Draft IEEE P2800.2 Working Group Meeting Minutes, October 30 - November 1, 2024

IEEE P2800.2 Recommended Practice for Test and Verification Procedures for Inverter-Based Resources Interconnecting with Bulk Power Systems

Chair: Andy Hoke
Secretary: Manish Patel
Vice-Chairs: Jens Boemer, Bob Cummings, Divya Chandrashekhara,
Julia Matevosyan, Mahesh Morjaria, Steve Wurmlinger

Meeting Date/Time/Location**:** October 30 – November 01, 2024, 11 am – 4 pm ET, Virtual Meeting

October 30, 2024, Notes:

Andy Hoke kicked-off the meeting with a brief introduction. The meeting was held virtually. In lieu of a roll call, attendees were requested to put their name and affiliation in the chat window. Attendees were also asked to record attendance at https://imat.ieee.org/attendance. The TEAMS attendance will be used along with data from iMat to record attendance.

Quorum was achieved. The agenda was presented. Pouyan Pourbeik moved to approve the agenda. Stephen Wurmlinger seconded. During discussion, Jens Boemer proposed to amend the agenda to allow a presentation regarding IECRE OD-009 certification scheme on day 2 of the meeting. Chris Milan moved to approve the amended agenda. Jens Boemer seconded. No discussion, objection or abstentions were noted. Agenda was approved.

The IEEE SA Patents & Copyright policies along with Participants Behavior Expectations were presented. Vanessa Lalitte made a call for potentially essential patents; no one raised concerns for consideration.

Chris Milan moved to approve meeting minutes for the previous meeting. Pouyan Pourbeik seconded. No discussion, objection or abstentions were noted. Meeting minutes were approved.

The scope and objective of the IEEE P2800.2 was discussed. It was emphasized that the P2800.2 WG is large and encouraged everyone to contribute.

Attendees were informed that ESIG hosted a DOE-supported i2X FIRST Hybrid Workshop titled "Interconnection Standards Workshop with the Focus on Conformity Assessment." The agenda is available at https://www.esig.energy/event/i2x-first-hybrid-workshop-interconnection-standards-workshop/ and the consolidated slide deck can be downloaded under “past meetings” at and the consolidated slide deck can be downloaded under "Past Meetings" at https://www.energy.gov/eere/i2x/i2x-forum-implementation-reliability-standards-transmission-first. The purpose of the workshop was to educate industry stakeholders on the draft IEEE P2800.2, along with IEEE 2800 adoption and related NERC reliability standards efforts.

The scope and objective of the IEEE P2800.2 was discussed. Attendees were reminded that defining or re-defining an interconnection process is not in the scope of IEEE P2800.2. Then overview of conformity assessment steps in IEEE P2800.2 was presented.

The Draft 2.0 was then discussed. Comments from WG members is requested with focus on technical and big picture items. Comments on formatting, grammar, minor wording changes, etc. are not requested

currently. WG members are requested to comment on the clean version focus on technical content in the draft. The chair proposed to submit comments by November 27, 2024. But given the length of this documents, few members spoke up to delay deadline to late in November. The deadline will be communicated via email. Email completed comment spreadsheet, including your vote, to Andy Hoke or upload on iMeet. A vote is to answer following question: Do you approve of sending draft 2.0 to IEEE-SA for balloting? Voting options are approve, disapprove, or abstain. The "disapprove" vote without comments will not be counted.

A brief review of comment resolution for comments received with draft 1.0 was presented.

Chair will check with IEEE-SA staff regarding if WG roster could be posted on iMeet or project website.

SG1 Discussion

Andy Hoke led the SG1 discussion. Key changes since last meeting:

- Added informational frontmatter: abstract, keywords, introduction, etc.
- Deleted some redundant language in clause 1.5.
- Consistent use of "conformity verification" or "conformity assessment" throughout
- New definitions: commissioning test, hardware-in-the-loop, controller hardware-in-the-loop, steady-state
- Minor edits to other definitions
- Clause 4.2 – Added list of elements that need to be IPID. It was noted that data store does not really exist today. Source of data is from many different places (departments, OEMs, etc.). Some concerns were raised regarding use of term "database". SG1 replaced "database" with "datastore" but Figure 2 still needs updating. A suggestion was made that a statement is added to clarify that "datastore" does not imply that all data should be stored at one place.
- SGs and TFs were reminded to send in references that should be included (normative and informative).
- Annex B is still work in progress. There was some discussion regarding pros and cons of a table (representing a checklist) in this annex. The type test clause and design evaluation clause already have summary tables. Such summary tables may not be necessary for commissioning tests and post-commissioning activities. SG1 will discuss further.
- Annex M (BESS Augmentation) was rewritten to align language with other parts of the document. Intent and information presented remains same.

PQTF Discussion

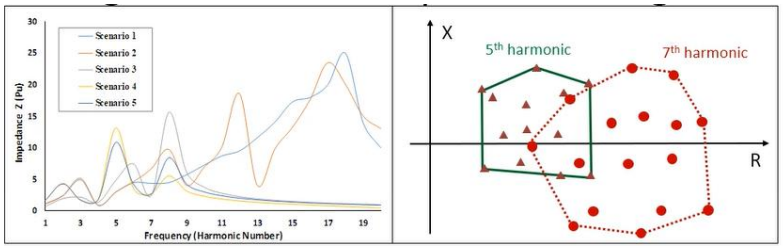
Eugen Starschich, Amir Kazemi, and Reigh Walling led the discussion regarding power quality. The PQTF has contributed to SG2 and SG3 contents.

Revisions to type test related content are as follows:

- Made some editorial changes.
- Added clarification on calculation of phase angle adjustment between different harmonic impedance test cases.
- A new proposal is added for inter-harmonic current calculation. Original proposal was based on IEC 61000-4-7-2008. The new proposal is like integer harmonics at specific frequency interval.

PQTF's thoughts regarding design evaluation are detailed below. It was noted that verification is performed using steady-state phasor analysis of both plant and transmission system at each harmonic. A detailed

- PQTF recommends non-quantitative screening criteria to determine when detailed design evaluation should be performed. Example
    - *The IBR plant has a transmission tie line with a large amount of shunt capacitance, such as a cable or very long overhead line.*
    - *The IBR plant includes a shunt capacitor bank for reactive power compensation or tuned filters.,*
    - *IBR plants with geographically-extensive collector systems (e.g., large wind plants),*
    - *Very large IBR plants relative to the strength of the interconnection, (i.e., low SCR)*
    - *Projects where background harmonic voltages are a substantial fraction of the recommended limits,*
    - *IBR unit harmonic impedance characteristic shows negative resistance (damping) in the harmonic frequency range.*
    - *Plants where the developer would consider that harmonics studies are prudent to minimize the risk of harmonic nonconformance of the plant.*
- IBR plant model to include:
    - IBR units to modeled by Norton (or Thevenin) equivalent sources (model developed based on type test results)
    - Single-source topology model, including balance of plant equipment.
- Design evaluation should consider operational topological variations.
- TS model:
    - Components need to be modeled with appropriate frequency-dependent characteristic.
    - Model needs to extend deep enough into the TS to obtain sufficient accuracy of TS driving point impedance at each harmonic.
    - Harmonic impedances may change significantly for variations in the TS operating condition. Grid changes can significantly affect IBR plant performance.
    - There are a couple of ways to define TS harmonic impedance ranges:



R and X curves for individual cases

+ Allows evaluation of multi-frequency metrics like TRD with scenario-consistent impedances
+ Less conservative, in practice
- More analysis cases are needed to fill in for variations that are continuous in nature
- Requires transfer of a potentially massive amount of data

Impedance polygons

+ Requires fewer analysis cases because it "fills in" for variations and inherently recognizes the imprecision of data
+ Less information to be transferred
- Unreasonable to use for multi-frequency metrics like TRD
- Defining boundaries can be somewhat subjective

- The design evaluation procedure was briefly discussed.

The working group members are requested to provide comments.

Frequency Scanning TF

Wes Baker and Shahil Shah provided a brief overview of the draft content in Draft 2.0. The Annex D in draft 1.0 had two methods for performing frequency scan: simple method and comprehensive method. The TF decided to include the simple method into normative language in clause 5 (type test). In other words, in Draft 2.0, it is recommended that frequency scan is performed on IBR unit using a simple method for purposes of model validation. Subclause 5.18 includes a recommended test procedure. The Annex D includes a comprehensive method and considerations on when it should be used. The criteria for model validation remains qualitative.

An attendee noted that a simple method of frequency scan appears like type test procedure in clause 5.14 for harmonic impedance scan. There may be an opportunity to harmonize these test procedures. The FSTF will work with PQTF to see if there is a way to combine procedures in clauses 5.14 and 5.18.

Meeting in recess at approximately 4 pm ET. WG to reconvene at 11 am ET on October 31, 2024.

October 31, 2024, Notes:

Andy Hoke kicked-off session with a reminder to be mindful of IEEE policies and requested attendees to log attendance on iMat.

The meeting started with a presentation from Bernhard Schowe-von der Brelie from FHG regarding IECRE OD-009 – A new international certification scheme on grid interconnection requirements. The presentation (available at https://ieee-sa.imeetcentral.com/p/aQAAAAAFJmJV) based on a previous presentation at the International Wind and Solar Integration Workshop) touched on following:

1. Importance of grid code compliance
2. Importance of certification (third-party statement of conformity) – why and which?
3. Introduction to IECRE (the IEC system for certification to standards relating to equipment for use in renewable energy application)
4. OD 009 – Power generating unit certification scheme for grid code compliance – restricted to power generating units only. BESS are also not included currently. Conformity assessment with respect to national grid code is not possible. The alternate is to certify capability. The capability certificates may provide a reliable basis for subsequent conformity assessments with specific national grid codes.

The intent of the presentation was to understand how IBR unit level conformity (not certification) could support plant-level assessment.

SG2 Discussion

Steve Wurmlinger, Pramod Ghimire, and Michael Ropp led the SG2 discussion. After brief review of scope, changes to clause 5 since the last meeting were presented. Refer to draft 2.0 - redline of draft 1.0 to review the changes.

A few points noted during the discussion are as follows:

- Be careful when referring to power hardware in the loop compared to hardware in the loop.
- Need to align language for consistency between SG2 and SG3, regarding three type test methods.

- Regarding conventions use for fault current injection requirement, use generation convention. This may be mentioned in the base standard.
- Phase angle jump subclause refers to test procedure in IEEE 1547.1. The IEEE 1547.1 should be added to normative references.
- What is being tested? Capability or performance? The answer is sort of both capability and performance are being tested.
- Regarding transient overvoltage ride-through requirements, it is noted that OEM should provide IBR unit's transient withstand capability and internal protection that may cause IBR unit to trip. The type testing is impractical. This debate continues and may not be addressed adequately in initial version of this recommended practice.
- ROCOF test is required only if IBR unit is equipped with ROCOF protection.
- There may be an opportunity to clarify that tests proposed in 5.17 are not the only tests for power plant controller. Other tests outside of clause 5.17 from clause 5 may apply to PPC too.
- Newly added annexes were briefly discussed as well. There may be an opportunity to remove phase angle change examples of individual phases.

Working group members were encouraged to submit comments.

SG5 Discussion

Julia Matevosyan led the discussion of subgroup 5's scope: post commissioning model validation and monitoring, and periodic tests and verifications. The progress since last meeting was summarized and is included below.

- Some language clean up and clarifications based on the WG Review Comments
- Clause 11 Post-Commissioning Monitoring: reshuffled language on changing system conditions during the lifetime of the plant and potential need to re-study in case of IBR performance issues.
- Clause 11 Post-Commissioning Monitoring: Re-added a discussion on IBR plant conformity assessment during disturbance events beyond just model validation
- Clause 11.1 Selecting Event Triggers & Clause 11.3 Frequency and number of model validation instances: Reduced the discussion/prescriptiveness on the number and frequency of the events to capture
- Clause 11.5.1 Voltage Ride-Through: re-worded clarification of Table 11 and Table 12 of base standard (on settlement time after the voltage step at POC)
- Clause 11.7 Harmonic Distortion Assessment (new): Added new language
- Clause 13 Periodic Verification: Added language/warning on firmware updates
- Annex C: Added language on the use of unbalanced fault events for positive sequence phasor domain model validation

Meeting in recess at approximately 4 pm ET. WG to reconvene at 11 am ET on November 01, 2024.

November 01, 2024, Notes:

Andy Hoke kicked-off session with a reminder to be mindful of IEEE policies and requested attendees to log attendance on iMat.

SG4 Discussion

Divya Kurthakoti kicked off the SG4 discussion with a brief overview of SG4 scope. Following was noted:

- The as-built evaluation clause is intentionally very short.
- Redlines to draft 1.0 takes care of contradictory and vague statements and consistently uses conformity assessment instead of compliance.
- Commissioning tests as written allow TS owner/operator to define test conditions.
- All commissioning tests are recommended regardless of plant rating.
- If plant is equipped with capacitor bank, then test involving switching in/out of capacitor bank should be done. Perhaps, switching in/out of transmission capacitor bank/reactor could also be considered, as switching transients or other conditions incited by switching might cause multiple plants to trip.
- Regarding BESS, are there different controls or control logic for BESS frequency regulation in charging and discharging mode? Specifically, how does the BESS do frequency regulation if it is discharging and overfrequency response command is used? A couple of attendees noted that typically a same controller is used regardless of mode of operation. There may be a couple of grid codes that require different response depending on mode of operation.
- Approach to measuring voltage harmonic should be same as for measuring current harmonic. The PQTF to review and ensure consistency.

SG3 Discussion

Jens Boemer kicked off the SG3 discussion with a brief overview of SG3 scope. The objectives of design evaluation were presented.

A high-level SG3 work since past WG meeting was highlighted, which includes redlines to definitions in clause 3.1, restructuring of clause 6, changes to clause 7, and new informative annexes. Summary of clause 6 revisions follows:

- Moved quantitative IBR unit model validation error bands moved into Annex I
- Rewritten with a focus on qualitative model validation.
- Moved considerations for example qualitative IBR unit model validation assessment into Annex H.
- Created new and revised Annexes:
    - Annex H (Informative) – Considerations for IBR unit and Supplemental IBR device qualitative model validation assessment.
    - Annex I (informative) Framework for quantitative model validation.
    - Annex J (informative) Concepts of model quality assessment.

Then, design evaluation scope and procedure types in clause 7 were presented. A few items to note are as follows:

- Assessment using EMT model for transient overvoltage ride-through requirement should be an option in addition to OEM documentation.
- The design evaluation should be also done with IBR plant connected to actual grid model. The commenter will provide a write-up to SG3 leads.
- Where applicable, design evaluation using EMT and PDT model should be done. The intent is to benchmark PDT model against the EMT model. Some considerations for benchmarking models are included in clause 7. Is benchmarking of PDT models required by the IEEE 2800? The answer

is ‘no’, so, perhaps use “may” language. But more importantly, review clause 6 and clause 7.2.4 and see if model benchmarking is inherently included.

- An attendee suggested in aggregated model if the voltage is close to trip setting then further investigation should be necessary (perhaps based on non-aggregated model). But not all protection functions are straightforward.
- Aggregated model includes fully and partially aggregated model.
- Definitions of model verification, model validation, and model benchmarking were discussed.
- A brief review of unit level model validation – why and what?, challenges, considerations were discussed. Effects of insufficient care in modeling practice and uncertainties in system conditions may be reason for difference between type test and simulated response of IBR unit. An annex providing a framework for quantitative model validation was discussed. It was noted that framework applies to EMT models only and only for voltage ride-through tests.
- Procedures to develop a verified IBR plant model was also reviewed, along with test systems to use for design evaluation. It was noted that active power reference test proposed in the design evaluation is not required by the IEEE 2800. Regarding the small step voltage test, an attendee noted that relative tests are relative grid volage change only. The relative V/Q/power factor reference change tests are not relevant in the design evaluation.
- Which short-circuit ratios should be used for design evaluation? Should an informational test where IBR plant is exposed to series of step changes in SCR progressing from high to low SCR included? The SG3 to discuss further.

Closing Remarks

The working group members were requested to submit comments by November 27, 2024. The WG is aiming to have next draft ready for approval to send to IEEE-SA for balloting, perhaps in Q1 of 2025. The next WG meeting will be scheduled based on number of received comments.

The meeting adjourned at 4:02 pm ET.