# NERC Lessons Learned

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# Publication

Misoperation of 87N Transformer Ground Differential Relays Causing Loss of Load

Northeast Power Coordinating Council

April 14, 2020

# Problem Statement

- 345 kV ring bus with 4 in-service XFMRs (1 standby)
- 13 kV feeder fault
- (3) 87N neutral/ground diff relays misoperated clearing the XFMRs
- Remaining XFMR overloaded before standby could be switched in
- (1) 345 kV path stayed in service
- Loss of load

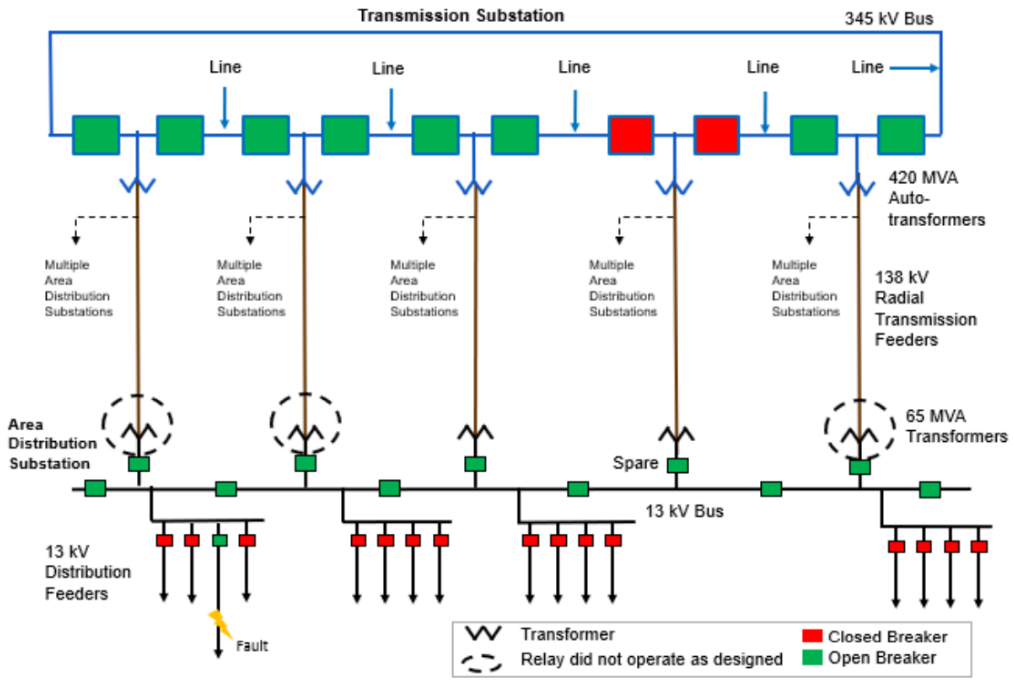


*Figure 1: One-line Diagram of Transmission and Area Substations [1]*

# Details

- 87N relays misoperated from open or missing connection between the 13 kV transformer CTs and the neutral auxiliary CT that supplies each 87N relay
- Missing connection unbalances the differential configuration
- Missing neutral connection occurred during a 13 kV breaker retrofit program
- Original overall schematic not used
- Separate crew found issue later on 4$^{th}$ XFMR

*Figure 2: Wiring in Rear of Relay Panel [1]*

# Lessons Learned

- Missing wiring was corrected
- Process developed to redraw AC circuits with templates
- Standardization of commissioning testing for substation equipment and relay protection systems
- Provide feedback to supervision and engineering when problems are encountered

*Figure 3: Added Neutral CT Connection to Complete 87N Circuit Post-Event [1]*

# Publication

Protracted Fault in a Transmission Substation

Northeast Power Coordinating Council

April 14, 2020

# Problem Statement

- Single-phase-to-ground fault on CCVT
- Output temporarily isolated but coupling capacitors remained connected
- Communications equipment shut down because of an electrical transient associated with the fault
- Loss of communications prevented the line differential relaying from properly detecting the fault
- Remote back-up relays slow to detect fault for multiple reasons

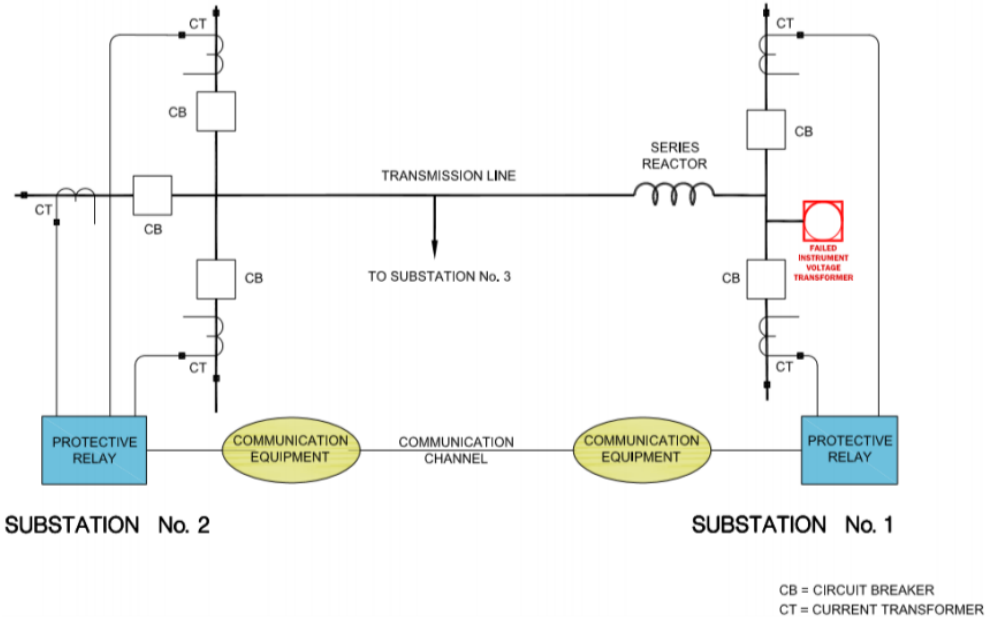


*Figure 4: One Line Diagram of Faulted Circuit and Line Differential Protection [2]*

# Details

- Fault was not cleared by either the primary or the back-up relay protection
- Four multiplexers (with 8 power supplies) automatically shut down from transient
- Control scheme intended to protect the power supply from overloading
- Transient generated coupled into the 125V DC battery supply
- Continuity between two adjacent ground grids

*Figure 5: Failed C Phase CCPD [2]*

# Lessons Learned

- All damaged equipment replaced
- DC supply for multiplexers shortened
- Ground grids reinforced
- Extent of condition review conducted system-wide to replace power supplies modified to disable shutdown scheme
- Diversify primary and backup equipment
- Equipment out of service should be completely isolated

*Figure 6: Remnants of Bus Insulators [2]*

# Publication

Loss of Automatic Generation Control During Routine Update

Western Electricity Coordinating Council

April 14, 2020

# Problem Statement

- Typical weekly AGC system build was being deployed
- AGC was controlled from Control Center #1 with a completely redundant hot-standby system at Control Center #2
- Installation done at CC #2 and control transferred
- Critical AGC task aborted and critical control functionality lost
- Switch back to CC #1 AGC since deployment completed
- Same critical task aborted on the Control Center #1 AGC
- Generation schedules could not be set and ACE could not be automatically calculated

# Details

- Change made to primary inadvertent interchange (PII) alarm text
- PII alarm text were modified from i4 to i5 to allow excess of +/- 999
- New alarm exceeded limit of 80
- Run-time abort after first alarm
- Immediately deployed code to ignore the PII alarm
- Permanent remedy to shorten text to 72 characters with 5 digits for MW

**PRIOR TO BUILD**: LARGE CHANGE IN PII FROM XXXX TO XXXX MW. SELECT ACCEPT TO ALLOW PII TO UPDATE. (79 characters)

**AFTER BUILD**: LARGE CHANGE IN PII FROM XXXXX TO XXXXX MW. SELECT ACCEPT TO ALLOW PII TO UPDATE. (81 characters)

**CURRENT**: LARGE CHANGE IN PII FROM XXXXX TO XXXXX MW. SELECT ACCEPT TO UPDATE PII. (72 characters)

*Figure 7: PII Alarm Text [3]*

# Lessons Learned

- Validate changes in a test environment first regardless of size
- Software testing process should include:
  - Test Scope
  - Test Design
  - Test Execution
  - Test Closure
- Operate in parallel enough time to determine that no adverse condition has been introduced prior putting that center in control
- Avoid standard library functions that are not bounds checked

# References

1. Misoperation of 87N Transformer Ground Differential Relays Causing Loss of Load

   https://www.nerc.com/pa/rrm/ea/Lessons%20Learned%20Document%20Library/LL20200401_Transformer_Ground_Differential_Relay_Misop.pdf
2. Protracted Fault in a Transmission Substation

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3. Loss of Automatic Generation Control During Routine Update

   https://www.nerc.com/pa/rrm/ea/Lessons%20Learned%20Document%20Library/LL20200403_Loss_of_AGC_During_Routine_Update.pdf