Introduction

1. Title: Southwest Power Pool (SPP) Automatic Underfrequency Load Shedding

2. Number: PRC-006-SPP-01

3. Purpose: To develop, coordinate and document requirements for automatic underfrequency load shedding (UFLS) programs to arrest declining frequency and assist recovery of frequency following underfrequency events.

4. Applicability:

   4.1. Planning Coordinator

   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. Effective Date: Requirements R4, R5, and R6 shall become effective the first day of the first calendar quarter one year after regulatory approval.

   The remaining requirements shall become effective the first day of the first calendar quarter three years after regulatory approval.

6. Basis for Standard Development: UFLS entity’s planning data for the upcoming calendar year.

   UFLS program performance will be measured based on the entity’s planning values and not the one-minute average of the entity’s load prior to the first underfrequency relay action. This has changed from the current SPP Criteria.
Requirements and Measures

R1. Each UFLS entity that has a total forecasted peak Load greater than or equal to 100 MW shall develop and implement an automatic UFLS program that meets the following requirements: [VRF: High][Time Horizon: Long-term Planning]

1.1. A minimum of 10% shall be shed at each UFLS step in accordance with the table below.

<table>
<thead>
<tr>
<th>(1) UFLS Step</th>
<th>(2) Frequency (hertz)</th>
<th>(3) Minimum accumulated load relief as percentage of forecasted peak Load (%)</th>
<th>(4) Maximum accumulated load relief as percentage of forecasted peak Load (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>59.3</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>59.0</td>
<td>20</td>
<td>35</td>
</tr>
<tr>
<td>3</td>
<td>58.7</td>
<td>30</td>
<td>45</td>
</tr>
</tbody>
</table>

1.2. The intentional relay time delay for UFLS shall be less than or equal to 30 cycles.

1.3. Undervoltage inhibit setting shall be less than or equal to 85 percent of nominal voltage.

M1. Each UFLS entity shall have evidence such as reports, program plans, or other documentation of its UFLS program that demonstrates it meets requirement R1 Parts 1.1 through 1.3.

The current SPP UFLS program includes three separate UFLS steps with a minimum load shedding percentage of 10%, 20%, and 30%, cumulatively, for each of the three steps. These have remained unchanged from the SPP Criteria. The SDT believed that it was reasonable to increase the maximum load shedding percentages in steps 1 and 2. The maximum load shedding percentages in steps 1 and 2 were increased from 15% and 30%, respectively, to 25% and 35%, allowing more flexibility for those steps.

Total forecasted peak Load is the projected planning value of an entity’s end-use customers’ coincident system peak load for the upcoming calendar year.
R2. Each UFLS entity that has a total forecasted peak Load less than 100 MW shall develop and implement an automatic UFLS program that meets the following requirements: [VRF: Medium][Time Horizon: Long-term Planning]

2.1. A minimum of one UFLS step with the frequency set point as assigned by the Planning Coordinator.

2.2. The minimum accumulated Load relief shall be at least 30% of the forecasted peak Load.

2.3. The intentional relay time delay for UFLS shall be less than or equal to 30 cycles.

2.4. Undervoltage inhibit setting shall be less than or equal to 85 percent of nominal voltage.

M2. Each UFLS entity shall have evidence such as reports, program plans, or other documentation of its UFLS program that demonstrates it meets requirement R2 Parts 2.1 through 2.4.

The SDT realized that some small UFLS entities may experience difficulty in achieving more than one UFLS step due to a smaller arrangement of loads and meeting the tolerances set forth in the load shedding table of R1.1. The basis for selecting 100 MW as the threshold comes from the use of this same value in other regional UFLS standards and a reasonable judgment that the total forecasted load served by most smaller electric utilities is less than 100 MW. R2 was structured to accommodate these small entities and its inclusion within this standard indicates the importance of having all entities participate in the UFLS program.
R3. Each UFLS entity electing to use underfrequency islanding schemes shall design those islanding schemes to operate after all 3 steps of UFLS have been exhausted and the frequency continues to fall to 58.5 Hz or below. For islanding schemes designed to operate at or between 58.5 Hz and 58.0 Hz, the minimum time delay shall be 2 seconds. For islanding schemes designed to operate below 58.0 Hz, no time delay is required. [VRF: Lower][Time Horizon: Long-term Planning]

M3. Each UFLS entity electing to use islanding schemes shall have evidence such as reports, program plans, or other documentation of its UFLS program that demonstrates it meets requirement R3.

UFLS entities may elect to implement schemes following operation of all three underfrequency steps should the frequency continue to decay. The SDT believes that a time delay on initiation of islanding for frequencies slightly below the third step of load shedding is necessary to allow time for system recovery and to accommodate some frequency overshoot. The SPP UFLS study, conducted by Powertech, showed that frequency excursions between 58.5 and 58.0 Hz would recover in less than 2 seconds. Therefore, having a 2 second time delay may avoid islanding.

This Requirement does not include Out-of-Step trip relaying designed to isolate portions of the power grid for unstable power swings.
R4. The Planning Coordinator shall perform and document a UFLS technical assessment within one year after the occurrence of any of the following situations: [VRF: Medium][Time Horizon: Long-term Planning]

- Performance characteristic changes to PRC-006 or the SPP UFLS standard.
- Changes to the boundaries of a specified island are identified.

M4. The Planning Coordinator shall have evidence that it performed a technical assessment per requirement R4.

Assessment and documentation of the effectiveness of the design and implementation of the Regional UFLS is required by NERC PRC-006-0 R1.3 to be conducted periodically (at least every five years or required by changes in system conditions). The purpose of the SPP UFLS requirement R4 is to expand upon NERC PRC-006-0 R1.3. “Changes in system conditions” includes performance characteristic changes in PRC-006 or this SPP UFLS document. This also includes changes to the boundaries of a specified island, for example when Nebraska was brought into the SPP specified island. The SDT believes after such changes it is imperative to perform a new assessment to ensure UFLS program effectiveness.
R5. Each UFLS entity shall maintain and submit the following UFLS data based on the forecasted peak Load to the Planning Coordinator within (30) calendar days upon request from the Planning Coordinator: [VRF: Lower][Time Horizon: Long-term Planning]

5.1. Location of installed UFLS equipment

5.2. Trip frequency(s) for each location

5.3. Total relay operating time of each location (time required for the relay to reliably sense the frequency + intentional delay time (if any))

5.4. Breaker operating time (nameplate) of each location

5.5. Percentage and/or MW of bus load to be shed at the location

5.6. Total amount of load shed by each trip frequency and the total forecasted peak Load

5.7. Tie tripping schemes and the frequency and time delay at which they operate

5.8. Islanding schemes and the frequency and time delay at which they operate

M5. Each UFLS entity shall have evidence that the information was supplied to the Planning Coordinator per requirement R5.

The NERC standard requires that; “Each Planning Coordinator shall maintain a UFLS database containing data necessary to model its UFLS program for use in event analyses and assessments of the UFLS.” The information requested in R5 is the data required by the Planning Coordinator to model the UFLS program and maintain compliance to the NERC standard.
R6. Each Generator Owner shall maintain and submit the following data to the Planning Coordinator within (30) calendar days upon request from the Planning Coordinator: [VRF: Lower][Time Horizon: Long-term Planning]

6.1. Location of underfrequency and overfrequency equipment

6.2. Trip frequency(s) for each location

6.3. Total relay operating time of each location (time required for the relay to reliably sense the frequency + intentional delay time (if any))

6.4. Breaker operating time (nameplate) of each location

6.5. MW of generation shed at each location

M6. Each Generator Owner shall have evidence that the information was supplied to the Planning Coordinator per requirement R6.

The SDT believes this generator data is needed by the Planning Coordinator for the following reasons:
1.) better modeling for UFLS technical assessments,
2.) performing routine UFLS studies, and
3.) post-event analysis.

This data will enable the Planning Coordinator to evaluate whether the generator can meet the R7 requirement and determine if additional load shedding is required on the part of the UFLS entities.
R7. Each Generator Owner shall verify that their generating unit(s) will not trip above the Generator underfrequency curve in Attachment 1 and will not trip below the Generator overfrequency curve in Attachment 2 as a result of the unit(s) frequency protective relay settings. [VRF: Medium][Time Horizon: Long-term Planning]

7.1. For generating units with operating characteristics that limit the unit’s ability to perform in accordance with R7, the Generator Owner shall provide to the Planning Coordinator technical evidence demonstrating that the unit cannot operate within the specified frequency range without causing equipment damage or violating manufacturer’s published equipment ratings.

M7. Each Generator Owner shall have evidence that it complies with R7 or that the information was supplied to the Planning Coordinator, if appropriate, as required in R7.1.

In order to effectively study and evaluate the performance of the UFLS system the generator relay protection trip values must be known. The ultimate goal is to balance the generation and load so that a total collapse does not occur. Therefore, the generator trip values are critical to evaluating the performance of the UFLS system. With this information the system can then be studied.
R8. The Planning Coordinator shall determine if the Generator Owner has provided technical evidence demonstrating that the unit cannot operate within the specified frequency range without causing equipment damage or violating manufacturer’s published equipment ratings. [VRF: Medium][Time Horizon: Long-term Planning]

8.1. The Planning Coordinator shall determine if the UFLS program performance is degraded due to the removal of any generation identified in accordance with R7.1 and verified in accordance with R8.

8.1.1. If the Planning Coordinator determines the UFLS program is degraded in accordance with R8.1 and that supplementary load shedding is, therefore, required, the Planning Coordinator shall notify the Generator Owner or UFLS entity(s) in accordance with the following:

- Where the Generator Owner is a UFLS Entity and has the required amount of supplementary Load available, the Planning Coordinator shall notify the Generator Owner of Load the entity is required to shed (in addition to that required in accordance with R1 and R2)

- Where the Generator Owner is not a UFLS Entity, or does not have the required supplementary Load available for shedding, the Planning Coordinator shall notify any other UFLS Entity(s) within the Planning Coordinator Area of Load the entity(s) is required to shed (in addition to that required in accordance with R1 and R2)

M8. The Planning Coordinator shall have evidence that it complies with the requirements in R8.

The Planning Coordinator is required to verify the Generator Owner’s technical justification for not being able to operate throughout the Attachment 1 and 2 curves and to review the consequences to the UFLS program performance for the loss of that additional generation after the initiation of an under frequency event. It also provides a mechanism for the Planning Coordinator to resolve the detrimental effects of the loss of this additional generation if it determines that the performance of the UFLS program is degraded.
**R9.** The Generator Owner or other UFLS entity(s) shall implement supplementary shedding of Load required by the Planning Coordinator in accordance with R8.1.1. [VRF: Medium][Time Horizon: Long-term Planning]

**M9.** The Generator Owner or other UFLS entity shall have evidence that it complies with the requirements in R9.

The SDT’s decision to include R9 is to prevent blackouts caused by early removal of generating units from the system. In a real time load shedding event, if the UFLS is degraded in accordance with R8.1.1, removal of units will make the system condition worse. This is the main reason for the supplementary shedding of loads to compromise the loss of generation. This action is critical to bring back the unstable system to stable.
Compliance

1. Compliance Monitoring Process

1.1. Compliance Enforcement Authority

- SPP Regional Entity
- SERC (for Planning Coordinator only)

1.2. Data Retention

The Planning Coordinator and each UFLS entity and Generator Owner shall keep data or dated evidence to show compliance as identified below unless directed by SPP Regional Entity to retain specific evidence for a longer period of time as part of an investigation:

- Each UFLS entity shall retain the current evidence of Requirements R1 or R2, and R3, Measures M1 or M2, and M3, as well as any evidence necessary to show compliance since the last compliance audit.

- Each UFLS entity shall retain evidence of UFLS data transmittal to the Planning Coordinator since the last compliance audit in accordance with Requirement R5, Measure M5.

- The Planning Coordinator shall retain the current evidence of Requirement R4, Measure M4 as well as any evidence necessary to show compliance since the last compliance audit.

- Each Generator Owner shall retain evidence of UFLS data transmittal to the Planning Coordinator since the last compliance audit in accordance with Requirement R6, Measure M6.

- Each Generator Owner shall retain evidence of Requirements R7, Measures M7 as well as any evidence necessary to show compliance since the last compliance audit.

If the 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.

1.3. Compliance Monitoring and Assessment Process
1.4. Additional Compliance Information

UFLS entities may implement an aggregated UFLS program with other UFLS entities. In R1 and R2, the 100 MW limit refers to the aggregated UFLS program, if one exists.
## 2. Violation Severity Levels

<table>
<thead>
<tr>
<th>R#</th>
<th>Time Horizon</th>
<th>VRF</th>
<th>Lower</th>
<th>Moderate</th>
<th>High</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>Long-Term Planning</td>
<td>High</td>
<td>N/A</td>
<td>UFLS entity developed a program, but failed to meet any one (1) of the following 5 requirements:</td>
<td>UFLS entity developed a program, but failed to meet any two (2) of the following 5 requirements:</td>
<td>UFLS entity developed a program, but failed to meet three (3) or more of the following 5 requirements:</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Part 1.1 (Step1-3)</td>
<td>Part 1.1 (Step1-3)</td>
<td>Part 1.1 (Step1-3)</td>
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<td></td>
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<td>Part 1.2</td>
<td>Part 1.2</td>
<td>Part 1.2</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Part 1.3</td>
<td>Part 1.3</td>
<td>OR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Failed to develop a UFLS program</td>
</tr>
<tr>
<td>R2</td>
<td>Long-Term Planning</td>
<td>Medium</td>
<td>UFLS entity developed a program, but failed to meet one (1) of the requirements in Parts 2.1 through 2.4</td>
<td>UFLS entity developed a program, but failed to meet two (2) of the requirements in Parts 2.1 through 2.4</td>
<td>UFLS entity developed a program, but failed to meet three (3) of the requirements in parts 2.1 through 2.4</td>
<td>UFLS entity developed a program, but failed to meet all four (4) of the requirements in Parts 2.1 through 2.4</td>
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<tr>
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<td></td>
<td>OR</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Failed to develop a UFLS program</td>
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### Regional Reliability Standard: PRC-006-SPP-01

**Title:** SPP Automatic Underfrequency Load Shedding

<table>
<thead>
<tr>
<th>R #</th>
<th>Time Horizon</th>
<th>VRF</th>
<th>Violation Severity Level</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
</tr>
<tr>
<td>R3</td>
<td>Long-Term Planning</td>
<td>Lower</td>
<td>N/A</td>
</tr>
<tr>
<td>R4</td>
<td>Long-Term Planning</td>
<td>Medium</td>
<td>The Planning Coordinator performed a technical assessment within five years and three months or within one year and three months after one of the situations listed in R4</td>
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<tr>
<td>R5</td>
<td>Long-Term Planning</td>
<td>Lower</td>
<td>UFLS entity provided required data more than 30 calendar days and up to and including 45 calendar days following the request</td>
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</table>
### R6: Long-Term Planning

<table>
<thead>
<tr>
<th>R#</th>
<th>Time Horizon</th>
<th>VRF</th>
<th>Violation Severity Level</th>
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</thead>
<tbody>
<tr>
<td>R6</td>
<td>Lower</td>
<td>Generator Owner provided required data more than 30 calendar days and up to and including 45 calendar days following the request OR Generator Owner did not provide one piece of information listed in R6 (e.g., 6.1.)</td>
<td>Generator Owner provided required data more than 45 calendar days and up to and including 60 calendar days following the request OR Generator Owner did not provide two pieces of information listed in R6 (e.g., 6.1. and 6.2.) OR Generator Owner did not provide required data after the request was made OR Generator Owner did not provide three or more pieces of information listed in R6 (e.g., 6.1. and 6.2. and 6.3.)</td>
</tr>
</tbody>
</table>

- **Lower**
  - (e.g., 5.1.)
- **Moderate**
  - Information listed in R5 (e.g., 5.1. and 5.2.)
- **High**
  - Made
    - OR
      - UFLS entity did not provide three or more pieces of information listed in R5 (e.g., 5.1. and 5.2. and 5.3.)
### Regional Reliability Standard: PRC-006-SPP-01

**Title:** SPP Automatic Underfrequency Load Shedding

<table>
<thead>
<tr>
<th>R #</th>
<th>Time Horizon</th>
<th>VRF</th>
<th>Lower</th>
<th>Moderate</th>
<th>High</th>
<th>Severe</th>
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<tbody>
<tr>
<td>R7</td>
<td>Long-Term Planning</td>
<td>Medium</td>
<td>N/A</td>
<td>N/A</td>
<td>The Generator Owner did not provide technical evidence to the Planning Coordinator demonstrating that the unit cannot operate within the specified frequency range without causing equipment damage or violating manufacturer’s published equipment ratings for their generating units with operating characteristics that limit the unit’s ability to perform in accordance with R7.</td>
<td>The Generator Owner did not verify that their generating unit(s) will not trip above the Generator underfrequency curve in Attachment 1 and will not trip below the Generator overfrequency curve in Attachment 2 due to the generator unit frequency protective relay settings.</td>
</tr>
<tr>
<td>R8</td>
<td>Long-Term Planning</td>
<td>Medium</td>
<td>N/A</td>
<td>N/A</td>
<td>The Planning Coordinator determined that the UFLS program was degraded in accordance with R8.1, but did not notify the Generator Owner or the UFLS entity of the Load that they were required to</td>
<td>The Planning Coordinator did not determine if the UFLS program performance was degraded due to the removal of any generation identified in accordance with R7.1 and verified in accordance with R8.</td>
</tr>
</tbody>
</table>
### SPP Automatic Underfrequency Load Shedding

<table>
<thead>
<tr>
<th>R#</th>
<th>Time Horizon</th>
<th>VRF</th>
<th>Violation Severity Level</th>
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</thead>
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<tr>
<td></td>
<td></td>
<td>Lower</td>
<td>Moderate</td>
</tr>
<tr>
<td>R9</td>
<td>Long-Term Planning</td>
<td>Medium</td>
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### B. Associated Documents

#### Version History

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Action</th>
<th>Change Tracking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Draft 1</td>
<td>3/31/2009 thru 4/30/2009</td>
<td>Posted for 1&lt;sup&gt;st&lt;/sup&gt; Comment Period</td>
<td>Initial version</td>
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<tr>
<td>Draft 2</td>
<td>8/31/2009 thru 9/30/2009</td>
<td>Posted for 2&lt;sup&gt;nd&lt;/sup&gt; Comment Period</td>
<td>Revised to address comments from Draft 1</td>
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<td>Draft 3</td>
<td>3/29/2010 thru 4/28/2010</td>
<td>Posted for 3&lt;sup&gt;rd&lt;/sup&gt; Comment Period</td>
<td>Revised to address comments from Draft 2</td>
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<td>Draft 4</td>
<td>12/18/2010 thru 1/7/2011</td>
<td>Posted for 4&lt;sup&gt;th&lt;/sup&gt; Comment Period</td>
<td>Revised to address comments from Draft 3</td>
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<td>Draft 5</td>
<td>1/18/2011</td>
<td>Posted for 1&lt;sup&gt;st&lt;/sup&gt; Open Vote</td>
<td>Revised to address comments from Draft 4</td>
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<td>Draft 6</td>
<td>6/10/2011 thru 7/10/2011</td>
<td>Posted for 6&lt;sup&gt;th&lt;/sup&gt; Comment Period</td>
<td>Revised to address comments from Draft 5</td>
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<td>Draft 7</td>
<td>9/30/2011</td>
<td>Posted for 2&lt;sup&gt;nd&lt;/sup&gt; Open Vote</td>
<td>Revised to address comments from Draft 6 and changed to results-based format</td>
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PRC-006-SPP-1 - Attachment 1
Underfrequency Curves for Requirement R7

Time (sec)

Frequency (Hz)

Generator Underfrequency Trip Modeling
PRC-006-SPP-1 - Attachment 2
Overfrequency Curves for Requirement R7

Frequency (Hz)

Time (sec)

Generator Overfrequency Trip Modeling