

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).

Proposed Action Plan and Description of Current Draft:

This is the first draft of the proposed standard including Time Horizons, Data Retention, Violation Risk Factors, and Violation Severity Levels; and is being submitted for a 30-day formal comment period.

Future Development Plan:

Anticipated Actions	Anticipated Date
1. Post first draft revision of standard.	April-May 2011
2. Post response to comments and second version draft revision of standard.	July – August 2011
3. Post response to comments and request authorization to ballot the revised standard.	September - October 2011
4. Conduct initial ballot.	November 2011
5. Post response to comments.	December 2011
6. Conduct recirculation ballot.	January 2012
7. BOT adoption.	February 2012
8. File with regulatory authorities.	March 2012

A. Introduction

1. **Title:** Coordination of Generating Unit or Plant Voltage Regulating Controls with Generating Unit or Plant Capabilities and Protection
2. **Number:** PRC-019-1
3. **Purpose:** To improve the reliability of the Bulk Electric System by preventing tripping of generating units and generating Facilities due to mis-coordination of generating unit and generating Facility voltage regulating controls and limit functions with generator capabilities and protection system settings.
4. **Applicability:**
 - 4.1. **Functional Entities**
 - 4.1.1 Generator Owner
 - 4.1.2 Transmission Owner
 - 4.2. **Facilities**
 - 4.2.1 Individual generating unit or synchronous condenser > 20 MVA (gross nameplate rating) connected at the point of interconnection at 100 kV or above.
 - 4.2.2 Generating plant and generating Facility > 75 MVA (gross aggregate nameplate rating) connected at the point of interconnection at 100 kV or above.
 - 4.2.3 Blackstart Resources, regardless of size included in a Transmission Operator's restoration plan.
5. **Effective Date:**
 - 5.1. In those jurisdictions where regulatory approval is required:
 - 5.1.1 By the first day of the first calendar quarter, one calendar year following applicable regulatory approval each Generator Owner and Transmission Owner shall have verified at least 20% of its applicable units.
 - 5.1.2 By the first day of the first calendar quarter, two calendar years following applicable regulatory approval each Generator Owner and Transmission Owner shall have verified at least 40% of its applicable units.
 - 5.1.3 By the first day of the first calendar quarter, three calendar years following applicable regulatory approval each Generator Owner and Transmission Owner shall have verified at least 60% of its applicable units.
 - 5.1.4 By the first day of the first calendar quarter, four calendar years following applicable regulatory approval each Generator Owner and Transmission Owner shall have verified at least 80% of its applicable units.

5.1.5 By the first day of the first calendar quarter, five calendar years following applicable regulatory approval each Generator Owner and Transmission Owner shall have verified 100% of its applicable units.

5.2. In those jurisdictions where regulatory approval is not required:

5.2.1 By the first day of the first calendar quarter, one calendar year following Board of Trustees approval each Generator Owner and Transmission Owner shall have verified at least 20% of its applicable units.

5.2.2 By the first day of the first calendar quarter, two calendar years following Board of Trustees approval each Generator Owner and Transmission Owner shall have verified at least 40% of its applicable units.

5.2.3 By the first day of the first calendar quarter, three calendar years following Board of Trustees approval each Generator Owner and Transmission Owner shall have verified at least 60% of its applicable units.

5.2.4 By the first day of the first calendar quarter, four calendar years following Board of Trustees approval each Generator Owner and Transmission Owner shall have verified at least 80% of its applicable units.

B. Requirements

R1. Each Generator Owner and Transmission Owner with applicable Facilities shall coordinate its generating unit and generating Facility voltage regulating system controls, including limiters and protection functions with the generating unit and Facility or synchronous condenser capabilities and protective system settings; to include as applicable: *[Violation Risk Factor: High] [Time Horizon: Long-term Planning]*

- **In-service**¹ excitation system and voltage regulating system control, limiters and protection functions
- **In-service** generator or synchronous condenser protection system settings
- Generating equipment or synchronous condenser capabilities
- Steady state stability limit

1.1. This coordination requires the following steps:

1.1.1. Verify that the limiters are set to operate before the protection and the protection is set to operate before conditions exceed equipment capabilities (including the steady state stability limit) assuming normal AVR control loop and system steady state operating conditions.

1.1.2. Check that the settings determined in Step 1.1.1 are applied to the in-service equipment.

1.2. Each Generator Owner and Transmission Owner shall verify the existence of the coordination identified in Requirement R1 at least once every five years or within

¹ Limiters or protective functions that are installed and activated on the generator or synchronous condenser.

90 calendar days following the identification or implementation of systems, equipment or setting changes that are expected to affect this coordination, including but not limited to the following

- Voltage regulating equipment changes
- Protection system settings or component changes
- Generating or synchronous condenser equipment capability changes
- Generator or synchronous condenser step-up transformer changes

C. Measures

M1. Each Generator Owner and Transmission Owner will have evidence, such as example plots provided in PRC-019 Section G, to show that its generating unit and generating Facility or synchronous condenser excitation system and voltage regulating system controls and protection functions are coordinated with the generating unit and generating Facility capabilities and protective system settings applied to in-service equipment as specified in Requirement R1, Section 1.1, and one previous dated set of evidence that demonstrates the latest coordination review has been done within the intervals specified in Requirement R1, Section 1.2. If the latest coordination review is performed due to a change in the equipment or settings that changes the coordination, the Generator Owner and Transmission Owner will have evidence (such as a work order) that demonstrates when the change was implemented.

D. Compliance

1. Compliance Monitoring Process

1.1. Compliance Enforcement Authority

Regional Entity

1.2. Data Retention

Each Generator Owner and Transmission 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 and Transmission Owner shall retain the latest and the prior evidence of compliance with Requirement R1, Measure M1.

If a Generator Owner or Transmission 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 Violation Investigation
- Self-Reporting
- Complaint

1.4. Additional Compliance Information

None

2. Violation Severity Levels

R #	Lower VSL	Moderate VSL	High VSL	Severe VSL
R1	The Generator Owner or Transmission Owner verified the coordination specified in Requirement R1 more than 90 calendar days but less than or equal to 100 calendar days following the identification or implementation of a change that affected the coordination.	The Generator Owner or Transmission Owner verified the coordination specified in Requirement R1 more than 100 calendar days but less than or equal to 110 calendar days following the identification or implementation of a change that affected the coordination.	The Generator Owner or Transmission Owner verified the coordination specified in Requirement R1 more than 110 calendar days but less than or equal to 120 calendar days following the identification or implementation of a change that affected the coordination.	The Generator Owner or Transmission Owner failed to verify the existence of the coordination specified in Requirement R1 at least once every five years. OR The Generator Owner or Transmission Owner failed to verify the existence of the coordination specified in Requirement R1 within 121 calendar days following the identification or implementation of a change that affected the coordination.

E. Regional Variances

None.

F. Associated Documents

None.

Version History

Version	Date	Action	Change Tracking

G. Reference

Examples of Coordination

The evidence of coordination associated with Requirement R1 may be in the form of one or more plots including (but not limited to):

- P-Q Diagram (Attachment 1), or
- R-X Diagram (Attachment 2), or
- Inverse Time Diagram (Attachment 3)

These plots contain the equipment capabilities, the operating region for the limiters and protection function such as; under-excitation limiters, steady state stability limits, or loss of field protection curves. Additional limiters and protection function that are installed and in-service can be incorporated as an Inverse Time Limit/Protection Characteristic Plot (Attachment 3) or into the Generator Reactive Capability Curve Plot or an R-X diagram plot, identified above.

Equipment limits, types of limiters and protection functions which could be coordinated include:

- Field over-excitation limiter and associated protection functions.
- Inverter over current limit and associated protection functions.
- Volts per hertz limiter and associated protection functions.
- Stator over-voltage protection system settings.
- Generator and transformer volts per hertz capability.
- Time vs. field current or time vs. stator current.
- Converter over-temperature limiter and associated protection function.

NOTE: This listing is for reference only. This standard does not require the installation or activation of any of the above limiter or protection functions.

For the coordination required by this standard, the Steady State Stability Limit (SSSL) is the limit to synchronous stability in the under-excited region with fixed field current.

On a P-Q diagram using X_d as the direct axis saturated synchronous reactance of the generator, X_s as the equivalent reactance between the generator terminals and the “infinite bus” including the reactance of the generator step-up transformer and V_g as the generator terminal voltage (all values in per-unit), the SSSL can be calculated as an arc with the center on the Q axis with the magnitude of the center and radius described by the following equations

$$C = V_g^2/2*(1/X_s-1/X_d)$$

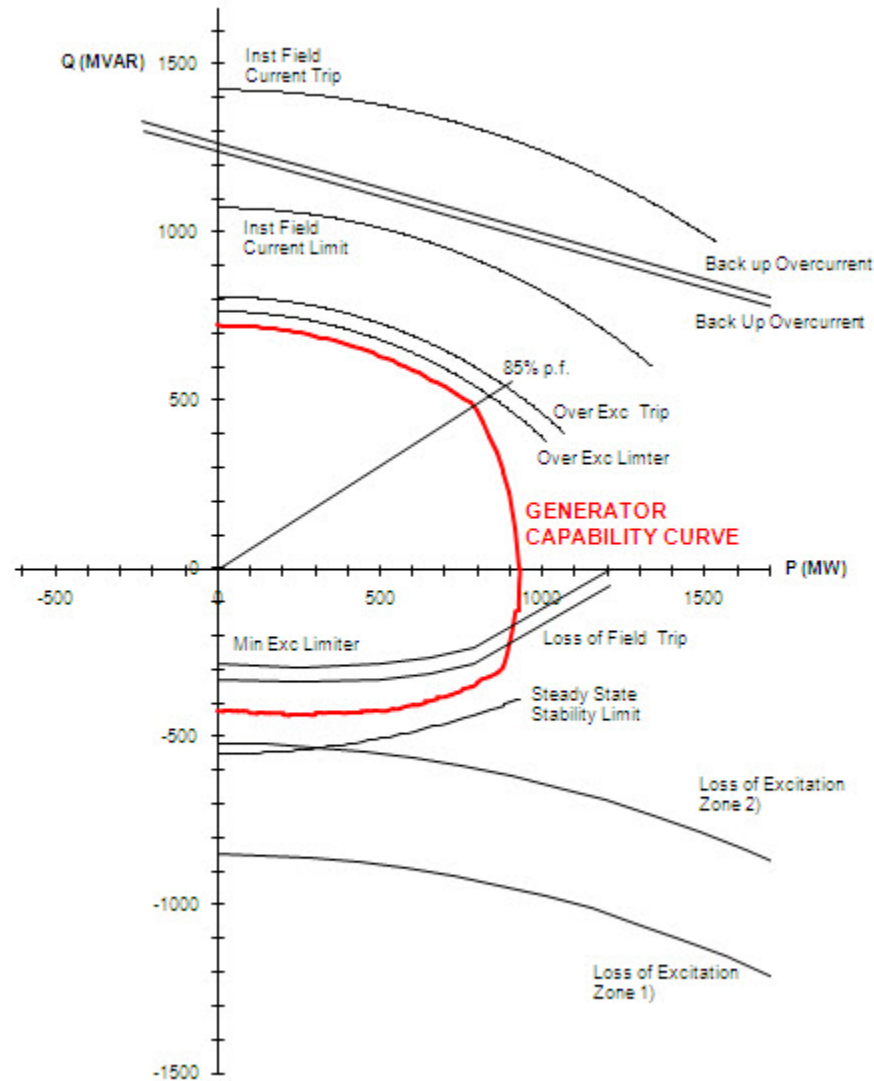
$$R = V_g^2*(1/X_s+1/X_d)$$

On an R-X diagram using X_d as the direct axis saturated synchronous reactance of the generator, and X_s as the equivalent reactance between the generator terminals and the “infinite bus” including the reactance of the generator step-up transformer the SSSL is an arc with the center on the X axis with the center and radius described by the following equations:

$$C = (X_d-X_s)/2$$

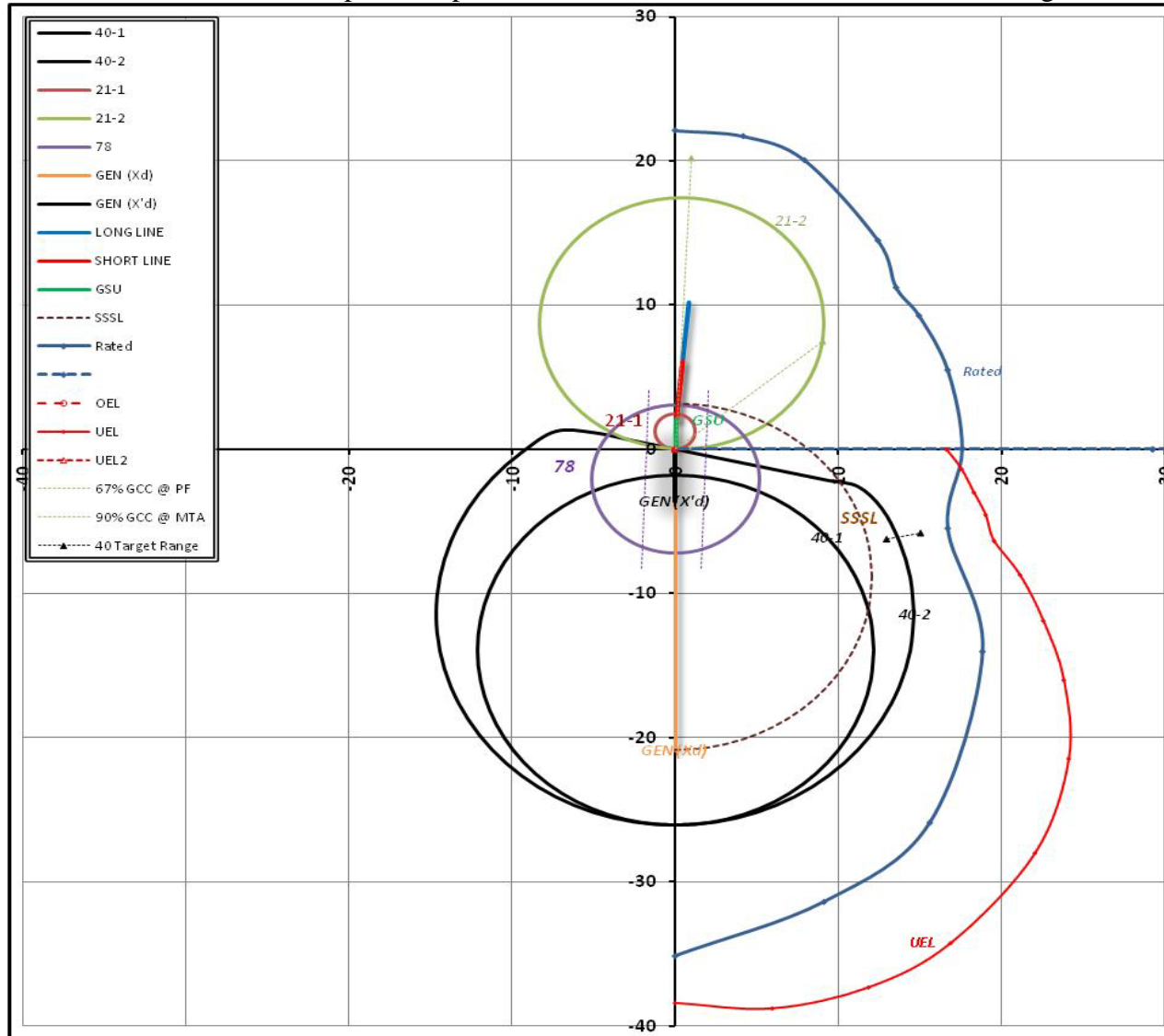
$$R = (X_d+X_s)/2$$

Attachment 1 – Example of Capabilities, Limiters and Protection on a P-Q Diagram



Example of Generator Capability Curve with Protection Elements Visible

Attachment 2 – Example of Capabilities, Limiters, and Protection on an R-X Diagram



Attachment 3 - Example of Capabilities, Limiters, and Protection on an Inverse Time Characteristic Plot

