Agenda

- Background
- Summary of the event
- Event analysis
- Subsequent findings
- Mitigation plan and execution
- Lessons Learned
- Conclusion
- Questions/Answers
Background

- Natural gas, combined cycle PP
- 660MW total capacity
- 3\textsuperscript{rd} party “turnkey” Project
- The utility ultimate owner/operator
- First online in 2010
CTG1 GSU’s Failed CT Bushing
At 21:59 on Thursday 3/13/2014

1. CB 1001 tripped - CTG1
   Target – 87U - Legit Operation.

2. STG GSU’s CB 0001 tripped on REF.
   Target: 51N - Miss-Operation
### Summary of REF Event’s Analysis - Findings

<table>
<thead>
<tr>
<th></th>
<th>CTG1</th>
<th>STG</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PH DIFF OP</strong></td>
<td>Yes - (Correct)</td>
<td>No - (Correct)</td>
</tr>
<tr>
<td><strong>REF OP</strong></td>
<td>No - (Incorrect)</td>
<td>Yes - (Incorrect)</td>
</tr>
<tr>
<td><strong>FAULT LOCATION</strong></td>
<td>In Zone</td>
<td>Out of Section</td>
</tr>
<tr>
<td><strong>PH CT WIRING</strong></td>
<td>Floating</td>
<td>Floating</td>
</tr>
<tr>
<td><strong>NEUT CT WIRING</strong></td>
<td>2 Grounds</td>
<td>2 Grounds</td>
</tr>
</tbody>
</table>
Restricted Earth Fault Protection

- Provides sensitive detection of Y-Grounded Transformer’s internal ground faults.

- Operates on comparing measured ground current of the neutral CT (In) and the calculated zero sequence current from the 3 phase CTs (3I0 = IA + IB + IC)

- The element is “restricted” to ground faults within a zone defined by neutral and line CT placement.
STG’s REF: Expected vs as-found CT Drawing

Expected

As-found
As-found Neutral CT : Equivalent circuit

\[ I_{\text{in Sec}}: \text{The expected Neutral current,} \quad I_{\text{in Sec}} = I_{\text{Gnd}} + I_{\text{Relay}} \]

\[ I_{\text{Relay}}: \text{Recorded Neutral Current,} \quad I_{\text{Relay}} = I_{n}, \quad I_{n} < 3I_{0} \]
Operating (3I0) Vs Polarizing Current (In)
REF Operation

32IE: Dir Supervision
32IF: Internal Fault
50GC: Min Pickup
REFP
TRIP1

\[ |I_{op} \cdot CTR1| \cdot |I_{pol} \cdot CTR4| \cdot \cos(\theta_{Iop} - \theta_{Ipol}) \]

(-90° to +90°)
Generator Damage

- Why was this open winding not detected?

- The type of winding:
  - “Split-phase” winding
  - Three circuits/conductors per phase

- Where were the open points in the winding:
  - Open winding on one circuit/conductor for each phase
STG – Steps taken to bring the generator to service

- Installation of Partial Discharge Analysis for “Split-Phase” circuit Monitoring.
- The generator rotor was removed and tested, the stator was completely rewound.
- Resolved wiring issues
- Test department on board for Testing / Commissioning
- Review of Relay Settings for GSU and Generator
Lessons Learned: “Turnkey” Process Gap

- “Turnkey” projects need special attention
  - The Gap: Several entities who may be unfamiliar with in-house standards and long-term maintenance issues
  - Need for overall Protection Engineer and Test Team
    - Ensure Relays are Designed, Set and Commissioned per standard

- Fast Tracked Project: Pressure to go online per schedule.
  - PDA monitoring was designed but was not installed
  - Event recording may be an afterthought:
    - Critical for Root Cause Analysis
Lessons Learned: Need for Collaboration

- FERC order 1000: The need for Collaboration to insure reliability of the Bulk Electric System
  - Allows the installation of 3rd party substations in areas historically served by utilities
  - Stations Built, Owned and Maintained by the 3rd party
  - Need to coordinate and have the same level of review of their protective schemes as those for generation and load interconnections.

- The Gap: Liability vs Reliability from Protection viewpoint
  - Overreaching protection requirements
  - Include agreement provisions in contracts to protect involved parties from liability to insure reliability.
## Conclusion

### Event analysis
- More issues than expected
- Wiring, settings, documentation, commissioning
- Pressure to generate ASAP

### Subsequent findings
- Event on 3/13/2014
- Plant back online on 6/18/2014
- Team work effort /Collaboration
- More issues than expected
- Wiring, settings, documentation, commissioning
- Pressure to generate ASAP
- Root cause Analysis (RCA)
- Involved Test department
- Corrected Wiring, settings, & tested GSU, CTG and STG Rlys

### Mitigation plan
- Event on 3/13/2014
- Plant back online on 6/18/2014
- Team work effort /Collaboration
- Turnkey Power Plant Process gap
- Recommend overall Protection Engineer and Test Team
- Liability or Reliability?

### Mitigation time line

### Lessons learned

### Recommendations
Transmission Interconnection: Acquired Plant - Lessons Learned

Thank you

Questions?