Texas Reliability Entity
Event Analysis

Event:
March 14, 2011 Loss of Multiple Elements
Category 1b Event

Texas Reliability Entity
July 2011

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Executive Summary

On March 14, 2011 at 06:09, the ERCOT Region experienced the simultaneous loss of one 345 kV bus and two generating units, causing the loss of 922 MW within the first minute of the event. Cause of the event was a lightning strike on a 345 kV bus with severe thunderstorms moving through the area. This report provides: (1) an overview of the event; (2) background on system conditions just prior to the event; (3) the detailed sequence of events; (4) an analysis of the causal and contributing factors for concerns that arose in this event; and (5) recommendations for follow-up action.

I. Event Overview

On March 14, 2011 at 06:09, a lightning strike hit the 345 kV bus at the Generation Station A. Initially, the 345 kV bus B tripped by differential relay. There was evidence of a phase-to-ground fault on the "C" phase CT for GCB XXX-1.

Approximately 9 seconds later, the 345 kV bus C tripped from a second fault. The apparent cause of the bus C differential trip was a flashover across the "C" phase Current Transformer (CT) near gas circuit breaker (GCB) YYY.

Generation Station A, Unit D tripped off-line due to this event, with a net output of 98 MW.

Generation Station B, Unit E tripped at 06:09:44, with a net output of 824 MW, due to operation of the unit's automatic voltage regulator lockout relay, which initiated a trip signal to the generator lockout relay.

922 MW tripped during the event.

System frequency dropped from 60.033 Hz to 59.818 Hz as a consequence of the loss of generation. The drop was arrested by governor action of ERCOT Region generators. These actions led to system frequency recovery within 6 minutes and 24 seconds to the pre-disturbance value of 60 Hz (at 06:16). The Balancing Authority (BA) Physical Responsive Capability (PRC) remained above minimum target of 2300 MW set by ERCOT Protocols for the duration of the event. Physical Responsive Capability remained above 5200 MW.

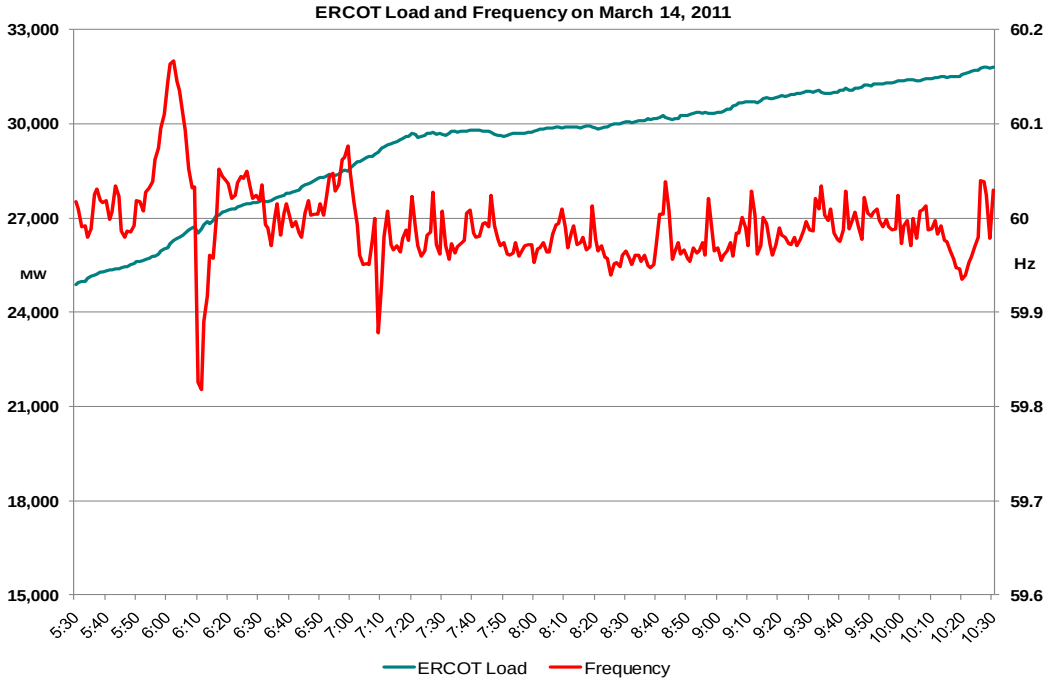
This event did not meet the criteria as a NERC Disturbance Control Standard (DCS) event since the loss of generation was below the 1083 MW threshold for the ERCOT Region. The event met the definition of both a Category 1b event (loss of three or more bulk power system elements (i.e. generators, transmission lines, and buses)) event under NERC's Event Analysis Working Group process.

II. Initial System Conditions Prior to Event

Initial system conditions just before the event of March 14, 2011 were:

System Load:	26,706 MW
System Frequency:	60.033 Hz
Physical Responsive Capability:	~5400 MW

At 06:09 ERCOT Region load was 26,706 MW and total wind generation was 5023 MW.



ERCOT Region Load and Frequency on January 09, 2011.

III. Sequence of Events on 03/14/2011

- 06:09:30 Lightning strike hits Generation Station A 345 kV bus B
  345 kV bus B trips
  GCB XXX-1 open
  GCB XXX-2 open

- 06:09:33 Generation Station A Unit D trips, operating at 98 MW

- 06:09:39 Generation Station A 345 kV bus C trips
  GCB YYY-1 open
  GCB YYY-2 open

GCB YYY-3 open
GCB YYY-1 breaker failure indication

- 06:09:44 Generation Station B, Unit E trips, operating at 824 MW
- 06:15:58 ERCOT Region frequency recovers to 60 Hz
- 08:39 Generation Station A, Unit D returned to service

3/15/2011

- 04:50 Generation Station B, Unit E returned to service

IV. Analysis of Event

A. Transmission Owner A

A lightning strike hit the 345 kV bus B at Generation Station A. Initially the bus B differential tripped out. Transmission Owner A reported evidence of a phase to ground fault on the C phase of a Current Transformer (CT) near GCB XXX-1, which appears to be the cause of the bus B differential. Approximately 9 seconds later, the 345 kV bus C tripped out from a second fault due to a flashover across the "C" phase CT near GCB YYY-1. All faults were cleared by appropriate relay action in 3-4 cycles (Bus B differential, Bus C Differential and GCB YYY-1 breaker failure).

The 345 kV CT on GCB YYY-1 was replaced. The 345 kV CT on GCB XXX-1 was inspected and insulator was cleaned, but did not require replacement. Both breakers and CTs have been returned to service.

The fault recorder traces Generation Station A are below.

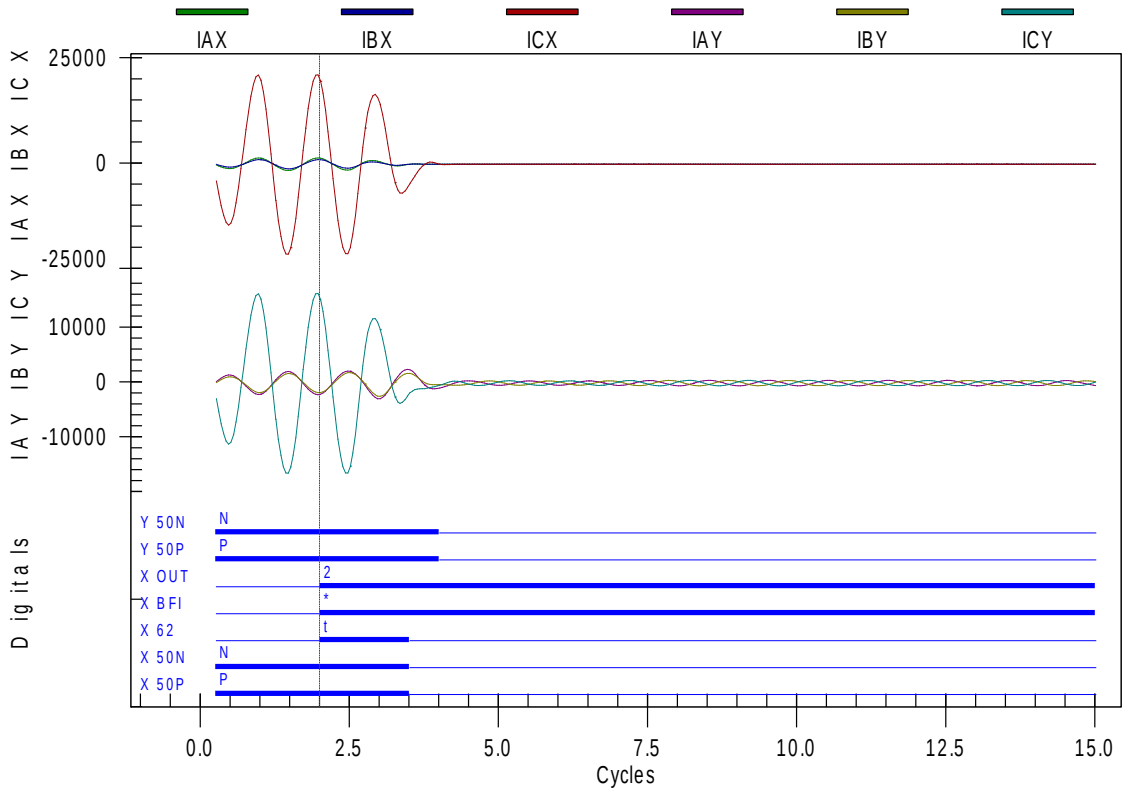


Figure 1: Initial fault at Generation Station A

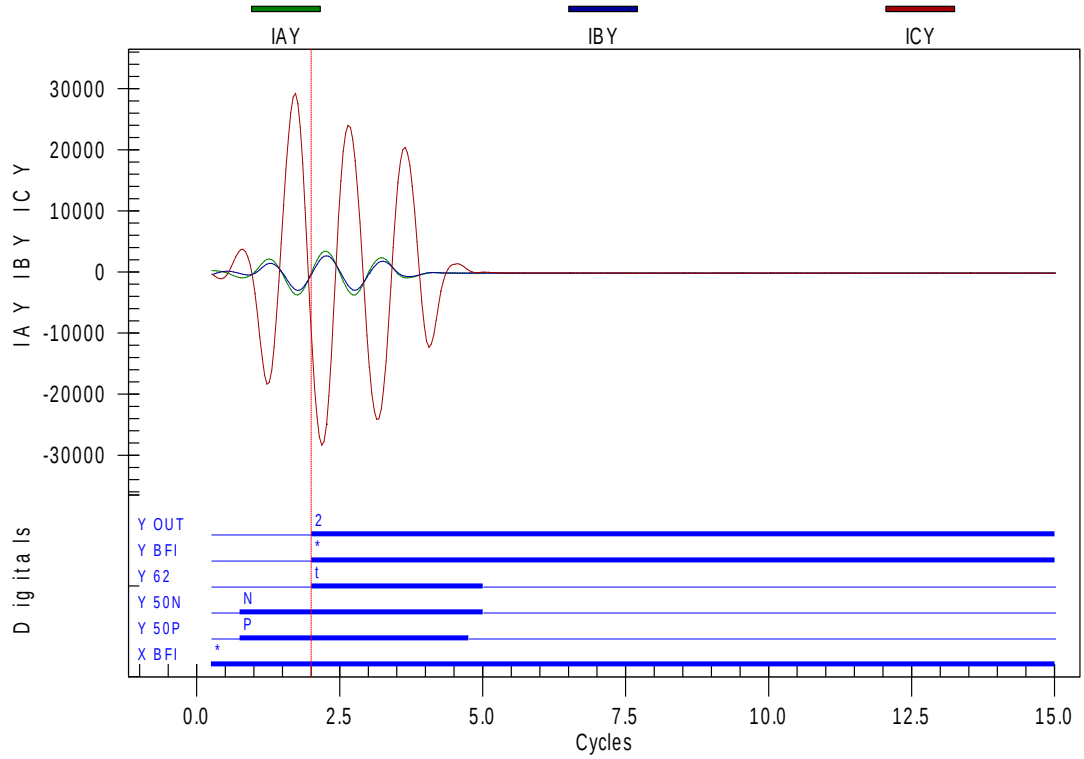


Figure 2: Second fault at Generation Station A

All other breakers involved operated as per design during this event. No personnel injuries or other equipment damage were identified. No protective system misoperations were reported.

B. Generator Owner A (Generation Station A, Unit B)

Generation Station A, Unit B tripped coincident with the 345 kV B bus fault at 06:09. The unit was generating a net output of approximately 98 MW at the time of the trip. The unit returned on-line at 08:39 and was dispatched to full load at 14:48.

All breakers involved operated as per design during this event. No personnel injuries or equipment damage were identified. No protective system misoperations were reported.

A. Generator Owner B (Generation Station B, Unit E)

Generation Station B, Unit E tripped at 06:09:44. A fault on the 345KV transmission system, located close to the plant, caused the unit automatic voltage regulator lockout relay to operate and initiated a trip signal to the generator lockout relay. The generator lockout relay removed the unit from service.

The original equipment manufacturer was consulted after the trip of Unit E and indicated that the root cause of the voltage regulator lockout operation was caused by an externally induced voltage, resulting from the 345 kV transmission fault, within the generator excitation cabinet. The induced voltage created a signal which resulted in the operation of the lockout relay.

Unit E was connected to the grid at 04:50 on 3/15/2011 and was released for full load operations at 08:21 on 3/15/2011.

The Generation Owner is currently investigating a possible modification to the generator excitation protection system to prevent a future occurrence of this nature.

All breakers involved operated as per design during this event. No personnel injuries or equipment damage were identified. No protective system misoperations were reported.

V. Response Analysis

A. Initial Response

The loss of 922 MW of generation and multiple BES elements in the ERCOT Region on March 14, 2011 constituted a significant disturbance to grid operations. The BA used the Region's resources and reserves to balance resources and demand and return system frequency to pre-disturbance frequency.

ERCOT Region frequency (measured at the RC control center) was at 60.033 Hz immediately prior to the disturbance. Immediately after the disturbance, system frequency dropped to 59.818 Hz. Generator governor response arrested the frequency decline. The system frequency returned to its pre-disturbance value of 60 Hz within 6 minutes and 24 seconds. The following are among the actions that registered entities initially took to stabilize the system:

- Generator governor response arrested the frequency decline, as analyzed by the Performance, Disturbance, Compliance Working Group (PDCWG) in its report. The initial calculated system frequency response, termed the "B" point, was 456.08 MW/0.1 Hz, which met the target of 420 MW/0.1 Hz established in ERCOT Protocols. The second calculated response point, termed "B+30" to denote that it measures how well response is sustained 30 seconds after the event, was 411.14 MW/0.1 Hz, which failed to met the minimum response level of 420 MW/0.1 Hz.

B. Reserves

The recovery from the initial disturbance did not take Physical Responsive Capability below 3000 MW, the point at which an "Advisory" is called for in ERCOT Protocols. The Physical Responsive Reserve capability remained above 5200 MW during the event and recovery.

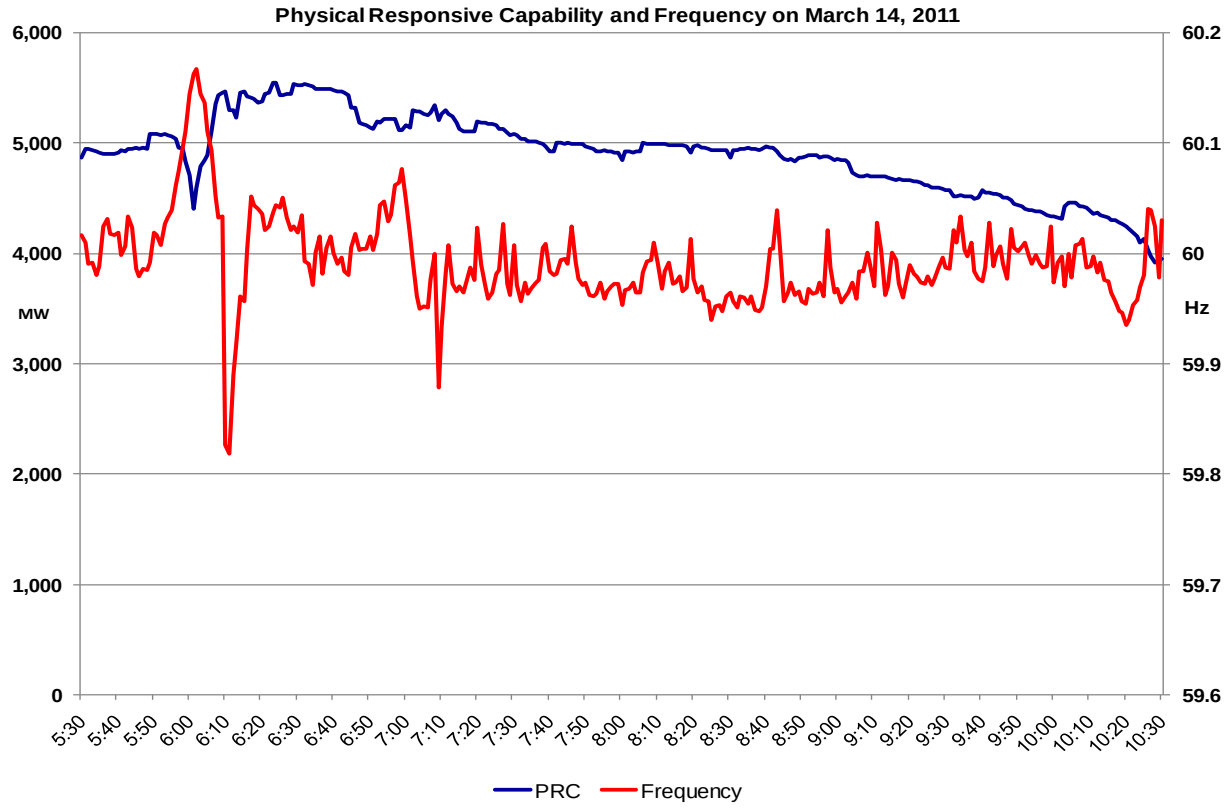


Figure 3: Physical Responsive Capability and Frequency on March 14, 2011.

C. Registered Entity Corrective Actions

Equipment owners have taken the following actions to address the problems noted:

- Transmission Owner A replaced the 345 kV CT on GCB XXX-1. The 345 kV CT on GCB YYY-1 was inspected and insulator was cleaned, but did not require replacement. Both breakers and CTs have been returned to service.
- Generation Owner B is currently investigating a possible modification to the generator excitation protection system to prevent a future occurrence of this nature.

VI. Conclusions

In general, the steps taken in the recovery from this event achieved the desired results. Given the number BES elements outaged during the event, and the high volume of incoming communications, RC and BA operators handled the situation effectively.

Equipment owners have taken actions to address problems as noted previously.