

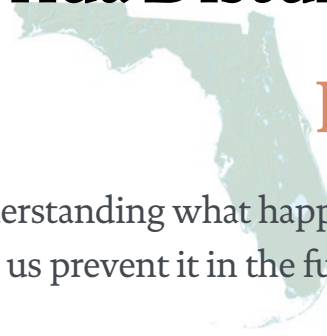


by Clare Duffy, ESBI, Ireland

Florida Disturbance 2008

Blackout Watch

Understanding what happened can help us prevent it in the future.



- Additional underfrequency load shedding of approximately 2300 MW of distribution-level customers dispersed across the southern part of Florida
- Loss of an additional 1800 MW of generation across the Region

ON TUESDAY, FEBRUARY 26, 2008, THE FRCC (Florida Reliability Coordinating Council) Bulk Electric System experienced a wide area disturbance that was initiated by delayed clearing of a three-phase fault that developed on a 138 kV switch located at one of FPL's (Florida Power & Light) Miami area substations.

The primary root cause of the disturbance was the delayed clearing of a 138 kV fault, resulting in frequency and voltage swings across southern and central Florida. The remote clearing of the fault by backup protection relays resulted in:

- Tripping of twenty two transmission lines
 - 6 - 230 kV lines
 - 15 - 138 kV lines
 - 1 - 69 kV line
- Disconnection of approximately 1350 MW of customer load in the vicinity of the fault
- Loss of approximately 2500 MW of generation near the fault location

The FRCC Bulk Electric System did not experience any system islanding and remained connected to the Eastern Interconnection throughout the disturbance. Except for the transmission line outages required to remotely clear the initial fault, some additional single-end operations in the vicinity of the fault and the opening of a radial line feeding the southern keys of Florida, the transmission system within the FRCC remained intact and did not experience any additional transmission line outages or overloads.

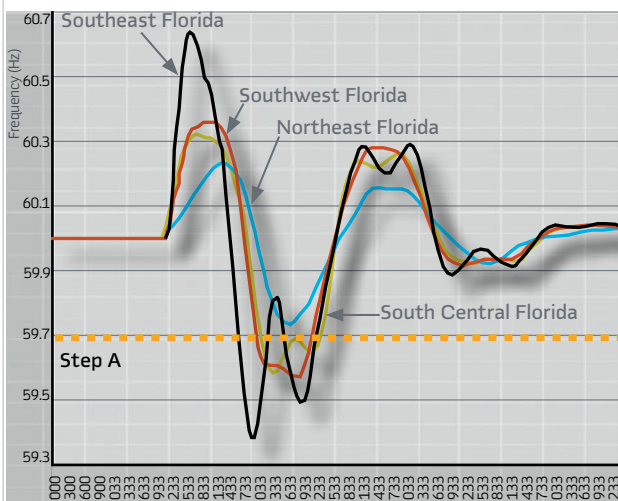
The FRCC Operating Committee quickly established a task force including experts from within and outside the region, as well as observers from several regulatory bodies. The goal was to analyze the event and ensure understanding of the causes and effects of the disturbance. Seven sub-teams analyzed different aspects of the disturbance.

The results of their analysis were compiled in the report FRCC System Disturbance and Underfrequency Load Shedding Event Report February 26th, 2008. The Final

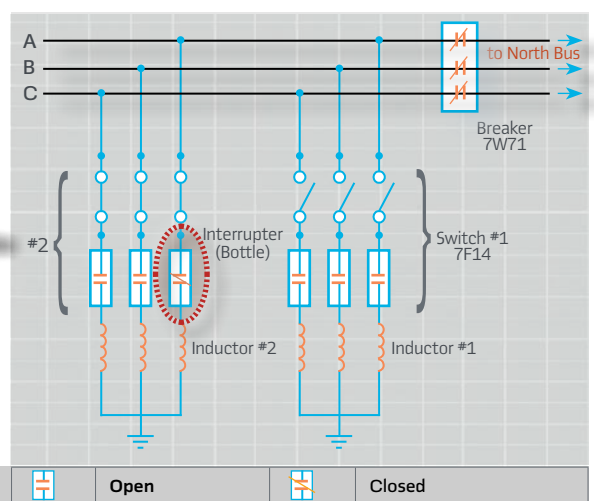
Florida Disturbance

Delayed fault clearing resulted in frequency swings and underfrequency load-shedding across Florida.

1 Frequency variation



2 Initial switch failure



Report was issued by the FRCC Event Analysis Team on October 30, 2008. The report includes detailed observations, conclusions and twenty four recommendations to prevent such events in the future, as well as to enhance the performance of the FRCC system.

Event Analysis

According to the report, the first event that initiated the sequence leading to the disturbance was a fault that developed on a 138 kV switch. This itself should have never led to a wide area disturbance, since protection relays should have detected and cleared the fault. However, an FPL field relay engineer had manually removed from service the local primary protection and local back-up breaker failure protection on an energized piece of equipment. This action was taken while troubleshooting and diagnosing a malfunction on that equipment.

As a result, since the fault was not cleared locally, remote backup protection relays provided the time delayed fault clearing.

According to the report “Two major contributing factors of the event were the component failure related to the 138kV switch contact mechanism that failed internally in a mode that made detection difficult and a failed semaphore mechanism that was providing false information to the field engineer. Both of these items significantly contributed to the overall pre-event decision making process ultimately leading to the removal from service of the protection during the troubleshooting activities.”

The total duration of the fault was approximately 1.7 seconds. This was longer than the typical Zone 2 operating time. The analysis of the events determined that while nine relays seeing the remote fault operated with Zone 2, the relays at three of the remote terminals did not trip, which required the operation of protection devices further away from the fault to operate. This was explained as “... continuing changes in the line flows from the delayed and sequential clearing by other relay protection schemes in the area prevented the schemes for these three lines from operating.”

The remote clearing of the fault resulted in approximately 1350 MW of disconnected load concentrated in the area west of Miami. The long fault duration (1.7 seconds) resulted in an electromechanical power imbalance on the generators in south Florida causing large swings in frequency, power, and voltages across the region. Out of ninety generating units that were on-line at the time of the fault, seventeen individual generators (equivalent to eleven units) were lost during the fault, including a fossil fuel unit near the fault location and two nuclear units that tripped as designed for nuclear safety related protection. The analysis concluded that the trips were due to the plants’ response to low voltage transients or the frequency swing.

As can be seen from Figure 1, an initial upswing in frequency was followed by a downswing resulting in underfrequency load-shedding (UFLS) relay operations and tripping of distribution feeders with approximately 2273 MW of load, leading to customer outages in areas from

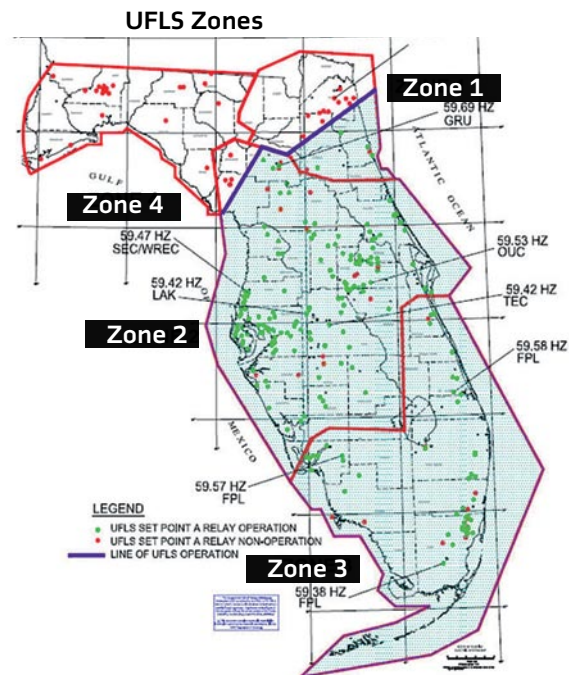
southern and central parts of Florida. The amplitude of the frequency swings and voltage perturbations were highest in southeast Florida and diminished at locations further north. The underfrequency load shedding occurred on the first step or set-point of the nine step FRCC UFLS program.

Further analysis and simulations determined that “the underfrequency load shedding had a beneficial effect on the grid’s transient response and appears to have prevented the disturbance from developing into a more widespread event”.

Throughout the disturbance the FRCC system remained connected to the Eastern Interconnection. Analysis of data from PMUs (Phasor Measurement Unit) outside of Florida showed that some inter-area oscillations occurred as a result of the disturbance.

The analysis of the nature of the Florida disturbance in February 2008 and the fact that most of the protection relays are electromechanical rule out any concerns for a cyber security breach. The sequence of events was explained in the report by expected operations of the different devices based on their status, settings and the dynamic changes in frequency, voltage and load flows caused by the initial fault and the sequential tripping of transmission lines in the neighboring area. All protection systems that were in service on lines that contributed to the isolation of the fault operated as designed. ■

3 The underfrequency load-shedding zones in Florida - 2008



Clare Duffy is a Chartered Engineer with over 12 years experience in the electricity industry. Ms. Duffy has an honours degree in Electronic and Electrical Engineering from the University of Strathclyde, UK and has post-graduate qualifications in Finance and Management. Ms. Duffy is a member of CIGRE and has authored several international conference papers on system protection and transmission-related topics. She has broad international experience gained from working on power system projects in Bahrain, France, Georgia, Ireland, Kosovo, Panama, Romania, South Africa, United States, UK and Vietnam. Currently, Ms. Duffy is head of the Strategic Consultancy Group in ESB International, Ireland.