



# ERCOT Region Protection System Misoperations

April 9, 2013

Texas A&M Relay Conference

David Bueche

Compliance Team Lead

# Objectives

---

- **Raise awareness of recent statistical data on Protection System Misoperations.**
  - Overview of applicable NERC Standards and Definitions
  - Review of ERCOT region Misoperations data
  - Review of NERC-wide Misoperations data
- **Compliance best practices**

- **Protection System:**

- Protective relays which respond to electrical quantities
- Communications systems necessary for correct operation of protective function.
- Voltage and current sensing devices providing inputs to protective relays
- Station dc supply associated with protective functions (including batteries, battery chargers, and non-battery-based dc supply)
- Control circuitry associated with protective functions through the trip coil(s) of the circuit breakers or other interrupting devices

- **Misoperation:**

- Any failure of a Protection System element to operate within the specified time when a fault or abnormal condition occurs within a zone of protection.
- Any operation for a fault not within a zone of protection (other than operation as backup protection for a fault in an adjacent zone that is not cleared within a specified time for the protection for that zone).
- Any unintentional Protection System operation when no fault or other abnormal condition has occurred unrelated to on-site maintenance and testing activity.

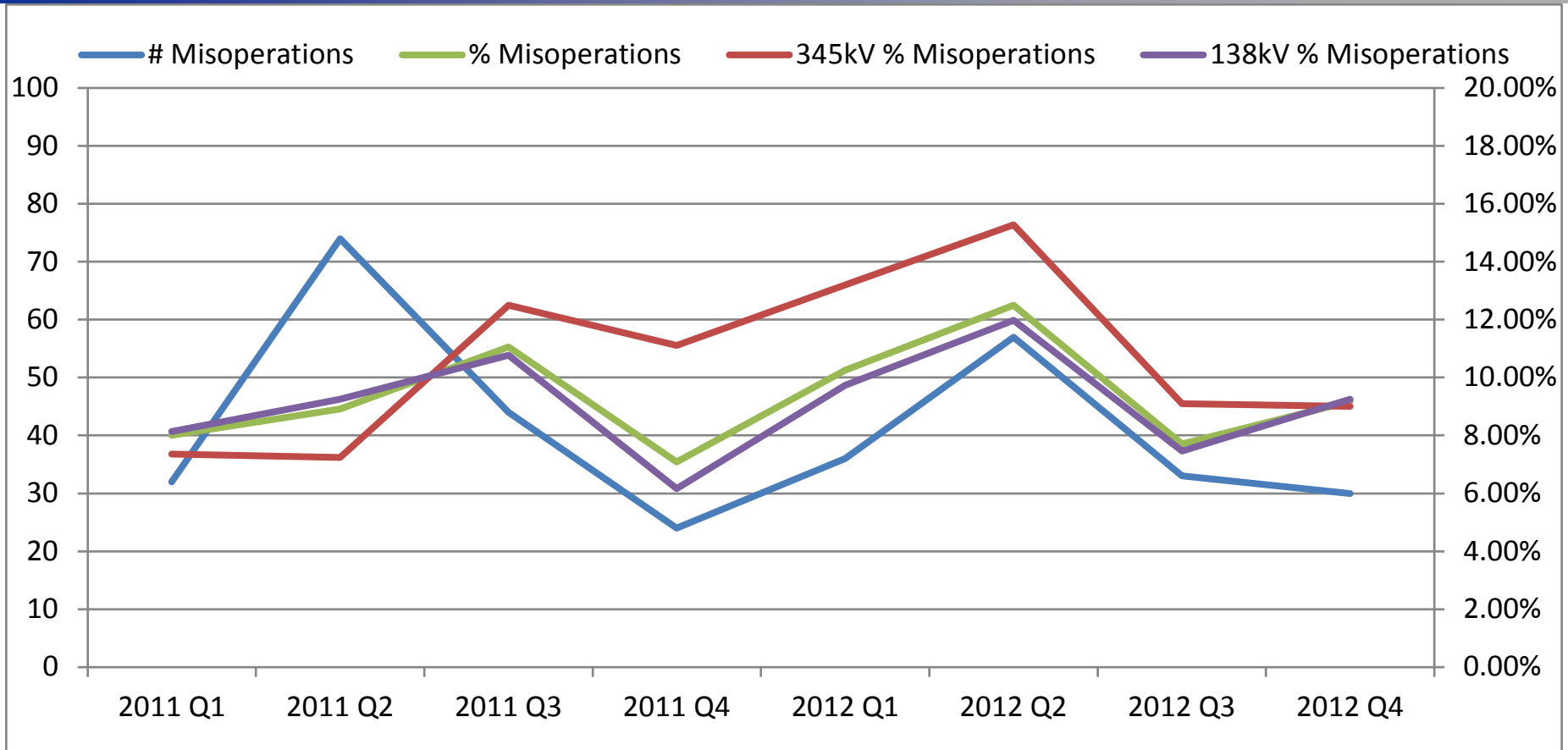
# NERC Reliability Standard PRC-004-2a

**R1.** The Transmission Owner and any Distribution Provider that owns a transmission Protection System shall each analyze its transmission Protection System Misoperations and shall develop and implement a Corrective Action Plan to avoid future Misoperations of a similar nature according to the Regional Entity's procedures.

**R2.** The Generator Owner shall analyze its generator Protection System Misoperations, and shall develop and implement a Corrective Action Plan to avoid future Misoperations of a similar nature according to the Regional Entity's procedures.

**R3.** The Transmission Owner, any Distribution Provider that owns a transmission Protection System, and the Generator Owner shall each provide to its Regional Entity, documentation of its Misoperations analyses and Corrective Action Plans according to the Regional Entity's procedures.

# ERCOT Region Protection System Misoperations Statistics

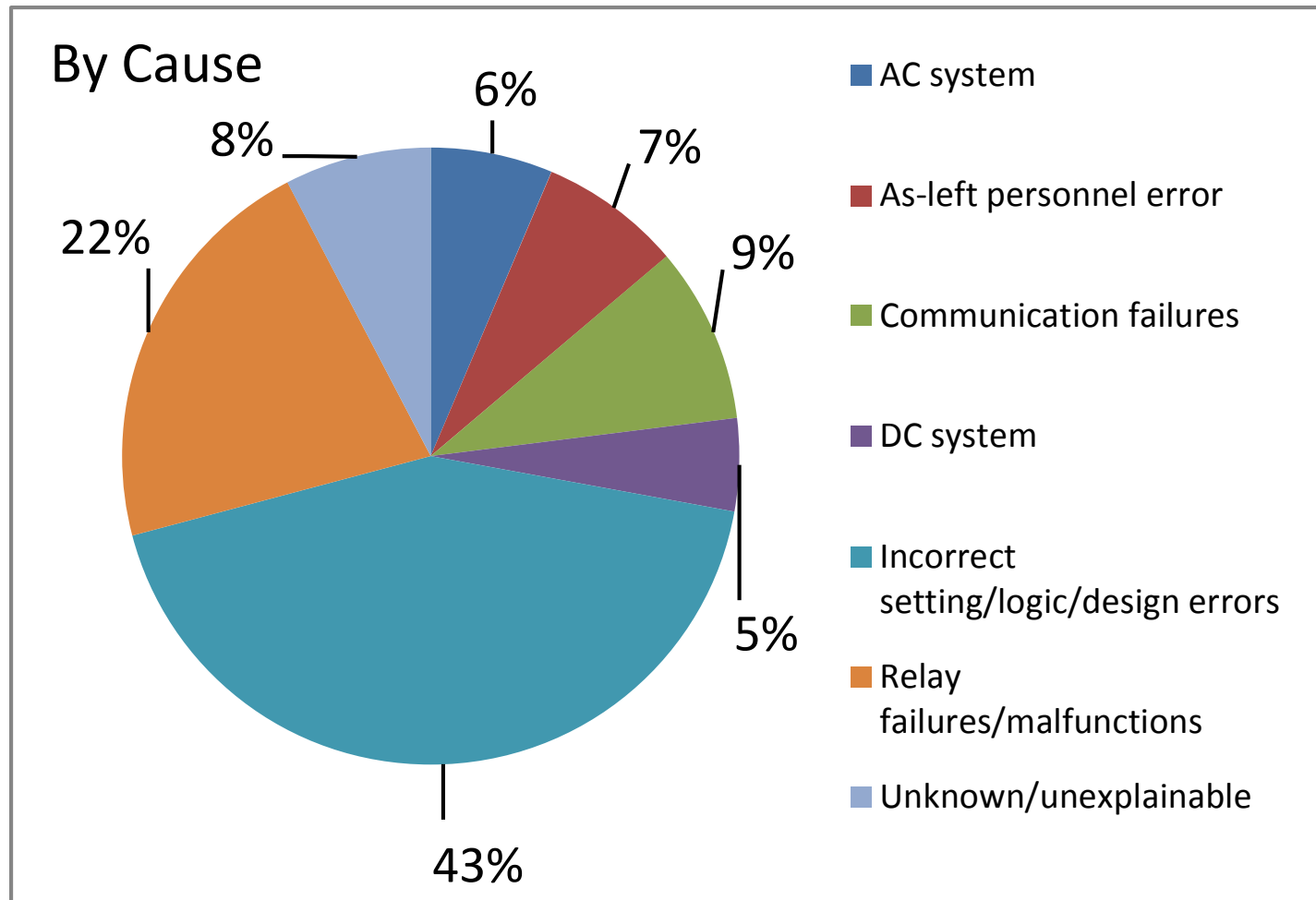


- Data is shared with ERCOT System Protection Working Group (SPWG) quarterly.

# ERCOT Region Misoperations Statistics

- **>94% of total misoperations are dependability-based (vs. security-based).**
- **Incorrect settings, relay failures, and communication failures comprise 74% of the total misoperations.**
- **Misoperations from microprocessor-based relays continue to be the dominant type, in part due to the large installed base of microprocessor relays as well as the complexity in applying and setting these devices.**

# ERCOT Region Misoperations Statistics – Cause

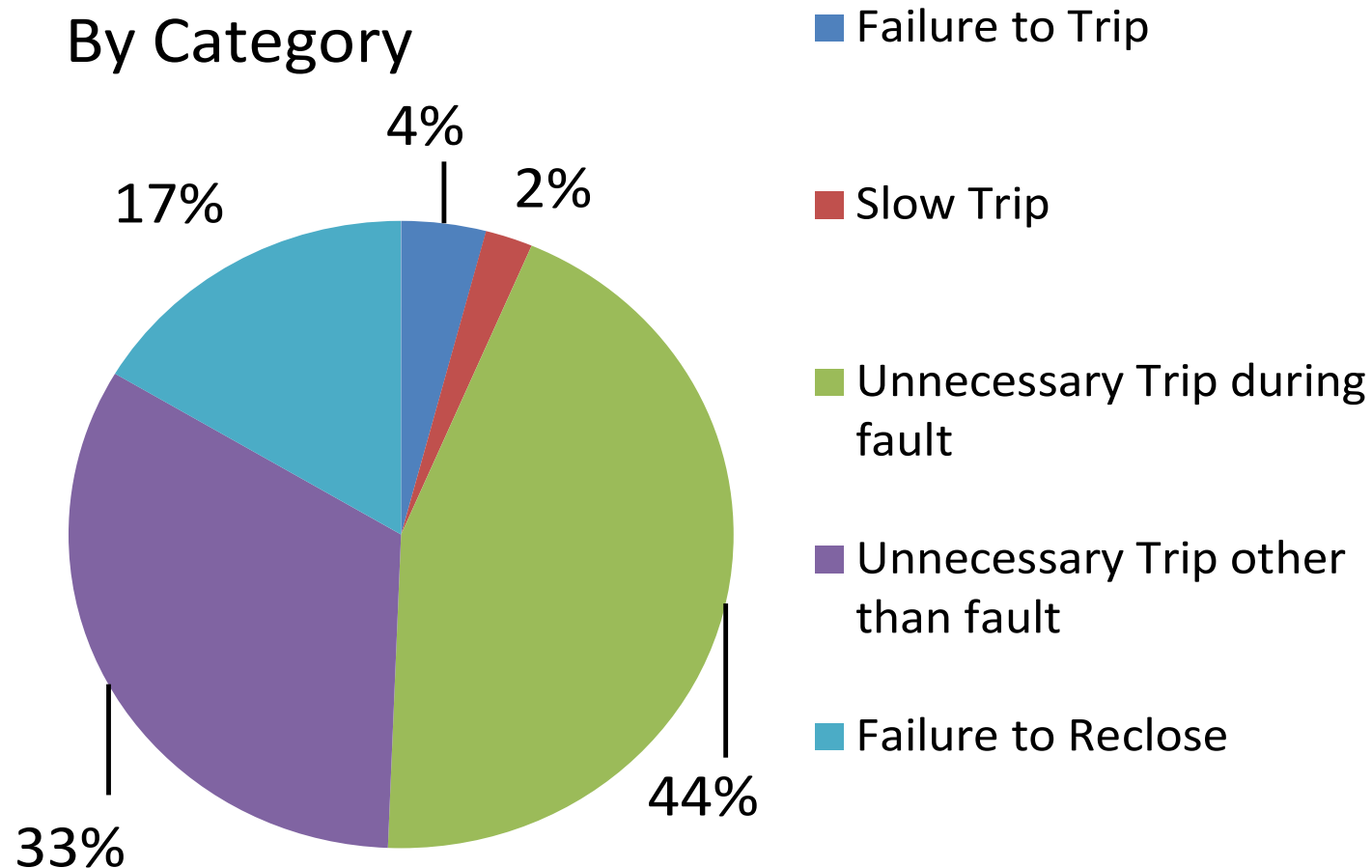




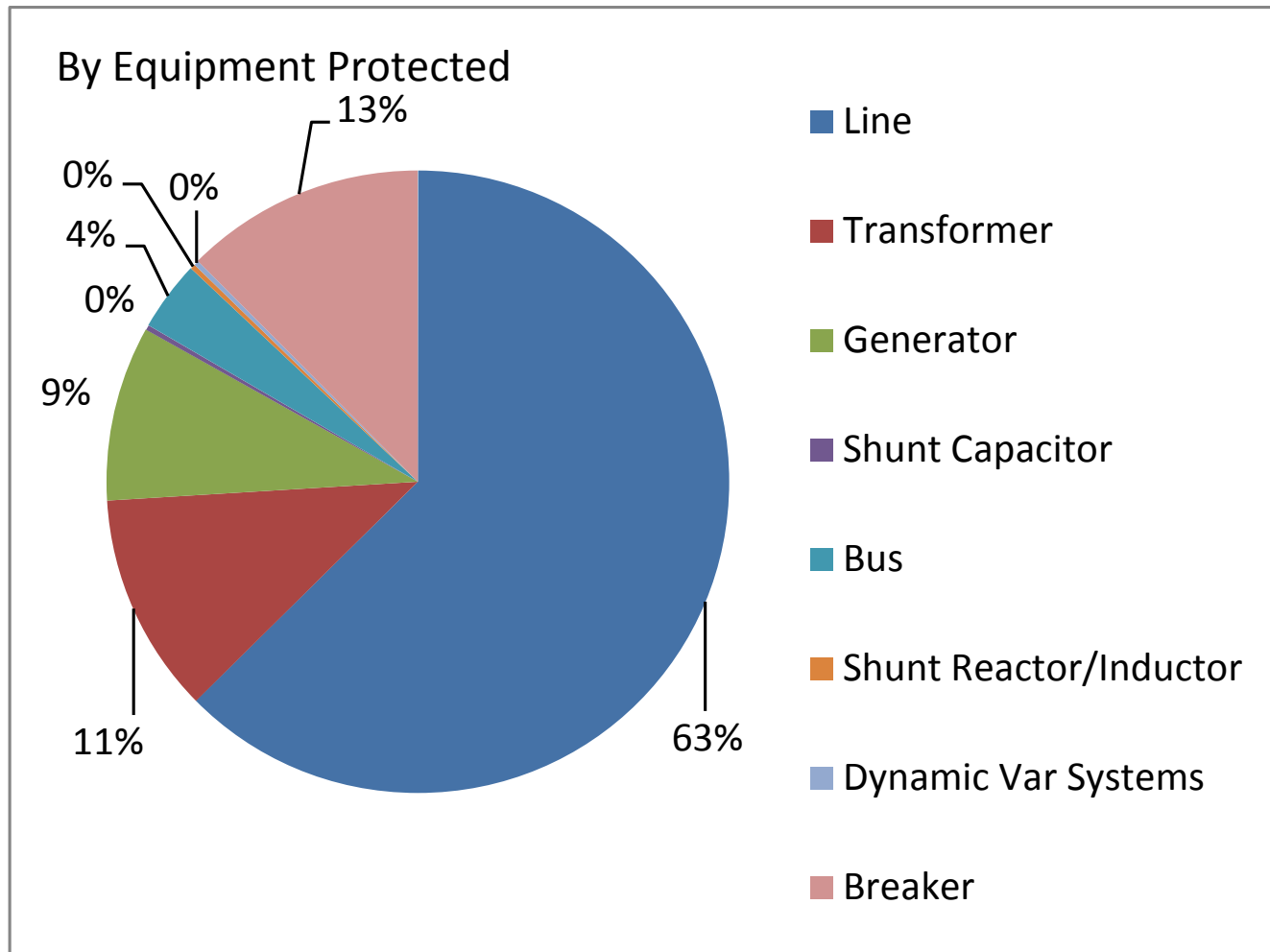
# ERCOT Region Misoperations Statistics – Category



## By Category



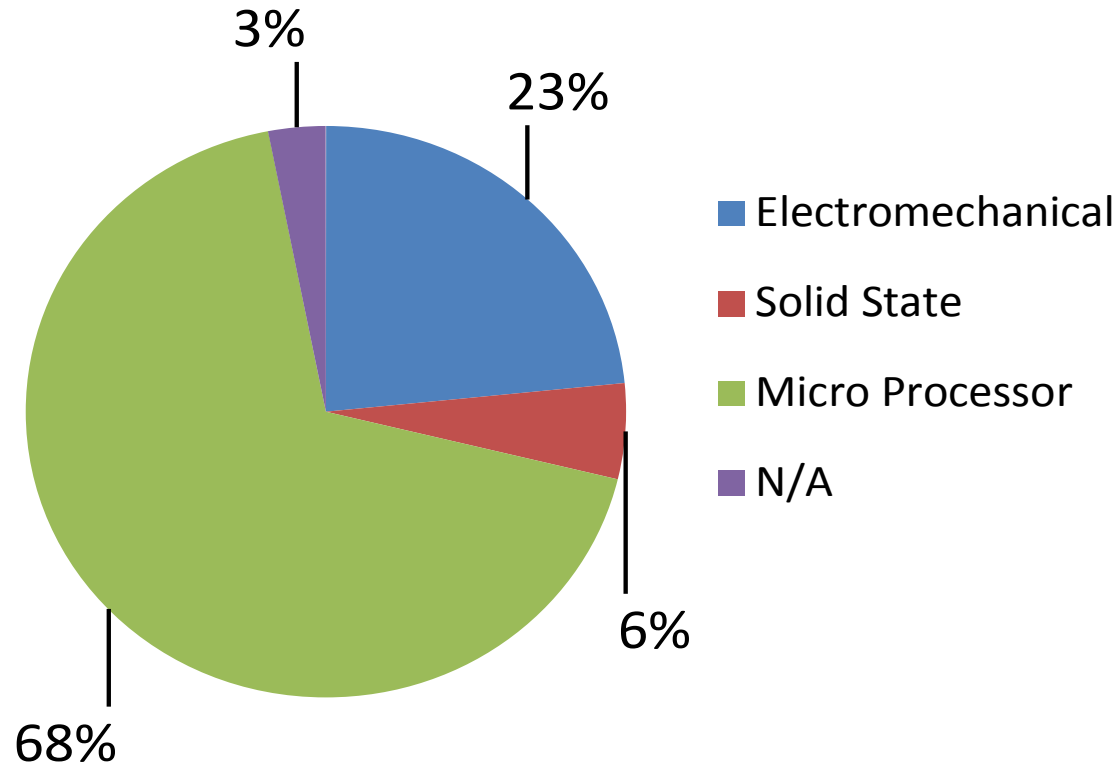
# ERCOT Region Misoperations Statistics – Equipment Protected



# ERCOT Region Misoperations Statistics – Relay System Type



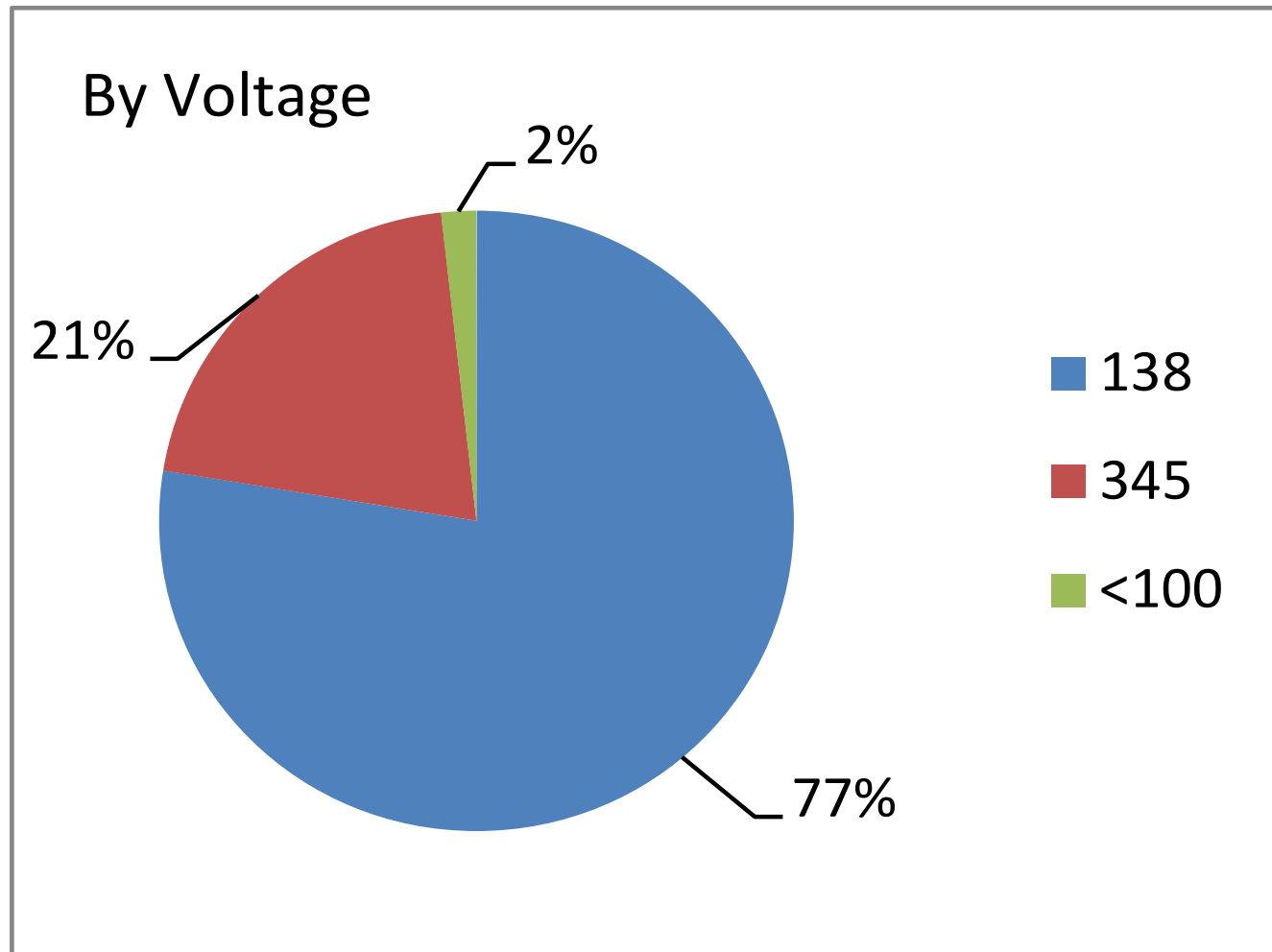
## By Relay System Type



# ERCOT Region Misoperations Statistics

- **Misoperations by Voltage are equivalent to installed base of transmission.**
- **Relay Failures are evenly split between microprocessor-based and electromechanical systems.**
- **Human Error is the cause of over 50% of reported misoperations.**

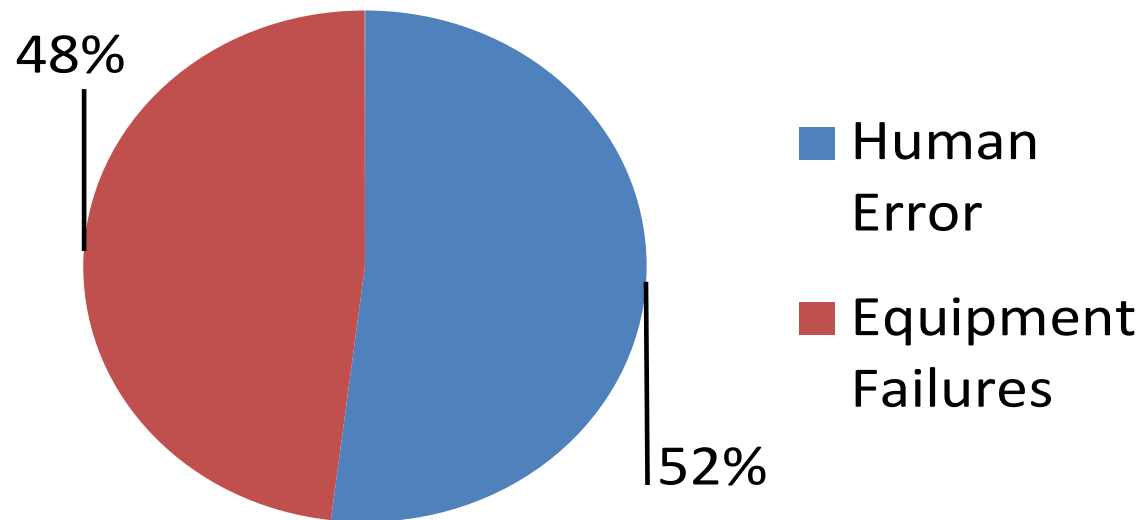
# ERCOT Region Misoperations Statistics – Voltage



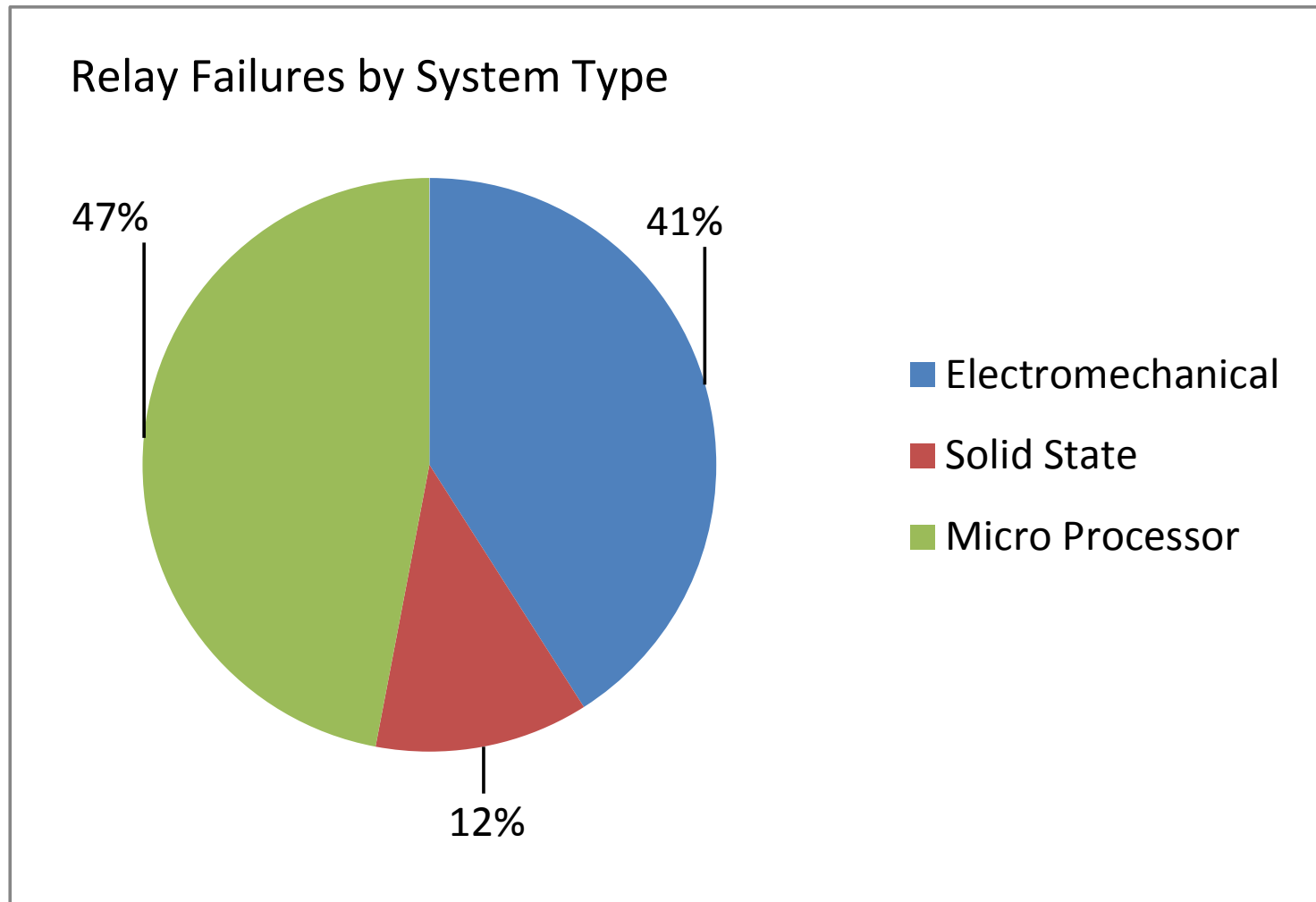
# ERCOT Region Misoperations Statistics – Cause Code

□

## By Cause Code



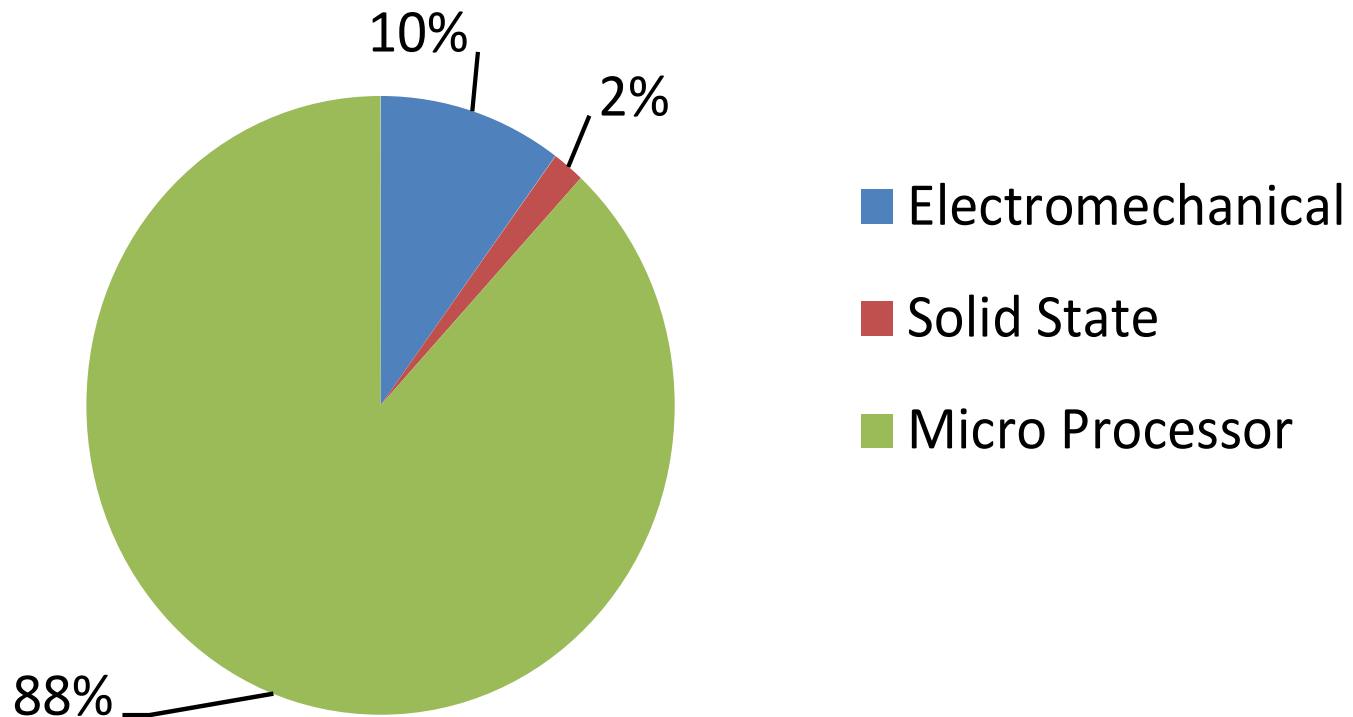
# ERCOT Region Misoperations Statistics – Relay Failures by System Type



# ERCOT Region Misoperations Statistics – Incorrect Settings by System Type

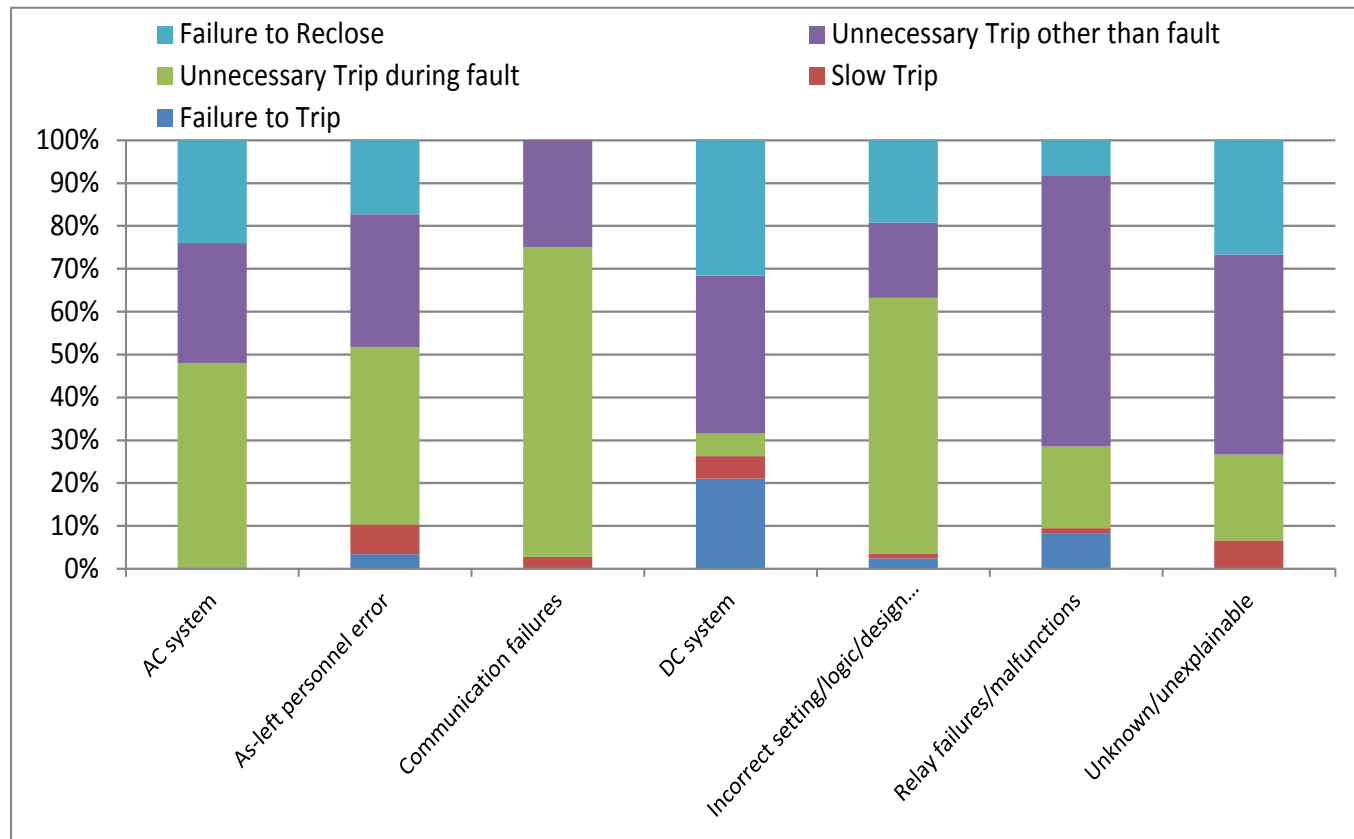


## Incorrect Settings by System Type



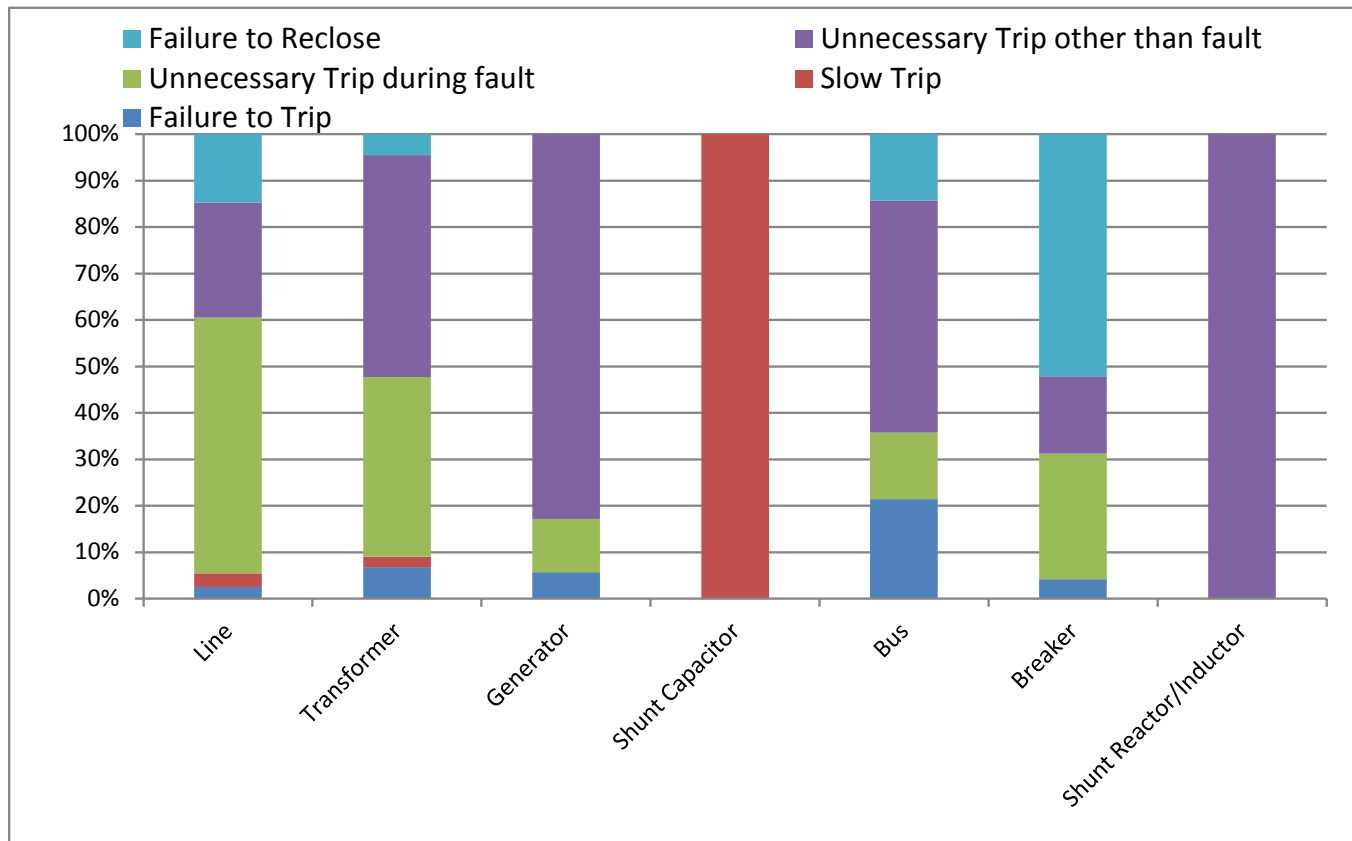


# ERCOT Region Misoperations Statistics



- **Communication failures and incorrect settings typically result in an overtrip.**
- **Relay malfunctions/failures typically result in a trip for a non-fault condition.**

# ERCOT Region Misoperations Statistics



- **Predominant misoperation mode for generators is trips for a non-fault condition.**
- **Predominant misoperation mode for lines is overtrips.**

# ERCOT Region “Human Error” Misoperation Reports

- **Zone 1 overreach due to incorrect line impedance data used to calculate relay settings.**
- **Multiple grounds in CCVT circuit used for ground polarizing voltage caused carrier overtrip.**
- **Bus differential misoperation due to incorrect CT circuit polarity.**
- **Special Protection System (SPS) misoperation following relay replacement project due to miscommunication between design engineer and relay setting engineer on project scope and setting needs.**
- **Autotransformer differential misoperation due to incorrect settings, settings engineer used delta-wye instead of wye-wye.**
- **Contractor uploaded settings into in-service breaker, causing trip of in-service transformer.**
- **Breaker failure misoperation due to incorrect settings.**

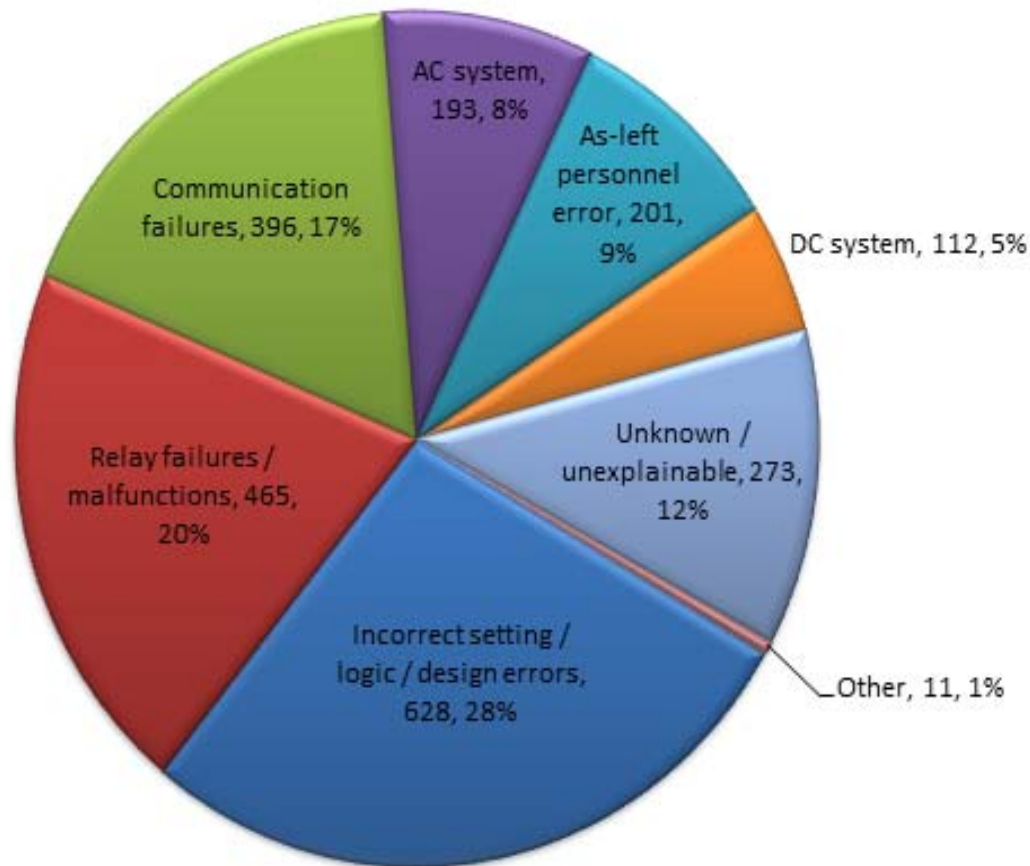
# ERCOT Region “Human Error” Misoperation Reports

## Cont’d.

- **63BX Alarm (low spring charge) contact inadvertently used as breaker failure initiate contact.**
- **Carrier coupler on wrong phase.**
- **Incorrect CT polarity on transformer differential circuit following transformer replacement.**
- **Trip diode missing from panel as well as drawings.**
- **Incorrect settings left on relay after maintenance.**
- **Actual line impedances did not match ASPEN model due to mutual coupling from nearby circuit.**
- **Field CT ratio did not match drawings.**
- **Auxiliary contact wired incorrectly.**
- **Polarizing potential inadvertently set to zero sequence instead of negative sequence.**
- **Loose secondary voltage connections in CCVT caused relay to lose directionality.**

# NERC-Wide Protection System Misoperation Data

## NERC-wide Misoperations by Cause Code (Jan 1, 2011 – April 1, 2012)



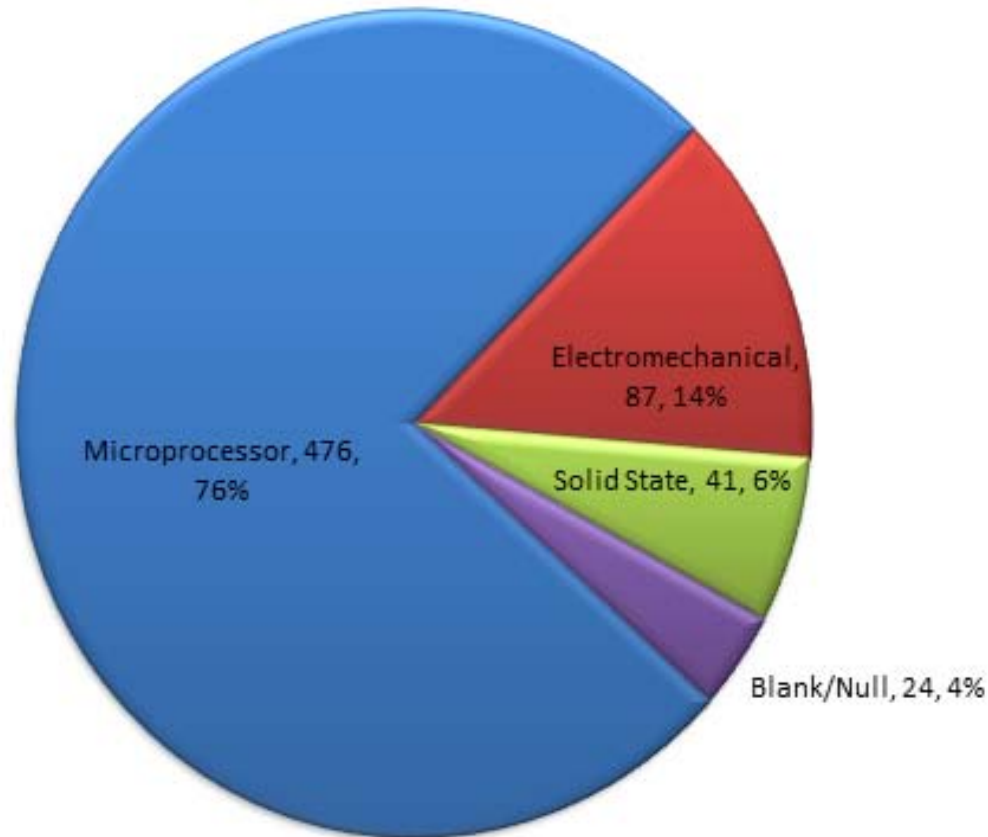
# NERC-Wide Protection System Misoperation Data

---

## **NERC-wide Misoperations by Category (Jan 1, 2011 – April 1, 2012)**

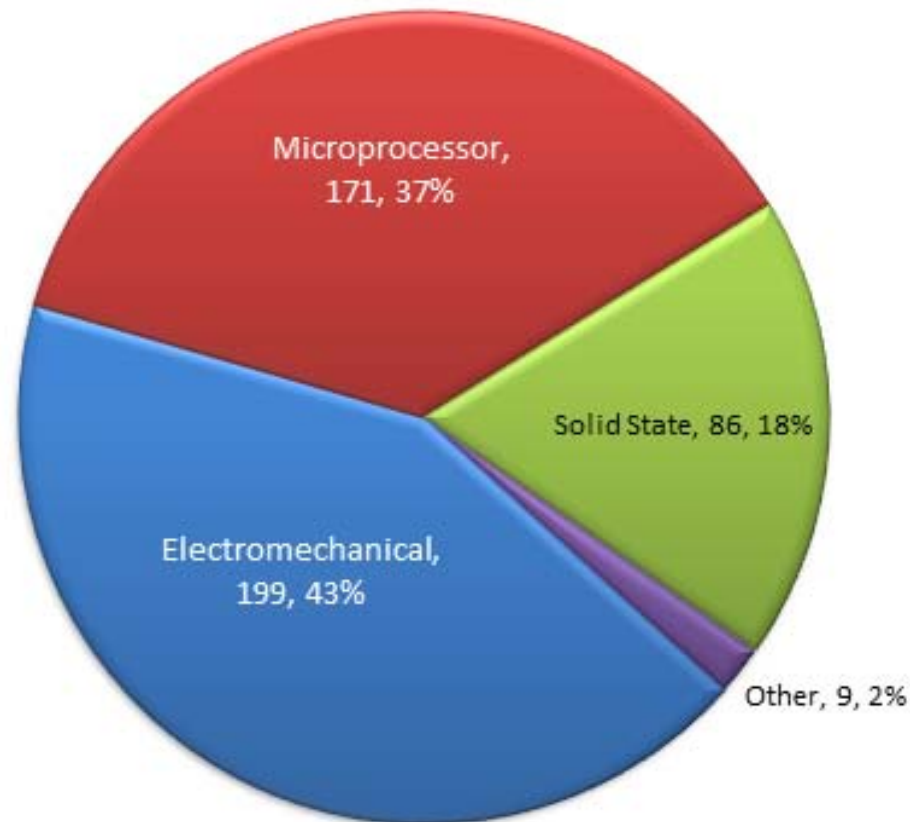
# NERC-Wide Protection System Misoperation Data

## NERC-wide Misoperations by Technology (Jan 1, 2011 – April 1, 2012)



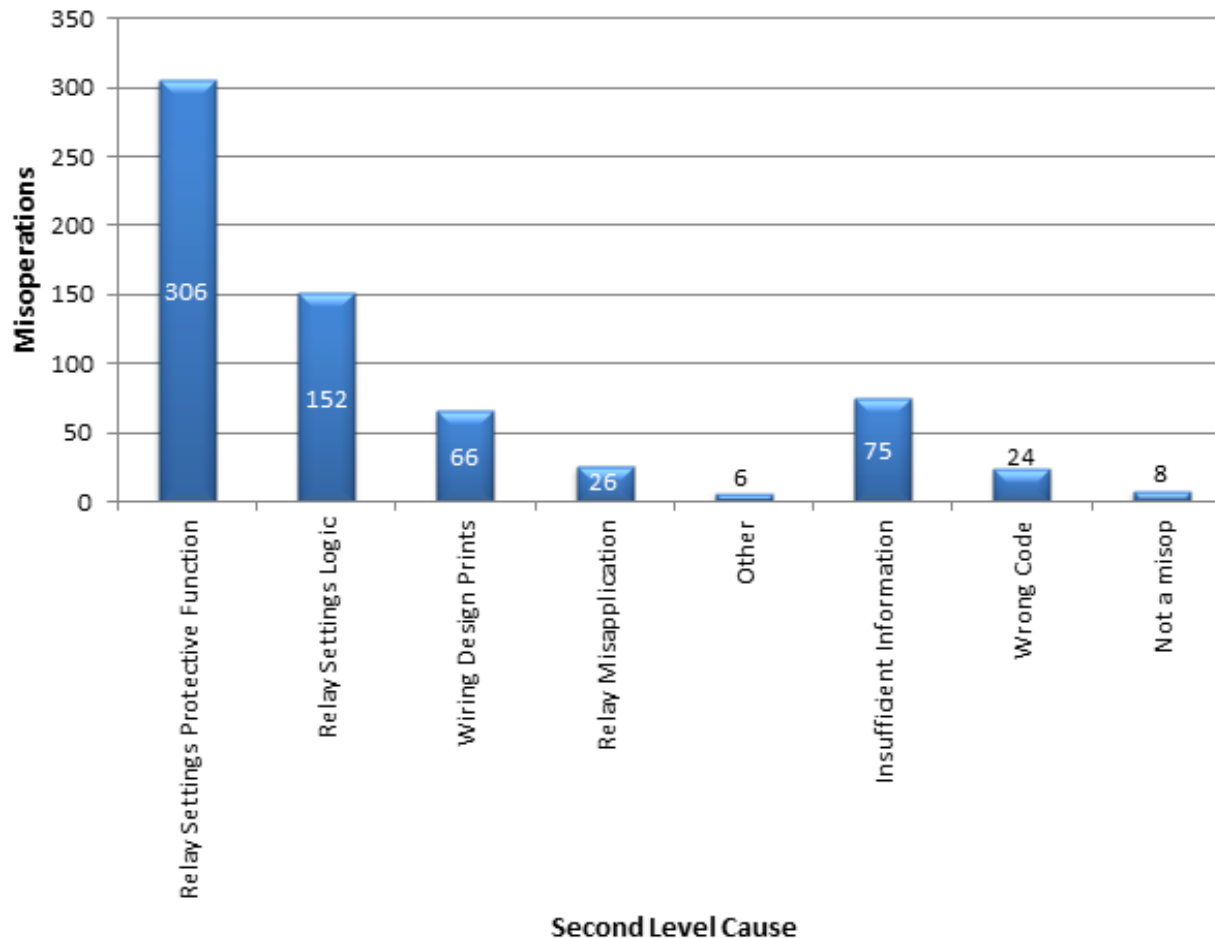
# NERC-Wide Protection System Misoperation Data

## NERC-wide Relay Failures by Technology (Jan 1, 2011 – April 1, 2012)





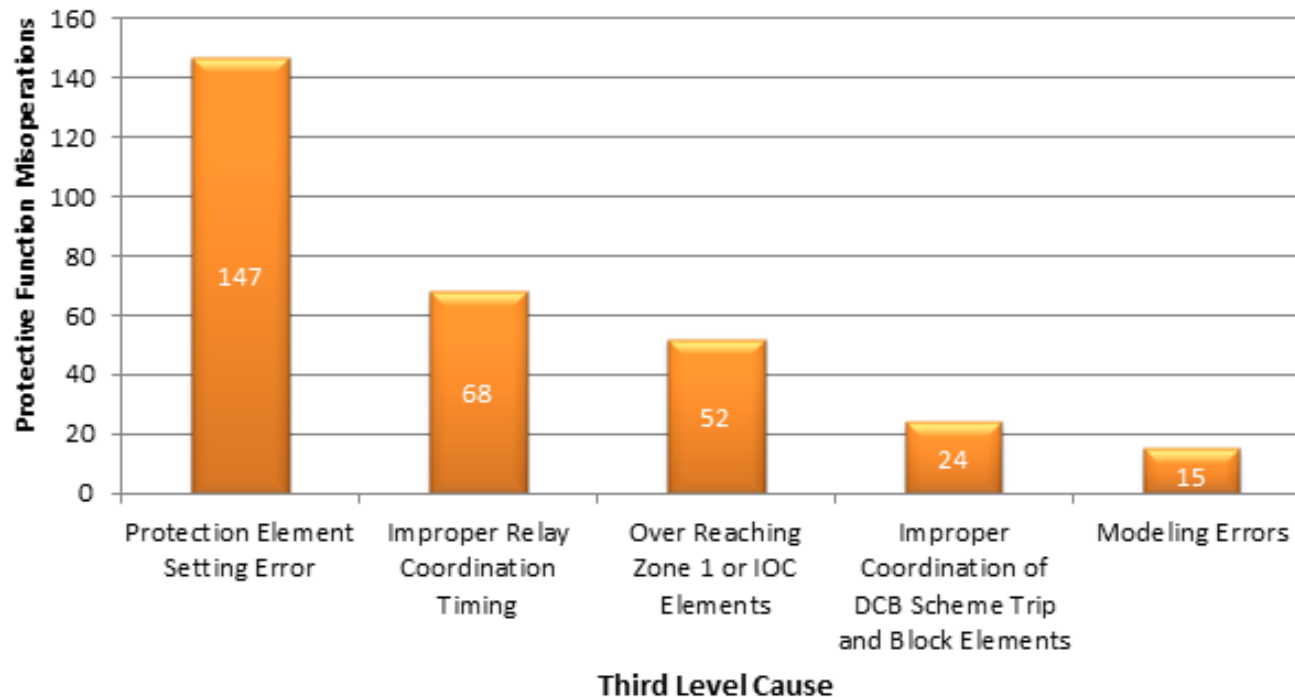
# NERC-Wide Protection System Misoperation Data



## Incorrect Settings/ Logic Design:

- **Four main sub-causes:**
  - Relay Settings – Protection Function
  - Relay Settings – Logic
  - Wiring/ Design/Prints
  - Relay Misapplication

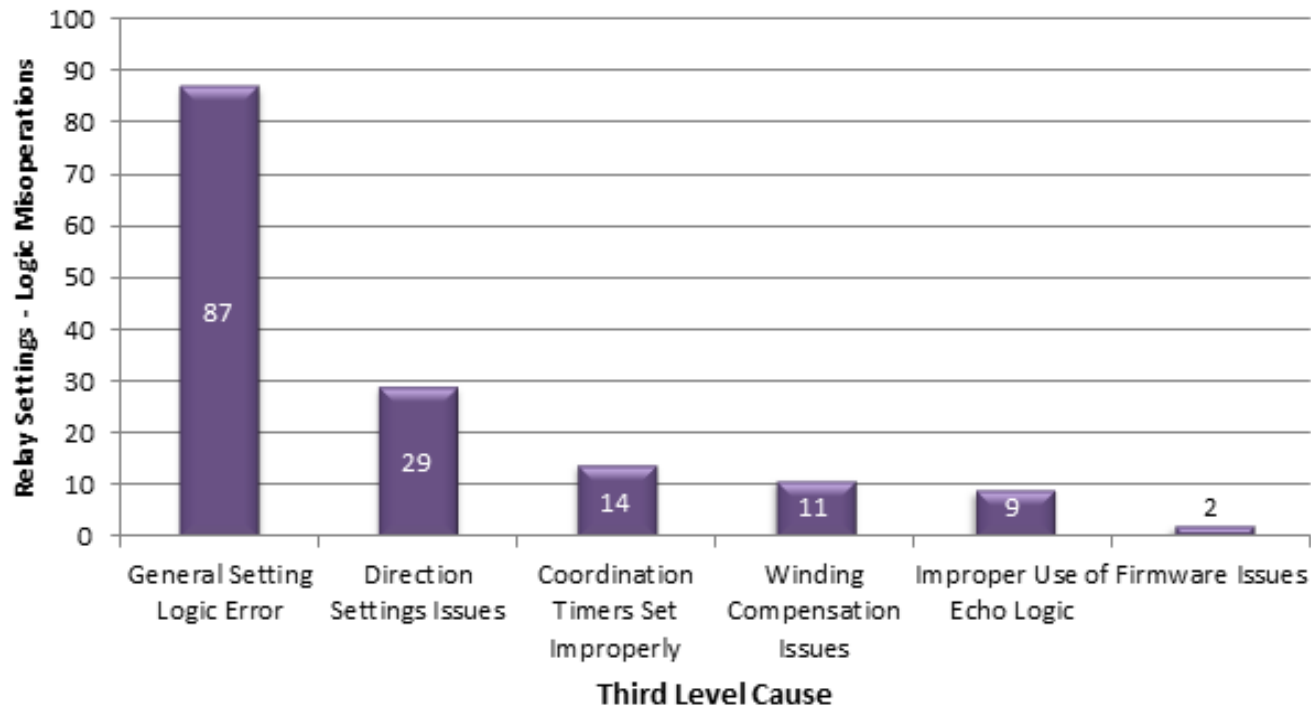
# NERC-Wide Protection System Misoperation Data



## Protection function errors:

- Protection element setting error: impedance reaches, line current differential settings, and overcurrent pickup values and time dials.
- Improper relay coordination timing: zone timers and time overcurrent coordination.
- Overreaching zone 1 and instantaneous overcurrent elements.
- Improper coordination of DCB scheme trip and block elements: reverse zone elements not seeing as far as remote forward zone elements.
- Modeling errors: line impedances and transformer connections.

# NERC-Wide Protection System Misoperation Data



## Protection logic errors:

- Relay logic setting error, such as trip equations.
- Directionality related settings, including V, I and Q designations, and forward and reverse element designations.
- Carrier coordination timers not set properly.
- Winding compensation issues such as in transformer differential relays, and harmonics.
- Improper use of echo logic.

# Reducing Human Error Misoperations

- **Misoperations due to setting errors can potentially be reduced.**
  - Techniques:
    - 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.

# Reducing Human Error Misoperations

- **Peer review generally consists of:**
  - Verifying that the relay scheme is wired according to the design drawings
  - Verifying the correct potential and current transformer ratios
  - Verifying the input/output connections for used for tripping and control.
- **Increased training will help reduce the numerous calculation and application misoperation discovered during analysis.**
- **More extensive fault studies and periodic review of existing settings are crucial to ensure that changes to the system do not result in misoperations.**

# References

- **ERCOT Nodal Operating Guide, Section 6, Disturbance Monitoring and System Protection**
- **NERC Standard PRC-004-2a, Analysis and Mitigation of Transmission and Generation Protection System Misoperations**
- **Texas RE Regional Procedure For Analysis, Mitigation and Reporting of Transmission and Generation Protection System Misoperations**

# Compliance Expectations for PRC-004-2a – Protection Systems Misoperations

- **If you own any part of a protection system:**
  - You are responsible for demonstrating compliance for that part you own.
- **If you have a CFR/JRO, let us know.**
- **Applicability:**
  - Transmission Owner (TO)
  - Distribution Provider (DP) (that owns a transmission Protection System)
  - Generator Owner (GO)

# Compliance Expectations for PRC-004-2a – Protection Systems Misoperations Cont'd.

- **Requirements:**
  - Analyze each Misoperation.
  - Develop and implement Corrective Action Plan.
  - To avoid future similar Misoperations.
  - Report to Regional Entity (Texas RE).
- **Schedule, Procedure and Reporting Template are available on the Texas RE website.**
  - <http://www.texasre.org/compliance/datasubmit/misoperationsreporting/Pages/Default.aspx>



# Compliance Expectations

- **Don't forget about PRC-001-1, System Protection Coordination!**
  - Requirement 2 Applicability:
    - Transmission Operator (TOP)
    - Generator Operator (GOP)
  - Relay or equipment failures
    - GOP coordinates with its TOP and Balancing Authority.
    - GOP shall take corrective action.
    - TOP coordinates with its Reliability Coordinator and its affected TOPs and Balancing Authority.
    - TOP shall take corrective action.
- **Remember you could have multiple TOPs.**



# Questions?

Contact Information

[information@texasre.org](mailto:information@texasre.org)

(512) 583-4900

Texas RE Contacts

[http://www.texasre.org/about/contact/  
Pages/Default.aspx](http://www.texasre.org/about/contact/Pages/Default.aspx)