The meeting of the P1547.7 Working Group was called to order by Robert (Bob) Saint, chair P1547.7 (Annex A – Attendees). The agenda for the two-day meeting was presented and the IEEE SA Bylaws on Patents in Standards and other guidelines were reviewed and discussed. The status of 1547 Series Working Groups was discussed as was the status of IEEE Std P2030 (Annex B – P1547.7 Agenda and Meeting Introductory Information; for P2030 see P2030 Meeting Minutes - June 3-5, 2009 at http://grouper.ieee.org/groups/scc21/2030/2030_logistics.html. The group was informed that development of IEEE Std 2030 may draw from the 1547 series of standards and may propose updates to IEEE Std 1547.1 and IEEE Std 1547.3. It was noted that more utility participation is needed for the IEEE Std P2030 development process.

A report by Bob Saint was made on the PES DR Integration Working Group meeting on July 28, 2009 in Calgary. There was a discussion in Calgary about other groups within PES that are interested in following and commenting on P1547.7. Two groups were identified: 1) Distribution Working Group under the Power System Planning & Implementation Committee and 2) Distribution System Analysis Subcommittee. The P1547.7 chair attended the Calgary meeting, and a representative from each of these groups was in attendance at this P1547.7 meeting in San Francisco.

Two presentations were given (see Annex C). The first, by Tom McDermott of MelTran, Inc., focused on the United Wind Integration Group (UWIG) Distributed Wind Impacts Project. Tom presented information on a series of guides, tools, and case studies related to the interconnection of wind projects. Tom offered some of this information to be used in IEEE Std 1547.7. We will post such reports after we get appropriate releases. The second presentation was by Charlie Williams of S&C Electric Company. This presentation showed the results of some data logging exercises in Florida that recorded PV output variations.

The Working Group reviewed the P1547.7 Scope and Purpose from the PAR that was approved in January by the IEEE Standards Board. It was noted that the changes to the scope and purpose discussed at the P1547.7 ad hoc meeting in January were not included in that PAR and P1547.7 will proceed with the IEEE approved PAR. Then, a review of the Intended Audience clause was conducted. The Limitations clause was reviewed and changes were made, and a new clause on Document Organization was decided to be added to the outline (clause 1.5).

A review of the outline of clause 4 and the beginning of clause 5 was made, and review and changes were made to those sections of the initial P1547.7 draft 1 document.
On August 20, the outline and the initial P1547.7 draft 1 document from the rest of clause 5 and clause 6 were reviewed and modified (through clause 6.2 as renumbered in P1547.7 draft 1.1). The screens from California Rule 21 (i.e., units up to 11 kVA) included in clause 6.1 were discussed, and it was decided the P1547.7 document should also discuss screens from other sources, such as those from FERC and/or other states (i.e., screens up to 10 MVA). A number of ideas to re-organize the document were also discussed.

The following P1547.7 writing volunteer assignments were identified and can also be found in P1547.7 draft 1.1 posted at:
http://grouper.ieee.org/groups/scc21/1547.7/private/stddrafts.html

Basso, Tom: 4.1.1; for screen 7 ask Jim Daley for source of numbers.

Burdis, Joe: 5 study sequence structure/approach

Cleary, James
5.1.7 operational use of DR
5.2 directory of studies needed
5.2 step voltage write up

Haggenmiller, J
5.4 supplemental review
6.1 rule 21 diagram and URL

McDermott Tom
5.2 step voltage write-up

Morton, Bee Zinn
5.1.7 operational use of DR

Rogers, Charlie 4.5 penetration

Saint, Bob
screen 5 reconcile 519 and 1453
7.3.1 design review
7.3.4 PQ study

Salas, R.
7.3.1 design review
7.3.3 steady state study

Sheaffer, Paul: Annex Z (URLs)

Smith, Mark
5.1 application info needed;
screen 6 – why those values?
7.1 data for studies;
7.3.2 system protection

Tolentino, B.:  5.4 supplemental review

Williams, Charlie:  5. Study sequence

The inputs from those identified above are due September 17, 2009 so we may include them in an updated draft to post prior to the next P1547.7 meeting. If others submit inputs we’ll include those. For example, there are a number of clauses without information or a writing volunteer – if you would like to submit information for one of these clauses, please send a note to the listserv and submit the information per the instructions that follow.

Send your inputs to the following:

    Thomas.Basso@NREL.gov
    Sheaffer@RDCnet.com
    Robert.Saint@NRECA.coop

Please send your inputs (in a separate word file external to the posted P1547.7 draft 1.1 file) drafted to be consistent with the revised clause numbers in draft 1.1. We would appreciate if you can provide as complete text and figures as possible so we may easily drop them into the next version. However, if you don’t fully complete your inputs as detailed as you would have liked to, then please include “considerations,” e.g., bulleted items. Contributors are responsible for providing copyright release, as applicable, and full citation when submitting documents, references, or Web links.

The next P1547.7 meeting is confirmed for October 6-7, 2009 in Atlanta, GA hosted by Georgia Power Company at their conference center in Atlanta (details to follow soon).

Respectfully submitted,

Bob Saint, P1547.7 chair, and Tom Basso, P1547.7 secretary

-------------------------------------------------------------
## Annex A – Attendees

**P1547.7 Working Group Meeting, August 19-20, 2009, San Francisco, CA**

<table>
<thead>
<tr>
<th>Name</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bob Arritt</td>
<td>EPRI</td>
</tr>
<tr>
<td>David Bassett</td>
<td>PPL Electric Utilities</td>
</tr>
<tr>
<td>Thomas Basso</td>
<td>National Renewable Energy Laboratory</td>
</tr>
<tr>
<td>Joe Burdis</td>
<td>PJM Interconnection</td>
</tr>
<tr>
<td>John Bzura</td>
<td>National Grid</td>
</tr>
<tr>
<td>James Cleary</td>
<td>National Grid USA</td>
</tr>
<tr>
<td>Michael Coddington</td>
<td>National Renewable Energy Laboratory</td>
</tr>
<tr>
<td>James Daley</td>
<td>Asco Power Technologies</td>
</tr>
<tr>
<td>Dick DeBlasio</td>
<td>National Renewable Energy Laboratory</td>
</tr>
<tr>
<td>Michael Doyle</td>
<td>ONCOR Electric Delivery</td>
</tr>
<tr>
<td>Jeffrey Duff</td>
<td>Duke Energy</td>
</tr>
<tr>
<td>Omar Faruque</td>
<td>Florida State University</td>
</tr>
<tr>
<td>Jack Haggemiller</td>
<td>Southern California Edison</td>
</tr>
<tr>
<td>Jeffrey Hauber</td>
<td>Westar Energy</td>
</tr>
<tr>
<td>Peter Hoffman</td>
<td>Progress Energy</td>
</tr>
<tr>
<td>Gerald Johnson</td>
<td>Basler Electric</td>
</tr>
<tr>
<td>Thomas McDermott</td>
<td>MelTran, Inc.</td>
</tr>
<tr>
<td>Bee Zinn Morton</td>
<td>Pepco Holdings, Inc.</td>
</tr>
<tr>
<td>Emeka Okafor</td>
<td>American Electric Power</td>
</tr>
<tr>
<td>Jaime Peralta</td>
<td>BC Hydro</td>
</tr>
<tr>
<td>Charles Rogers</td>
<td>Consumers Energy</td>
</tr>
<tr>
<td>Michael Ropp</td>
<td>Northern Plains Power Technologies</td>
</tr>
<tr>
<td>Robert Saint</td>
<td>National Rural Electric Cooperative</td>
</tr>
<tr>
<td>Colin Schauder</td>
<td>Satcon Technology Corporation</td>
</tr>
<tr>
<td>Paul Sheaffer</td>
<td>Resource Dynamics Corporation</td>
</tr>
<tr>
<td>Mark Smith</td>
<td>American Electric Power</td>
</tr>
<tr>
<td>Wayne Stec</td>
<td>Distregen, LLC</td>
</tr>
<tr>
<td>Sylvester Toe</td>
<td>Georgia Power</td>
</tr>
<tr>
<td>Brandon Tolentino</td>
<td>Southern California Edison</td>
</tr>
<tr>
<td>Charlie Williams</td>
<td>S&amp;C Electric Company</td>
</tr>
</tbody>
</table>
Annex B – P1547.7 Agenda and Meeting Introductory Information
P1547.7 Working Group Meeting, August 19-20, 2009, San Francisco, CA

IEEE SCC21 1547™ Series Standards Development
P1547.7 Working Group Meeting
August 19-20, 2009; San Francisco, CA

P1547.7 Draft Guide to Conducting Distribution Impact Studies for Distributed Resource Interconnection

Chairperson: Robert Saint
Secretary: Tom Basso

1547 Series of Meetings: Aug. 18-21, 2009
Draft Timeline: see each work group agenda exact times

Registration: Monday – Friday, 8 a.m. to 8:30 a.m. (Continental Breakfast)

Tuesday, August 18
8:30 a.m.–5 p.m. P1547.4

Wednesday, August 19
8:30 a.m.–3:30 p.m. P1547.4
8:30 a.m.–3:30 p.m. P1547.7

Thursday, August 20
8:30 a.m.–5 p.m. P1547.6
8:30 a.m.–5 p.m. P1547.7

Friday, August 21
8:30 a.m.–4:30 p.m. P1547.6
General Agenda: P1547.7 Aug. 19-20, 2009

- Welcome and Introductions: sign the attendee list - correct and/or add your contact information.
- Approval of past minutes, and this meeting’s agenda (see accompanying detailed agenda)
- IEEE Standards Development
- PES General Meeting in Calgary (working group representation)
  - Distribution Subcommittee, DR Interconnection WG – Charlie Williams
  - Power System Planning and Implementation Committee, Distribution WG – James Cleary
  - Distribution System Analysis Subcommittee – Tom McDermott
- Requested Presentations
  - Tom McDermott
  - Charlie Williams
- P1547.7 Discussion and Breakouts
- Next Actions; Adjourn

Participants, Patents, and Duty to Inform

All participants in this meeting have certain obligations under the IEEE-SA Patent Policy. Participants:

- “Shall inform the IEEE [or cause the IEEE to be informed]” of the identity of each “holder of any potential Essential Patent Claims of which they are personally aware” if the claims are owned or controlled by the participant or the entity the participant is from, employed by, or otherwise represents.
  - “Personal awareness” means that the participant “is personally aware that the holder may have a potential Essential Patent Claim,” even if the participant is not personally aware of the specific patents or patent claims.
- “Should inform the IEEE [or cause the IEEE to be informed]” of the identity of “any other holders of such potential Essential Patent Claims” (that is, third parties that are not affiliated with the participant, with the participant’s employer, or with anyone else that the participant is from or otherwise represents).
- The above does not apply if the patent claim is already the subject of an Accepted Letter of Assurance that applies to the proposed standard(s) under consideration by this group.

Quoted text excerpted from IEEE-SA Standards Board Bylaws subclause 6.2

- Early identification of holders of potential Essential Patent Claims is strongly encouraged.
- No duty to perform a patent search.
Patent Related Links

All participants should be familiar with their obligations under the IEEE-SA Policies & Procedures for standards development. Patent Policy is stated in these sources:

IEEE-SA Standards Boards Bylaws
http://standards.ieee.org/guides/bylaws/sect6-7.html#6

IEEE-SA Standards Board Operations Manual

Material about the patent policy is available at
http://standards.ieee.org/board/pat/pat-material.html

If you have questions, contact the IEEE-SA Standards Board Patent Committee Administrator at patcom@ieee.org or visit http://standards.ieee.org/board/pat/index.html

This slide set is available at http://standards.ieee.org/board/pat/pat-std11est.ppt

Call for Potentially Essential Patents

- If anyone in this meeting is personally aware of the holder of any patent claims that are potentially essential to implementation of the proposed standard(s) under consideration by this group and that are not already the subject of an Accepted Letter of Assurance:
  - Either speak up now or
  - Provide the chair of this group with the identity of the holder(s) of any and all such claims as soon as possible or
  - Cause an LOA to be submitted
Other Guidelines for IEEE WG Meetings

- All IEEE-SA standards meetings shall be conducted in compliance with all applicable laws, including antitrust and competition laws.
  - Don’t discuss the interpretation, validity, or essentiality of patents/patent claims.
  - Don’t discuss specific license rates, terms, or conditions.
    - Relative costs, including licensing costs of essential patent claims, of different technical approaches may be discussed in standards development meetings.
    - Technical considerations remain primary focus.
  - Don’t discuss or engage in the fixing of product prices, allocation of customers, or division of sales markets.
  - Don’t discuss the status or substance of ongoing or threatened litigation.
  - Don’t be silent if inappropriate topics are discussed. Do formally object.

See IEEE-SA Standards Board Operations Manual clause 3.3.10 and “Promoting Competition and Innovation: What You Need to Know about the IEEE Standards Association’s Antitrust and Competition Policy” for more details.

IEEE 1547 Series Web Site

1547 series public Web site
http://grouper.ieee.org/groups/scc21/dr_shared/

- Archives
  - Meeting information
  - Registration Information – First time attendees, please return a completed registration form to David Glickson and Tom Basso, the SCC21 secretary, at least two weeks before the meeting. Ongoing attendees, please RSVP and provide any changes to your contact information.
  - Agenda – for most recent meeting
  - Minutes
1547 Series Web Site Work Group Areas

P1547.7 Work Group Areas (password protected)

Contacts – WG member information (standards development use only).

Special Topics – background information for the Work Group

StdDrafts – Drafts under development

Listserv – listserv archived e-mails

P1547.7 IEEE ListServ

ListServ is for IEEE standards development use only. IEEE code of ethics identified in information file sent to each subscriber.

To: stds-p1547-7@listserv.ieee.org
From: you@yourISP.com
Only subscribers can send to the list. Exchanges between individuals and among your self-established small groups are encouraged.

ListServ e-mails are immediately sent to all subscribers.
  Reply to all – sent to all
  Reply to sender – only sent to sender
E-mail to listserv is auto-archived at
  P1547.7 Work Group Area (password protected)
  at ListServ
Archived e-mails can be viewed under
  Subject Thread or Date Thread.
IEEE Standards Classification

**Standard**: documents with mandatory requirements (shall)

**Recommended Practice**: documents in which procedures and positions preferred by the IEEE are presented *(should)*

**Guide**: documents in which alternative approaches to good practice are suggested but no clear-cut recommendations are made *(may)*

---

**IEEE SCC21 1547 Series of Interconnection Standards**

- **IEEE Std 1547™ (2003)** Standard for Interconnecting Distributed Resources with Electric Power Systems
  - **P1547.6 Draft Recommended Practice for Interconnecting Distributed Resources with Electric Power Systems Distribution Secondary Networks**
  - **P1547.7 Draft Guide to Conducting Distribution Impact Studies for Distributed Resource Interconnection**
  - **P1547.4 Draft Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems**
  - **P1547.5 Draft Technical Guidelines for Interconnection of Electric Power Sources Greater Than 10 MVA to the Power Transmission Grid**


- **IEEE Std 1547.3™ (2007)** Guide for Monitoring, Information Exchange and Control of DR Interconnected with EPS


*(publication year in parentheses; P1547.x are under development; other topics are under consideration by SCC21 work group members)*
### Current SCC21 Interconnection Projects

<table>
<thead>
<tr>
<th>Title</th>
<th>Scope &amp; Purpose</th>
</tr>
</thead>
</table>
| **IEEE Std 1547™ (2003, reaffirmed)** Standard for Interconnecting Distributed Resources with Electric Power Systems | • The **Standard** establishes criteria and requirements for interconnection of distributed resources (DR) with electric power systems (EPS).  
• This document provides a uniform standard for interconnection of distributed resources with electric power systems. It provides requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection. |
| **IEEE Std 1547.1™ (2005) Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems** | • The **Standard** specifies the type, production, and commissioning tests that shall be performed to demonstrate that interconnection functions and equipment of a distributed resource (DR) conform to IEEE Std 1547.  
• Interconnection equipment that connects distributed resources (DR) to an electric power system (EPS) must meet the requirements specified in IEEE Standard 1547.  
Standardized test procedures are necessary to establish and verify compliance with those requirements. These test procedures must provide both repeatable results, independent of test location, and flexibility to accommodate a variety of DR technologies. |
• This document facilitates the use of IEEE 1547 by characterizing the various forms of distributed resource technologies and the associated interconnection issues.  
Additionally, the background and rationale of the technical requirements are discussed in terms of the operation of the distributed resource interconnection with the electric power system. Presented in the document are technical descriptions and schematics, applications guidance and interconnection examples to enhance the use of IEEE 1547. |
| **IEEE Std 1547.3™ (2007) Guide for Monitoring, Information Exchange and Control of Distributed Resources Interconnected with Electric Power Systems** | • This document provides guidelines for monitoring, information exchange, and control for distributed resources (DR) interconnected with electric power systems (EPS).  
• This document facilitates the interoperability of one or more distributed resources interconnected with electric power systems. It describes functionality, parameters and methodologies for monitoring, information exchange and control for the interconnected distributed resources with, or associated with, electric power systems. Distributed resources include systems in the areas of fuel cells, photovoltaic solar power systems, wind turbines, microturbines, other distributed generators, and distributed energy storage systems. |
<table>
<thead>
<tr>
<th>Title</th>
<th>Scope and Purpose</th>
</tr>
</thead>
</table>
| P1547.4 Draft Guide for Design, Operation, and Integration of        | • This document provides alternative approaches and good practices for the design, operation, and integration of distributed resource (DR) island systems with electric power systems (EPS). This includes the ability to separate from and reconnect to part of the area EPS while providing power to the islanded local EPSs. This guide includes the distributed resources, interconnection systems, and participating electric power systems.  
• This guide is intended to be used by EPS designers, operators, system integrators, and equipment manufacturers. The document is intended to provide an introduction, overview and address engineering concerns of DR island systems. It is relevant to the design, operation, and integration of DR island systems. Implementation of this guide will expand the benefits of using DR by targeting improved electric power system reliability and guide upon the interconnection requirements of IEEE 1547. |
| Distributed Resource Island Systems with Electric Power Systems      |                                                                                                                                                                                                                                                                                                                                                  |
| P1547.5 Draft Technical Guidelines for Interconnection of Electric   | • This document provides guidelines regarding the technical requirements, including design, construction, commissioning acceptance testing and maintenance performance requirements, for interconnecting dispatchable electric power sources with a capacity of more than 10 MVA to a bulk power transmission grid.  
• The purpose of this project is to provide technical information and guidance to all parties involved in the interconnection of dispatchable electric power sources to a transmission grid about the various considerations needed to be evaluated for establishing acceptable parameters such that the interconnection is technically correct. |
| Power Sources Greater Than 10 MVA to the Power Transmission Grid     |                                                                                                                                                                                                                                                                                                                                                  |
| P1547.6 Draft Recommended Practice for Interconnecting Distributed    | • This standard builds upon IEEE Standard 1547 for the interconnection of distributed resources (DR) to distribution secondary network systems. This standard establishes recommended criteria, requirements and tests, and provides guidance for interconnection of distribution secondary network system types of area electric power systems (Area EPS) with distributed resources (DR) providing electric power generation in local electric power systems (Local EPS).  
• This standard focuses on the technical issues associated with the interconnection of Area EPS distribution secondary networks with a Local EPS having DR generation. The standard provides recommendations relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection. In this standard consideration is given to the needs of the Local EPS to be able to provide enhanced service to the DR owner loads as well as to other loads served by the network. Equally, the standard addresses the technical concerns and issues of the Area EPS. Further, this standard identifies communication and control recommendations and provides guidance on considerations that will have to be addressed for such DR interconnections. |
| Distributed Resources With Electric Power Systems Distribution        |                                                                                                                                                                                                                                                                                                                                                  |
| Secondary Networks                                                 |                                                                                                                                                                                                                                                                                                                                                  |
### Current SCC21 Interconnection Projects

<table>
<thead>
<tr>
<th>Title</th>
<th>Scope and Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1547.7 Draft Guide to Conducting Distribution Impact Studies for Distributed Resource Interconnection</td>
<td>This guide describes criteria, scope, and extent for engineering studies of the impact on area electric power systems of a distributed resource or aggregate distributed resource interconnected to an area electric power distribution system. The creation of IEEE Std 1547, &quot;IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems,&quot; has led to the increased adoption of DR throughout distribution systems. This document describes a methodology for performing engineering studies of the potential impact of a distributed resource interconnected to an area electric power distribution system. Study scope and extent are described as functions of identifiable characteristics of the distributed resource, the area electric power system, and the interconnection. Criteria are described for determining the necessity of impact mitigation. Establishment of this guide allows distributed resource owners, interconnection contractors, area electric distribution power system owners and operators, and regulatory bodies to have a described methodology for when distribution system impact studies are appropriate, what data is required, how they are performed, and how the study results are evaluated. In the absence of such guidelines, the necessity and extent of DR interconnection impact studies has been widely and inconsistently defined and applied.</td>
</tr>
</tbody>
</table>

### Next Actions

- Summary list of action items (due date and volunteer lead)
- Timeline for P1547.7 development
- Next meeting (tentative dates and location)
- Other actions:
Annex C – Presentations

- Tom McDermott: United Wind Integration Group (UWIG) Distributed Wind Impacts.
- Charlie Williams: PV Output Variations.

UWIG Distributed Wind Impacts Project

IEEE P1547.7 Working Group Meeting
San Francisco, CA
August 19-20, 2009

Tom McDermott, tom@meltran.com
MelTran, Inc.

UWIG – A Little Background

- Established by 6 utilities in 1989 with support from EPRI and DOE/NREL
- Non-profit corporation governed by board of directors from utility and ISO/RTO members
- Focus on technical issues
  - Semi-annual workshops (Cedar Rapids, IA, October 7-9, 2009)
  - Five user groups
- Mission: To accelerate the appropriate integration of wind power into the electric system
- Has about 150 members from US, Canada, and Europe
  - Utility: IOUs, public power, rural electric, RTOs, and ISOs
  - Associate: wind developers, equipment vendors, and consultants
  - Ex officio: APPA, NRECA, EEI, and EPRI
DistWind Project Overview

<table>
<thead>
<tr>
<th>Objective</th>
<th>Deliverables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide Tools for Utilities to Assess Wind Projects on Distribution Feeders</td>
<td>Screening Web Software: Economics, Flicker</td>
</tr>
<tr>
<td></td>
<td>Engineering Web Software: Voltage Control, Protection</td>
</tr>
<tr>
<td>Provide Assistance in Complying with IEEE Stds. 1547 and 1453</td>
<td>3 Application Guides on DG Interconnection, Flicker</td>
</tr>
<tr>
<td></td>
<td>3 Case Studies</td>
</tr>
<tr>
<td>Guide New Research Efforts</td>
<td>Monitor 3 Sites, 1 Year Each</td>
</tr>
</tbody>
</table>

◆ www.uwig.org/distwind

UWIG Offers to P1547.7

◆ Application Guide Texts and Graphics
◆ Screening Methodology
◆ Distributed Wind Case Study for Annex C
Guide for Distributed Generation Interconnection (115 pp.)

1. Introduction
2. Utility Distribution System Design
   Steady-state Operation/Voltage Regulation
   Overcurrent Protection
3. DR Interconnection Technologies
   DG Models for Power System Studies
   Characteristics of Rotating Machines
   Characteristics of Static Power Converters
4. Interconnection Requirements
   General Protection Requirements
   Protection of the DR/EPS Interface
   Effect of Transformer Connections
5. Power Quality and Reliability
   Voltage Regulation Issues
   Impact on Utility Overcurrent Protection
   Improving Reliability with DR
   Adverse Impacts of DR on Utility Reliability
   Harmonics from DR
6. Application Problems
   Voltage Change upon Interconnection or Reclose After a Fault
   Harmonic Surprises with Rotating Machines
   Desensitizing Utility Relays
   Coordinating with Reclosing
   Ferroresonance
   Capacitor Switching
7. Engineering Analysis of DR Interconnection
   Basic Power Flow
   Fault Studies
   Dynamics
   Electromagnetic Transients
8. References

Guide for Wind Turbine Interconnection (58 pp.)

1. Introduction
2. Wind Turbine Technologies
   2.1 Overview of Wind Turbine Technology
   2.1.1 Mechanical Systems and Control
   2.1.2 Electrical Systems and Control
   2.2 Fixed Speed
   2.3 Semi-Variable Speed
   2.4 Variable Speed
   3. Static Inverter
3. Power System Studies and Models
   3.1 Steady-State Power Flow
   3.1.1 Solution Techniques
   3.2 Short-Circuit
   3.3 Dynamic
   3.4 Electromagnetic Transients
4. Voltage Reguation
   4.1 Reactive Power Management
   4.1.1 Static Var Control
   4.1.2 Switched Capacitor Banks
   4.1.3 Control Modes
4.2 Continuous Operation
   4.2.1 Wind Profile
   4.2.2 Voltage Regulation Impact with Varying System Parameters
   4.3 Turbine Start-Up (Synchronization)
   4.4 Feeder Device Coordination
5. Protection Coordination and Response to Abnormal Conditions
   5.1 Protection Requirements
   5.1.1 1547 Interconnection Requirements
   5.1.2 Detecting Utility-Side Faults
   5.1.3 Recloser Coordination
   5.2 Desensitizing Utility Relays
   5.3 WTG Response to Disturbances
   5.4 Islanding
6. Power Quality
   6.1 Flicker
   6.2 Harmonics and DC Injection
7. References
DistWind Flicker Guide (34 pp.)

1 Introduction
2 Flicker Background
  2.1 What is Flicker?
  2.2 What Causes Flicker?
3 Wind Turbine Operation and Flicker
  3.1 Continuous Operation
  3.2 Switching Operations
4 Flicker Measurement, Assessment, and Prediction
  4.1 Measurement
  4.1.1 Flicker Curves and RMS Strip Charts
  4.2 Flicker Meters
  4.2.1 Acceptable Levels
5 Flicker Mitigation
6 Case Studies
7 References

Screening Tool Inputs

- WTG Library
- Estimate Z

<table>
<thead>
<tr>
<th>Home</th>
<th>Index</th>
<th>Log Out</th>
<th>Information</th>
<th>Help</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select Project:</td>
<td>Pike County</td>
<td>Calc / Update</td>
<td>Calc / Update</td>
<td>Calc / Update</td>
</tr>
</tbody>
</table>
Project Name | Pike County |
Turbine (WTGs) Inputs: | | |
| Turbine Type | Vesta 30/1050 | Unlisted Type |
| Size | | kW |
| Generator / Interface | | |
| Number of Turbines | | 1 |
| Average Wind Speed at Site | 13.50 n/s |
| Feeder Inputs: | | |
| Substation Transformer | 5.00 MVA |
| Feeder Primary Voltage | 12.47 kV |
| Line Conductor Type | Unlisted 338/ACSR |
| WTG Distance from Sub | 22.84 kft |
| Peak Load | 2.40 MW |
| Capacitor Banks | 0.00 kVAR |
| Regulator Distance from Sub | 0.00 kft |
Screening Tool Outputs

FERC Fast-Track Acceptance (not in all jurisdictions)
- Design is certified
- Project size ≤ 3 MW
- Size ≤ 12% of Segment Load
- Contribute <10% Utility Fault Current
- All Utility Devices ≤ 81.2% Fault Rating

Flicker Planning Levels (IEEE Std. 1455)
- Continuous, \( P_f \leq 0.9 \)
- Switching, \( P_f \leq 0.9 \) and \( R_f \leq 0.1 \)

Adding in 2009:
1. Voltage Change Estimate
2. Temporary Overvoltage Estimate

30-minute Screening Method - 1

- Basic DR size and technology data
  - Equivalent X, 0.17 – 0.9 p.u., based on technology
  - Ask for IEC 61400-21 Wind Power Quality test report

- Obtain System Z1 and Z0 at POI
  - Short-circuit results from a feeder model
  - Estimated from transformer size, line conductor/length, and feeder voltage level

- Peak load of the smallest switched segment
  - Need to consult a feeder map
  - Include other DR already on that segment
30-minute Screening Method - 2

Estimated % Voltage Change:

\[ V_{\text{drop}} = \frac{100}{U_n} (R_1 + jX_1) (P_n - jQ_n) \]

\[ \frac{dV}{U_n} = \sqrt{100 + \text{Re}(V_{\text{drop}})^2 + (\text{Im}(V_{\text{drop}}))^2} - 100 \]

Flicker Estimates:

\[ P_{k-n} = C_k \phi \left( \frac{S_n}{S_k} \right) \]

\[ P_{k-k} = 12 \sqrt{N_k} K \left( \frac{S_n}{S_k} \right) \]

\[ P_{k+k} = 6.9 \sqrt[3]{N_{k-k}} K \left( \frac{S_n}{S_k} \right) \]

Multiple WTG Weighting:

\[ P_2 = \sqrt{\sum P_{2,\text{wt}}} \]

\[ P_3 = 2 \sqrt{3} \sum P_{3,\text{wt}} \]

Case Study #1: TVA Buffalo Mountain

- Three Vestas V47 WTGs, Total 2 MW
- 13.2-kV Feeder, 9.6 miles long, 69-kV Source
- No Voltage Control Problems
- Removed the High-Speed Reclose Operation
- No Reduction of Reach or Sympathetic Trip
Case Study #2: PGE Hunter’s Point

- 12-kV Feeder, 6.4 miles long
- One GE 1.5xLE Turbine, 1500 kW
- Use high-efficiency turbine, greater hub height, and higher wind shear factor than in CEC study
- No Flicker Problems or Limits
- Voltage Control and Overcurrent Protection limit the WTG to 7500 kW

Case Study #3: Illinois Rural Electric

- One NM82 Vestas/NEG Micon Turbine, 1.65 MW
- Operating since May 2005
- 12.47-kV Feeder, 34.5-kV Transmission Source
- IREC Filled out the Feeder Simulator Data Sheet
- Overvoltage and Undervoltage Trip Functions are Essential
- Evaluated Use of CREB (actual project had 46% grant funding, before CREB available)
- Two Turbines → Flicker and Tap Changer Issues
Case Study #4: East River Coop, Chamberlain, SD

- Two Nordex N60/1300 Turbines
- 69/12.47-kV Substation Transformer, 3750 kVA
- 4/0 Cable, 1/3 Concentric Neutral, 12 kft from Sub
- On a Dedicated Feeder, but **Still** had Flicker Complaints
- Solutions implemented by Basin Electric:
  - Turbine Vendor adjusted Controls
  - Dynamic VAR compensation
  - Dedicated Transformer (2500 kVA)
PV Output Variations