The fourth meeting of the P1547.1 Working Group (WG) was held in Tempe, AZ, on June 20, 2017, at the headquarters of the Salt River Project (SRP). The targeted outcome for the meeting was to review Draft 3 of the full revision to IEEE Std 1547.1. The P1547.1 standard is intended to develop test procedures to conform with IEEE P1547, which is currently balloting.

Summary highlights: Background and introductory material was presented by the WG chair in the morning, followed by presentations from the chairs of a subset of P1547.1 subgroups. Each subgroup reviewed its draft material or discussed related topics. The meeting will be followed up by various electronic communications and teleconferences to continue drafting the revised standard. The next P1547.1 WG meeting will be held November 14 to 16, 2017, in Charlotte, North Carolina, hosted by the Electric Power Research Institute (EPRI).

*Items that require follow-up actions are shown in bold italics.*

**Wednesday, June 20, 2017, Day 1 of 2**

**Meeting called to order and introduction:**

The meeting was called to order by the WG chair, Sudipta Chakraborty, at 8:10 am. Catherine O’Brien, representative of SRP, the meeting host, welcomed the meeting participants and went over facility details including emergency procedures. Sudipta introduced the P1547.1 WG officers who were present.

Sudipta introduced the scope and purpose of P1547.1 and presented the meeting agenda, which is shown in the attached slides. Sudipta then reviewed the IEEE introductory material.

Sudipta reviewed the scope and guidelines for P1547.1 development. He stated that as an IEEE Standard, IEEE P1547.1 should contain mandatory requirements for test procedures to verify compliance to IEEE P1547.

Sudipta requested attendees to state their names and affiliations. Each attendee accordingly stated his or her name and affiliation.
Sudipta reviewed the IEEE policies and procedures, including the policy on potentially essential patents. Sudipta then asked attendees to provide information on any potentially essential patents. No potentially essential patent claims were raised.

A count of WG members present was taken by raising of hands. Forty-five present WG members were counted, establishing a quorum of over 50% of the WG membership.

Sudipta asked for comments on the previously posted meeting minutes from the March WG meeting. No comments were offered. Andy moved to approve the March meeting minutes. The motion was seconded by Richard Bravo and approved by the WG.

Sudipta reviewed the P1547.1 WG leadership structure, the P1547.1 subgroups, and the subgroup chairs responsible for each component of the draft standard. He reviewed the schedule of subgroup meeting calls.

Sudipta then described the proposed timeline for P1547.1. The next meeting will be held at EPRI’s facility in Charlotte, NC. Sudipta presented the timeline for completion of 1547.1, currently scheduled to go to ballot in July 2018, with the intent to accelerate if possible. The timeline is available in the attached meeting slides.

Unintentional islanding subgroup:

Sig Gonzalez introduced the UI subgroup’s work. He mentioned that a new test will be developed to use permissive signals for island detection. He also discussed an alternative UI test method intended to reduce the number of test iterations while still providing confidence in DER island detection. He also mentioned the possibility of using reverse power detection as a UI detection method.

Greg Kern walked through the new document. Reigh Walling asked about the use of the “grid supportive DER” in the text. Andy and Howard Liu mentioned that this language was a holdover from UL 1741 SA. John Berdner, Tim, and Chase Sun discussed the process of certifying new DER, how existing inverters certified to older standards would be dealt with, and related issues. Tim explained how UL 1741 in the past has referenced 1547.1, and how that is the plan once 1547.1 is published. Chase and Tim pointed out that not all states and jurisdictions will necessarily adopt IEEE 1547 simultaneously. George Berntsen mentioned that many DERs will have the ability to enable or disable grid support functions, depending on requirements of the areas where DERs will be installed. Some states may simply require 1547, which would likely refer to the revised standard once it is published. The discussion continued.

Reigh asked how “partially compliant” DERs would be addressed in UI tests. Greg, John, and Sig made a note to work on addressing that in the subgroup.

Greg made a note to fix language reading “EPS support DER”, and similar, which may create confusion.
Greg discussed the considerations for transformers that are required parts of DER installations. He also discussed the different load configurations for Y-connected and D-connected DERs. John pointed out that the dotted line in Fig. 3 indicates a neutral connection may or may not exist, and Greg noted that a note may be needed to explain this.

Greg pointed out that some DER may sense line-neutral voltages but deliver power line-to-line. John said that some language may need to be added to address such DERs. He also said that the test may need to explicitly specify where voltages and currents should be measured, for example when transformers are included in DERs. This also relates to the full-compliance vs partial compliance issue.

Reigh asked how it’s determined whether a DER is Y- or D-connected. John and Greg said this is specified by the DER manufacturer. Greg and John said the subgroup should consider how to deal with DERs that can be either D- or Y-connected. This could be addressed by picking one scenario as “worst-case” and testing only that case.

Reigh discussed the possibility of using zero-sequence to detect islands in an unrealistically easy way. John proposed that perhaps for D-connected DER, the simulated EPS should also be D-connected. John said the WG is trying to be more specific regarding grounding of test configurations, and will need to continue to work on this.

The WG discussed ground faults during grounding. Marcelo pointed out that these concerns are the purview of the PQ subgroup, not the UI subgroup. Greg mentioned that these issues are also addressed in a UL CRD published in December 2016.

Babak asked how a lab test can reflect different field conditions, especially different grounding and load configurations. Sig said the intent of the new test is to create worst-case load conditions and grounding conditions.

Howard pointed out that different island detection methods may respond differently in different scenarios. Howard asked whether for very large DERs, UI tests could be run below full power, especially for certain island detection methods. Sig said this may depend on whether the island detection method scales proportionally with power. Bob White asked for a generic test that does not consider what AI methods are being used. Greg agreed. Howard also asked whether electronic loads could be used.

Reigh stated that the RLC load UI test may not be relevant for island detection methods that do not operate at the fundamental-frequency. But he acknowledged that he does not have a good solution to this problem. Greg countered that the RLC helps maintain a 60 Hz island, regardless of UI method, and that this helps create a reproducible test.

Jay Liu asked what number the percentages in the UI test are relative to. Jay said this question relates to the ability of inverters to supply reactive support and fault current. Sudipta clarified that these issues will be addressed in another subgroup.
John said that we should avoid the term “simulated utility”, which could be confused with HIL testing. Greg made a note to address this.

Greg asked for a better term for “constant var” mode.

Brian Lydic asked whether frequency-watt is enabled by default in 1547. Sig said that it is currently.

Greg discussed the equations used provided in P1547.1 to determine how island frequency and voltage vary with reactive and real power balance. Brian asked why the initial voltage tolerance is +/- 5%, which is fairly large. Greg and John pointed out that this allows for a wider range of test equipment, including potentially the real grid. Greg took a note to discuss this in the subgroup.

Chase asked if the equations apply to synchronous DERs. Greg said they apply to current-source DERs. A WG member pointed out that the term “current-source” can be confusing, as most inverters are “voltage source converters”. Andy and Reigh suggested “current-regulated” be used instead of “current-source”.

Andy asked if the equations are guidance, or if they are required to be calculated. Sig said all but the QF equation are guidance.

Reigh asked why we have two separate tests for UI: one for inverters and one for synchronous machines. Greg expressed that it may make sense to keep it separate. Chase stated that PG&E has used UI tests for synchronous machines.

The WG then discussed the potential future test for permissive signal island detection. Reigh asked how this would be tested. John Berdner explained that it would be a partial compliance tests, and that some field verification would be needed. P1547.1 would not define what form the permissive signal would take. The WG continued to discuss this topic, and reviewed the initial proposed language from the subgroup. Tony Eason asked how DERs would respond to a loss of permissive signal, which could be unintentional. The WG discussed this for some time. The subgroup chairs stated that permissive signal testing is very much a work in progress and will be discussed further in the subgroup.

GR subgroup session:

Sudipta presented the draft materials for the general requirements (GR) subgroup. He introduced himself and Wayne Stec, the co-chair of the subgroup. The scope of the subgroup is covered in Clause 4 of 1547.1-2005. Subgroup biweekly calls started last month and will continue on the same schedule.
Sudipta asked whether any new safety concerns would be raised by new tests. No concerns were raised.

Sudipta stated that the Test Result Accuracy clause (4.1) will have additional implications given the more stringent requirements in P1547. The subgroup may add a footnote stating that manufacturer’s stated accuracy (MSA) must meet P1547 requirements. This may have implications for test equipment.

Sudipta brought up the distinction between MSA and performance accuracy. Bob White mentioned that ISO 17025 may be a good reference on this topic, and could be referred to by P1547.1.

Clause 4.2 (test environment) may have minimal changes, but subgroups should feel free to propose requirements needed for their tests.

Sudipta mentioned that the GR subgroup should describe requirements that apply across all tests, but individual subgroups can add or modify requirements. He requests that each subgroup designate a representative to the GR subgroup.

Chase stated that safety tests are covered in UL 1741. Sudipta clarified that the safety requirements in P1547.1 are for lab engineer safety, not to test the safety of the DER.

Clause 4.3 covers measurement accuracy. This refers to test equipment measurement accuracy, not DER measurement accuracy. Sudipta mentioned that ISO 17025 can also help here. ISO 17025 is a quality standard for test labs and test equipment. John Berdner expressed concern that some locations where testing is done may find it burdensome to obtain 17025 certification. Bob said maybe the language can be written in a way that allows some flexibility. Soonwook asked whether large test labs such as NREL can or will obtain ISO 17025 certification. Mike Kipness stated that we must request ISO’s permission to reference ISO 17025.

Clause 4.4 covers product information that DER manufacturers must provide for testing.

Clause 4.5 covers test reports. Sudipta mentioned that the subgroup will need to consider how to harmonize with UL 1741 on this topic, and how to decide what content goes in what document.

Clause 4.6 covers test equipment requirements. Sudipta mentioned that prime mover or DC supply requirements may need to be specified. He stated that this clause will likely be the most challenging topic for this subgroup.

Sudipta also mentioned other topics that have come up in subgroup discussions. They include

- DC source or prime mover requirements, including time response
- How to collect input from subgroups
- How to keep the number of tests from becoming too large
• Whether to allow proxy testing

Sudipta indicated a desire not to be overly prescriptive with regard to test equipment. The standard should allow for some flexibility with respect to how tests are conducted, within limits.

Sudipta asked what may be needed in the GR clause related to interoperability tests and ICP tests. Interoperability is a new topic for P1547.1, and ICP will be greatly expanded relative to 1574.1-2005.

Marcelo asked about the temperature stability requirements. He asked how this section may change, and how very large DERs should be addressed.

Jesse Leonard stated that perhaps not all details of the AC source need to be specified. A WG member stated that only minimum requirements should be included.

Sync subgroup discussion:

Marcelo Algrain, chair of the synchronization subgroup (Sync) led a discussion of the synchronization tests. Marcelo stated that the subgroup delivered their input a couple of months ago and paused meetings, waiting for the input from this WG meeting. He stated who has been involved in subgroup meetings.

Marcelo stated that the requirement to measure inrush current was eliminated from P1547, so the corresponding test has been eliminated from P1547.1

Only DER that produce fundamental voltage has type tests currently in P1547.1. He pointed out that this does not treat all DER types equally.

Marcelo asked how partially compliant DER should be addressed, and noted that coordination with the ICP subgroup will be needed.

Greg Kern asked how it is determined whether a DER is fully or partially compliant. Wayne Stec and Andy stated that all DERs that require a supplemental device are partially compliant, and all that do not are fully compliant, according to P1547 definitions. The subgroup continued to discuss this, and how it would apply in the synchronization tests.

Marcelo stated the Sync tests have not changed a lot. He briefly described the three different methods, which apply to three different DER configurations.

Jay and Reigh asked why three separate tests are need. Marcelo stated that this accommodates different DER types, and that the tests have been done this way historically in 1547.1-2005. He stated that the subgroup could consider whether the number of tests could be reduced.

Marcelo stated that subgroup meetings will resume following the WG meeting.
REG subgroup session:

Brian Lydic presented the draft test materials for the voltage and frequency regulation (REG) subgroup. The subgroup has been focusing on the overfrequency test, which will be separate from the underfrequency test. The frequency time response is proposed as a separate test, which has been drafted but is not as complete.

Brian reviewed the draft frequency regulation (droop) test procedure, which is based on the UL 1741 SA test for the same function. Brian clarified that the material he is presenting is from P1547.1 Draft 3, with some modifications. He reviewed the draft test procedure details.

Brian asked whether the test setup diagram needs to be included if it is already included in clause 4.

The test is coordinated with the ROCOF ride-through requirements from P1547.

Greg asked if he could use frequency steps to run the test.

Greg asked whether the relevant MSA of frequency is the “fast” one or the steady-state one. Bob White expressed the steady-state accuracy is the relevant one. Brian made a note to update the draft standard.

It was asked if 1547.1a Annex A is in Draft 3. Andy confirmed that it is. Brian stated that his subgroup would take responsibility for updating Annex A if needed.

Andy suggested adding a test where the input power is limited by the input source. Brian and Reigh agreed this is a useful scenario to test, and will consider adding it. George Berntsen asked how this could be applied to non-PV DERs.

Reigh asked when it’s appropriate to use an ideal DC source, and when it might be appropriate to use a better emulation of the DC source or prime mover.

Reigh pointed out that it would be possible game the test by stating a very large performance accuracy margin. He suggested some limit on performance accuracy is needed. Sudipta asked Brian to discuss this in the subgroup. Jens Boemer agreed that some requirement on accuracy is also needed.

Brian then reviewed the frequency droop time response test. Brian asked if time response accuracy would be the same for all functions. Sudipta and John Berdner stated that time response accuracy will be different for different functions.

Andy asked whether there’s an implied requirement that DER have single-mHz resolution in input droop parameters. The WG debated this, and the related question of frequency measurement accuracy. Most seemed to agree that single-mHz programming accuracy is not mutually exclusive with 10 mHz measurement accuracy.
Greg pointed out that many DERs can respond very quickly, and asked that the test not preclude testing large signal frequency response. Andy agreed.

Mamadou asked how P1547.1 will address the use of fleets of inverters with a communications system to respond to frequency. Sudipta clarified that that is not the purview of the REG subgroup.

The WG discussed allowing larger frequency changes to be tested, and generally agreed that this is desirable. **Brian stated the subgroup will work on this.**

**V&F subgroup discussion:**

Jens Boemer led a discussion of a gap analysis of existing tests relative to P1547 requirements, as shown in the P1547 verification matrix. He was assisted by subgroup co-chairs John Berdner and Marcelo Algrain. He summarized meeting times, and how to get involved.

Jens then summarized V&F subgroup progress. He discussed the possibility of randomizing some tests to confirm compliance while reducing the total number of tests conducted. He stated that measurement accuracy has requirements in P1547, but performance accuracy does not. He summarized the various tests that will be required.

He then summarized the proposed changes in Draft 3.

Marcelo described a way to perform a low voltage ride-through test using a voltage divider (aka fault simulator) rather than an AC source. Sudipta asked if this could be used for single-phase voltage changes. Marcelo confirmed that it can. This method is used in Europe. Reigh mentioned that this method will need to be applied differently if the DER has high fault current. He also said there would be challenges with unbalanced faults: SLG transmission faults look like phase to phase voltage dips on the distribution system. Jens emphasized that the objective of ride-through is to improve bulk system reliability. Richard Bravo asked how distribution faults will be addressed. Jens stated that transmission faults are higher priority due to bulk system reliability needs, but distribution faults may also be addressed in tests. Paul asked what transformer configuration is assumed. Reigh stated that a D:Yg transmission:distribution transformer is most common. Paul stated that DER transformers and distribution transformers also come into the picture, so other fault scenarios should be considered. **Jens agreed that the subgroup will consider this feedback.**

John Berdner then discussed the implications of the WECC Blue Cut Fire event (August 16, 2016) on ride-through testing. One conclusion was that more event data would be helpful to design a test. John pointed out that such transmission events will be moderated at the transmission level by three-phase motor loads. The subgroup conclusion was that the phase jump test will likely address this issue. Bob Cummings mentioned that the task force analyzing this issue will continue its work, and will continue to coordinate with P1547 and P1547.1 WGs. Reigh mentioned that the base P1547 may need to be edited to address this, and that the **P1547**
Ballot resolution team will work on this. Brian Lydic asked what the FR tests could do to address this. John said it perhaps could, but that a requirement in the base standard would need to be written or identified. The WG discussed at length how best to address events like this through P1547.1. Jeannie asked if there is a requirement for DERs to capture event waveform data. John said that there is not, but that some DERs do capture data for their own purposes. This was discussed in P1547, and it was decided not to require event capture.

John described a proposal from the subgroup to design tests that check corners of the ride-through envelope, rather than testing many possible ride-through events. This applies to all DER types.

The subgroup also discussed brainstorming regarding how to test large synchronous DERs for frequency ride-through. One proposal was to test it in an isolated grid by dropping loads. Another involved injecting frequency signals. Chase asked whether it’s necessary to test large synchronous DER ride through. Reigh and Jens said “yes”.

Testing the tests:

Sig, Andy, and Tim discussed effort at Sandia, NREL and UL to “test the tests” of the grid support functions. Sig summarized the test equipment Sandia uses, and discussed the effect of PV I-V curve emulation on effective DC supply power rating.

Sig then reviewed some LVRT test results, and noted that the device performed as expected. He pointed out that DER power quality (current waveforms) during LVRT tests can be poor. He also pointed out that changes in firmware made to fix one issue may cause other unintended issues. Tim pointed out that this is why UL requires re-testing following firmware version updates.

Sig then showed a test of a change in commanded power factor.

Sig mentioned that some PV simulators will interact in undesired ways with PV inverter MPPT controls. Sig, Tim, and Andy discussed those issues briefly.

Sig showed volt-var test results. Marcelo asked why real power is reduced when reactive power is demanded. Aminul, Babak, and John clarified P1547 requirements on reactive power.

Andy discussed several lessons learned from NREL testing. Details can be found in the attached presentation slides.

Tim discussed lessons learned from UL testing. He mentioned that there are 175 parameters that must be provided. He said 90+% of issues are related to performance, not safety. There are mountains of data produced (GB per inverter). He mentioned grid simulators can fail unexpectedly. He confirmed PV simulator issues mentioned earlier. Finding large grid simulators is challenging. Tim confirmed that the number of tests is enormous, with at least 768 tests. The best automated UL 1741 SA test time is 3-4 weeks – double that for non-automated testing. Testing at full power can be challenging – Tim suggested making full power testing
optional where it makes sense. Distinguishing ride-through from trip can be difficult. Tim confirmed the long time duration of frequency tests. Tim also mentioned that long adjustable trip times can make tests take a very long time. More inverters are using non-SFS AI methods with the larger FRT ranges.

George asked if the slides can be available. **Andy will make the slides available.**

Howard asked about revising UL 1741 SA to reduce some surge and EMI test sequence requirements, to reduce the number of tests required.

Babak asked about how 1547 and/or 1547.1 can help utilities address concerns around fault current characterization. Andy mentioned that the M&S subgroup will cover that to some extent, and Sudipta mentioned that potential future P1547.x standards could also be developed to provide guidance on this; this is on the agenda for Thursday’s P1547 meeting.

**ICP subgroup session:**

Marc Siira and Wayne Stec presented an overview of DER evaluation and commissioning, and presented several examples. Marc discussed how the P1547 requirements verification matrix will guide how this is achieved through a combination of type tests, DER evaluations, and commissioning tests. He and Wayne described how there are two possible “reference points of applicability”: the PCC and the PoC.

Brian Lydic commented that P1547, as worded, may not allow for a PoC that is not the terminals of the DER. He submitted a comment to P1547 in the balloting process.

Wayne then described the distinction between “fully compliant” and “partially compliant” DERs.

Howard asked how NRTLs should deal with partially compliant DERs. Aminul commented that listing/certification will no longer be a binary process.

Roger Salas asked whether utilities can have their own definition of PCC or PoC. Bob Cummings stated that for P1547 and P1547.1 purposes, the internal PCC PoC definitions apply, but utilities can use their own definitions if desired. Discussion continued.

Andy pointed out that for DERs that comply at the PCC, we need to consider how (or whether) full compliance can be achieved through type testing. The WG discussed this for some time. Sudipta pointed out that P1547.1 applies to DERs, not equipment.

Wayne described the current methodology being considered by the ICP subgroup for DER evaluations and commissioning tests. The WG discussed whether protection studies and impact studies are in the scope of P1547.1.

Babak clarified that the evaluations listed in the draft material may not be required for all DERs.
Reigh pointed out that the subgroup could take an approach of writing guidance in some cases, rather than requirements, and that the *guidance could be placed in annexes to P1547.1*.

The subgroup requests additional participation from the WG, specifically from utilities and DER installers or EPCs.

Babak emphasized that flexibility must be left to utilities on how to implement the commissioning tests and evaluations.

**Overview of IEEE PC62.92.6**

Reigh presented and overview of PC62.92.6, which is a guide for grounding of current-regulated DERs. This guide was recently approved in balloting and is expected to be published soon.

The focus of PC62.92.6 is on how to analyze how and whether supplemental grounding is needed with current-regulated DERs. It points out that current-regulated DERs (i.e. nearly all grid-interactive inverters) must be analyzed differently from synchronous DERs. He discussed modeling of inverters for ground fault overvoltage (GFOV) analysis, including inverter negative sequence impedance modeling.

A key point was that load impedances cannot be neglected when analyzing GFOV with current-regulated DERs. Phase-to-ground connected load tends to provide effective grounding.

Chase asked to have the presentation made available. *Reigh will provide the slides for posting with the meeting minutes.*

The subgroup discussed the topic further.

**PQ subgroup session:**

Soonwook Hong led a discussion of new material from the power quality (PQ) subgroup.

He stated that C62.92.1 is already in the original 1547.1 so Reigh’s presentation is related to this group.

Soonwook stated that the scope of this subgroup covers type testing only.

Soonwook stated that the DC injection test has not changed from 1547.1-2005.

Soonwook mention the various new P1547 conditions on harmonics, including a requirement for recording subharmonics.

Tim summarized various product differences, and mentioned that operating modes change test results. He stated that some products may only good be good for the test and not for real-world conditions, and asked whether the subgroup can *add a clause in 1547.1 that helps make sure we catch such cases in type testing.*
Mamodou asked why we are not testing at various power levels. Soonwook replied that we are testing TRD here so decided to test one power level, which should captured the worst case. Mamodou state that DERs may experience higher harmonics at lower power. Greg agreed with the approach of testing the worst case.

Sig asked about AC source requirements. Soonwook stated that the requirements in the draft were there in 1547-2005. Bob stated that some PQ tests are present to inform design evaluation, so are not guaranteed for all conditions.

Aminul asked how we know that the manufacturer’s stated worst condition is the actual worst condition. Greg stated that the subgroup may need to discuss the condition that gives less room for passing.

Reigh stated that the maximum impedance seen by the DER during testing may need to be part of the test procedure.

Soonwook summarized how inter harmonics are defined. There were some issues with the harmonic requirements in IEEE 1547-2003. Greg stated that IEC 61000-4-7(?) already has input on this topic.

Bob stated that the subgroup already looked into that standard.

Soonwook summarized the instantaneous over voltage clause in P1547, which leads to two possible type tests: load rejection overvoltage (LROV) and ground fault overvoltage (GFOV).

The proposed LROV test is similar to the NREL/FIGII test procedure, but has added additional RC elements in the test circuit following an Australia standard. The RC circuit may help in mitigating unintentional instantaneous overvoltage. Andy stated that the test procedure may need to define the max R and min C values for the additional circuit. Greg stated the time constant looks high for the Australian R and C values. Reigh stated that the subgroup may need to define the time constant for the RC circuit.

Andy stated that the test procedure may need to specify a minimum sampling rate for voltage measurements. Soonwook stated that it already does.

Soonwook stated that the purpose of the GFOV test procedure is to verify whether a DER is is current regulated or not. A subgroup member asked whether the NREL/FIGII test method, which disconnects the grid before creating the ground fault, is realistic.

Other subgroups are working on similar test setup concepts: V&F with voltage divider, and M&S for fault current. Can we converge on single test circuit?

To use the NREL test without islanding first, we need series impedance for current limiting. How much impedance is needed, and how will that impact the results? A WG member stated that we
need a national lab to do the testing and validate the test methods. If we use the M&S test circuit, we need various design parameters to be defined.

Jesse Leonard stated that there may be way to drop a phase voltage and then create the fault instantaneously. Then you can have the grid simulator connected one that phase, but you need to open other the phases.

Sudipta and Aminul stated that EPRI test did a similar test with their sag generator. Andy stated the he created the fault immediately after disconnecting the grid simulator using a custom analog circuit.

Reigh stated that utilities may want a test that emulates the real world conditions.

Bob White stated that this is optional test for evaluation purposes, so if it is not super realistic that will be fine.

**M&S subgroup session:**

Mike Ropp and Jeannie Amber led a discussion of the M&S subgroup content. Mike stated that the content is not just from P1547.1 D3; it also includes content drafted after the submission of D3.

Mike showed the fault current characterization test circuit. Richard Bravo stated that one could reduce switch the number of switches from six to four. Mike agreed.

Reigh asked how you know the impedance Zs with a grid simulator.

Bob White stated that test would need a grid simulator three times bigger for the subgroup’s proposed test setup which came from the German FGW standard. Bob prefers the test setup that PQ is using. Mie stated that the PQ setup is also not fool proof because the grid is absent.

Richard stated that the grid simulator may self limit the current to 1.3 times nominal current, and that the test may need some over current protection.

Jesse made some comments on the voltage specification, and asked whether this test can be the same as an LVRT at zero voltage. Richard stated that zero volts is not the same as a fault. The WG debated on this point if we can use zero voltage; some stated that it depends on the current path.

A WG member stated that the test needs to be reproduced by various grid simulators and labs.

The WG discussed whether the impedance of the grid needs to be included.

It was asked whether an LVRT test (less than 50%) is similar to a fault test. It was noted that this would not be a short circuit test.
The WG discussed whether the test should characterize fault response for both line-line and line-line-ground faults. Jeanie stated that running both tests helps to characterize the inverter. Adam Cordova agreed.

The WG discussed how to determine the worst case result among four test iterations. Load transients can give the worst peak but may not be true worst case.

The WG discussed whether to run the tests at full power or at low power. The fault current amplitude may be the same but the duration may be different.

It was stated that doubly-fed induction generators may need to be tested in the same manner as an inverter.

**Interop subgroup discussion:**

Bob Fox and Karl Schoder led a discussion of interoperability testing.

Chase expressed a concern about whether control functions are include in read/write functional settings.

Aminul asked about timing and speed requirements for communications tests. Bob clarified the scope of the P1547.1 interoperability tests, which only includes the final communications connection to the DER, (not end-to-end communications).

It was stated that information exchange is an important role for the DER to play.

Bob Fox clarified that P1547 and P1547.1 do not cover all aspects of interoperability. Other standards will cover other pieces of communications and interoperability, including protocol specifics.

Bob discussed two possible levels of P1547.1 tests: general tests that are generic with respect to protocol, and protocol-specific tests that include protocol details. *Which level will be included is still to be determined.*

Jay Liu asked about how DERs would be integrated into future markets and end-to-end communication systems. Bob clarified that the scope of P1547.1 only covers the communications interface with the DER, not the rest of the network. Bob described how each of the three protocols specified in P1547 apply to different use cases. Jay continued to ask for more information on the full communications path.

Bob then discussed the relationship between function testing and communications testing, and whether the two would be tested together in P1547.1. He proposed that at least one setting of each type should be tested with communications and functional testing together. Bob asked if the communications testing and functional testing could be performed simultaneously. Bob answered that they can.
Andy asked the subgroup whether there was opposition to the idea of coupling communications and power testing. Marcelo objected to requiring automation. Aminul Huque opined that all relevant power tests should be done using one of the protocols specified in P1547, not just one test per. Greg objected to that, as it would be burdensome to testing. Nachum Sadam stated that testing just one point will not validate the DER behavior. Bob clarified that the proposal is to test one setting of each function, not just one test per DER. James Mater stated that using communications interfaces for testing may actually accelerate testing by killing two birds with one stone. The WG continued to discuss this topic at length.

Chase asked when 2030.5 would be updated to cover California Rule 21. Bob stated that is will be completed in the fall.

**HIL subgroup discussion:**

Karl Schoder and Jesse Leonard, co-chairs of the hardware-in-the-loop subgroup (HIL), led a discussion of that subgroup’s input.

Karl mentioned that the IEEE P2004 Working Group has begun to develop standards for HIL and Power HIL testing for power systems applications. This will be relevant to P1547.1 if HIL tests are included or allowed.

Karl stated that the HIL subgroup would like to broaden its participation. He described the concept of HIL testing. He stated that most P1547.1 tests have no need to HIL testing. He stated that UI tests and GFOV tests could benefit from power HIL testing, and commissioning tests of plant controllers could benefit from controller HIL. He summarized the challenges inherent in HIL testing, which include ensuring accuracy and repeatability, and the need to establish validated, trusted models.

Jesse described how Clemson University runs HIL tests, and described how a UI test could be run using power HIL to avoid the need for an RLC load bank. He then described the use of power HIL and controller HIL in the same test to test volt-var capability of a multi-unit DER plant controlled by a plant controller. This could be used for field testing when it is desired to test functions that require modifying voltage or frequency (e.g. volt-var control or frequency-watt control). Richard Bravo asked about other options for running HIL tests. Sudipta emphasized that certain tests such as ride-through certainly cannot be run using controller HIL since verifying the behavior of the actual hardware must be verified. Greg commented that the PHIL test for RLC load UI tests is interesting. The WG discussed details and challenges of HIL testing.

Bob White asked if there is a process to certify or validate labs running PHIL tests. Karl said there is not. He also asked whether HIL tests can be validated against pure hardware tests. Andy and Sudipta answered that you can in some cases. Andy then described some examples of the use of PHIL to test DER interconnection issues that go well beyond the scope of P1547.1.

**Meeting closeout and next steps**
Sudipta wrapped up the WG discussion. He thanked the officers, volunteer subgroup leaders, subgroup members, and the WG for their work. He reviewed the timeline to complete the standard, which currently targets going to ballot in 2018. He emphasized the need to make a strong effort to meet timeline so that P1547.1 is available without too much delay. The next WG meeting will take place in Charlotte, NC, November 14 to 16, 2017.

Sudipta reviewed the tasks and deadlines leading up to the next WG meeting. Those can be seen in the meeting slides attached to these minutes.

Sudipta reviewed the meeting times of each subgroup and took updates from the subgroup chairs. **Andy requested subgroup chairs to copy him on meeting times.**

Lyman offered for Hawaiian Electric to host a future P1547.1 meeting. Andy asked the WG to let him know if meeting in Hawaii would be a major problem for you.

Bob White asked about future 1547.x updates. Sudipta said that is on the agenda for the P1547 meeting.

Sudipta moved to adjourn the meeting. The motion was seconded by Bob White and approved. Sudipta adjourned the meeting.

The meeting was adjourned at 4:35 pm June 21, 2017.

Respectfully submitted,

Andy Hoke, P1574.1 Secretary, for

P1547.1 Chair, Sudipta Chakraborty

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Attachment A – Attendees

Attachment B – Meeting Slides (separate document)
<table>
<thead>
<tr>
<th></th>
<th>Name</th>
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<tr>
<td>1</td>
<td>Michael Abba</td>
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<td>Mid-hat Abdulrehan</td>
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<td>Marcelo Algrain</td>
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<td>4</td>
<td>Jason Allnutt</td>
<td>IEEE-SA: ICAP</td>
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<td>5</td>
<td>Jeannie Amber (Piekarz)</td>
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<td>Daniel Arjona</td>
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<td>John Berdner</td>
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<td>George Berntsen</td>
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<td>David W Blackledge</td>
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<td>Jason Bobruk</td>
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<td>Jens Boemer</td>
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<td>Richard Bravo</td>
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<td>Sean Carr</td>
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<td>17</td>
<td>Sudipta Chakraborty</td>
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<td>Paul Krell</td>
<td>Unitil Service Corp.</td>
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42 Christopher Lee MEPPI
43 Jesse Leonard Clemson University
44 Jay Liu PJM Interconnection
45 Haiwen (Howard) Liu Intertek ETL
46 Brian Lydic Fronius USA
47 James Mater QualityLogic, Inc
48 McPharlen Mgunda SMA America
49 Jeremiah Miller DOE
50 Lyman Morikawa Morikawa & Associates, LLC
51 Naga Raja Rao Mosam Caterpillar, Inc
52 David Narang National Renewable Energy Laboratory
53 Catherine O'Brien Salt River Project
54 Denisse Rivera POWER Engineers, Inc.
55 Michael Ropp Sandia National Laboratories
56 John Ruddock Deep Sea Electronics PLC
57 Nachum Sadan GridEdge Networks
58 Roger Salas Southern California Edison
59 Karl Schoder CAPS - FSU
60 Ron Shipman Oncor Electric Delivery
61 Mark Siira ComRent International
62 Jaspreet Singh Enphase Energy
63 Mark Smith American Electric Power
64 Lincoln Sprague Dynapower
65 James Sprecher Sunverge Energy
66 Wayne Stec Distregen LLC
67 Chase Sun PG&E
68 Francisco Velez Dominion Energy
69 Sarah Walinga Tesla
70 Reigh Walling Sandia National Lab
71 Bob White ABB
72 Nicolas Wrathall Kinectrics Inc.
73 Mehran Zamani Schneider
74 Tim Zgonena UL
Appendix B: Meeting Slides

<Attached as a separate document.>