• What is NERC – North American Electric Reliability Corporation
• 2003 Blackout – Section 215 Federal Power Act - FERC
• Electric Reliability Organization (ERO)
• NERC and 7 Regions
  ▪ WECC
  ▪ TRE
  ▪ MRO
  ▪ RF
  ▪ NPCC
  ▪ SERC
  ▪ FRCC
• Why are we talking about Misoperations?

• State of Reliability Report (SOR)
  ▪ Every SOR (2012 -2018) has concluded that Misoperations are a significant reliability risk

• Reliability Issues Steering Committee (RISC)
  ▪ Every RISC Report has identified Misoperations as a risk

• NERC goal to reduce misoperations
Misoperations Data Sources

- 1600 Data Request
  - MIDAS
  - Transmission Availability Data System (TADS)
- Event Analysis
Overall 278 Cat 1a events, with 218 of these cause coded Missoperations 10.11% 9.53% 9.66% 8.97% 7.52%

NERC Misoperation rate

- 2013: 10.11%
- 2014: 9.53%
- 2015: 9.66%
- 2016: 8.97%
- 2017: 7.52%
Overall 278 Cat 1a events, with 218 of these cause coded Misoperations.
Overall 278 Cat 1a events, with 218 of these cause coded

NERC vs WECC 2017 Misop rate

NERC: 7.52%
WECC: 5.71%
Overall 278 Cat 1a events, with 218 of these cause coded

Misoperations

NERC
WECC

Misop rate by voltage

NERC
WECC

100-200kV 230kV 345kV 500kV 735kV
2017 # of misops by voltage

- 100-200kV
- 230kV
- 345kV
- 500kV
- 735kV

NERC
WECC
Overall 278 Cat 1a events, with 218 of these cause coded.

### 2017 misops by category

- Unnecessary trip: 1500
- Fail to trip: 100
- Slow trip: 50

**Graph:**
- X-axis: Unnecessary trip, Fail to trip, Slow trip
- Y-axis: 0 to 1600
Overall 278 Cat 1a events, with 218 of these caused by misoperations.
Event Analysis Misoperation Data

Incorrect ground settings

- Incorrect Relay Settings
- Incorrect Ground Overcurrent Setting
Event Analysis Trends

- Instantaneous Ground Overcurrent settings
- Breaker failure scheme misoperations
- Current transformer circuit errors
- Commission Testing
  - Need to reinforce robust detailed commission testing
  - Lesson Learned 20140302 - Verification of Alternating Current Quantities during Protection System Commissioning
  - Relay Checking/System Simulator
• Breaker failures
• Incorrect breaker failure Design / Logic / Wiring
  ▪ Slow breaker operation
    o Lubrication
    o exercise does not equal maintenance
Lessons Learned

Disclaimer for Lessons Learned: These documents are designed to convey lessons learned from NERC’s various activities. They are not intended to establish new requirements under NERC’s Reliability Standards or to modify the requirements in any existing Reliability Standards. Compliance will continue to be determined based on language in the NERC Reliability Standards as they may be amended from time to time. Implementation of these lessons learned is not a substitute for compliance with requirements in NERC’s Reliability Standards.

For a brief summary of the lessons learned that have been posted, please refer to the Lessons Learned Quick Reference Guide.

<table>
<thead>
<tr>
<th>Lessons Learned</th>
<th>Category</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>LL20161001</td>
<td>DC Grounds and AC Tied to DC Cause Multiple Relay Maloperations</td>
<td>10/4/2015</td>
</tr>
<tr>
<td>LL2016201</td>
<td>Tie Line Relay Coordination</td>
<td>8/20/2016</td>
</tr>
<tr>
<td>LL2016301</td>
<td>Transmission Relaying - Relay Setting Issue</td>
<td>6/7/2016</td>
</tr>
<tr>
<td>LL2015002</td>
<td>Relay Design and Testing Practices to Prevent Scheme Failures</td>
<td>9/15/2015</td>
</tr>
<tr>
<td>LL2015041</td>
<td>Detailed Installation and Commissioning Testing to Identify Wiring or Design Errors</td>
<td>4/21/2015</td>
</tr>
<tr>
<td>LL2015022</td>
<td>Consideration of the Effects of Mutual Coupling when Setting Ground Instantaneous Overcurrent Elements</td>
<td>2/10/2015</td>
</tr>
<tr>
<td>LL2015012</td>
<td>Digital Inputs to Protection Systems May Need to be Desensitized to Prevent False Tripping Due to Transient Signals</td>
<td>2/10/2015</td>
</tr>
<tr>
<td>LL2014120</td>
<td>Bus Differential Power Supply Failure</td>
<td>12/9/2014</td>
</tr>
<tr>
<td>LL2014003</td>
<td>System Protection Review Prior to Disabling Protective Relays</td>
<td>6/30/2014</td>
</tr>
<tr>
<td>LL2014050</td>
<td>Generation Relaying - Overexclusion</td>
<td>6/8/2014</td>
</tr>
<tr>
<td>LL2014060</td>
<td>Generation Relaying - Underfrequency Protection Coordination</td>
<td>6/15/2014</td>
</tr>
<tr>
<td>LL2014051</td>
<td>High AC Voltage can Lead to Remote Terminal Unit Failures</td>
<td>5/20/2014</td>
</tr>
<tr>
<td>LL2014010</td>
<td>Verification of Alternating Current Quantities during Protection System Commissioning</td>
<td>3/1/2014</td>
</tr>
<tr>
<td>LL2014020</td>
<td>Identify Relay Programming Errors to Prevent Unintended Operations</td>
<td>2/5/2014</td>
</tr>
</tbody>
</table>
PROTECTION SYSTEM MISOPERATIONS
Report and Mitigation Approaches
January 2017

WECC
A Review of Ground Fault Protection Methods For Transmission Lines
Developed by the ERCOT System Protection Working Group

An examination of methods and best practices associated with transmission system ground fault protection.

ERCOT SPWG Ground Fault Focus Group
3/2/2017
## System Protection and Control Subcommittee (SPCS)

### Reliability Guidelines

<table>
<thead>
<tr>
<th>File Type</th>
<th>Size</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrobat</td>
<td>434 KB</td>
<td>1/10/2012</td>
<td>Transmission System Phase Backup Protection</td>
</tr>
<tr>
<td>Acrobat</td>
<td>290 KB</td>
<td>6/12/2006</td>
<td>Methods to Increase Line Relay Loadability (June 2006)</td>
</tr>
<tr>
<td>Acrobat</td>
<td>87 KB</td>
<td>6/12/2006</td>
<td>Switch-on-to-Fault Schemes in the Context of Line Relay Loadability (June 2006)</td>
</tr>
<tr>
<td>Acrobat</td>
<td>366 KB</td>
<td>12/13/2005</td>
<td>Increase Line Loadability by Enabling Load Enforcement Functions of Digital Relays (December 2005)</td>
</tr>
<tr>
<td>Acrobat</td>
<td>366 KB</td>
<td>8/19/2005</td>
<td>Relay Loadability Exceptions - Determination and Application of Practical Relaying Loadability Ratings (August 2005)</td>
</tr>
<tr>
<td>Acrobat</td>
<td>365 KB</td>
<td>8/19/2005</td>
<td>Protection System Review Program - Beyond Zone 3 (August 2005)</td>
</tr>
<tr>
<td>Acrobat</td>
<td>17 KB</td>
<td>8/19/2005</td>
<td>Operationally Significant Circuits (August 2005)</td>
</tr>
<tr>
<td>Acrobat</td>
<td>397 KB</td>
<td>9/29/2004</td>
<td>Relay Loadability Exceptions Interim Document</td>
</tr>
<tr>
<td>Acrobat</td>
<td>83 KB</td>
<td>7/26/2004</td>
<td>System Protection and Control Task Force's Initial Recommendations Concerning NERC Recommendation 8A Loadability Requirements on Transmission Protective Relaying Systems</td>
</tr>
<tr>
<td>Acrobat</td>
<td>43 KB</td>
<td>6/22/2004</td>
<td>Clarification of the Transmission Line Emergency Ampere Rating to be used to Determine Compliance with Loadability Requirements for Zone 3 Relays (Blackout Recommendation 8a)</td>
</tr>
</tbody>
</table>

### References

- Acrobat 756 KB 9/17/2004: Application of Line Loadability Concepts to Operating Studies
- Acrobat 719 KB 9/17/2004: EHV and UHV Line Loadability Dependence on VAR Supply Capability
# Power System Relaying Committee

## I25 - Commissioning of Substation Protection and Control Schemes

**Assignment**
Write a report to provide guidance in the commissioning of power system protection systems. This report will cover overall system testing procedures for generators, lines, line reactors, transformers, capacitors, and special protection schemes.

**Chair**
Garcia

**Vice Chair**
Kevin Donahoe
Misoperations Reduction Strategy

Purpose and Request

Protection systems are critical to the reliable operation of the electric grid. When protection systems fail to operate or operate incorrectly, the grid is operating in a less reliable state. In recent years, an increasing number of outages and events on the system have involved misoperations of protection systems, and these events tend to be more severe than events without misoperations. Addressing misoperations of protection systems is an important step in assuring the reliability of the bulk power system.

Reducing the number of protection system misoperations in the Western Interconnection requires coordination, communication, and partnership across industry, regulators, and vendors. To focus a coordinated effort, the WECC Misoperations Reduction Strategy Advisory Group, which included members from industry, WECC and its sister Regions, and NERC, created this draft Misoperations Reduction Strategy.

The advisory group requests and welcomes comments from all interested parties on all aspects of the draft Misoperations Reduction Strategy. The advisory group intends to use the comments to revise and refine the draft, with the hope of launching a coordinated, Interconnection-wide Misoperations Reduction Strategy in early 2018.

Misoperation Analysis

The draft Misoperations Reduction Strategy focuses on the top three causes of misoperations in the Western Interconnection. These cause categories make up 72 percent of all reported misoperations:

- Incorrect setting/logic/design errors
- Relay failures/malfunctions
- Unknown/unexplainable

By targeting these three causes, the West can take actions that will have the most impact in reducing the rate of misoperations.

Navigating the Strategy:
The draft Misoperations Reduction Strategy is organized in eight issue-specific documents with four components:

1. Issue Summary – Provides a description of the issue.
2. Analysis – Provides additional insight into why the advisory group included the issue.
3. Action Plan – Outlines a set of proposed actions and actors to address the issue.
4. Time Estimate – Anticipated duration of each individual action, from creation to execution.

How to Comment:

1. Go to: https://www.wecc.biz/Performance/Analysis/ Pages/Misoperations.aspx
2. Open the “Reduction Strategy” bar.
3. Review the issue documents.
4. Click “Submit Comments” button (You must be logged in to the WECC website. Anyone with an email address can create a WECC website login).
5. Complete and submit the comment form.
Evaluation of Unknown Outages and Misoperations

Related Entity Best Practices
WECC Performance Analysis
December 1, 2016
• WECC Misoperations Workshop June 5\textsuperscript{th} and 6th
• Bi-monthly webinars on Misoperations (4\textsuperscript{th} Thursday of every even month)
• RF Misoperation workshop August 14\textsuperscript{th} and 15\textsuperscript{th}
• MRO Spring Reliability Conference May 23\textsuperscript{rd}
Lessons Learned

230kV

500kV

Fault
Lessons Learned

230kV

500kV

Fault

terminals trip
Lessons Learned

Fault

230kV

500kV

500kV

Reclose
Lessons Learned

Simplified LR1 Scheme

- Rcvd DTT
- Remote Terminal 2
- Remote Terminal 3

LR1 Trip

- DTT2a
- DTT2b
- DTT3a
- DTT3b

- Trip 2B TC1
- Trip 2C TC1

Auxiliary trip relay contacts

52a A 2B
52a B 2B
52a C 2B
52a A 2C
52a B 2C
52a C 2C

Simplified LR2 Scheme

- Rcvd DTT
- Remote Terminal 2
- Remote Terminal 3

LR2 Trip

- Trip 2B TC2
- Trip 2C TC2

Auxiliary trip relay contacts

52a A 2C
52a B 2C
52a C 2C
52a A 2B
52a B 2B
52a C 2B
LR2 Scheme (Simplified)

Remote Terminal 2
- DT T1
- DT T2

Remote Terminal 3
- LR2 Trip (311L)
- DT T1
- DT T2

LR2 Trip (311L)

Auxiliary trip relays
- AR

Auxiliary trip relay contacts
- Trip 2B TC2
- Trip 2C TC2
- BFI 2B
- BFI 2C

Recl Init 2B
- Spare

Recl Init 2C
- Spare
• **NERC System Protection and Control Subcommittee Reference documents**

• **WECC Misoperation Reduction Strategy**
  - [https://www.wecc.biz/PerformanceAnalysis/Pages/Misoperations.aspx](https://www.wecc.biz/PerformanceAnalysis/Pages/Misoperations.aspx)

• **WECC Misoperation Reference documents**
  - [https://www.wecc.biz/PerformanceAnalysis/Pages/Default.aspx](https://www.wecc.biz/PerformanceAnalysis/Pages/Default.aspx)

• **NERC Lessons Learned**
Questions

Rich Bauer
Associate Director
Reliability Risk Management, Event Analysis
Office (404) 446-9738
Cell (404) 357-9843
rich.bauer@nerc.net