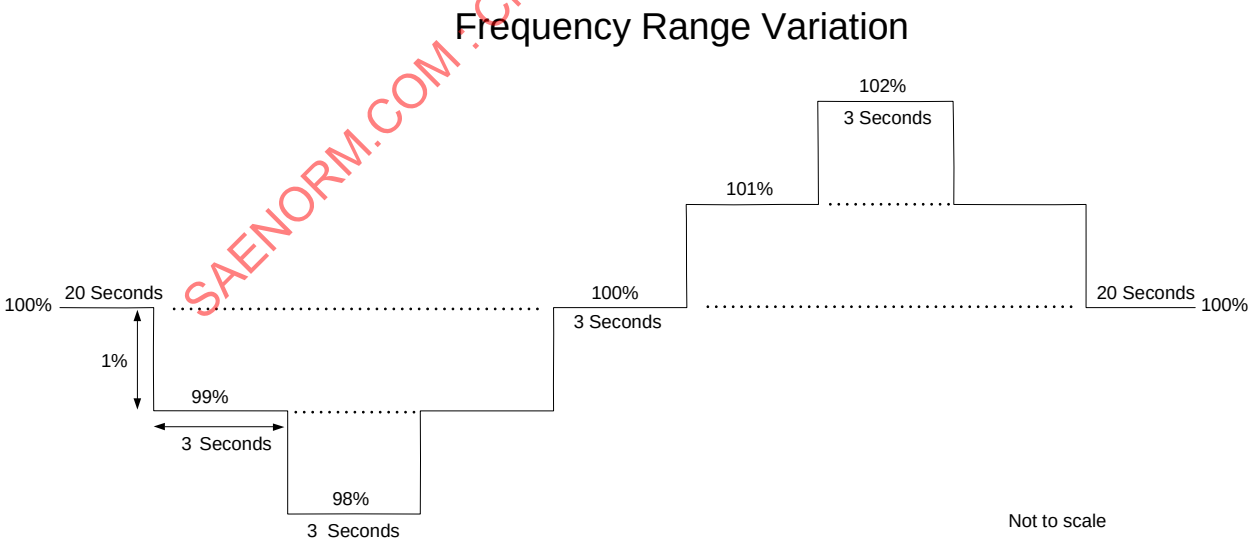

FIGURE 4.10 - FREQUENCY RANGE VARIATION

Acceptance Criteria

An EVSE and PEV pair passes this test when a charge session can continue through each of the 6 described dynamic grid events. In the case that the charge session cannot continue through the grid event it must re-establish successfully without intervention by the operator in order to pass the test. During the charging process the EVSE – PEV pair must meet the following applicable SAE J2953/1 requirements; 4.1.1.3, 4.1.2.1 – 4.1.2.7, 4.1.3.1 – 4.1.3.12, 4.1.5.1 – 4.1.5.3, 4.1.6.3 – 4.1.6.5, 4.1.6.9. EVSE and PEV may display fault conditions or interrupt the charge session but are expected to recover and begin a new charge session once the event is complete.

Initial Conditions

PEV must not be running; PEV must be in park. PEV must have a minimum of 10 minutes of charge remaining at max on-board charger current draw. EVSE must be properly connected to branch circuit. Follow J1772 Table 5.2 Electrical Rating for North America for proper branch circuit ratings. EVSE must be connected to a preprogrammed AC power supply. EVSE must not be connected to the PEV and the EVSE must be in a ready state (no faults or busy indicators). Use of a breakout fixture is required for Indefinite Grid Event tests. EVSE connector is disconnected from the PEV and breakout fixture. The breakout fixture connector is disconnected from the PEV.

NOTE: Do not disconnect the breakout fixture connector from the pev inlet when the system is charging. This action may result in arcing which may cause equipment damage.

Test Steps:

- *Setup the programmable AC supply for remote application of the listed 6 grid event scenarios.*
  - *Voltage Range Variation*
  - *Voltage Swell*
  - *Voltage Sag*
  - *Momentary Outage*
  - *Indefinite Outage*
  - *Frequency Range Variation*

- *Power on the EVSE through the programmable AC supply using nominal voltage and frequency.*

- *Open the vehicle inlet cover.*

- *Setup the breakout fixture to begin data acquisition and logging.*

- *Insert the EVSE connector to the breakout fixture inlet.*

- *Plug the breakout fixture connector in to the PEV inlet. Make sure that the system begins a charge session.*

- ***Event Iteration:*** *Fill top portion of Tier 2 Test Form #2 with the first or next grid event of the list in step 1. Start data logging software. Administer the grid event using the preprogrammed AC power supply. Observe and record EVSE and PEV for any fault indication or interruptions in charge.*

- *If the charge session is unhindered by the grid event 20 seconds after the event is completed then stop data logging software, fill Section 2 of Tier 2 Test Form #2 by conducting post-processing of the data samples, and return to the step labeled "Event Iteration" and administer the next test case of the list. Otherwise, wait up to 20 minutes for the EVSE-PEV pair to re-establish a charge session.*

- *If charge session is re-established record the amount of time required for the session to begin again, stop data logging system, and fill Section 2 of Tier 2 Test Form #2 by conducting post-processing of the data samples. Return to the step labeled "Event Iteration", and administer the next grid event on the list using a new test form. If the charge system is unable to re-establish a charge session stop data logging and safely power off the EVSE.*

- *If there is an untested grid event test return the test setup back to initial conditions and restart the procedure using a new test form and implementing the untested grid events in the "Event Iteration" step.*

- *Power down the EVSE and return the charge system to the initial conditions.*

- *Fill Section 2 of Tier 2 Test Form #2 by conducting post-processing of the data samples.*

4.7 Tier 3 Interoperability Test Procedures for AC Level 1 and AC Level 2 Charging

Tier 3 Interoperability testing is intended to test charge systems that contain non-standard or non-required charge features. Some of these features may be general, while others may be specific to certain EVSE manufactures or PEV OEMs.

This section addresses the interoperability test procedures of a charge system consisting of a SAE J1772 conforming PEV and SAE J1772 conforming EVSE. Please conduct Tier 3 Interoperability procedure in conjunction with Tier 3 Procedure Test Form. Fill out Section 1 of the test form before proceeding to any of the test sections.

4.7.1 Ampacity Control Test

This test is intended to verify the charge system's capability of responding to an EVSE change in PWM duty cycle. An EVSE may be capable of modifying PWM duty cycle during an ongoing charge session to communicate a change in ampacity. This is a feature that is not required by SAE J1772 in order to charge a PEV however SAE J1772 does have a requirement in the case that this feature is used.

Acceptance Criteria

An EVSE and PEV pair passes this test only when a charge session can continue properly through a change of ampacity by the EVSE. During the charging process the EVSE - PEV pair must meet the following applicable J2953/1 requirement; 4.1.6.6. EVSE and PEV may not display fault conditions or stop the charge session in order to pass the test.

Initial Conditions

PEV must not be running; PEV must be in park. PEV must have a minimum of 10 minutes of charge remaining at max on-board charger current draw. EVSE must be properly connected to branch circuit. Follow SAE J1772 Table 5.2 Electrical Rating for North America for proper branch circuit ratings. It is recommended that the EVSE is powered by a regulated supply to ensure optimal test result. EVSE must not be connected to the PEV and the EVSE must be in a ready state (no faults or busy indicators). Use of a breakout fixture is required for Indefinite Grid Event tests. EVSE connector is disconnected from the PEV and breakout fixture. The breakout fixture connector is disconnected from the PEV.

NOTE: Do not disconnect the breakout fixture connector from the pev inlet when the system is charging. This action may result in arcing which may cause equipment damage.

Test Steps:

- *Power on the EVSE. If possible set the EVSE to the highest ampacity it is capable of.*

- *Open the vehicle inlet cover.*

- *Setup the breakout fixture to begin data acquisition and logging.*

- *Start data logging.*

- *Insert the EVSE connector to the breakout fixture inlet.*

- *Plug the breakout fixture connector in to the PEV inlet. Make sure that the system begins a charge session.*

- *Issue a decrease in ampacity by the EVSE, to the next possible ampacity setting. Wait 10 seconds before decreasing the ampacity to the next lowest step. Continue to decrease the ampacity in the smallest possible increments, be sure to allow a minimum of 30 seconds between each decrease in ampacity.*

- *Once the EVSE has reached its lowest possible ampacity setting wait 30 seconds before increasing the ampacity to the next level. Repeat the previous steps process but instead increasing the ampacity step by step until a maximum is reached by the EVSE. Be sure to wait a minimum of 30 seconds between each ampacity change.*

- *Wait 30 seconds, stop data logging.*

- *Power down the EVSE and return the charge system to the initial conditions.*

- *Fill Section 2 of Tier 3 Test Form by conducting post-processing of the data samples.*

4.7.2 Scheduled Charge Test

This test is intended to verify the charge system's capability of perform a scheduled charge session. An EVSE or PEV may be capable of delaying a charge session upon plugin to a user defined time. This is a feature that is not required by SAE J1772 in order to charge and SAE J1772 does not have a specification for this feature.

Acceptance Criteria

An EVSE and PEV pair passes this test only when a charge session can continue properly through a scheduled charge. The scheduled charge may be implemented through the EVSE or PEV. In the case that both devices are capable of scheduling a charge the test must be completed twice; once test for the EVSE scheduled charge feature and one test for the PEV scheduled charge feature. During the charging process the EVSE – PEV pair must meet the following applicable J2953/1 requirements; 4.1.1.3, 4.1.2.1, 4.1.2.2, 4.1.2.3, 4.1.2.4, 4.1.2.7. EVSE and PEV may not display fault conditions before or during the charge session.

Initial Conditions

PEV must not be running; PEV must be in park. PEV must have a minimum of 10 minutes of charge remaining at max on-board charger current draw. EVSE must be properly connected to branch circuit. Follow SAE J1772 Table 5.2 Electrical Rating for North America for proper branch circuit ratings. It is recommended that the EVSE is powered by a regulated supply to ensure optimal test result. EVSE must not be connected to the PEV and the EVSE must be in a ready state (no faults or busy indicators). Use of a breakout fixture is required for Indefinite Grid Event tests. EVSE connector is disconnected from the PEV and breakout fixture. The breakout fixture connector is disconnected from the PEV.

NOTE: Do not disconnect the breakout fixture connector from the pev inlet when the system is charging. This action may result in arcing which may cause equipment damage.

Test Steps:

- *Power on the EVSE.*

- *If testing the EVSE charge scheduler set the EVSE to charge in 2 hours. If the EVSE is not capable of scheduling 2 hours ahead then schedule a charge in the maximum time capable. If testing the PEV charge scheduler set the PEV to charge in 2 hours. If the PEV is not capable of scheduling 2 hours ahead then schedule a charge in the maximum time capable.*

- *Open the vehicle inlet cover.*

- *Setup the breakout fixture to begin data acquisition and logging.*

- *Start data logging.*

- *Insert the EVSE connector to the breakout fixture inlet.*

- *Plug the breakout fixture connector in to the PEV inlet.*

- *Wait until the scheduled charge is supposed to be issued.*

- *If the scheduled charge session begins move onto the next step. If the scheduled charge session does not begin allow 2 minutes for the session to begin.*

- *Wait 30 seconds, stop data logging.*

- *Power down the EVSE and return the charge system to the initial conditions.*

- *Fill Section 3 of Tier 2 Test Form #1 by conducting post-processing of the data samples.*

4.7.3 Staggered Schedule Charge Test

This test is intended to verify the charge system's capability of perform a staggered scheduled charge session. This test only applies to an EVSE and PEV pair that are both capable of scheduling a charge session. A staggered schedule charge session occurs when both the PEV and EVSE are programmed to begin a charge session but at different times. This is a feature that is not required by SAE J1772 in order to charge and SAE J1772 does not have a specification for this feature.

Acceptance Criteria

An EVSE and PEV pair passes this test only when a charge session can continue properly through a staggered scheduled charge. EVSE and PEV pair must pass the test twice, once with the PEV scheduled to charge before the EVSE is scheduled to charge, and once with the PEV scheduled to charge after the EVSE is scheduled to charge. During the charging process the EVSE – PEV pair must meet the following applicable J2953/1 requirements; 4.1.1.3, 4.1.2.1, 4.1.2.2, 4.1.2.3, 4.1.2.4, 4.1.2.7. EVSE and PEV may not display fault conditions before or during the charge session.

Initial Conditions

PEV must not be running; PEV must be in park. PEV must have a minimum of 10 minutes of charge remaining at max on-board charger current draw. EVSE must be properly connected to branch circuit. Follow SAE J1772 Table 5.2 Electrical Rating for North America for proper branch circuit ratings. It is recommended that the EVSE is powered by a regulated supply to ensure optimal test result. EVSE must not be connected to the PEV and the EVSE must be in a ready state (no faults or busy indicators). Use of a breakout fixture is required for Indefinite Grid Event tests. EVSE connector is disconnected from the PEV and breakout fixture. The breakout fixture connector is disconnected from the PEV.

NOTE: Do not disconnect the breakout fixture connector from the pev inlet when the system is charging. This action may result in arcing which may cause equipment damage.

Test Steps:

- *Power on the EVSE.*

- *Program the EVSE to charge in 2 hours. Program the PEV to charge in 1 hour.*

- *Open the vehicle inlet cover.*

- *Setup the breakout fixture to begin data acquisition and logging.*

- *Start data logging.*

- *Insert the EVSE connector to the breakout fixture inlet.*

- *Plug the breakout fixture connector in to the PEV inlet.*
- *Wait until the scheduled charge is supposed to be issued.*
- *If the scheduled charge session begins move onto the next step. If the scheduled charge session does not begin allow 2 minutes for the session to begin.*
- *Wait 10 seconds, stop data logging.*
- *Power down the EVSE and return the charge system to the initial conditions.*
- *Fill Section 4 of Tier 2 Test Form #1 by conducting post-processing of the data samples.*
- *If not tested yet; repeat the procedure instead programming the PEV to charge in 2 hours and programming the EVSE to charge in 1 hour.*

4.7.4 Charge Interrupt and Resume Test

This test is intended to verify the charge system's capability of perform a user initiated charge interrupt and resume cycle without the need to remove the EVSE connector from the vehicle. A user may be able to initiate the interrupt and resume cycle through an EVSE or PEV interface. This is a feature that is not required by SAE J1772 in order to charge and SAE J1772 does not have a specification for this feature.

Acceptance Criteria

An EVSE and PEV pair passes this test only when a charge session can stop and resume without unplugging the EVSE connector. The stop and resume cycle may implemented through the EVSE or PEV. In the case that both devices are capable of stopping and resuming a charge the test must be completed twice; once test for the EVSE stop/resume charge feature and one test for the PEV stop/resume charge feature. During the stop and resume cycle the EVSE – PEV pair must meet the following applicable SAE J2953/1 requirements; 4.1.1.3, 4.1.2.1, 4.1.2.2, 4.1.2.3, 4.1.2.4, 4.1.2.7. EVSE and PEV may not display fault conditions before, during or after the interruption and restart.

Initial Conditions

PEV must not be running; PEV must be in park. PEV must have a minimum of 10 minutes of charge remaining at max on-board charger current draw. EVSE must be properly connected to branch circuit. Follow SAE J1772 Table 5.2 Electrical Rating for North America for proper branch circuit ratings. It is recommended that the EVSE is powered by a regulated supply to ensure optimal test result. EVSE must not be connected to the PEV and the EVSE must be in a ready state (no faults or busy indicators). Use of a breakout fixture is required for Indefinite Grid Event tests. EVSE connector is disconnected from the PEV and breakout fixture. The breakout fixture connector is disconnected from the PEV.

NOTE: Do not disconnect the breakout fixture connector from the pev inlet when the system is charging. This action may result in arcing which may cause equipment damage.

Test Steps:

- *Power on the EVSE.*
- *Open the vehicle inlet cover.*
- *Setup the breakout fixture to begin data acquisition and logging.*
- *Start data logging.*
- *Insert the EVSE connector to the breakout fixture inlet.*

- *Plug the breakout fixture connector in to the PEV inlet.*
- *Wait until the system begins a charge session.*
- *Interrupt the charge session either through the PEV or EVSE interface.*
- *Verify that the charge session has stopped, the system should be in state B and mains voltage must not be present. This may take a few seconds. If the charge system continues to charge after 30 seconds the system has failed the test; power down the EVSE and return the charge system to the initial setup conditions.*
- *Wait 30 minutes without unplugging any connectors from the vehicle or the breakout fixture. Resume the charge session through the same interface that the charge was interrupted.*
- *Wait for the charge session to resume, the system should be in State C; mains power is apparent and the PEV is pulling mains current through the EVSE. Resuming charge session may take a few seconds. If the charge session did not resume within 30 seconds the pair did not pass the test.*
- *Stop data logging.*
- *Power down the EVSE and return the charge system to the initial conditions.*
- *Fill Section 5 of Tier 3 Test Form by conducting post-processing of the data samples.*

4.7.5 Other Tier 3 Testing

This section allows for testing of other non-standard EVSE or PEV features that may have not been included in the Tier 3 test procedures. EVSE and PEV features such as dynamic charging sessions that vary based on pricing or other user preference are available currently and will be more common in the future. Because of the varying behavior of the charge sessions between each manufacture it is difficult to prescribe test procedures to test proper functionality. It is up to the test operator to customize a test procedure for each unique feature. Ultimately, these features must be setup per manufacture recommendation. The acceptance criteria must be based on the systems functioning as intended by the manufacture. It may be the case the some PEVs or EVSE do not interoperate with some of the more unique charging features found in EVSEs and PEVs on the market. For this reason it is important to test these features during interoperability testing.

5. DC LEVEL1 AND DC LEVEL2 CHARGING COMPATIBILITY TESTS

6. VEHICLE TO GRID COMMUNICATION COMPATIBILITY TESTS

7. VEHICLE TO GRID COMMUNICATION AND DC CHARGING COMPATIBILITY COMBINED TESTS

8. NOTES

8.1 Marginal Indicia

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

APPENDIX A

A.1 BREAKOUT FIXTURE CAPACITANCE MEASUREMENT

The breakout fixture described in Section 4.3.2 is designed for minimal disturbance to the EVSE – PEV charge system under test. The most consequential factor of the tool design is the Pilot circuit capacitance that it will add to the test system. This capacitance should only affect the rise/fall and settling times of the Pilot PWM. In order to properly compensate for the test fixture's added Pilot capacitance Table 4.2 shows the revised rise, fall, and settling times with a test fixture of 275pF.

Capacitance measurement of the breakout fixture should be done using an LCR meter capable of measuring capacitance at 1000 Hz. Before making the measurement, connect all pilot measurement equipment on the pilot circuit; be sure that all of the equipment is turned off. The breakout fixture should be disconnected from any EVSEs and PEVs. The measurement should be made across the Pilot and Ground conductors at any points within the breakout fixture. To be sure of accurate measurement an operator should measure similar results at different junction points within the fixture.

A.2 TEST FORMS

Tier 1 Procedure Test Form

Testing Information		
Use in conjunction with SAE J2953/2 Interoperability Procedures Document		
Tier 1 Testing	J2953/2 Section #: 4.4	Page #: XXX
Section 1: Operator and test article information *Fill this section completely prior to beginning any testing.*		
PEV Year and Make:	PEV Model:	
EVSE Manufacture:	EVSE Model:	
Operator Name:	Start Date/Time:	
Fill the above section completely prior to beginning any testing.		
Section 2: Mechanical Interoperability	**J2953/2 Section: 4.5.1**	

☐ 4.1.7.1 Insertion of connector into vehicle inlet is intuitively obvious and free of multiple orientations.

☐ 4.1.7.2 Human effort for coupling and decoupling is less than 75 newtons.

☐ 4.1.7.3 Connector and inlet provide an audible and/or tactile feedback once fully engaged.

☐ 4.1.7.4 Latch is present and prevents inadvertent or accidental decoupling.

☐ 4.1.7.5 Latch provides a means in the connector to open the proximity circuit during decoupling.

Comment:_____
_____
_____Initials:_____

Section 3: Charge Functionality Test		J2953/2 Section: 4.5.2	
Start-up Sequence			
Specification	Measured	Requirement	Pass/Fail
4.1.1.1		None	N/A
4.1.1.2		None	N/A
4.1.1.3		≤ 3.0 seconds	

Comment:_____
_____
_____Initials:_____

Control Pilot State Voltage				
Specification	Max	Min	Requirement	Pass/Fail
4.1.2.1			11.40V ≤ V ≤ 12.60V	
4.1.2.2			8.36V ≤ V ≤ 9.56V	
4.1.2.3			5.48V ≤ V ≤ 6.49V	
4.1.2.4			2.62V ≤ V ≤ 3.25V	
4.1.2.7			-11.40V ≤ V ≤ -12.60V	

Comment:_____
_____
_____Initials:_____

Proximity Voltage				
Specification	Max	Min	Requirement	Pass/Fail
4.1.5.1			4.35V≤ V ≤ 4.55V	
4.1.5.2			2.51V≤ V ≤ 3.01V	
4.1.5.3			1.30V≤ V ≤ 1.72V	

Comment:_____
_____
_____Initials:_____

Control Pilot Waveform				
Specification	Max	Min	Requirement	Pass/Fail
4.1.3.1			8% < Duty Cycle ≤ 97%	
4.1.3.2			980 Hz ≤ Freq. ≤ 1020 Hz	
4.1.3.3		--	≤ 9.624µs	
4.1.3.4		--	≤ 12.479 µs	
4.1.3.5		--	≤ 6.937 µs	
4.1.3.6		--	≤ 12.508 µs	
4.1.3.7		--	≤ 4.689 µs	
4.1.3.8		--	≤ 12.655 µs	
4.1.3.9		--	≤ 17.660 µs	
4.1.3.10		--	≤ 13.191 µs	
4.1.3.11		--	≤ 8.625 µs	
4.1.3.12		--	≤ maximum current capacity communicated by EVSE	

Comment:_____

_____

_____Initials:_____

Shutdown Sequence			
Specification	Measured	Requirement	Pass/Fail
4.1.4.1		≤ 3 seconds	

Section 5: Safety Feature Functionality Test **J2953/2 Section: 4.5.4**

Specification	Measured	Requirement	Pass/Fail
4.1.6.1		≤ 100 milliseconds	
4.1.6.2		≤ 2 seconds	
4.1.6.7		≤ 100 milliseconds	

Comment:_____

_____

_____Initials:_____

Tier 2 Procedure Test Form #1

Testing Information		
Use in conjunction with SAE J2953/2 Interoperability Procedures Document		
Tier 2 Testing	J2953/2 Section #: 4.6	Page #: XXX

Section 1: Operator and test article information *Fill this section completely prior to beginning any testing.*	
PEV Year and Make:	PEV Model:
EVSE Manufacture:	EVSE Model:
Operator Name:	Start Date/Time:
Fill the above section completely prior to beginning any testing.	

Section 2: Indefinite Grid Events Test	**J2953/2 Section: 4.6.1**
Percent Nominal Voltage:	Percent Nominal Frequency:

Start-up Sequence			
Specification	Measured	Requirement	Pass/Fail
4.1.1.1		None	N/A
4.1.1.2		None	N/A
4.1.1.3		≤ 3.0 seconds	

Comment:_____
_____
_____Initials:_____

State Voltage				
Specification	Max	Min	Requirement	Pass/Fail
4.1.2.1			11.40V ≤ V ≤ 12.60V	
4.1.2.2			8.36V ≤ V ≤ 9.56V	
4.1.2.3			5.48V ≤ V ≤ 6.49V	
4.1.2.4			2.62V ≤ V ≤ 3.25V	
4.1.2.7			-11.40V ≤ V ≤ -12.60V	

Comment:_____
_____
_____Initials:_____

Control Pilot Waveform				
Specification	Max	Min	Requirement	Pass/Fail
4.1.3.1			8% ≤ Duty Cycle ≤ 97%	
4.1.3.2			980 Hz ≤ Freq. ≤ 1020 Hz	
4.1.3.3		--	≤ 9.624µs	
4.1.3.4		--	≤ 12.479 µs	
4.1.3.5		--	≤ 6.937 µs	
4.1.3.6		--	≤ 12.508 µs	
4.1.3.7		--	≤ 4.689 µs	
4.1.3.8		--	≤ 12.655 µs	
4.1.3.9		--	≤ 17.660 µs	
4.1.3.10		--	≤ 13.191 µs	
4.1.3.11		--	≤ 8.625 µs	
4.1.3.12		--	≤ maximum current capacity communicated by EVSE	

Comment:_____
_____
_____Initials:_____