

Standard Development Roadmap

This section is maintained by the drafting team during the development of the standard and will be removed when the standard becomes effective.

Development Steps Completed:

1. SAR posted for comment (April 20–May 21, 2007).
2. Revised SAR and response to comments posted.
3. Revised SAR and response to comments approved by SC (June 14, 2007).
4. SDT appointed on (August 18, 2007).
5. Initial draft of PRC-024-1 was posted for a 45 day formal comment period (February 17 – April 2, 2009).
6. Draft 2 PRC-024-1 was posted for a 45 day concurrent comment and ballot period from June 15 – August 1, 2011.

Proposed Action Plan and Description of Current Draft:

This is the third draft of the standard and includes Time Horizons, Data Retention, Violation Risk Factors, and Violation Severity Levels. This second posting is for a 30-day comment and successive ballot period.

Future Development Plan:

Anticipated Actions	Anticipated Date
1. Develop responses to comments and develop third version draft standard.	August 2011 – February 2012
2. Post response to comments and third version draft revision of standard for 30 day comment and successive ballot period.	February – March 2012
3. Develop responses to successive ballot comments.	April – June 2012
4. Post response to comments.	July 2012
5. Conduct recirculation ballot.	July 2012
7. BOT adoption.	August 2012
8. File with regulatory authorities.	October 2012

Definitions of Terms Used in Standard

This section includes all newly defined or revised terms used in the proposed standard. Terms already defined in the Reliability Standards Glossary of Terms are not repeated here. New or revised definitions listed below become approved when the proposed standard is approved. When the standard becomes effective, these defined terms will be removed from the individual standard and added to the Glossary.

None

A. Introduction

1. **Title:** Generator Performance During Frequency and Voltage Excursions
2. **Number:** PRC-024-1
3. **Purpose:** Ensure generating units remain connected during frequency and voltage excursions, and ensure expected generating unit performance during frequency and voltage excursions, is communicated to Reliability Coordinators, Planning Coordinators, Transmission Operators and Transmission Planners for accurate system modeling.
4. **Applicability:**
 - 4.1. Generator Owner
5. **Effective Date:**
 - 5.1. Each Generator Owner shall verify that at least 33 percent of its applicable units are fully compliant with Requirements R1, R2, R3, R4, and R6 by the first day of the first calendar quarter one year following applicable regulatory approval; or, in those jurisdictions where no regulatory approval is required, the first day of the first calendar quarter one year following Board of Trustees adoption.
 - 5.2. Each Generator Owner shall verify that at least 66 percent of its applicable units are fully compliant with Requirements R1, R2, R3, R4, and R6 by the first day of the first calendar quarter two years following applicable regulatory approval; or, in those jurisdictions where no regulatory approval is required, the first day of the first calendar quarter two years following Board of Trustees adoption.
 - 5.3. Each Generator Owner shall verify that 100 percent of its applicable units are fully compliant with Requirements R1, R2, R3, R4, and R6 by the first day of the first calendar quarter three years following applicable regulatory approval; or, in those jurisdictions where no regulatory approval is required, the first day of the first calendar quarter three years following Board of Trustees adoption.
 - 5.4. Requirement R5 shall be effective on the first day of the first calendar quarter six years following applicable regulatory approval; or, in those jurisdictions where no regulatory approval is required, the first day of the first calendar quarter six years following Board of Trustees adoption.

B. Requirements

- R1.** Each Generator Owner that has generator frequency protective relaying¹ activated to trip its new or existing generating unit or generating plant shall set such protective relaying so that it does not trip within the “no trip zone” of PRC-024 Attachment 1, unless the Generator Owner has documented and communicated each equipment limitation in accordance with Requirement R3 for an existing generating unit.² [*Violation Risk Factor: High*] [*Time Horizon: Long-term Planning*]
- 1.1.** A generating unit or generating plant is allowed to trip within the “no trip zone” if the frequency rate of change is more than 2.5 Hz/sec.
 - 1.2.** A generating unit or generating plant may trip if the protective functions (such as out-of-step or loss-of-field functions) operate due to an impending or actual loss of synchronism or due to instability in power conversion control equipment.
- R2.** Each Generator Owner that has generator voltage protective relaying¹ activated to trip its new or existing generating unit or generating plant shall set its protective relaying such that it does not trip as a result of a voltage excursion (at the point of interconnection³) that remains within the “no trip zone” of PRC-024 Attachment 2 caused by an event on the transmission system external to the generating plant per the following operating conditions and relay settings, unless the Generator Owner has documented and communicated each non-protection system equipment limitation in accordance with Requirement R3 for an existing generating unit or generating plant.: [*Violation Risk Factor: High*] [*Time Horizon: Long-term Planning*]
- 2.1.** When operating within 95 percent to 105 percent of rated generator terminal voltage and during the transmission system operating conditions defined in PRC-024 Attachment 2, with the following clarifications:
 - 2.1.1.** If a Transmission Planner’s study (based on the location specific voltage recovery characteristics) allows less stringent voltage relay settings than those required to meet PRC-024 Attachment 2, set voltage relays either to

¹ Each Generator Owner is not required to have frequency or voltage protective relaying (including but not limited to frequency and voltage protective functions for discrete relays, volts per hertz relays evaluated at nominal frequency, impedance relays, voltage controlled overcurrent relays, multi-function protective devices or protective functions within control systems that directly trip or provide tripping signals to the generator based on frequency or voltage inputs) installed or activated on its unit.

² To include generators under construction, generators with an executed interconnection agreement or Power Purchase Agreement by the effective date of this standard, or generators with an executed equipment purchase contract and scheduled delivery of major components within 2 years of the effective date of Requirement R5 of Version 1 of this standard.

³ For the purposes of this standard, point of interconnection means the transmission (high voltage) side of the generator step-up or collector transformer.

- meet the Transmission Planner's voltage recovery characteristics or the characteristics in PRC-024 Attachment 2.
- 2.1.2.** Tripping a generator in accordance with a Special Protection System (SPS) or Remedial Action Scheme (RAS) is acceptable in the "no trip zone" of PRC-024 Attachment 2.
- 2.1.3.** If clearing a system fault necessitates disconnecting a generator, this action is acceptable within the "no trip zone" specified in PRC-024 Attachment 2.
- 2.1.4.** A generating unit or generating plant may trip if the protective functions (such as out-of-step or loss-of-field functions) operate due to an impending or actual loss of synchronism or due to instability in power conversion control equipment.
- R3.** Each Generator Owner of an existing generating unit or generating plant shall document each equipment limitation (excluding generator frequency and voltage protective relay limitations) that prevents a generating unit or generating plant, from meeting the criteria in Requirements R1 or R2 including study results, experience from an actual event, or manufacturer's advisory [*Violation Risk Factor: Lower*] [*Time Horizon: Long-term Planning*].
- 3.1.** The Generator Owner shall communicate the documented limitation, or the removal of a previously documented limitation, to its Reliability Coordinator, Planning Coordinator, Transmission Operator and Transmission Planner within 30 calendar days of identifying the limitation to ensure the accuracy of planning studies and system modeling studies. The existing generating unit or generating plant becomes subject to the full extent of Requirements R1 and R2 coincident with either of the following conditions:
- The equipment causing the limitation is repaired or replaced with equipment that removes the limitation.
 - The equipment causing the limitation is modified or upgraded resulting in an increase of generator nameplate capacity rating greater than 10 percent (cumulative from the first effective date of this Standard).
- R4.** Each Generator Owner of an existing generating unit or generating plant shall provide an estimate of that unit's performance during Frequency/Voltage Excursions to each requesting entity (Reliability Coordinator, Planning Coordinator, Transmission Operator or Transmission Planner that monitors or models the associated generating unit or generating plant) within 60 calendar days of receipt of a written request, to ensure the accuracy of planning studies and system modeling studies. The estimate shall include: [*Violation Risk Factor: Lower*] [*Time Horizon: Long-term Planning*]
- 4.1.** An estimate of the time duration the existing generating unit or generating plant will remain connected (considering performance of the auxiliary systems as well as the

generator) as a result of a frequency excursion or a voltage excursion defined by the voltage or frequency profile at the point of interconnection described by dynamic simulation provided by the Transmission Planner. If the Generator Owner expects the existing unit, generating plant will remain connected for longer than 10 minutes, the estimate should indicate the existing unit or generating plant is not expected to trip.

- 4.2.** Identification of the bases for the estimates developed for 4.1 which may include, but is not limited to: experience, actual event histories, or sound engineering judgment.
- R5.** Each Generator Owner shall design, build, and maintain its new ⁴ unit or new generating plant so that it will not trip due to a frequency excursion or voltage excursion at the point of interconnection, caused by an event on the transmission system external to the generating plant, within the parameters set forth in PRC-024 Attachments 1 and 2 and in accordance with the following conditions and exceptions: [*Violation Risk Factor: High*] [*Time Horizon: Real-time Operations*]
- 5.1.** (condition) When the generating unit or generating plant is operating at or above the minimum sustainable generation threshold.
- 5.1.1.** For a generating plant consisting of multiple units with total generation greater than 75 MVA (gross aggregate nameplate rating), when the generating plant is producing at least 20 percent of the plant's aggregate nameplate capacity.
- 5.2.** (exception) For a new generating plant consisting of multiple units less than 20 MVA each with total plant generation greater than 75 MVA (gross aggregate rating), 10 percent of the individual generating units may disconnect as a result of the frequency or voltage excursion.
- 5.3.** (exception) A generating unit or generating plant may operate to a less stringent voltage ride-through performance criterion than the duration curve identified in PRC-024 Attachment 2 based on the location-specific voltage recovery characteristics if provided by the Transmission Planner as described in Requirement 2, Part 2.1.1.
- 5.4.** (exception) A generating unit or generating plant may trip if this action is designed as part of a Special Protection System (SPS) or Remedial Action Scheme (RAS).
- 5.5.** (exception) A generating unit or generating plant may trip if clearing a system fault necessitates disconnecting the generating unit or generating plant.

⁴ Excluding generators in service prior to the effective date of Requirement R5 of Version 1 of this standard and excluding generators referenced in Footnote 2.

- 5.6.** (exception) A generating unit or generating plant may trip if the Generator Owner has a temporary exemption granted by its Reliability Coordinator based on a documented equipment limitation. The Reliability Coordinator may retroactively grant a temporary exemption for an equipment limitation identified following a plant trip caused by a frequency or voltage excursion if the Generator Owner develops and implements an acceptable Mitigation Plan.
- 5.7.** (exception) A generating unit or generating plant may trip if the protective functions (such as out-of-step or loss-of-field functions) operate due to an impending or actual loss of synchronism or due to instability in power conversion control equipment.
- R6.** Each Generator Owner shall provide its generator protection trip settings to the Reliability Coordinator, Planning Coordinator, Transmission Operator and Transmission Planner (that monitors or models the associated unit), within 30 calendar days of receipt of a written request for the data, and within 30 calendar days of any change to those trip settings, to ensure the accuracy of planning studies and system modeling. [*Violation Risk Factor: Lower*] [*Time Horizon: Operations Planning*]

C. Measures

- M1.** Each Generator Owner shall have evidence such as dated setting sheets, calibration sheets, or other documentation, that generator frequency protective relays have been set in accordance with Requirement R1.
- M2.** Each Generator Owner shall have evidence such as dated setting sheets, voltage-time curves, calibration sheets, coordination plots or dynamic simulation studies, that generator voltage protective relays have been set in accordance with Requirement R2.
- M3.** Each Generator Owner shall have evidence that it has documented and communicated any equipment limitations (Protection System excluded) that resulted in an exception to Requirements R1 or R2 in accordance with Requirement R3 such as a dated email or letter that contains such documentation as study results, experience from an actual event, or manufacturer's advisory.
- M4.** Each Generator Owner shall have evidence such as a copy of the performance report and correspondence, such as dated e-mails, or other documentation that an estimate of the performance of its existing generating unit(s) as a result of a Frequency Excursion or Voltage Excursion has been communicated in accordance with Requirement R4, and copies of any requests it has received for that information.
- M5.** Each Generator Owner shall have evidence, such as dated unit output records, trip investigation reports or disturbance monitoring records, showing that each unit trip did not result from a Frequency Excursion or Voltage Excursion as specified in Requirement R5, or evidence that a listed exception applied, or provide an attestation that the generating unit or generating plant did not trip.

- M6.** Each Generator Owner shall have evidence such as dated e-mails, correspondence or other evidence that it communicated generator protective relay settings to a requesting entity within 30 calendar days of a request or change in setting(s) in accordance with Requirement R6 and copies of any requests it has received for that information..

D. Compliance

1. Compliance Monitoring Process

1.1. Compliance Enforcement Authority

Regional Entity

1.2. Data Retention

The following evidence retention periods identify the period of time an entity is required to retain specific evidence to demonstrate compliance. For instances where the evidence retention period specified below is shorter than the time since the last audit, the Compliance Enforcement Authority may ask an entity to provide other evidence to show that it was compliant for the full time period since the last audit.

The Generator Owner shall keep data or evidence to show compliance as identified below unless directed by its Compliance Enforcement Authority to retain specific evidence for a longer period of time as part of an investigation:

- The Generator Owner shall retain the latest evidence of Requirement R1 through R6, Measure M1 through M6; and shall retain prior evidence for 3 calendar years or the next audit, whichever is longer.

If a Generator Owner is found non-compliant, it shall keep information related to the non-compliance until found compliant or for the time period specified above, whichever is longer.

The Compliance Enforcement Authority shall keep the last audit records and all requested and submitted subsequent audit records.

1.3. Compliance Monitoring and Assessment Processes

Compliance Audit

Self-Certification

Spot Checking

Compliance Investigation

Self-Reporting

Complaint

1.4. Additional Compliance Information

None

Draft

Standard PRC-024-1 — Generator Performance During Frequency and Voltage Excursions

2. Violation Severity Levels

R #	Lower VSL	Moderate VSL	High VSL	Severe VSL
R1	N/A	N/A	N/A	The Generator Owner that has frequency protection activated to trip a generator has no documented and communicated technical limitation per Requirement R3 and failed to set its generator frequency protective relaying so that it does not trip within the criteria listed in Requirement R1
R2	N/A	N/A	N/A	The Generator Owner with voltage protective relaying has no documented and communicated technical limitation per Requirement R3 and failed to set its voltage protective relaying so that it does not trip as a result of a voltage excursion at the point of interconnection, caused by an event external to the plant per the conditions specified in Requirement R2
R3	The Generator Owner documented the non-protection system equipment limitation that prevented it from meeting the criteria in Requirement R1 or R2 and communicated the documented limitation to its	The Generator Owner documented the non-protection system equipment limitation that prevented it from meeting the criteria in Requirement R1 or R2 and communicated the documented limitation to its	The Generator Owner documented the non-protection system equipment limitation that prevented it from meeting the criteria in h Requirement R1 or R2 and communicated the documented limitation to its	The Generator Owner failed to document any non-protection system equipment limitation that prevented it from meeting the criteria in Requirement R1 or R2.

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R #	Lower VSL	Moderate VSL	High VSL	Severe VSL
	Reliability Coordinator, Planning Coordinator, Transmission Operator and Transmission Planner more than 30 calendar days but less than or equal to 40 calendar days of identifying the limitation.	Reliability Coordinator, Planning Coordinator, Transmission Operator and Transmission Planner more than 40 calendar days but less than or equal to 50 calendar days of identifying the limitation.	Reliability Coordinator, Planning Coordinator, Transmission Operator and Transmission Planner more than 50 calendar days but less than or equal to 60 calendar days of identifying the limitation.	OR The Generator Owner failed to communicate the documented limitation to its Reliability Coordinator, Planning Coordinator, Transmission Operator and Transmission Planner within 61 calendar days of identifying the limitation.
R4	The Generator Owner provided an estimate of a unit's performance more than 30 calendar days but less than or equal to 40 calendar days of a written request.	The Generator Owner provided an estimate of a unit's performance more than 40 calendar days but less than or equal to 50 calendar days of a written request.	The Generator Owner provided an estimate of a unit's performance more than 50 calendar days but less than or equal to 60 calendar days of a written request. OR The Generator Owner failed to include documentation for one of the Parts specified in Requirement R4, Parts 4.1 and 4.2.	The Generator Owner failed to provide an estimate of a unit's performance within 61 calendar days of a written request. OR The Generator Owner failed to include any of the documentation specified in Requirement R4, Parts 4.1 and 4.2.
R5	N/A	N/A	N/A	The Generator Owner's generator tripped due to a Frequency Excursion within the no-trip parameters set forth in

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R #	Lower VSL	Moderate VSL	High VSL	Severe VSL
				<p>Attachment 1.</p> <p>OR</p> <p>The Generator Owner’s generator tripped due to a Voltage Excursion within the no-trip parameters set forth in Attachment 2.</p>
<p>R6</p>	<p>The Generator Owner provided its generator protection trip settings as specified by Requirement R6 more than 30 calendar days but less than or equal to 40 calendar days of any change to those trip settings or limitations.</p> <p>OR</p> <p>The Generator Owner provided trip settings more than 30 calendar days but less than or equal to 40 calendar days of a written request.</p>	<p>The Generator Owner provided its generator protection trip settings as specified by Requirement R6 more than 40 calendar days but less than or equal to 50 calendar days of any change to those trip settings or limitations.</p> <p>OR</p> <p>The Generator Owner provided trip settings more than 40 calendar days but less than or equal to 50 calendar days of a written request.</p>	<p>The Generator Owner provided its generator protection trip settings as specified by Requirement R6 more than 50 calendar days but less than or equal to 60 calendar days of any change to those trip settings or limitations.</p> <p>OR</p> <p>The Generator Owner provided trip settings more than 50 calendar days but less than or equal to 60 calendar days of a written request.</p>	<p>The Generator Owner failed to provide its generator protection trip settings as specified by Requirement R6 within 60 calendar days of any change to those trip settings or limitations.</p> <p>OR</p> <p>The Generator Owner failed to provide trip settings within 60 calendar days of a written request for the data.</p>

E. Regional Variances

None

F. Associated Documents

None

Version History

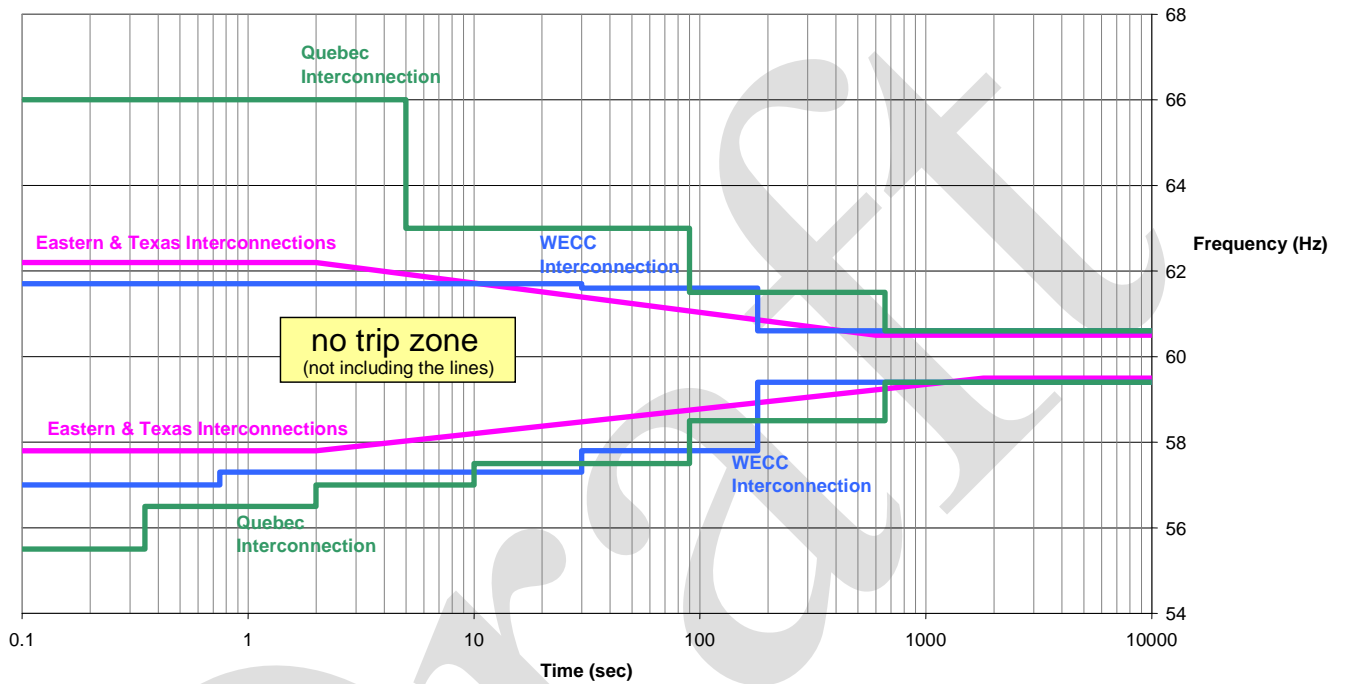
Version	Date	Action	Change Tracking

G. References

1. “The Technical Justification for the New WECC Voltage Ride-Through (VRT) Standard, A White Paper Developed by the Wind Generation Task Force (WGTF),” dated June 13, 2007, a guideline approved by WECC Technical Studies Subcommittee.

PRC-024 — Attachment 1

OFF NOMINAL FREQUENCY CAPABILITY CURVE



Curve Data Points:

Eastern and Texas Interconnections

High Frequency Duration		Low Frequency Duration	
Time (Sec)	Frequency (Hz)	Time (Sec)	Frequency (Hz)
0 - 2	62.2	0 - 2	57.8
2 - 600	$62.41 - 0.686\log(t)$	2 - 1800	$57.63 + 0.575\log(t)$
> 600	60.5	> 1800	59.5

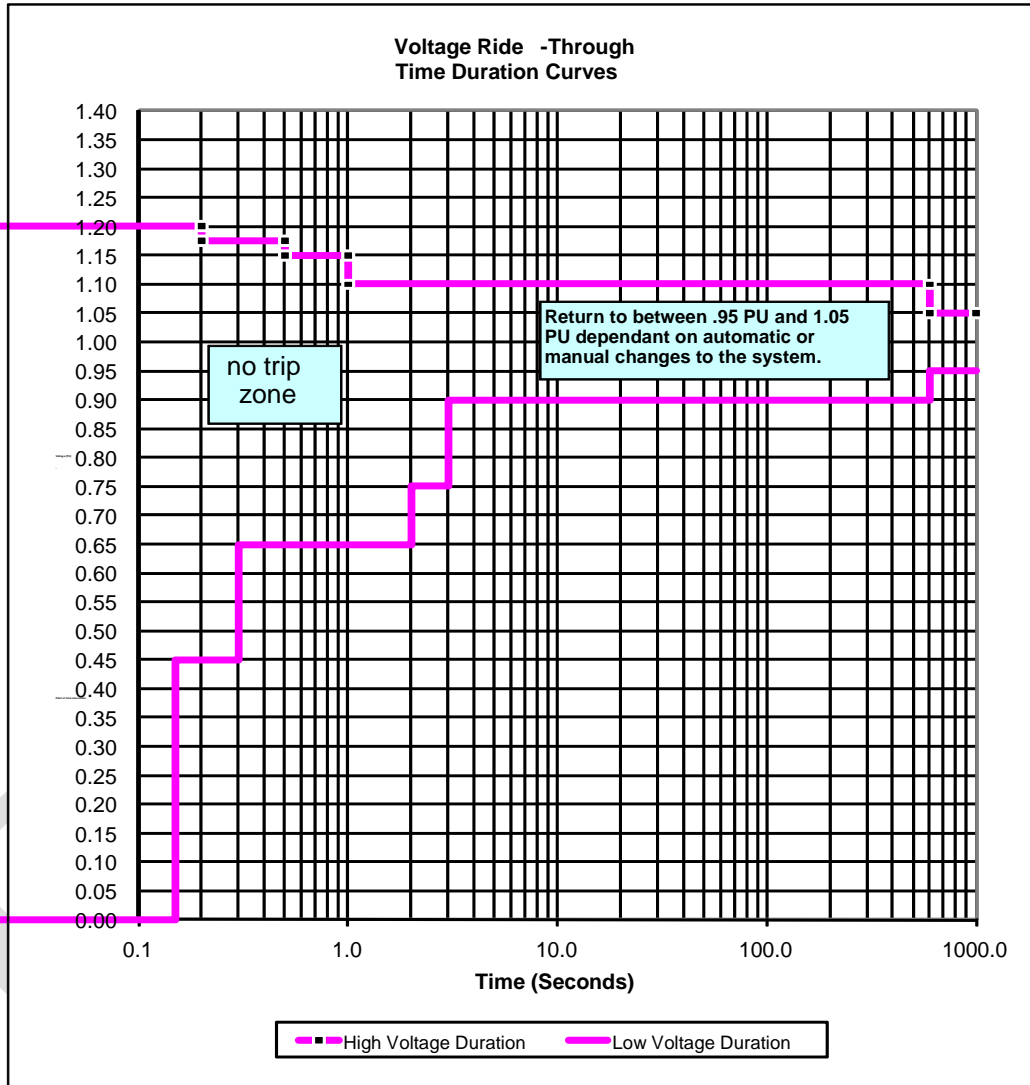
WECC Interconnection

High Frequency Duration		Low Frequency Duration	
Time (Sec)	Frequency (Hz)	Time (Sec)	Frequency (Hz)
0 – 30	61.7	0 – 0.75	57.0
30 – 180	61.6	0.75 – 30	57.3
> 180	60.6	30 – 180	57.8
		> 180	59.4

Quebec Interconnection

High Frequency Duration		Low Frequency Duration	
Time (Sec)	Frequency (Hz)	Time (Sec)	Frequency (Hz)
0 – 5	66.0	0 – 0.35	55.5
5 – 90	63.0	0.35 – 2	56.5
90 – 660	61.5	2 – 10	57.0
> 660	60.6	10 – 90	57.5
		90 – 660	61.5
		> 660	60.6

PRC-024— Attachment 2



Standard PRC-024-1 — Generator Performance During Frequency and Voltage Excursions

Curve Data Points:

High Voltage Ride Through Duration		Low Voltage Ride Through Duration	
Time (Sec)	Voltage (p.u.)	Time (Sec)	Voltage (p.u.)
0.20	1.200	0.15	0.000
0.50	1.175	0.30	0.450
1.00	1.150	2.00	0.650
600	1.100	3.00	0.750
		600	0.900

Voltage Ride-Through Curve Clarifications

Curve Details:

1. The per unit voltage base for these curves is the base voltage specified in the system models used by the Transmission Planner in the analysis of the reliability of the Interconnected Transmission Systems at the point of interconnection to the Bulk Electric System (BES).
2. The curves depicted were derived based on three-phase transmission system zone 1 faults with Normal Clearing not exceeding 9 cycles.
3. The envelope within the curves represents the cumulative voltage duration at the point of interconnection with the BES. For example, if the voltage exceeds 1.15 pu at 0.3 seconds after a fault, does not exceed 1.2 pu voltage, and returns below 1.15 pu at 0.4 seconds, then the cumulative time the voltage is above 1.15 pu voltage is 0.1 seconds and is within the no trip zone of the curve.
4. The curves depicted assume system frequency is 60 Hertz. Adjust the magnitude of the high voltage curve in proportion to deviations of frequency below normal.
5. Voltages in the curve assume minimum fundamental frequency phase-to-ground or phase-to-phase voltage for the low voltage duration curve and maximum crest phase-to-ground or phase-to-phase voltage for the high voltage duration curve.

Evaluating Protective Relay Settings:

6. Use the following assumptions to evaluate voltage protection relay setting calculations on the static case for steady state initial conditions:
 - a. All of the units connected to the same transformer are online and operating,
 - b. All of the units are at full nameplate real-power output.
 - c. Power factor is 0.95 lagging (i.e. supplying reactive power to the system) as measured at the generator terminals).
7. Evaluate voltage protection relay settings assuming that additional installed generating plant reactive support equipment (such as static VAR compensators, synchronous condensers, or capacitors) is available and operating normally.
8. Evaluate voltage protection relay settings accounting for the actual tap settings of transformers between the generator terminals and the point of interconnection.