• Protection System Misoperations Task Force Report
• Protection System Misoperations Dashboard
• NERC Misoperation Reporting Template
• Questions and Answers for NERC Misoperations Reporting
Questions and Answers from Webinar (1)

- **Is the 'Incorrect Protection Setting' category:** (1) a calculation error, (2) an incorrect transmittal of a setting to the field, (3) an incorrect placement of a setting on the protective device in the field or a combination of all these factors?
  - Incorrect settings are not due solely these factors, and they also include errors in impedances, fault models and element application.
  - Incorrect placement of a setting in the field should be cause coded as “as-left personnel error”.

- **In Rich Bauer's presentation - where did he get the "thru 4/13" data from? We haven't had to submit our data to SERC yet?**
  - The misoperations from Mr. Rich Bauer’s presentation are reported from NERC Event Analysis data. Event Analysis data is separate from the PRC-004 reporting to the Regional Entities and is reported within 10 days of a disturbance event.

- **Setting errors appear to stem from a training/experience issue. Are you expecting each entity to address this individually? Seems like a NERC series of workshops would be beneficial.**
  - A training module to address specific protection system issues is being considered to help address the problem NERC-wide. Individual entities should also address relevant issues internal to their company.
To what level of review are the relay settings peer reviews taken?

- “The review generally consists of verifying that the relay scheme is wired according to the design drawings, uses the correct potential and current transformer ratios, and checks the input/output connections for used for tripping and control. Once the relay application is reviewed, then the protection setting calculations are checked for correct application and mathematics.”

For misoperations resulting from the application of functionally different relay elements, was this primarily due to the sophistication of new microprocessor protective devices (many element types) or due to attempting to coordinate new microprocessor protective devices with existing legacy electromechanical relays?

- The misoperations resulting from the application of functionally different relay elements were primarily due to attempting to coordinate new microprocessor devices with electromechanical relays.
• Can you elaborate on the 24 hour bullet point from the last slide (slide 48)?
  ▪ Currently, multiple misoperations are reported if multiple trips occur before a field technician can troubleshoot the relay.
  ▪ Having a 24-hour window where the trips are considered one misoperation would help to consolidate multiple occurrences, that are essentially the same equipment, into the same corrective action plan.
  ▪ Instead of creating separate misoperations, the number of trips would be recorded for these misoperations.

• Are there any plans to mandate through the adoption of new reliability standards specific corrective actions relating to human performance (i.e. peer review of settings)?
  ▪ At this time, there are no plans to adopt new reliability standards to mandate specific actions relating to human performance.
• As far Microprocessor based relays, did you have any specific model that you recommend?
  ▪ Based on the NERC anti-trust guidelines, no specific model of relays can be recommended. However, the majority of the misoperations were related to the application of the relay rather than the attributes of a particular model.

• Was there an overall sense that utilities were not coordinating with each other well?
  ▪ Based on the analysis of the data, it could not be definitively determined that utilities were not coordinating well with each other. However, entities should strive to improve their coordination efforts amongst their neighboring entities to improve protection system reliability.
It is NERC’s policy and practice to obey the antitrust laws and to avoid all conduct that unreasonably restrains competition.

This policy requires the avoidance of any conduct that violates, or that might appear to violate, the antitrust laws.

Among other things, the antitrust laws forbid any agreement between or among competitors regarding prices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that unreasonably restrains competition.
• Participants are reminded that this webinar is public.
• The access number was posted on the NERC website and widely distributed.
• Speakers on the call should keep in mind that the listening audience may include members of the press and representatives of various governmental authorities, in addition to the expected participation by industry stakeholders.
• Objectives
  - Jeff Mitchell, NERC Planning Committee Chair, Director, Reliability Assessment and Performance Analysis, ReliabilityFirst Corporation

• NERC Event Analysis Trends in Protection System Misoperations
  - Rich Bauer, Senior Reliability Specialist, NERC

• Protection System Misoperations Task Force Report Key Findings
  - Andy Slone, NERC, Reliability Performance Analysis Engineer
  - Richard Quest, MRO, Principal Systems Protection Engineer
Objectives

- Provide insight into protection system misoperations
  - Identified as a significant reliability issue
- Lessen the disturbance event severity caused by misoperations
- Disseminate actionable information to prevent and reduce misoperations
• NERC Event Analysis
  • 2012
    o 116 Category 1-5 Events
    o 42 Events with Misoperations

- Events without Misops 64%
- Events with Misops 36%
2012 NERC EA Misoperations by Cause

- Incorrect protection setting: 29%
- Communications: 15%
- Failed relay: 17%
- CT circuit: 9%
- Other: 10%
- Incorrect logic: 10%
- Wiring/design error: 8%
- Control system: 0%
- Bad CT: 2%
NERC-wide Misoperations by Cause Code (Jan 1, 2011 – April 1, 2012)

- Incorrect setting / logic / design errors, 628, 28%
- Relay failures / malfunctions, 465, 20%
- Communication failures, 396, 17%
- AC system, 193, 8%
- As-left personnel error, 201, 9%
- Unknown / unexplainable, 273, 12%
- DC system, 112, 5%
- Other, 11, 1%
2012 EA Misoperations
Causes Aligned to PSMTF Categories

2012 EA Misops by Cause
(aligned to PSMTF codes)

- Incorrect protection, setting/logic/design errors: 46%
- Failed relay: 17%
- Communications: 15%
- Ct circuit: 10%
- Other: 10%
- Control system: 0%
- Bad ct: 2%
NERC EA 2012 Misops by Cause

NERC EA 2012 Misops by cause

incorrect protection setting
failed relay
communications
circuit
other
incorrect logic
wiring/design error
bad ct
control system
• A1 – Design / Engineering
• A2 – Equipment / Material
• A3 – Individual Human Performance
• A4 – Management / Organization
• A5 – Communication
• A6 – Training
• A7 – Other
• AZ – Unable to determine root cause

2012 Events – 43% AZ
NERC Event Analysis Cause Coding

Reference Material for Cause Analysis Methods & Tools

Preliminary 2013 Event Analysis as of 4/30/2013

- 33 events
  - 10 Misoperations
Protection System Misoperations Task Force

Report Key Findings

Andy Slone, NERC, Reliability Performance Analysis Engineer
Richard Quest, MRO, Principal Systems Protection Engineer
May 7, 2013
PSMTF formed by NERC Planning Committee in March 2012

PSMTF composed of protection system experts from all 8 Regional Entities to:

- Analyze relay misoperation data
- Research root causes
- Develop industry recommendations to reduce future relay misoperation occurrences

Throughout the process, PSMTF coordinated with NERC System Protection and Control Subcommittee (SPCS)
Protection System Misoperations Task Force (PSMTF) Analysis

- Reviewed historical (pre-2011) Regional Entity misoperations
- Analyzed misoperations from January 1, 2011 to April 1, 2012 submitted in NERC misoperations template
- Focused on top 3 misoperation causes:
  - Incorrect settings/logic/design
  - Relay failure/malfunction
  - Communication failures
- Classified misoperations in top 3 misoperation causes by sub causes
- Based on the analysis of top issues, developed suggestions for improvement to reduce top misoperation areas
- Recommended data monitoring and data improvements
• Reviewed historical (pre-2011) Regional Entity misoperations
• Top 3 misoperation causes from pre-2011 Regional Entity data
  ▪ Incorrect settings/logic/design errors
  ▪ Relay failures/malfunctions
  ▪ Communication failures
• Supported top causes of 2011Q1-2012Q1 misoperations
NERC-wide Misoperations by Cause Code (Jan 1, 2011 – April 1, 2012)

- Relay failures / malfunctions, 465, 20%
- Communication failures, 396, 17%
- AC system, 193, 8%
- As-left personnel error, 201, 9%
- DC system, 112, 5%
- Unknown / unexplainable, 273, 12%
- Other, 11, 1%
- Incorrect setting / logic / design errors, 628, 28%
NERC Wide Misoperations by Category (Jan 1, 2011 – April 1, 2012)

- Unnecessary Trip during fault, 1319, 58%
- Unnecessary Trip other than fault, 818, 36%
- Failure to Trip, 104, 4%
- Slow trip, 38, 2%
• Approximately 94% of misoperations in the study period resulted in unnecessary trips.

• Only 6% resulted in a failure to trip or slow trip.

• However, as the power system is worked closer to its limits, planners and protection engineers and other interested parties should work together to determine proper protection system scheme application and setup to ensure proper emphasis on both dependability and security.
NERC-wide Misoperations by Voltage Class (Jan 1, 2011 – April 1, 2012)

- 100-199 kV, 1501, 65.9%
- 200-299 kV, 388, 17.0%
- 300-399 kV, 258, 11.3%
- 400-599 kV, 70, 3.1%
- 600-799 kV, 12, 0.5%
- Undetermined, 50, 2.2%
NERC Wide Misoperations by Technology Type
(for Incorrect Settings/Logic/Design Cause Only)

- Microprocessor, 476, 76%
- Electromechanical, 87, 14%
- Solid State, 41, 6%
- Blank/Null, 24, 4%
NERC Wide Misoperations by Technology Type
(for Relay Failures Cause Only)

Microprocessor, 171, 37%

Electromechanical, 199, 43%

Solid State, 86, 18%

Other, 9, 2%
To maximize effort, focused on top 3 misoperation causes (1,489 or 65% of the misoperations):

- Incorrect settings/logic/design
- Relay failure/malfunction
- Communication failures

Three teams analyzed each misoperation by category

Categorized misoperations by second and (if possible) third level causes
• Settings/Logic/Design Errors
  ▪ John Zipp (Lead), ITC Holdings
  ▪ Rick Gurley, American Electric Power
  ▪ Richard Quest, Midwest Reliability Organization
  ▪ Thomas Teafatiller, Southwest Power Pool, Inc.

• Relay Failures/Malfunctions
  ▪ James Ryan (Lead), Florida Power & Light Co.
  ▪ Randy Spacek, Avista Corp.
  ▪ Ken Behrendt, Schweitzer Engineering Laboratories
  ▪ Quoc Le, Northeast Power Coordinating Council

• Communication Failures
  ▪ John Miller (Lead), Georgia Transmission Corporation
  ▪ Alex Echeverria, New York Power Authority
  ▪ David Greene, SERC Reliability Corporation
Incorrect Settings/ Logic/ Design Errors

• This category includes misoperations due to “engineering” errors by the protection system owner. These include:
  ▪ Setting errors;
  ▪ Errors in documentation;
  ▪ And errors in application.

• Examples include:
  ▪ Uncoordinated settings;
  ▪ Incorrect schematics;
  ▪ Or multiple CT grounds in the design.
Incorrect Settings/Logic/Design Errors by Second Level Cause

<table>
<thead>
<tr>
<th>Second Level Cause</th>
<th>Misoperations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relay Settings Protective Function</td>
<td>306</td>
</tr>
<tr>
<td>Relay Settings Logic</td>
<td>152</td>
</tr>
<tr>
<td>Wiring Design Prints</td>
<td>66</td>
</tr>
<tr>
<td>Relay Misapplication</td>
<td>26</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
</tr>
<tr>
<td>Insufficient Information</td>
<td>75</td>
</tr>
<tr>
<td>Wrong Code</td>
<td>24</td>
</tr>
<tr>
<td>Not a misop</td>
<td>8</td>
</tr>
</tbody>
</table>
Relay Settings – Protective Function Misoperations by Third Level Cause

- Protection Element Setting Error: 147
- Improper Relay Coordination Timing: 68
- Over Reaching Zone 1 or IOC Elements: 52
- Improper Coordination of DCB Scheme Trip and Block Elements: 24
- Modeling Errors: 15
Relay Settings – Logic Misoperations by Third Level Cause

- General Setting Logic Error: 87
- Direction Settings Issues: 29
- Coordination Timers Set Improperly: 14
- Winding Compensation Issues: 11
- Improper Use of Echo Logic: 9
- Firmware Issues: 2
• This category includes misoperations due to improper operation of the relays themselves.
• These may be due to:
  ▪ Component failures;
  ▪ Physical damage to a device;
  ▪ Firmware problems;
  ▪ Or manufacturer errors.
• Examples would include Misoperations caused by:
  ▪ Changes in relay characteristic due to capacitor aging;
  ▪ Misfiring thyristors;
  ▪ Damage due to water from a leaking roof;
  ▪ Relay power supply failure;
  ▪ Or internal wiring/logic error.
• Failures of auxiliary tripping relays fall under this category.
Reliability | Accountability

Relay Failure/Malfunction Misoperations by Second Level Cause and Relay Technology

Relay Failure/Malfunction Misoperations by Second Level Cause and Relay Technology

- Internal/Component Failure
- Out-of-Tolerance/Calibration
- Firmware/Algorithm/Design Issue
- Environmental
- Relay Wiring/Connection Issue
- Uncorrected Repetitive Failure
- Insufficient Information
- Incorrect Cause

- Other
- Solid State
- Microprocessor
- Electromechanical
This category includes misoperations due to failures in the communication systems associated with protection schemes inclusive of transmitters and receivers.

Examples would include misoperations caused by:

- Loss of carrier;
- Spurious transfer trips associated with noise;
- Telco errors resulting in malperformance of communications over leased lines;
- Loss of fiber optic communication equipment;
- Or microwave problems associated with weather conditions.
For power line carrier applications

Incorrect protection settings are not considered communications failures
Communication Failure Misoperations by Second Level Cause and Category

- Communication Interface Failure (Modulator): 95
- Communication Medium: 29
- Station Signal Path Failure: 61
- Incorrect Logic Settings Issued - Communications: 9
- Human Error (Misapplication in Field) - Communications: 9
- Relay wiring/connection: 13
- Multiple Second Level Causes: 74
- Insufficient Information: 23
- Wrong Code: 9
- Not a misoperation: 0

- Unnecessary Trip other than fault
- Unnecessary Trip during fault
- Slow Trip
- Failure to Trip
• Proper Application of Relay Elements
• Settings Errors
• Microprocessor-based Relay Firmware
• Application of Power Line Carrier Communication Aided Protection
• Performance Monitoring and Data Improvements
• Applications requiring coordination of functionally different relay elements should be avoided.
• If these applications cannot be avoided, the coordination should be studied and tested thoroughly.
• This type of coordination is virtually always problematic, and is the cause of numerous misoperations reported in the study period.
• Some examples to avoid include:
  ▪ Coordinating distance elements with overcurrent elements
  ▪ Directional overcurrent elements at opposite line terminals that use different directional polarization methods, particularly in the same pilot scheme
  ▪ Coordinating overcurrent elements that use different measurement methods, such as phase vs. residual ground vs. negative-sequence current measurement
• Misoperations due to setting errors can potentially be reduced.

• Techniques that could be used to reduce the application of incorrect settings include:
  ▪ Peer reviews
  ▪ Increased training
  ▪ More extensive fault studies
  ▪ Standard templates for setting standard schemes using complex relays
  ▪ Periodic review of existing settings when there is a change in system topography

• The IEEE Power System Relaying Subcommittee, IEEE PSRC, published a working group report to provide additional technical guidance for protective relay setting quality control.
• Entities should evaluate the need to apply updated firmware.
• While many firmware updates may not be critical to the relay protection functions, updated firmware that corrects critical protection functions should be given priority.
• IEEE Standard C37.231, IEEE Recommended Practice for Microprocessor-Based Protection Equipment Firmware Control
  ▪ Discusses various aspects of firmware version control and provides guidelines for the effective administration of firmware-related issues.
• Momentary signal loss (holes) sometimes caused by protective spark gaps firing during the fault.
  ▪ Spark gaps need to be inspected for build up and for the proper, manufacturer-required gap.
• Use of a carrier hole override timer on digital systems may be used as a means to reduce misoperations.
  ▪ While carrier hole timers can provide added security to DCB schemes, they can mask carrier system setting or component deficiencies.
  ▪ The decision to apply this logic should be weighed carefully.
• Modern check-back equipment is helpful to detect the failure to perform a carrier test.
  ▪ Provides better communication scheme condition indication than many older check-back test schemes
  ▪ Alternatively, frequency shift keying (FSK) carrier can be used with microprocessor based
• Resources for Power Line Carrier Communication Aided Protection
  ▪ Special Considerations in Applying Power Line Carrier for Protective Relaying, IEEE Power Systems Relaying Committee Special Paper.
• Detailed misoperation analysis should be continued on at least an annual basis by the respective Protection System Subcommittees within the Regions.

• This analysis will be forwarded to the NERC SPCS and NERC Performance Analysis Subcommittee for trending and metrics reporting.

• Adequate Level of Reliability Metric (ALR4-1) to monitor misoperations
• **Misoperations with Insufficient Information**
  - High percentage (over 24%) of misoperations did not have enough information to subcause
  - Improved data submission by entities would improve accuracy

• **Consistency in Reporting**
  - Improved Event Description field instructions to guide entities on needed information
  - Entities should verify with neighbors when tie-line misoperations occur to avoid double counting

• **Reporting Multiple Occurrences**

• **Template Enhancements**
Questions and Answers
If you have any additional questions, please contact:
Andy Slone, NERC
Andrew.Slone@nerc.net
(404) 446-9719

Thank You!