

# WHEN GOOD FAULTS GO BAD: A REVIEW OF GROUND FAULT PROTECTION METHODS FOR TRANSMISSION LINES

ERCOT SYSTEM PROTECTION WORKING GROUP

*ANDREW “MAYHEM” MATTEI, P.E.*



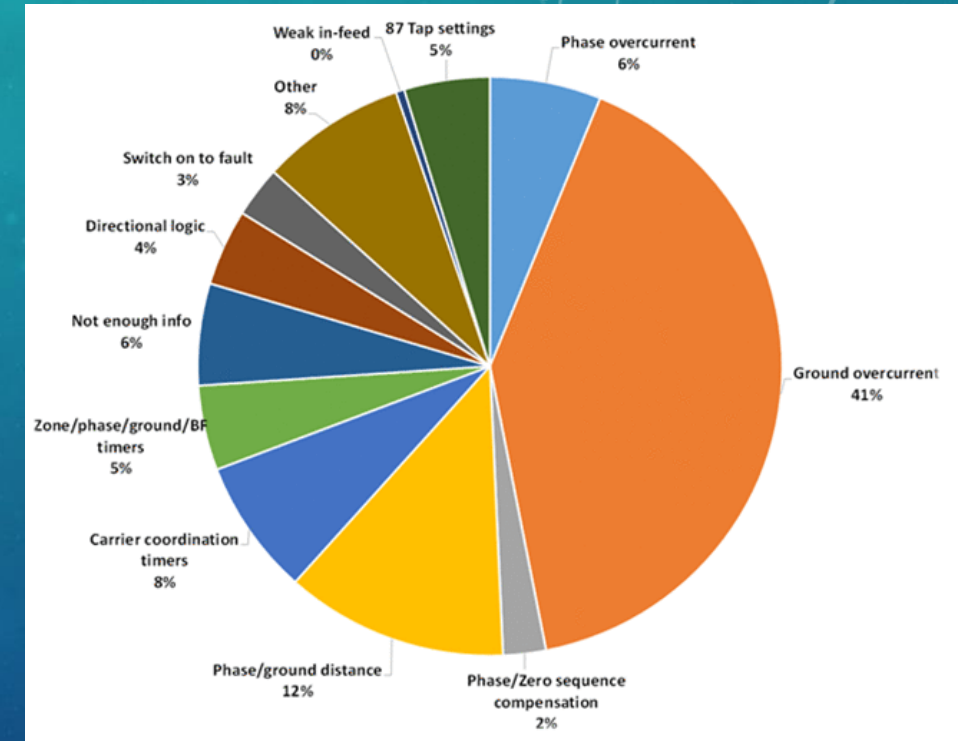
# BACKGROUND INFORMATION

- NERC *2013 State of Reliability Report* placed a high priority on investigating the root cause of misoperations
- What does NERC consider a misoperation?
  1. Failure to trip, during fault
  2. Failure to trip, other than fault
  3. Slow trip, during fault
  4. Slow trip, other than fault
  5. Unnecessary trip, during fault
  6. Unnecessary trip, other than fault



# MISOPERATION DATA

- NERC 2014 *State of Reliability* found that ~10% of all operations were a misoperation
- According to NERC, the most common causes of misoperations were incorrect setting / logic / design errors (41%)
- Analysis by the Texas Reliability Entity (TRE) of ERCOT misoperations found that 41% were due to miscoordination of ground overcurrent settings
- Do the math: >16% of misoperations are related to ground protection logic/design/settings – one misoperation out of every six!





# ERCOT SPWG DOCUMENT

- A set of best practices for ground fault protection methods
  - Ground Fault Characteristics
  - System Modeling & Mutual Coupling
  - Relay Elements & Schemes
    - Ground Instantaneous Overcurrent (50/67G)
    - Ground Time Overcurrent (51/67G)
    - Ground Distance (21G)
    - Directional Comparison Blocking (85 DCB)
    - Permissive Overreaching Transfer Trip (85 POTT)

# AN EXAMPLE – MAYHEM AT WORK

- 50G Settings
  - Advantages
  - Limitations
  - Recommended practice for setting
    - *Greater than the maximum external fault current plus some margin*
    - Periodic review of fault current levels
  - What would Mayhem do?

## AN EXAMPLE – MAYHEM AT WORK

- Brazos Electric uses 50G throughout transmission network
- Calculations for End-to-End Communications Testing has revealed trouble spots, particularly around high change areas.
- General rule-of-thumb for BEPC:
  - 2x Ground Fault at Remote End (OR)
  - Ground Fault at 20% from Remote End (+contingency)
- No misoperations on record, but possible

# ANOTHER EXAMPLE – MAYHEM AT WORK

## Highlight: 85 POTT Carrier System

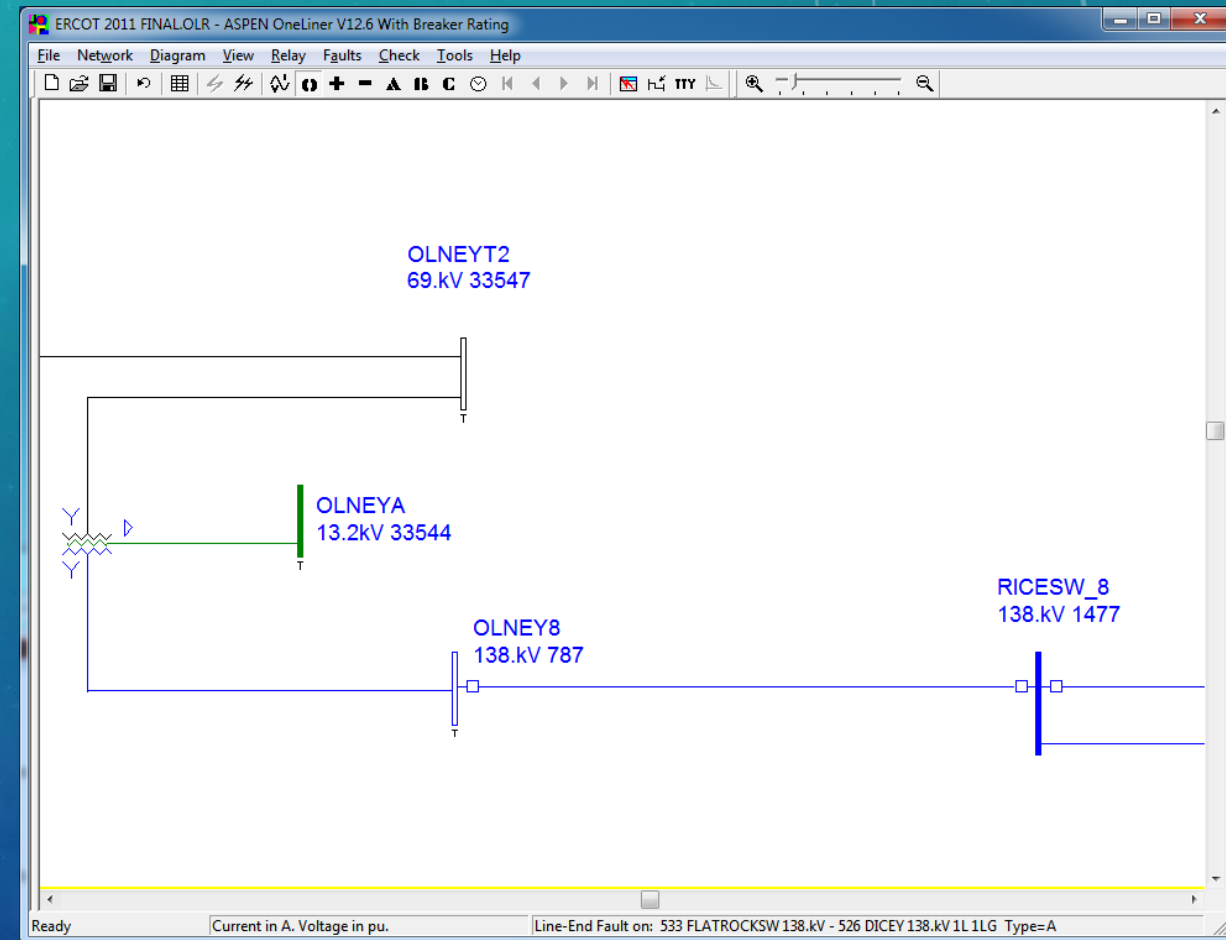
- POTT is biased more towards security rather than dependability
- Two levels of POTT – basic and echo
  - Basic only requires forward pilot elements at both ends
  - Echo returns trip permission unless reverse elements assert
  - Timers delay trip permission for directional determination
- Set a forward pickup and a reverse pickup, with necessary coordination of at least a factor of 2.
- What would Mayhem do?



# ANOTHER EXAMPLE – MAYHEM AT WORK

## 85 POTT System Misoperation

- Rice line looking in to Autotransformer
- Fault somewhere in 69kV system behind auto
- Olney:
  - 50G2P = 1.67 (Forward Element)
  - 50G3P = 0.5 (Reverse Element)
- Rice:
  - 50G2P = 1.0 (Forward Element)
  - 50G3P = 0.5 (Reverse Element)

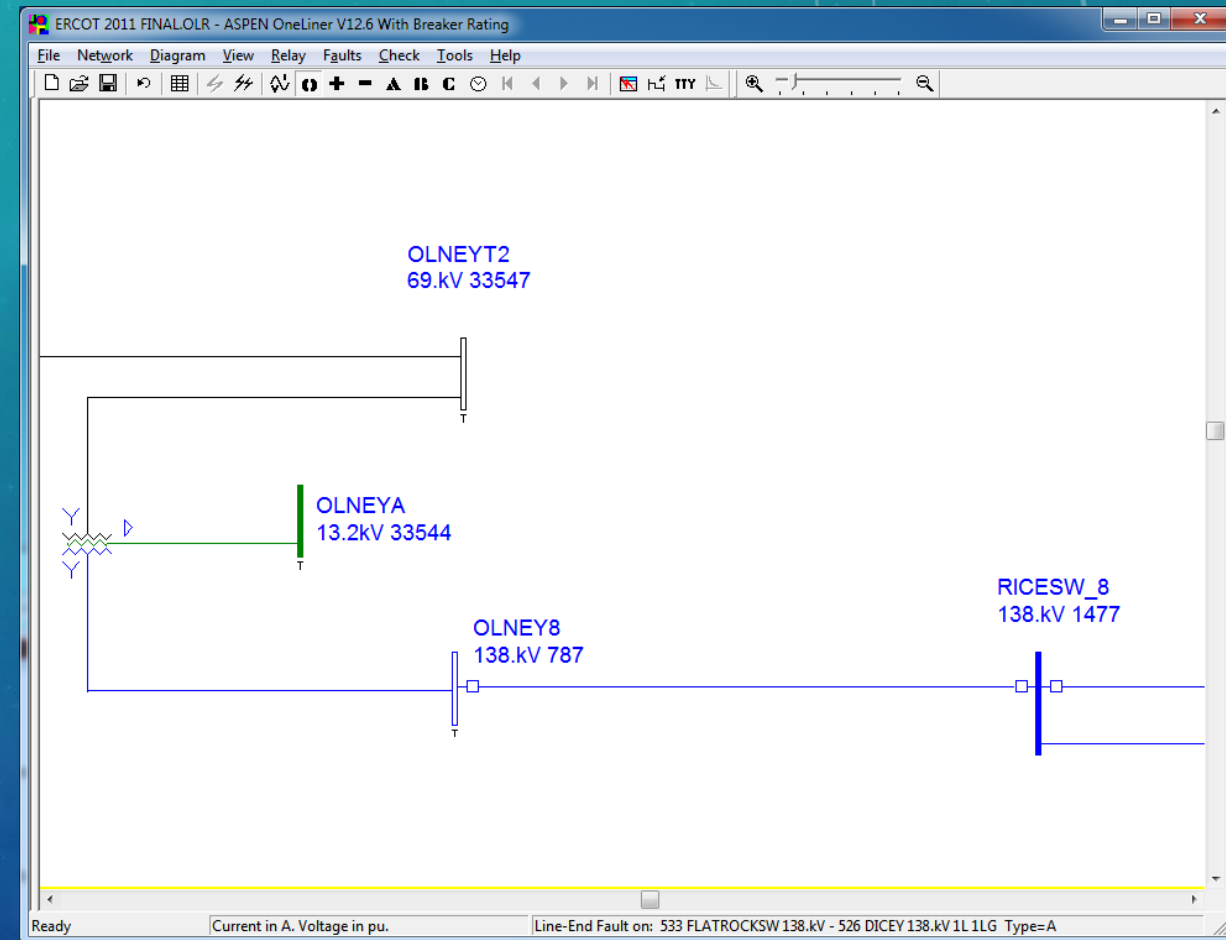




# ANOTHER EXAMPLE – MAYHEM AT WORK

## 85 POTT System Misoperation

- Guide says forward should be at least 2x the remote reverse
- We did that. Olney 50G3P = 0.5, Rice 50G2P = 1.0
- What went wrong?
  - CT Ratio Olney: 1200:5
  - CT Ratio Rice: 500:5
- Olney reverse picks up at 120 amps; Rice forward picks up at 100 amps. Olney Echoed because reverse did not assert.
- New Rice Settings: 50G2P = 2.4, 50G3P = 1.2



# RECOMMENDATIONS

- Engineers should ensure that models are accurate and up-to-date.
  - Use best practice techniques for determining relay settings – source out / line out, use tools for checking relay coordination.
  - Codify your techniques and document standardized methods to use. Modify as you go.
  - This document provides a jumping-off point.
- Technicians should ask if something doesn't seem right or test right. Engineers do the calculations, but we do make mistakes and sometimes don't have all of the answers.
- Share your knowledge.
- Avoid Mayhem. Like me.

# ERCOT SPWG FOCUS GROUP CREDITS – THANKS TO:

- Bret Burford, AEP (SPWG Chair 2016)
- Keith Calle, CPS Energy
- Mark Chronister, Oncor
- Brian Clowe, Centerpoint Energy (SPWG Chair 2015)
- Gene Corpuz, LCRA TSC (Chair of Task Force)
- Mike Davis, Centerpoint Energy
- Keith Fleming, Austin Energy
- Robert Jimerson, Oncor
- Kris Koellner, LCRA TSC
- David Penney, TRE
- Bill Tucker, AEP
- Mayhem

DOCUMENT WILL BE POSTED AT  
<http://www.ercot.com/committee/spwg>

## 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**  
**4/1/2016**