Protective Relay Upgrade Resolves Planning Criteria Violations

Texas A&M Relay Conference

College Station, TX

March 29, 2022

LCRA

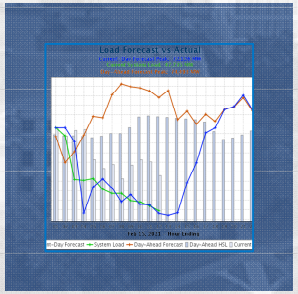
ENERGY • WATER • COMMUNITY SERVICES

Topics

Good morning!

Today we'll be covering the following:

- Background
- Transmission planning assessments



- Three-terminal line protection
- Project execution

- Corrective action plans
- Protective relay upgrade

- Real-world results
- Key takeaways

LCRA Background

- The Texas Legislature created the Lower Colorado River Authority in 1934.
- LCRA provides public power, manages the lower Colorado River, builds and operates transmission lines across the state, and more.
- LCRA's mission is to enhance the quality of life for the Texans we serve through water stewardship, energy and community service.

We will be the public utility that sets the standard for excellence.

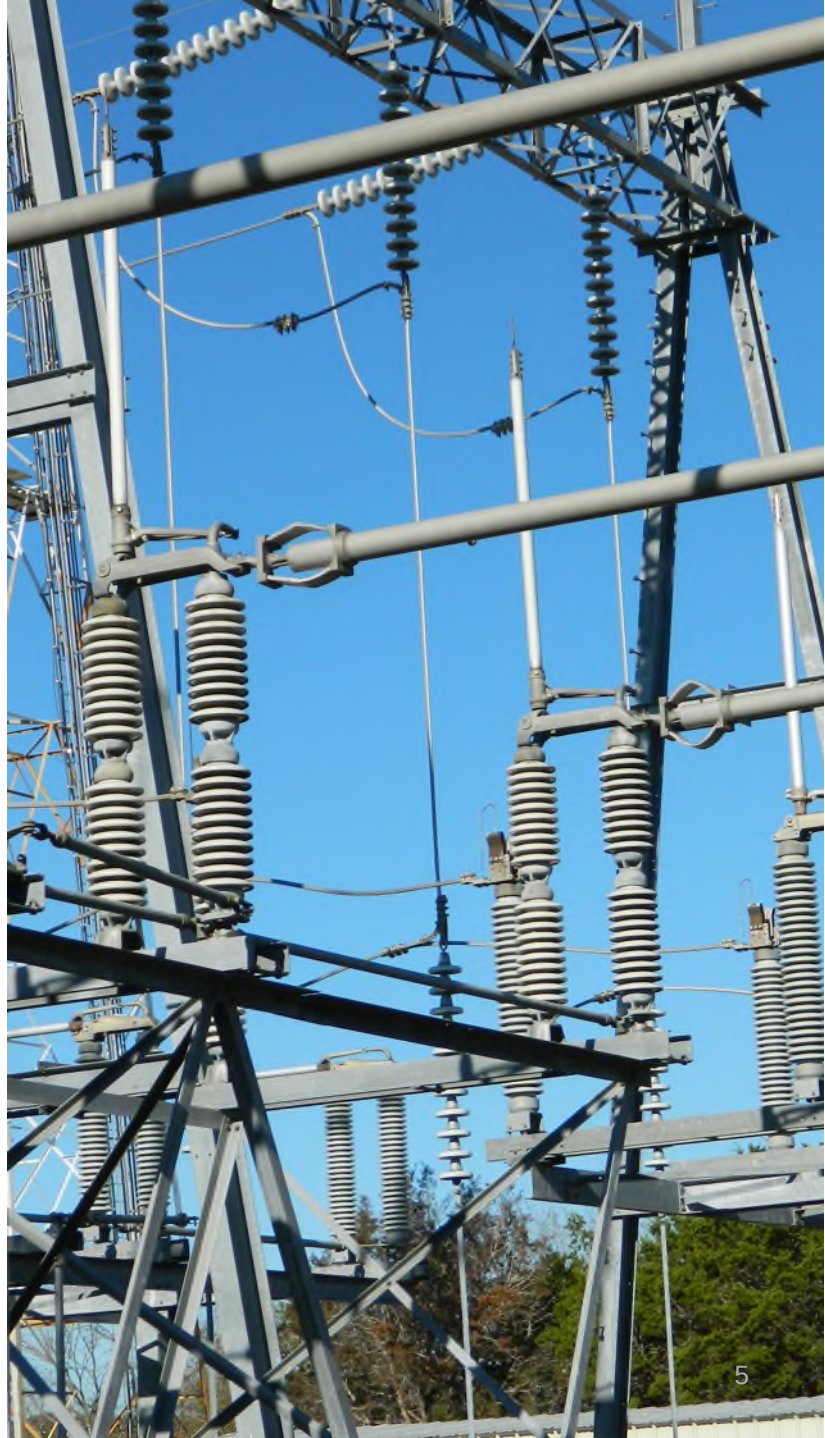
LCRA Lights Up Central Texas

LCRA Transmission Service Corporation

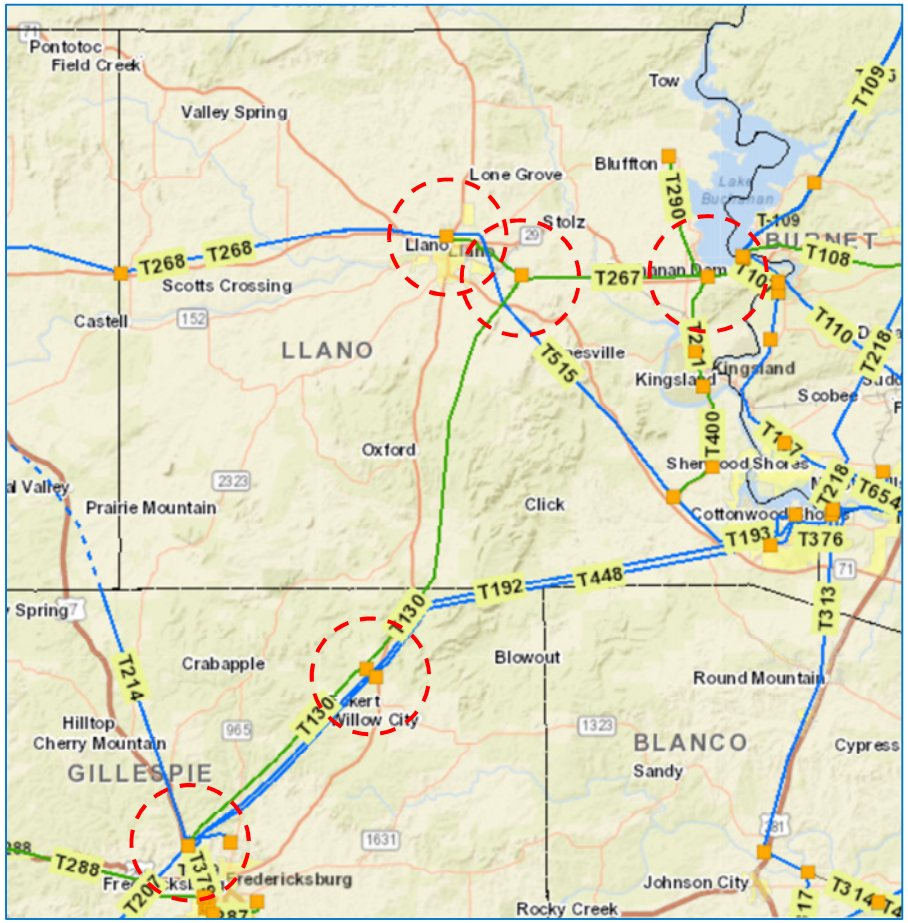
- LCRA created LCRA TSC as a nonprofit corporation for transmission operations after a 1999 state law changed how electric utilities manage and operate electric transmission facilities.
- On Jan. 1, 2002, LCRA transferred ownership of its transmission facilities to LCRA TSC to satisfy the state's requirements.

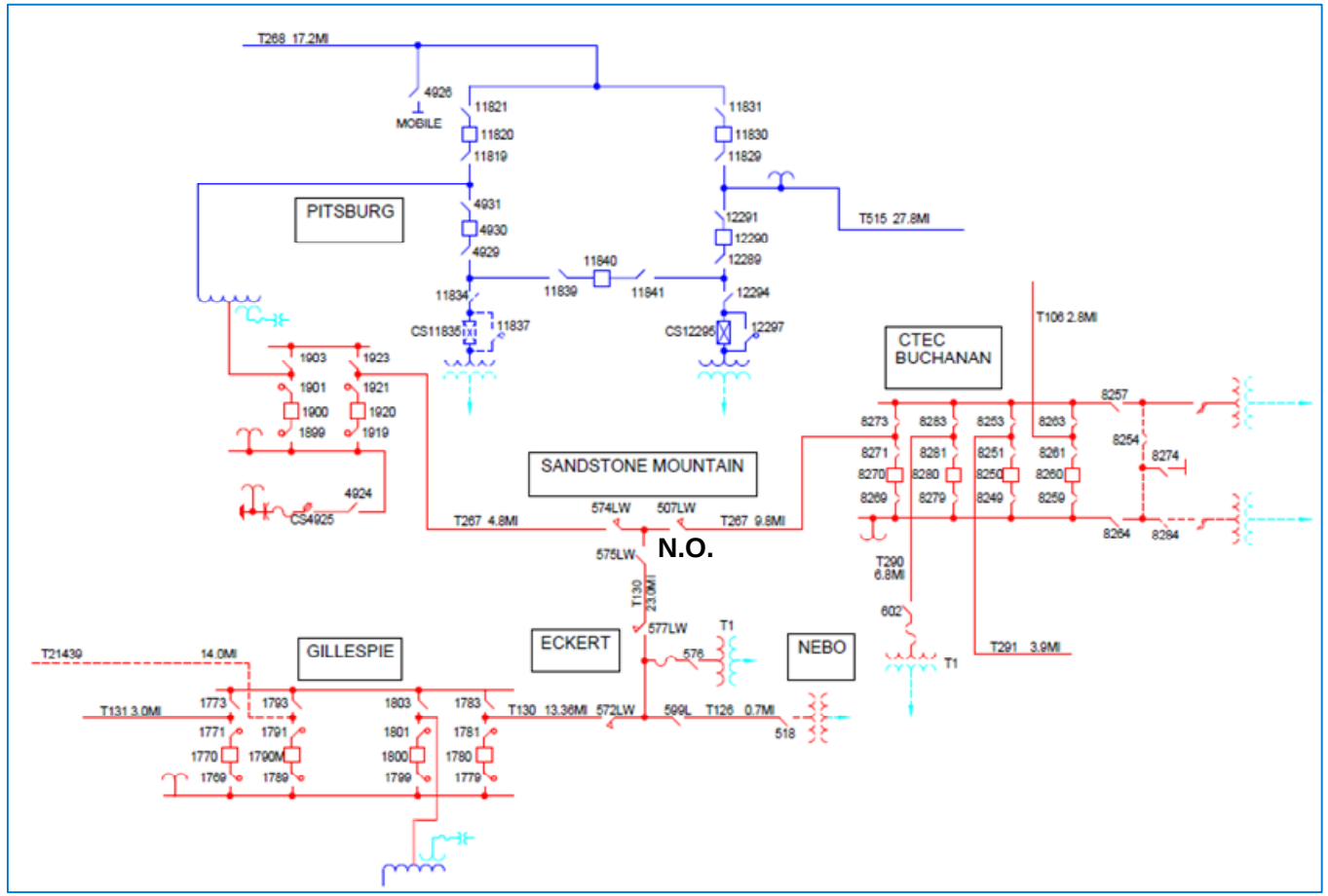
LCRA TSC Facts and Figures

- Over 5,500 miles of transmission owned/operated
  - 345-kV, 138-kV, 69-kV
- Over 420 substations owned/operated
- Facilities in over 75 counties
- Interconnecting 13.4 GW of generation
  - 55+ active gen interconnect requests
- Registered as NERC Transmission Owner, Operator, and Planner

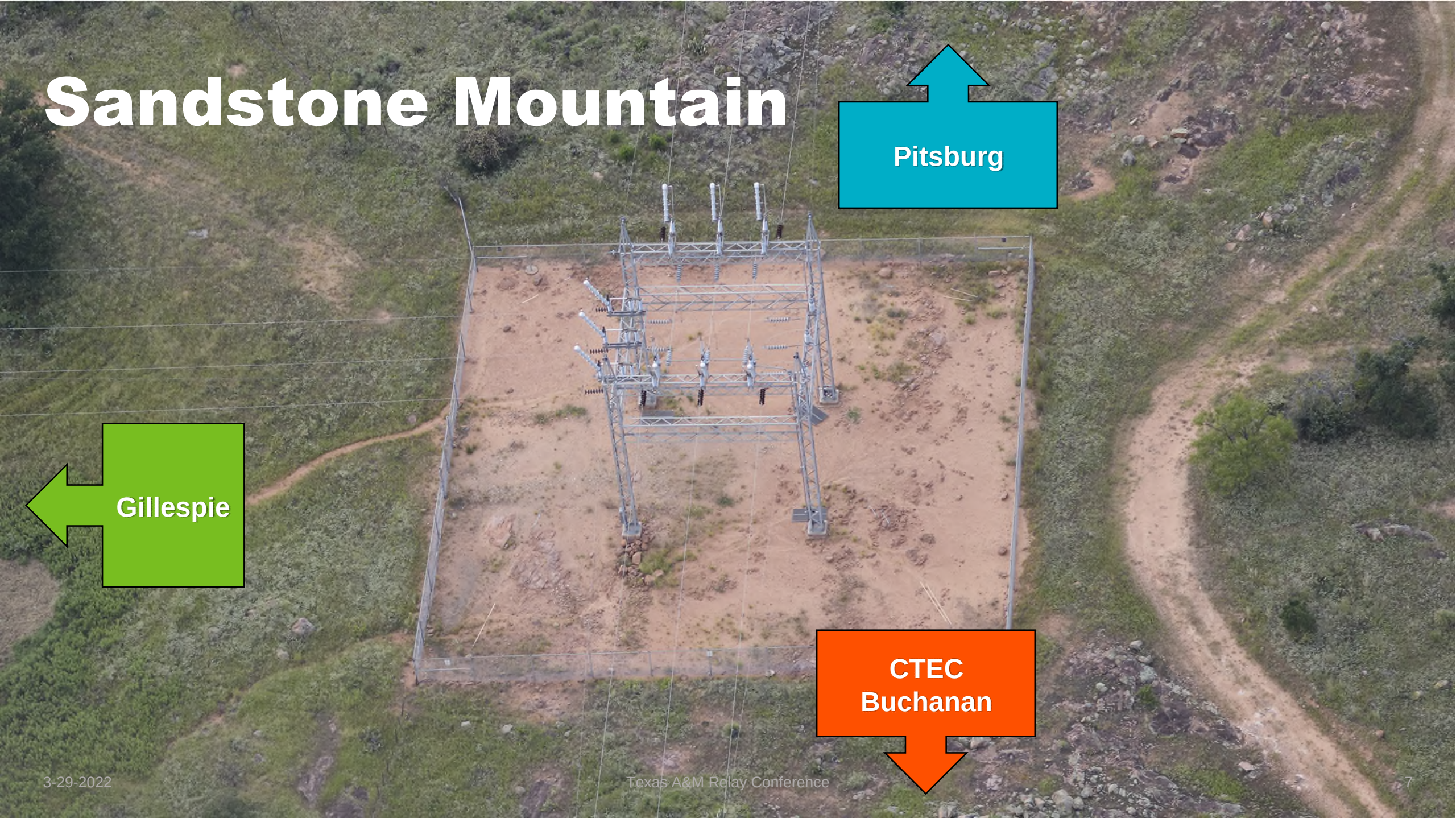


Area of Interest





Sandstone Mountain



Transmission Planning Assessments

Conducted annually or as-needed - steady-state, short circuit, stability
Key inputs noted below:

Load forecast	System topology	Contingencies	Generation dispatch	Facility ratings	Planning criteria
• Based on distribution system provider inputs	• Based on transmission service provider inputs	• Based on transmission service provider inputs	• Based on generation owner inputs	• Based on transmission service provider inputs	• NERC Reliability Standards • ERCOT Planning Guide • Local criteria

Goal is to (1) “stress” the system and evaluate performance versus criteria over a range of credible scenarios, and (2) identify corrective action plans such as system improvements

Sandstone Mountain Area Findings

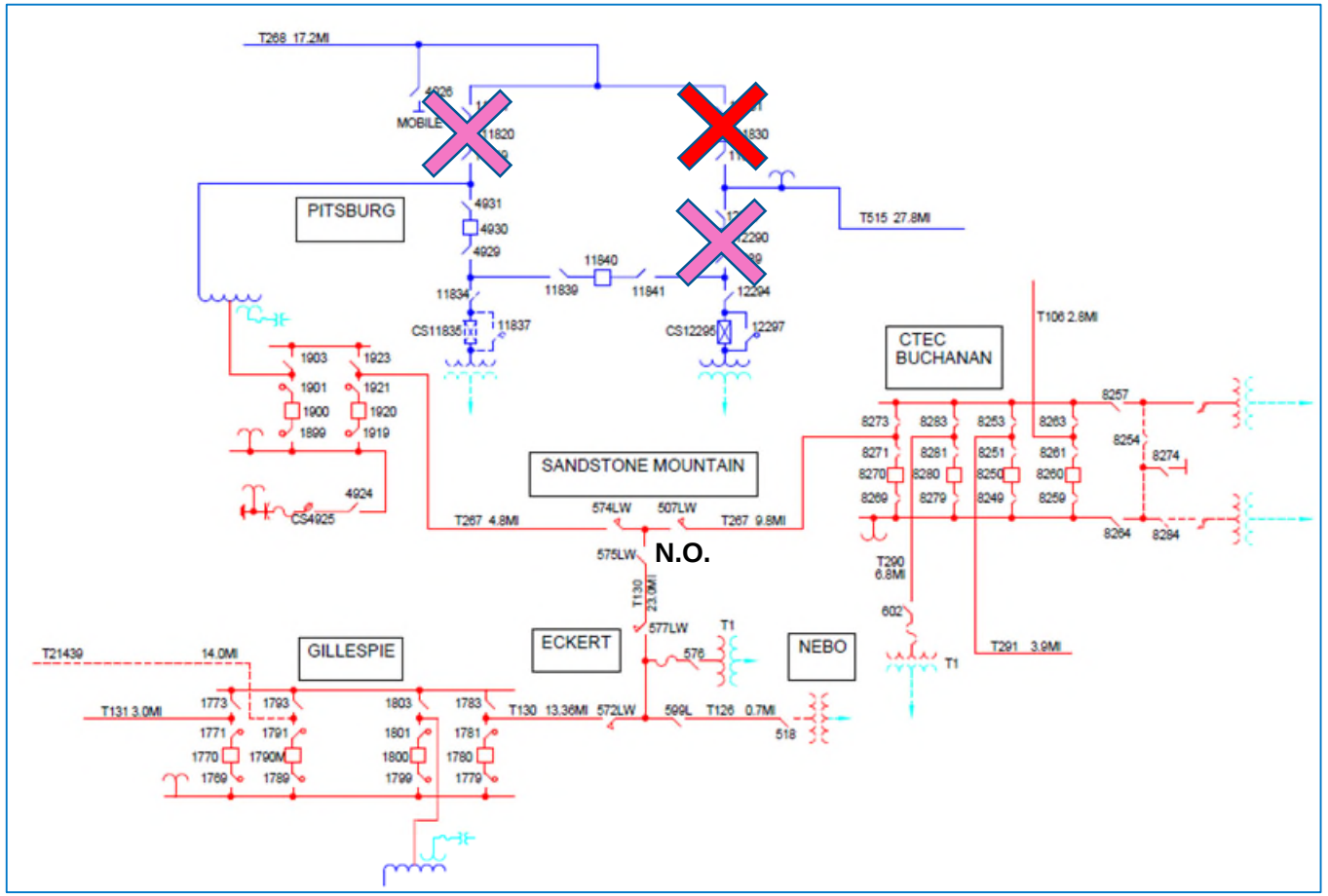
Contingency: Loss of T106 69-kV circuit (“P1”)

- Problem #1: Overloads Sandy Creek 138/69-kV 44 MVA autotransformer and downstream 69-kV system

Sandstone Mountain Area Findings

Contingency: Pitsburg CB 11830 failure (“P2.3”)

- Problem #2: Causes low voltages at Pitsburg 69-kV and 138-kV busses

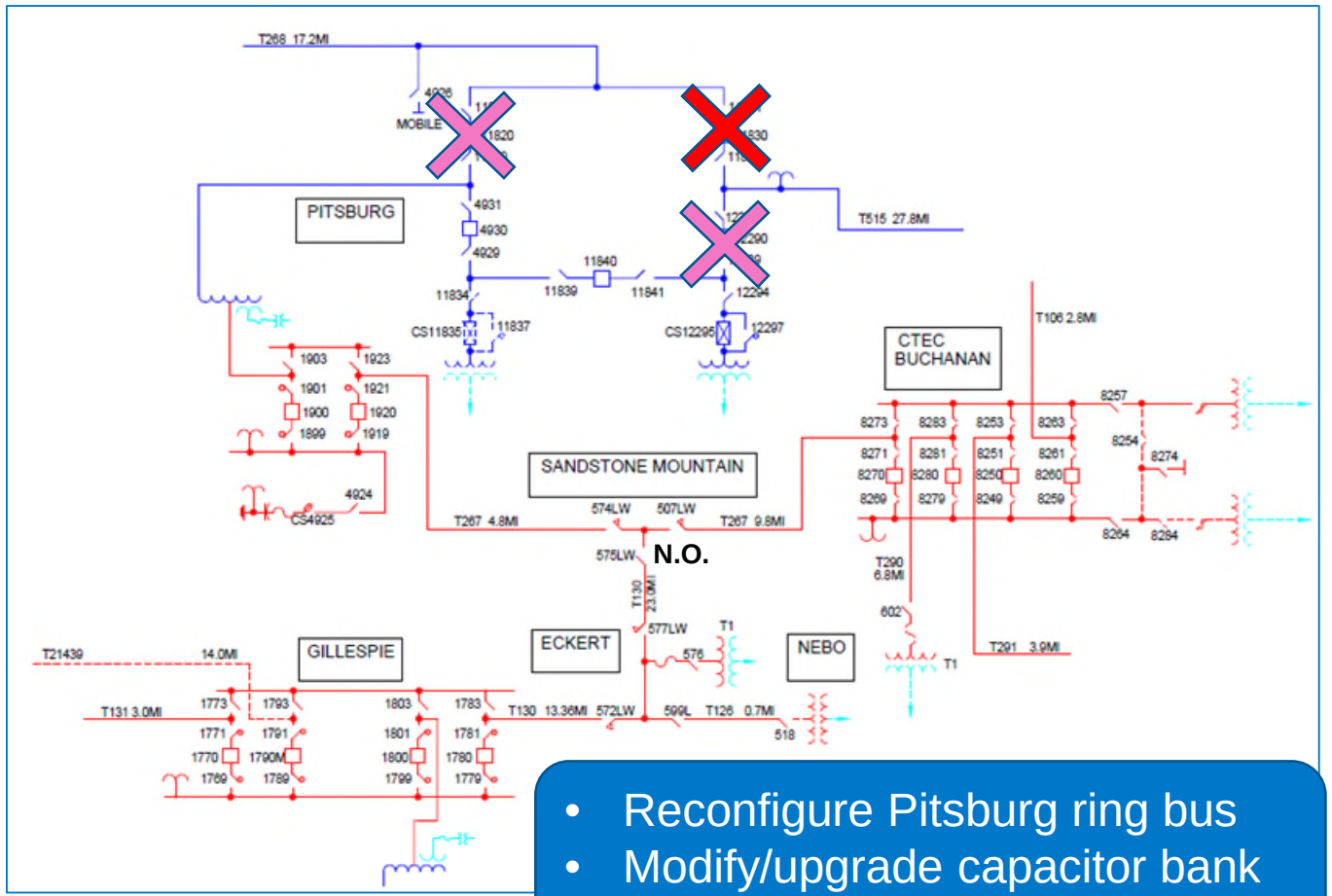


Corrective Action Plans

NERC definition:
A list of actions and an associated timetable for implementation to remedy a specific problem.

- ***When the analysis indicates an inability of the System to meet the performance requirements, the Planning Assessment shall include Corrective Action Plan(s) addressing how the performance requirements will be met.***
- ***The Corrective Action Plan(s) shall:***
  - *List System deficiencies and the associated actions needed to achieve required System performance. Examples of such actions include:*
    - *Installation, modification, retirement, or removal of Transmission and generation Facilities and any associated equipment.*
    - ***Installation, modification, or removal of Protection Systems or Special Protection Systems.***
    - *Installation or modification of automatic generation tripping as a response to a single or multiple Contingency to mitigate Stability performance violations.*
    - *Installation or modification of manual and automatic generation runback/tripping as a response to a single or multiple Contingency to mitigate steady state performance violations.*
    - *Use of Operating Procedures specifying how long they will be needed as part of the Corrective Action Plan.*
    - *Use of rate applications, DSM, new technologies, or other initiatives.*

Alternatives Analysis



- Reconfigure Pitsburg ring bus
- Modify/upgrade capacitor bank
- Add another source

- Upgrade autotransformer and 69-kV system
- Add another source

Alternatives Analysis

Reconfigure Sandstone Mountain to provide both new sources

- However, this leaves tapped load radially served
- Overloads autotransformers elsewhere
- Requires manual switching and temporary relay settings

Need to close in all three terminals at Sandstone Mountain

Breakered substation

- >$10M
- 18-24 months

Three-terminal line

- <$1.5M
- 6-12 months

Protective Relay Upgrades

At Pitsburg Substation:

- Install one (1) dual LCD leader panel (87A/87B)
- Remove CB 1920 panel 9 (digital relay)
- Install telecommunications equipment for relaying

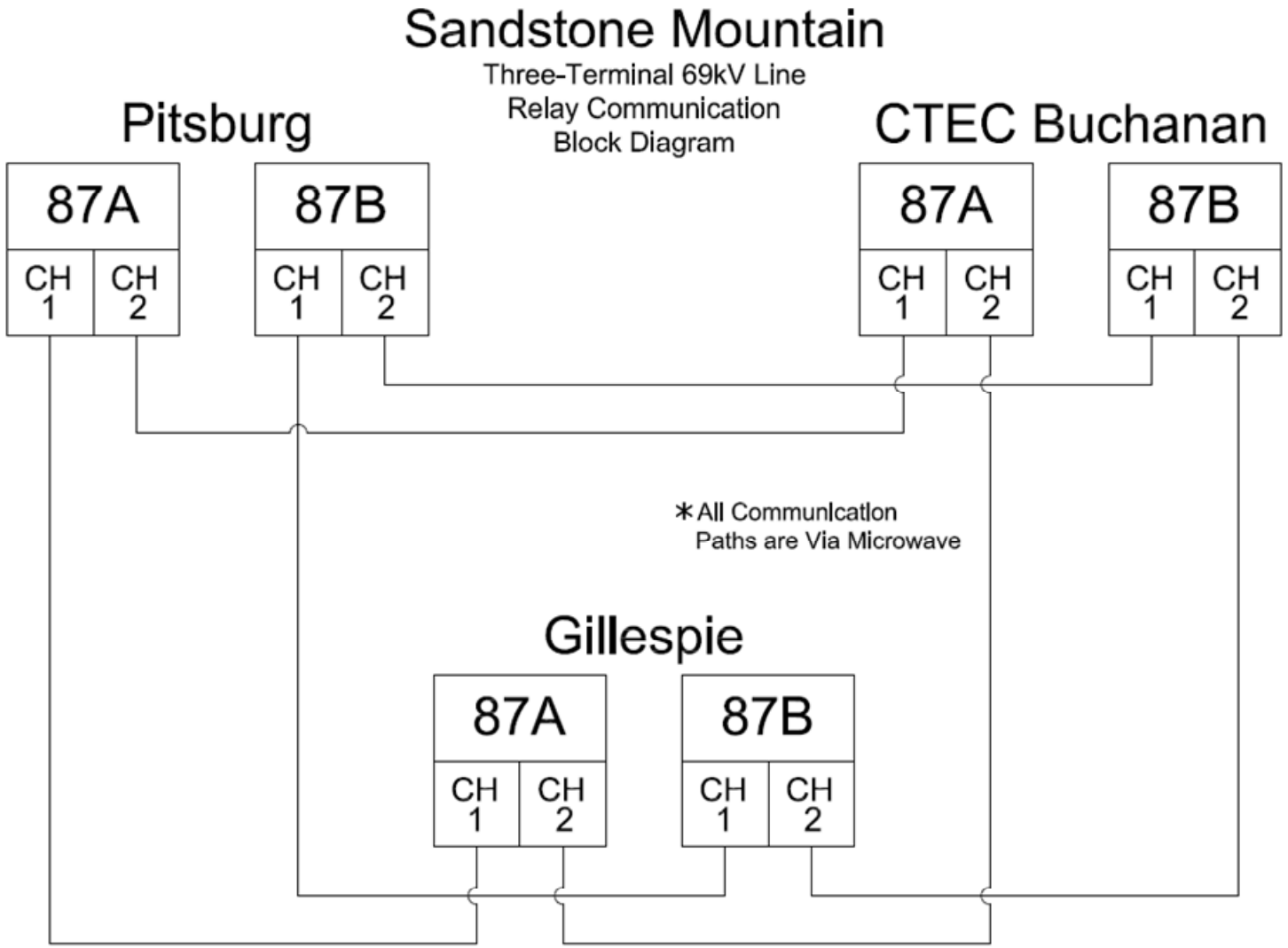
At Gillespie Substation:

- Install one (1) dual LCD leader panel (87A/87B)
- Remove CB 1780 panel 13 (electro-mechanical)
- Install telecommunications equipment for relaying
- **Replace CB 1780 with a 69-kV 40kA 1200 A gas circuit breaker**

At CTEC Buchanan Substation:

- Install one (1) dual LCD leader panel (87A/87B)
- Remove CB 8270 panel 3 (electro-mechanical relay)
- Install telecommunications equipment for relaying

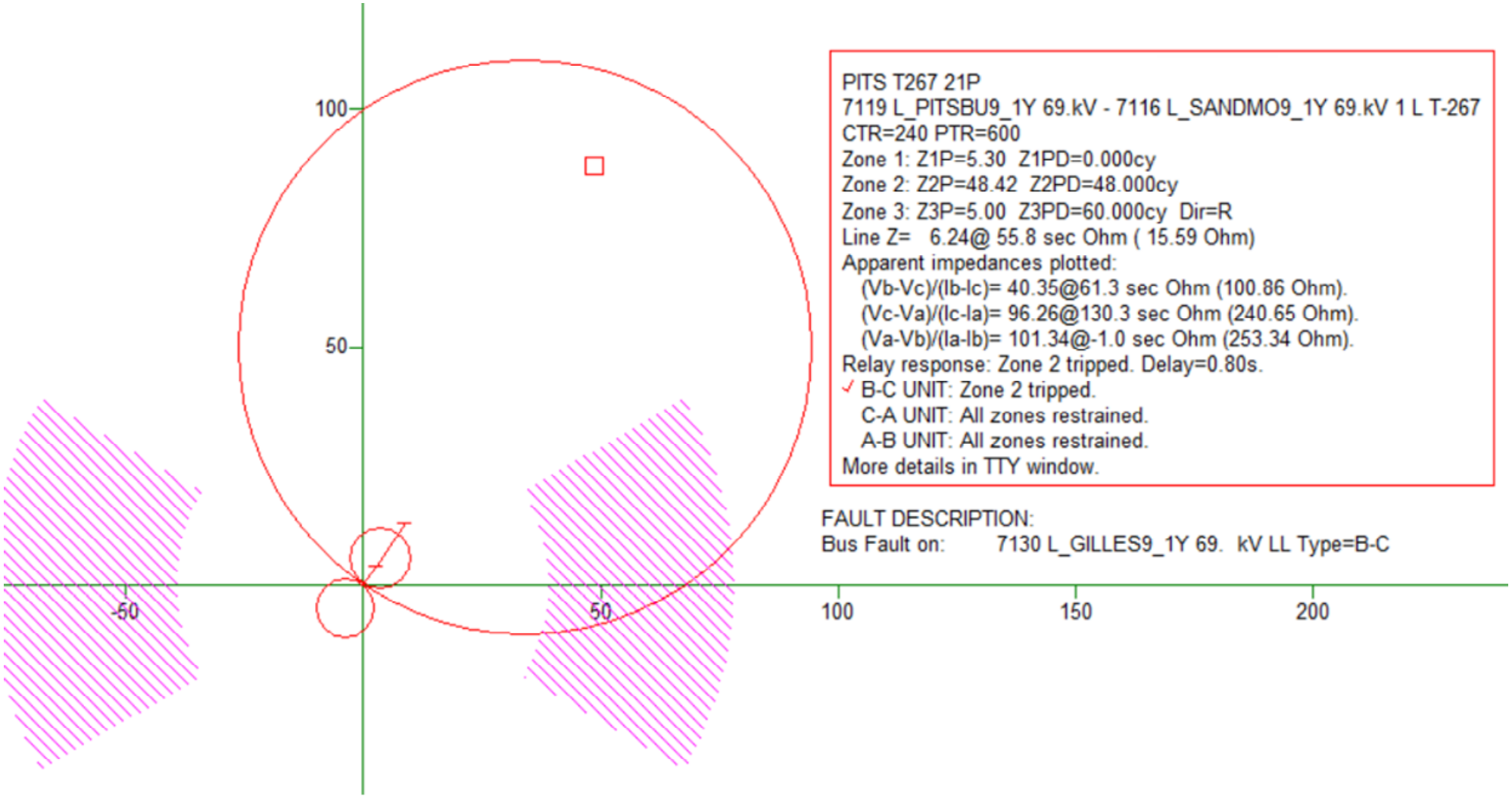
Differential Relay Pilot Channels



Three-terminal Line Protection

- **Key considerations:**
  - Infeed effects
    - Must reach to furthest end of line with all terminals in service
  - Tapped load in-zone
    - Must ensure security for low-side distribution system faults
  - Relay loadability
    - Must ensure full line rating is obtained and scheme is secure at high loads
  - Pilot relay channel availability
    - Must ensure security during loss of signal (microwave)
  - Differential element backups
    - Must ensure backup fault clearing – distance and ground overcurrent elements utilized
  - Group settings
    - Must accommodate multiple transmission line topologies

Infeed Effects

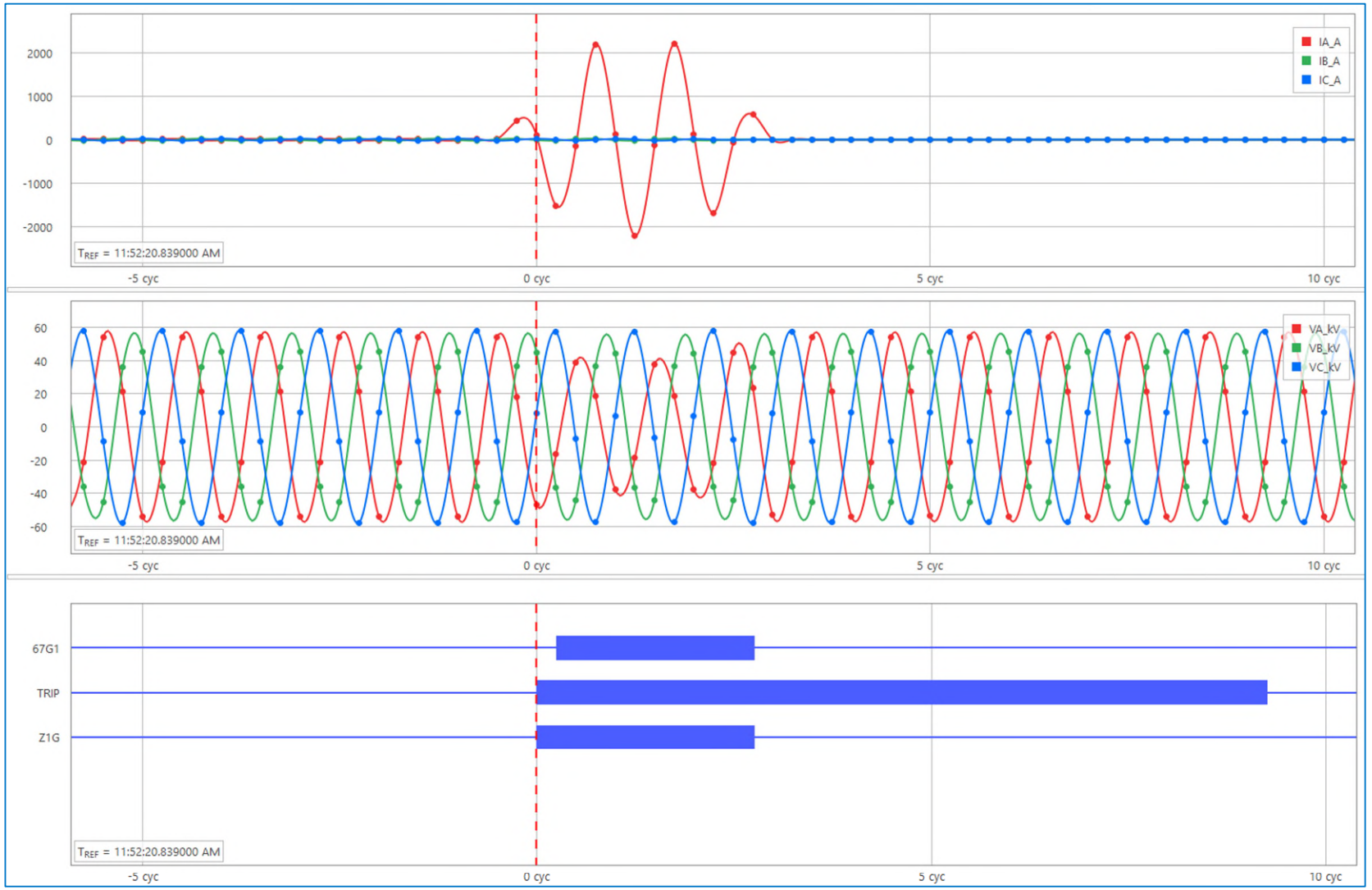


Project Execution

- Settings developed and relay panels built in-house
- Pilot channels implemented via microwave due to lack of OPGW
- Three-terminal fault simulations applied
  - 26 total faults: 12 internal, 12 external transmission, 2 distribution
  - 87 DTT tested during loss of pilot channels
- Two-terminal fault simulations applied
  - 22 total faults: 12 internal, 8 external transmission, 2 distribution
- Service maintained to two internal tapped loads during testing and commissioning

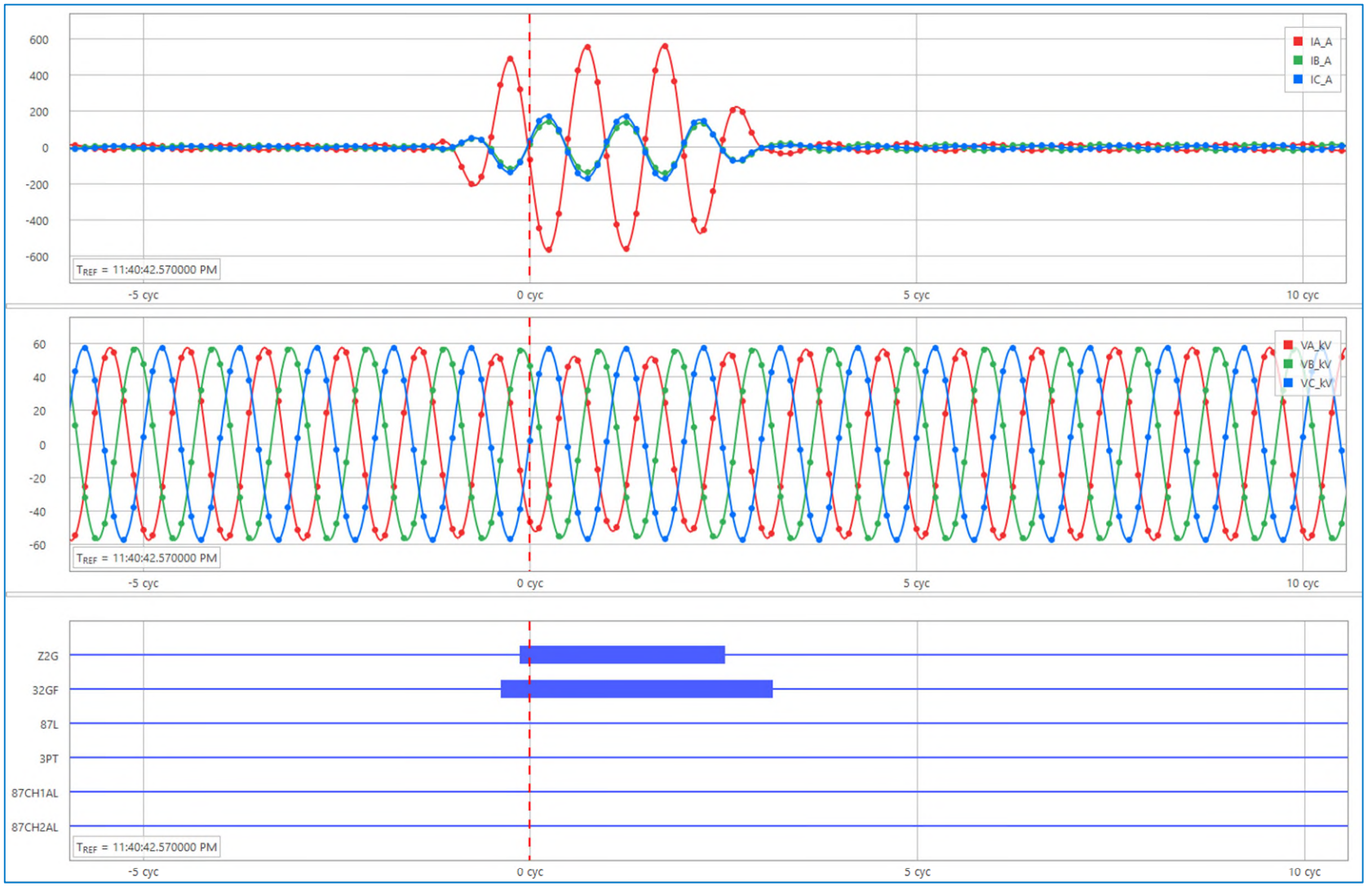
Results: Internal fault, no 87A/87B

- Gillespie T130 Primary Relay, 2/14/2021
- Line differential pilot channel not yet enabled at this time
- Proper trip on ground instantaneous and zone 1 ground



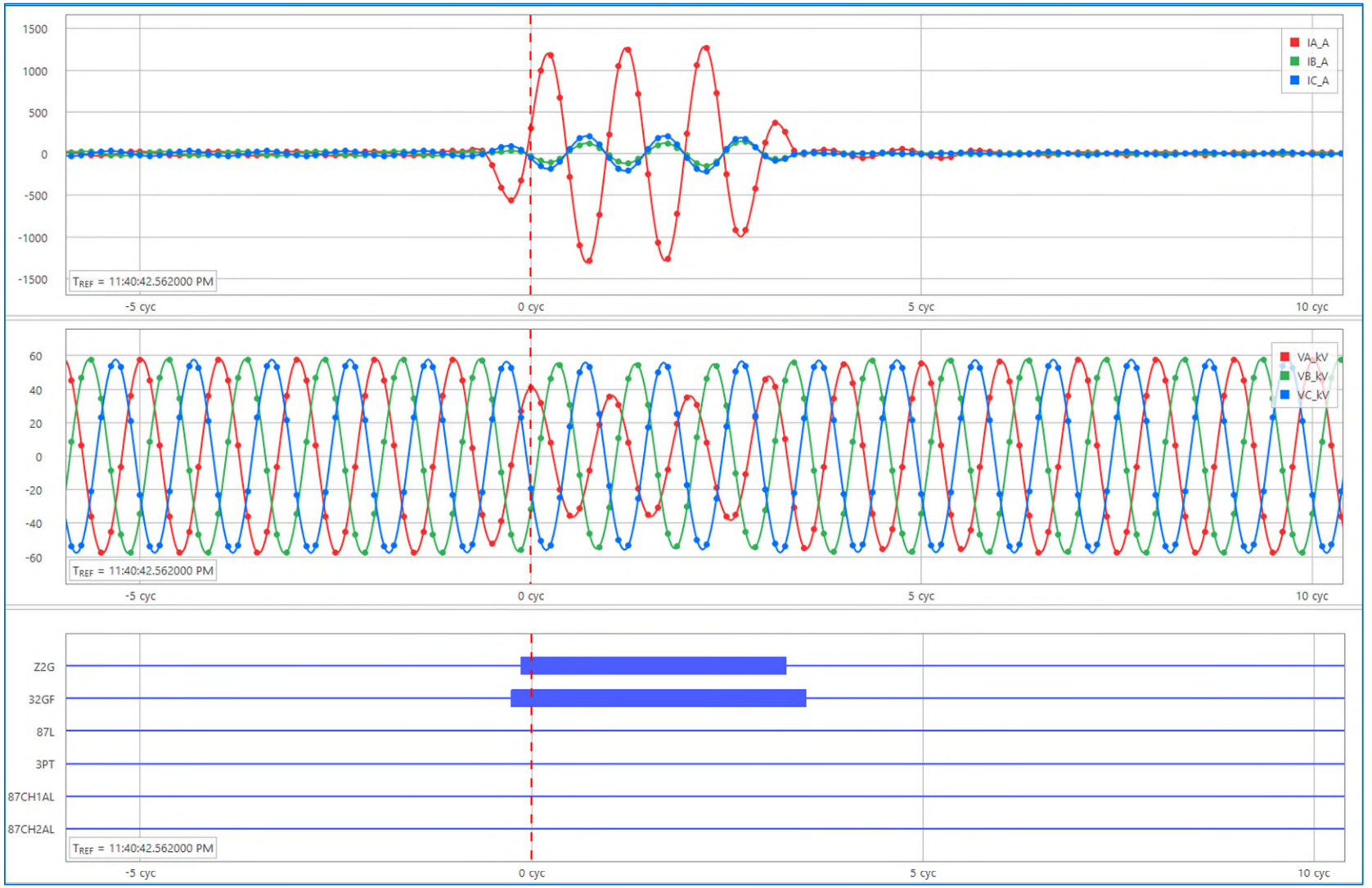
Results: External Forward Fault

- Gillespie T130 Primary Relay, 11/16/2021
- Line differential pilot channel enabled at this time
- Proper directional determination and differential element restraint



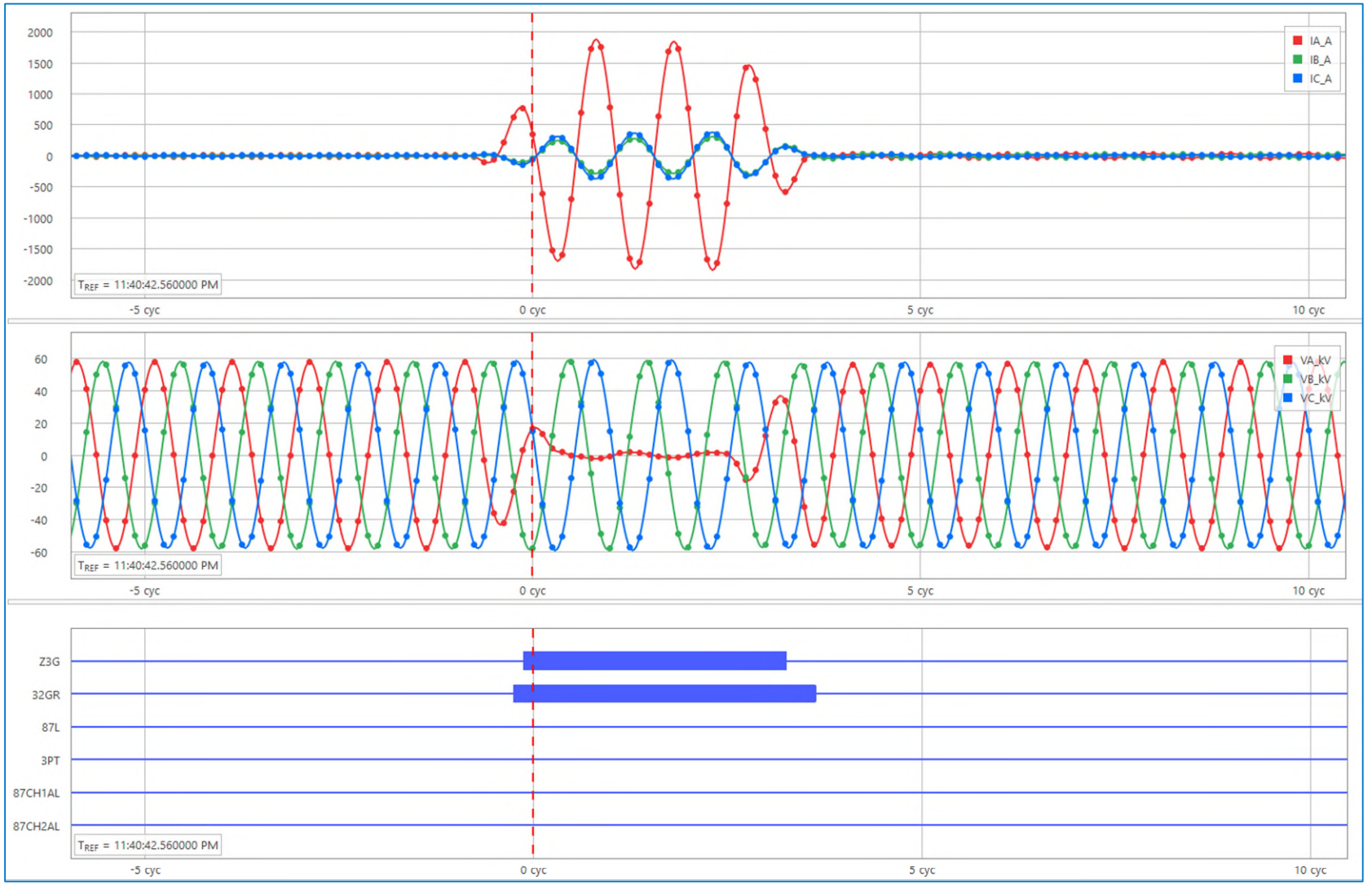
Results: External Forward Fault

- Pitsburg T130 Primary Relay, 11/16/2021
- Line differential pilot channel enabled at this time
- Proper directional determination and differential element restraint



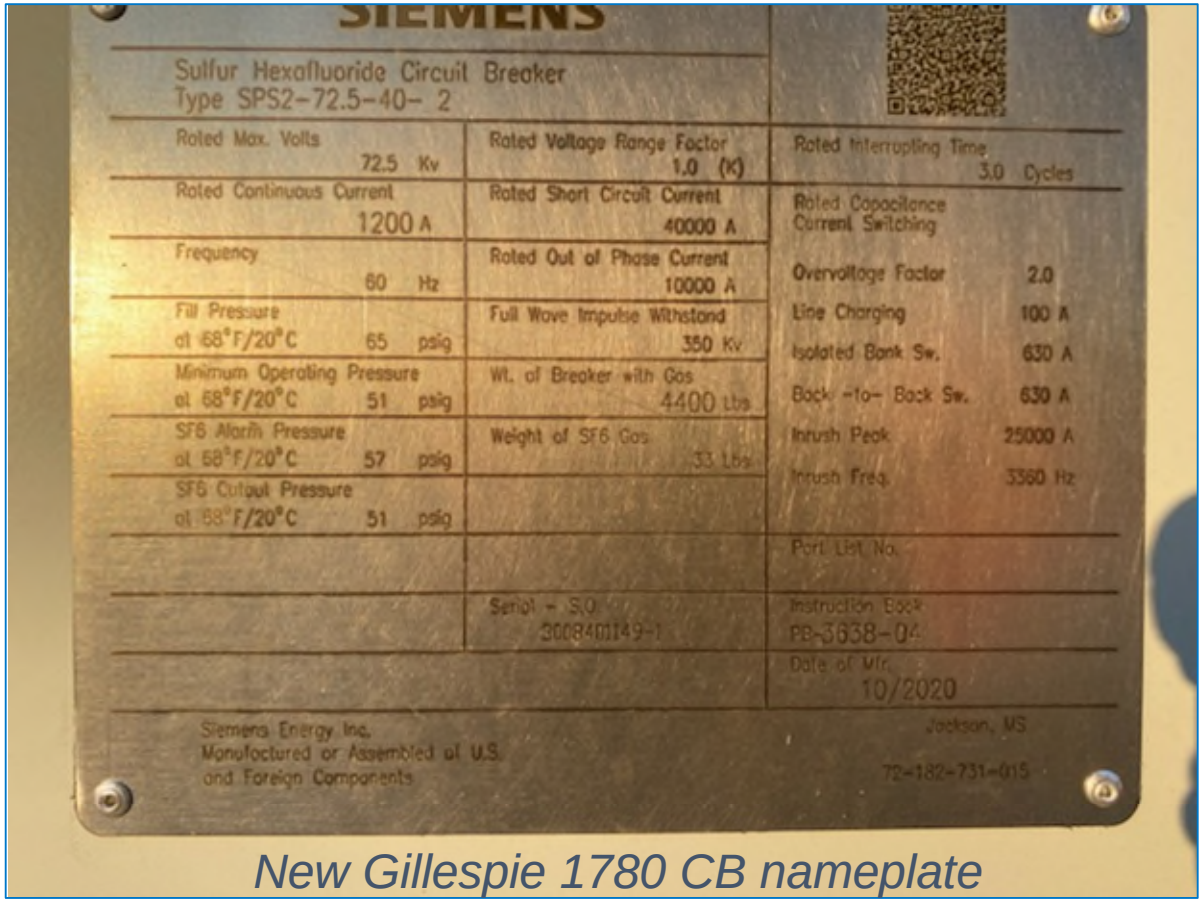
Results: External Reverse Fault

- CTEC Buchanan T267 Primary Relay, 11/16/2021
- Line differential pilot channel enabled at this time
- Proper directional determination and differential element restraint



Results – scope, schedule, budget

- Relay panel and obsolete oil circuit breaker upgrade work completed by Winter 2020
- Relay pilot channel implemented prior to Winter 2021
- Protective relaying scheme has performed well for internal and external faults
- Project actuals were $555K vs $1,285K budget



New Gillespie 1780 CB nameplate

Key Takeaways

- Planning assessments are vital to a well-operated system
- Corrective action plans must consider the time and cost to implement, as well as future needs
- Planning and Protection engineers are encouraged to collaborate and "think outside the box" to solve issues
- Three-terminal line configurations can be a great system benefit

Protective relay upgrades are a powerful "tool in the tool kit" to address planning criteria violations, add operational flexibility, and improve system reliability and safety

Acknowledgments

- **Transmission Planning**
  - Naved Khan and Dylan Preas
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