

## Effective Date

Effective for SERC Region applicable Registered Entities on the first day of the first calendar quarter after approved by FERC.

## Introduction

1. **Title:** Automatic Underfrequency Load Shedding Requirements
2. **Number:** PRC-006-SERC-02
3. **Purpose:** To establish consistent and coordinated requirements for the design, implementation, and analysis of automatic underfrequency load shedding (UFLS) programs among all SERC applicable entities.
4. **Applicability:**
  - 4.1 Planning Coordinators
  - 4.2 UFLS entities shall mean all entities that are responsible for the ownership, operation, or control of UFLS equipment as required by the UFLS program established by the Planning Coordinators. Such entities may include one or more of the following:
    - 4.2.1 Transmission Owners
    - 4.2.2 Distribution Providers
  - 4.3 Generator Owners
5. **Background**

The SERC UFLS Standard: PRC-006-SERC-01 (“SERC UFLS Standard”) was developed to provide regional UFLS requirements to entities in SERC. UFLS requirements have been in place at a continent-wide level and within SERC for many years prior to implementation of federally mandated reliability compliance standards in 2007.

When reliability standards were implemented in 2007, the Federal Energy Regulatory Commission (“FERC”), which is the government body with regulatory responsibility for electric reliability, issued FERC Order 693, recognizing 83 NERC Reliability Standards as enforceable by FERC and applicable to users, owners, and operators of the bulk power system (BPS). FERC did not approve the NERC UFLS standard, PRC-006-0 in Order 693. FERC’s reason for not approving PRC-006-0 was that it recognized PRC-006-0 as a “fill-in the blank standard,” and regional procedures associated with the standard were not submitted along with the standard. FERC’s ruling in Order 693 required Regional Entities to provide the regional requirements necessary for completing the UFLS standard.

In 2008, SERC commenced work on PRC-006-SERC-01. NERC also began work on revising PRC-006-0 at a continent-wide level. The SERC standard has been developed to be consistent with the NERC UFLS standard. PRC-006-SERC-02 was developed per periodic review of the standard.

PRC-006-1 clearly defines the roles and responsibilities of parties to whom the standard applies. The standard identifies the Planning Coordinator (“PC”) as the entity responsible for developing UFLS schemes within their PC area. The regional standard adds specificity not contained in the NERC standard for development and implementation of a UFLS scheme in the SERC Region that effectively mitigates the consequences of an underfrequency event.

## Requirements and Measures

- R1.** Each Planning Coordinator shall include its SERC subregion as an identified island in the criteria (required by the NERC PRC standard on UFLS) for selecting portions of the BPS that may form islands. *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*
- 1.1** A Planning Coordinator may adjust island boundaries to differ from subregional boundaries where necessary for the sole purpose of producing a contiguous subregional island more suitable for simulation.
- M1.** Each Planning Coordinator shall have evidence such as a methodology, procedure, report, or other documentation indicating that its criteria included selection of its SERC subregion(s) as an island per Requirement R1.
- R2.** Each Planning Coordinator shall select or develop an automatic UFLS scheme (percent of load to be shed, frequency set points, and time delays) for implementation by UFLS entities within its area that meets the following minimum requirements: *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*
- 2.1.** Have the capability of shedding at least 30 percent of the Peak Demand (MW) served from the Planning Coordinator's transmission system. The Peak Demand may be either summer or winter as determined by the Planning Coordinator.
- 2.2.** Shed load with a minimum of three frequency set points.
- 2.3.** The highest frequency set point for relays used to arrest frequency decline shall be no lower than 59.3 Hz and not higher than 59.5 Hz.
- 2.3.1** This does not apply to UFLS relays with time delay of one second or longer and a higher frequency setpoint applied to prevent the frequency from stalling at less than 60 Hz when recovering from an underfrequency event.
- 2.4.** The lowest frequency set point shall be no lower than 58.4 Hz.
- 2.5.** The difference between frequency set points shall be at least 0.2 Hz but no greater than 0.5 Hz.
- 2.6.** Time delay (from frequency reaching the set point to the trip signal) shall be at least six cycles.
- M2.** Each Planning Coordinator shall have evidence such as reports or other documentation that the UFLS scheme for its area meets the design requirements specified in Requirement R2.

- R3.** Each Planning Coordinator, when performing design assessments specified in the NERC PRC standard on UFLS, shall conduct simulations of its UFLS scheme for an imbalance between load and generation of 13%, 22%, and 25% for all identified island(s) where such imbalance equals  $[(\text{load minus actual generation output}) / \text{load}]$ . *[Violation Risk Factor: High] [Time Horizon: Long-term Planning]*
- M3.** Each Planning Coordinator shall have evidence such as reports or other documentation that it performed the simulations of its UFLS scheme as required in Requirement R3.
- R4.** Each UFLS entity that has a total load of 100 MW or greater in a Planning Coordinator area in the SERC Region shall implement the UFLS scheme developed by their Planning Coordinator. UFLS entities may implement the UFLS scheme developed by the Planning Coordinator by coordinating with other UFLS entities. The UFLS scheme shall meet the following requirements on May 1 of each calendar year. *[Violation Risk Factor: Medium] [Time Horizon: Operations Planning]*
- 4.1.** The percent of load shedding to be implemented shall be based on the actual or estimated substation or feeder demand (including losses) of the UFLS entities at the time coincident with the previous year's actual Peak Demand in the season specified by the Planning Coordinator in R2.
- 4.2.** The amount of load in each load shedding step shall be within -1.0 and +3.0 of the percentage specified by the Planning Coordinator (for example, if the specified percentage step load shed is 12%, the allowable range is 11 to 15%).
- 4.3.** The amount of total UFLS load of all steps combined shall be within -1.0 and +5.0 of the percentage specified by the Planning Coordinator for the total UFLS load in the UFLS scheme.
- M4.** Each UFLS entity that has a total load of 100 MW or greater in a Planning Coordinator area in the SERC Region shall have evidence such as reports or other documentation demonstrating that its implementation of the UFLS scheme on May 1 of each calendar year meets the requirements of Requirement R4 (including all the data elements in Parts 4.1, 4.2, and 4.3) unless scheme changes per Requirement R6 are in process.
- R5.** Each UFLS entity that has a total load less than 100 MW in a Planning Coordinator area in the SERC Region shall implement the UFLS scheme developed by their Planning Coordinator, but shall not be required to have more than one UFLS step. UFLS entities may implement the UFLS scheme developed by the Planning Coordinator by coordinating with other UFLS entities. The UFLS scheme shall meet the following requirements on May 1 of each calendar year. *[Violation Risk Factor: Medium] [Time Horizon: Operations Planning]*.

- 5.1.** The percent of load shedding to be implemented shall be based on the actual or estimated substation or feeder demand (including losses) of the UFLS entities at the time coincident with the previous year actual Peak Demand in the season specified by the Planning Coordinator in R2..
- 5.2.** The amount of total UFLS load shall be within  $\pm 5.0$  of the percentage specified by the Planning Coordinator for the total UFLS load in the UFLS scheme.
- M5.** Each UFLS entity that has a total load less than 100 MW in a Planning Coordinator area in the SERC Region shall have evidence such as reports or other documentation demonstrating that its implementation of the UFLS scheme on May 1 of each calendar year meets the requirements of Requirement R5 (including all the data elements in Parts 5.1 and 5.2) unless scheme changes per Requirement R6 are in process.
- R6.** Each UFLS entity shall implement changes to the UFLS scheme which involve frequency settings, relay time delays, changes to the percentage of load in the scheme, or changes to the peak season selected in R2.1 within 18 months of notification by the Planning Coordinator. *[Violation Risk Factor: High] [Time Horizon: Long-term Planning]*
- M6.** Each UFLS entity shall have evidence such as reports or other documentation demonstrating that it has made the appropriate scheme changes within 18 months per Requirement R6. Such evidence is only required if the Planning Coordinator makes changes to the UFLS scheme as specified in Requirement R6.
- R7.** Each Planning Coordinator shall provide the following information to SERC according to the schedule specified by SERC. *[Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*
- 7.1.** Underfrequency trip set points (Hz)
- 7.2.** Total clearing time associated with each set point (sec). This includes the time from when frequency reaches the set point and ends when the breaker opens.
- 7.3.** Amount of previous year actual or estimated load associated with each set point, both in percent and in MW. The percentage and the Load demand (MW) shall be based on the time coincident with the previous year actual Peak Demand.
- M7.** Each Planning Coordinator shall have evidence such as reports or other documentation that data specified in Requirement R7 was provided to SERC in accordance with the schedule.

- R8.** Each Generator Owner shall provide the following information within 30 days of a request by SERC to facilitate post-event analysis of frequency disturbances. *[Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*
- 8.1.** Generator protection automatic underfrequency and overfrequency trip set points (Hz).
  - 8.2.** Total clearing time associated with each set point (sec). This is defined as the time that begins when frequency reaches the set point and ends when the breaker opens. If inverse time underfrequency relays are used, provide the total clearing time at 59.0, 58.5, 58.0, and 57.0 Hz.
  - 8.3.** Maximum generator net MW that could be tripped automatically due to an underfrequency or overfrequency condition.
- M8.** Each Generator Owner shall have evidence such as reports or other documentation that data specified in Requirement R8 was provided to SERC as requested.

## Compliance

### **Compliance enforcement authority**

SERC Reliability Corporation

### **Compliance monitoring and assessment process**

- Compliance Audit
- Self-Certification
- Spot Checking
- Compliance Violation Investigation
- Self-Reporting
- Complaint

### **Evidence retention**

Each Planning Coordinator, UFLS Entity and Generator Owner shall keep data or evidence to show compliance as identified below unless directed by SERC to retain specific evidence for a longer period of time as part of an investigation.

Each Planning Coordinator, UFLS Entity and Generator Owner shall retain the current evidence of each Requirement and Measure as well as any evidence necessary to show compliance since the last compliance audit.

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

The compliance enforcement authority shall keep the last audit records and all requested and submitted subsequent audit records.

Time Horizons, Violation Risk Factors, and Violation Severity Levels

| Table 1 |                     |        |   |  |  |   |
|---------|---------------------|--------|---|--|--|---|
| R#      | Time Horizon        | VRF    | Violation Severity Level  |  |  |   |
|         |                     |        | Lower   | Moderate   | High   | Severe  |
| R1      | Long-term Planning  | Medium | N/A   | N/A  | N/A  | The Planning Coordinator did not have evidence that its criteria included selection of its SERC subregion(s) as an island, with or without adjusted boundaries. |
| R2      | Long-term Planning  | Medium | The Planning Coordinator's scheme did not meet one of the UFLS system design requirements identified in 2.2 through 2.6 | The Planning Coordinator's scheme did not meet two of the UFLS system design requirements identified in 2.2 through 2.6. | The Planning Coordinator's scheme did not meet three of the UFLS system design requirements identified in 2.2 through 2.6. | The Planning Coordinator's scheme did not meet 2.1<br><br><b>OR</b><br>Four or more of the UFLS system design requirements identified in 2.2 through 2.6.       |
| R3      | Long-term Planning  | High   | N/A   | The Planning Coordinator failed to conduct one of the required simulations of its UFLS scheme.                           | N/A  | The Planning Coordinator failed to conduct two of the required simulations of its UFLS scheme.  |
| R4      | Operations Planning | Medium | The UFLS entity's implemented UFLS scheme had one load shedding step outside the range specified in 4.                  | The UFLS entity's implemented UFLS scheme had two load shedding steps outside the range specified in 4.                  | The UFLS entity's implemented UFLS scheme had three or more load shedding steps outside the range                          | The UFLS entity's implemented UFLS scheme had three or more load shedding steps outside the range   |

| Table 1 |                     |        |  |   |  |   |
|---------|---------------------|--------|--|---|--|---|
| R#      | Time Horizon        | VRF    | Violation Severity Level   |   |  |   |
|         |                     |        | Lower  | Moderate  | High   | Severe  |
|         |                     |        | 2.   | 2.  | specified in 4.2.<br><br><b>OR</b><br>The UFLS entity's implemented UFLS scheme had a total load outside the range specified in 4.3. | specified in 4.2.<br><br><b>AND</b><br>The UFLS entity's implemented UFLS scheme had a total load outside the range specified in 4.3.   |
| R5      | Operations Planning | Medium | N/A  | N/A   | N/A  | The UFLS entity's implemented UFLS scheme had a total load outside the range specified in 5.2.  |
| R6      | Long-term Planning  | High   | The UFLS entity implemented required scheme changes but made them 1 to 30 days after the scheduled date. | The UFLS entity implemented required scheme changes but made them 31 to 40 days after the scheduled date. | The UFLS entity implemented required scheme changes but made them 41 to 50 days after the scheduled date.                            | The UFLS entity implemented required scheme changes but made them more than 50 days after the scheduled date<br><br><b>OR</b><br>The UFLS entity failed to implement the required scheme changes. |
| R7      | Long-term Planning  | Lower  | The Planning Coordinator provided the data required in R7 to SERC 1 to 10 days                           | The Planning Coordinator provided the data required in R7 to SERC 11 to 20 days                           | The Planning Coordinator provided the data required in R7 to SERC 21 to 30 days  | The Planning Coordinator provided the data required in R7 to SERC more than 30  |

| Table 1   |                    |       |   |   |  |   |
|-----------|--------------------|-------|---|---|--|---|
| R#        | Time Horizon       | VRF   | Violation Severity Level  |   |  |   |
|           |                    |       | Lower   | Moderate  | High   | Severe  |
|           |                    |       | after the scheduled submittal date.   | after the scheduled submittal date.<br><br><b>OR</b><br>The Planning Coordinator did not provide to SERC one piece of information listed in R7.   | after the scheduled submittal date.<br><br><b>OR</b><br>The Planning Coordinator did not provide to SERC two pieces of information listed in R7.   | days after the scheduled submittal date.<br><br><b>OR</b><br>The Planning Coordinator did not provide to SERC any of the information listed in R7.  |
| <b>R8</b> | Long-term Planning | Lower | The Generator Owner provided the data required in R8 to SERC 1 to 10 days after the requested submittal date. | The Generator Owner provided the data required in R8 to SERC 11 to 20 days after the requested submittal date.<br><br><b>OR</b><br>The Generator Owner did not provide to SERC one piece of information listed in R8. | The Generator Owner provided the data required in R8 to SERC 21 to 30 days after the requested submittal date.<br><br><b>OR</b><br>The Generator Owner did not provide to SERC two pieces of information listed in R8. | The Generator Owner provided the data required in R8 to SERC more than 30 days after the requested submittal date.<br><br><b>OR</b><br>The Generator Owner did not provide to SERC any of the information listed in R8. |

## Regional Variances

None

## Interpretations

None

## Guideline and Technical Basis

### 1. Existing UFLS schemes

Each Planning Coordinator should consider the existing UFLS programs which are in place and should consider input from the UFLS entities in developing the UFLS scheme.

### 2. Basis for SERC standard requirements

SERC Standard PRC-006-SERC-02 is not a stand-alone standard, but was written to be followed in conjunction with NERC Standard PRC-006-1. The primary focus of SERC Standard PRC-006-SERC-02 was to provide region-specific requirements for the implementation of the higher tier NERC standard requirements with the goals of a) adding clarity and b) providing for consistency and a coordinated UFLS scheme for the SERC Region as a whole.

Generally speaking, requirements already in the NERC standard were not repeated in the SERC standard. Therefore, both the NERC and SERC standards must be followed to ensure full compliance.

### 3. Basis for applying a percentage load shedding value to Forecast Load versus Actual Load

The Planning Coordinator will develop a UFLS scheme to meet the performance requirements of NERC Standard PRC-006-2 Requirement R3 and SERC Standard PRC-006-SERC-02 Requirement R2. This development will result in certain percentages of load for each UFLS entity in the Planning Coordinator's area for which automatic under frequency load shedding must be implemented. The Planning Coordinator develops these percentages based on forecast peak load demand. However, the UFLS entity implements these percentages based on the previous year's actual peak demand. Applying the same percentage to these different base values was intentional to ensure that both the Planning Coordinator and UFLS entities had a clear, measurable value to use in performing their respective roles in meeting the standard. Planning Coordinators typically use forecast demands in their work. Whereas the previous year's actual (or estimated) demand is typically more available to UFLS entities. Additionally, the use of percentages based on these different base values tends to minimize the error due to the time lag between design and actual field implementation. Since a percentage is provided by the Planning Coordinator to the UFLS entities, any differences between the design values (i.e., forecast load) and the implemented values (i.e., previous year's actual) would naturally tend to match up reasonably well. For example, if the total planning area load in MW for which UFLS was installed during the time of implementation was slightly higher or lower than the MW value used in the design by the Planning Coordinator, multiplying by the specified percentage would result in an implemented load shedding scheme that also had a reasonably similar higher or lower MW value.

#### **4. Basis for May 1 and 18 month time frames**

Each UFLS entity must annually review that the amount of UFLS load shedding implemented is within a certain tolerance as specified by SERC Standard PRC-006-SERC-02 Requirement R 4 or Requirement R5 by May 1 of the current year. May 1 was chosen to allow sufficient time after the previous year's peak occurred to make adjustments in the field to the implementation if necessary to meet the tolerances specified in Requirement R4 or Requirement R5. Therefore, the May 1 date applies only to implementation of the existing percentages of load shedding specified by the Planning Coordinator. On the other hand, the 18-month time frame specified in PRC-006-SERC-02 Requirement R6 is intended to allow sufficient budgeting, procurement, and installation time for additional equipment, or for significant setting changes to existing equipment necessary to meet a revised load shedding scheme design that has been specified by the Planning Coordinator. During this 18-month transition period, the May 1 measurement of R4 or Requirement R5 would not apply.

#### **5. Basis for smaller entity threshold of 100 MW**

Most distribution substations have transformers rated in the range of 10 to 40 MVA. Usually most transformers would serve 1 to 4 feeders and each feeder will normally carry between 8 and 10 MVA. In general, assuming that each feeder would carry 10 MW, an entity with a load slightly greater than 100 MW would have at least 10 feeders available. For a program with three 10 % steps, only 3 feeders would be required to have under frequency load shed capabilities. The 100 MW threshold seems to provide adequate flexibility for implementing load shedding in three steps for entities slightly greater than 100 MW.

#### **Rationale:**

During development of this standard, text boxes were embedded within the standard to explain the rationale for various parts of the standard. Upon BOT approval, the text from each of the rationale text boxes was moved to this section.

#### **Rationale for R1:**

Studying the Region as an island is required by the NERC standard. Most regions have only one or a few different UFLS schemes. Where there is more than one scheme, studying this island demonstrates that the schemes are coordinated and performing adequately. Because there are so many different UFLS schemes in SERC (18 different schemes were represented in the 2007 SERC UFLS study), the SDT believes that applying the schemes to each subregion as an island is a necessary additional test of the coordination of the various UFLS schemes. Without this additional test, a poorly performing scheme may be masked by the large number of good performing schemes in the Region. A subregion island study, which would have a smaller number of schemes, would be more likely to uncover the poorly performing scheme and therefore get it fixed. This approach will result in a much better overall performance of the UFLS programs in SERC. The SDT recognized that there may be simulation problems due to opening the ties to utilities outside the subregion. Therefore, the subregion island boundaries are allowed to be adjusted to produce an island more suitable for simulation.

(Note: The SERC Subregions are identified in paragraph 4.2 of the SERC Reliability Corporation Bylaws: “The Region is currently geographically divided into five subregions that are identified as Southeastern, Central, VACAR, Delta, and Gateway.”)

**Rationale for R2:**

These requirements for the UFLS schemes in SERC have been in place for many years (except 2.6). The SDT believes that these requirements are still needed to ensure consistency for the various schemes which are used in SERC. Part 2.6 is designed to prevent spurious operations due to transient frequency swings.

**Rationale for R3:**

R4 of the NERC standard PRC-006-1 requires the PC to conduct assessments of UFLS schemes through dynamic simulations to verify that they meet performance requirements for generation/load imbalances of up to 25%. This requirement defines specific imbalances that are to be studied within SERC. The 13% and 22% levels were determined from simulations of the worst case frequency overshoot for the UFLS schemes in SERC.

**Rationale for R4:**

The SDT believes it is necessary to put a requirement on how well the UFLS scheme is implemented. This requirement specifies how close the actual load shedding amounts must be to the percentage of load called for in the scheme. A 4 percentage point range is allowed for each individual step, but the allowed range for all steps combined is 6 percentage points.

**Rationale for R5:**

The SDT believes it is necessary to put a requirement on how well the UFLS scheme is implemented. This requirement specifies how close the actual load shedding amounts must be to the percentage of load called for in the scheme. The SDT recognizes that UFLS entities with a load of less than 100 MW may have difficulty in implementing more than one UFLS step and in meeting a tight tolerance. The basis of the 100 MW comes from typical feeder load dropped by UFLS relays, and the use of a 100 MW threshold in other regional UFLS standards.

**Rationale for R6:**

The SDT believes it is necessary to put a requirement on how quickly changes to the scheme should be implemented. This requirement specifies that changes must be implemented within 18 months of notification by the PC. The 18 month interval was chosen to give a reasonable amount of time for making changes in the field. All of the SERC Region has existing UFLS schemes which, based on periodic simulations, have provided reliable protection for years. Events which result in islanding and an activation of the UFLS schemes are extremely rare in SERC. Therefore, the SDT does not believe that changes to an existing UFLS scheme will be needed in less than 18 months. However, if a PC determines there is a need for changing the UFLS scheme faster than 18 months, then the PC may require the implementation to be done sooner as allowed by NERC Reliability Standard PRC-006-1.

**Rationale for R7:**

The NERC standard requires that a UFLS database be maintained by the Planning Coordinator. This requirement specifies what data must be reported to SERC. A SERC UFLS database is needed to facilitate data sharing across the SERC Region, with other regions, and with NERC.

**Rationale for R8:**

The SDT believes that generator over and under frequency tripping data is needed to supplement the UFLS data provided by the Planning Coordinator for post-event analysis of frequency disturbances. This requirement states what data must be reported to SERC by the Generator Owners.

Since the inverse time curve cannot easily be placed into the SERC database, four clearing times based on data from the curve are requested. These clearing times are intended to cover a range of frequencies needed for event replication as well as provide information about generators that trip at a higher frequency than is allowed by the NERC standard.

**Version History**

| Version | Date               | Action   | Change Tracking |
|---------|--------------------|--|-----------------|
| 1       | September 19, 2011 | SERC Board Approved  |                 |
| 1       | November 3, 2011   | Adopted by NERC Board of Trustees  |                 |
| 1       | December 20, 2012  | FERC Order issued approving PRC-006-SERC-01  |                 |
| 1       | March 11, 2013     | Modified the Rationale and changed the VRF for Requirement R6 from "Medium" to "High" per a compliance filing (Filed on 3/11/13) |                 |
| 2       | June 28, 2017      | SERC Board Approved  |                 |
| 2       | August 10, 2017    | Adopted by NERC Board of Trustees  |                 |
| 2       | October 16, 2017   | FERC Order issued approving PRC-006-SERC-02  |                 |