Wide-Area Voltage Control of Dynamic Shunt Compensation using Synchrophasors

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2015 NASPI Work Group Meeting (Chicago, IL)

October 14th, 2015
Presentation Overview

> Hydro-Québec and the IREQ Research Institute

> The GLCC Project

  • Context
  • Synchrophasor solution
  • R&D Pilot project
  • Results and conclusion
Hydro-Québec and the IREQ Research Institute
Hydro-Québec Power Grid

**Production:**
- 43GW Capacity
- 98% Hydro

**Transmission:**
- 735kV
- Serie compensated
- 34,000km of lines
  - 12,000km 735kV
- 17 asynchronous interconnection

**Distribution:**
- 60% of Load in Montreal

Major concerns are power system stability and voltage control.
IREQ – Hydro-Québec Research Institute

Research Areas:
- Smart grid
- Efficient use of electricity
- Renewable energy
- Aging materials and viability
- Battery materials

Team of 500 scientists, technicians and engineer

Annual investment:
- 100M$ Innovation project
- 5M$ University chairs and contracts

128 Partnership agreement

850 Patents over 40 years
IREQ Power System Simulation Lab

HYPERSIM
Power System Real-Time Simulator

SimPowerSystems™
User’s Guide

MATLAB®
SIMULINK®
The GLCC Project: Global and Local Control of Dynamic Shunt Compensator using Synchrophasors
Shunt compensation installation

- 9 Synchronous Condenser (CS)
- 14 Static Compensator (SVC)
- Total capacity of 7000 MVAR capacitive 4000 MVAR inductive

Main Purposes

- Post-event network stability
- Part of the voltage level control

Actual Control Strategy

- Same strategy in use since deployment in 1970-80.
- Independent voltage setpoint at each substation.
Contribution of compensators is not optimal because of the topology.

For a voltage collapse situation in the load area, northern substations would not « see » the voltage drop, and extra MVAR wouldn’t be generated by SVCs.

Need of a synchronized and robust solution to optimize the use of existing compensators.
**Objective**
Optimize the use of the actual compensator installation for voltage stability event.

**Concept**
Synchronized measurement of voltage variation to adjust the compensators setpoint accordingly.

**Solution**
Control using synchrophasors.

**GLOBAL CONTROL**
- Use of $V_{MTL}$
- Telecommunication
- PDC & SPDC

**LOCAL CONTROL**
- Estimation of $V_{MTL}$
- Local PMU for $V$, $I$
- PMU & SPDC
Effect on the Montreal voltage level following a severe fault:

- Detection of the drop and raising of the compensators voltage setpoint
- Voltage drop in Montreal area

* Simulated 2015 network using PSSE
Fault at the La Vérendrye substation, loss of line 7016 and 1 SVC

MAJOR GAIN ON POWER FLOW LIMITATIONS
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**R&D PILOT PROJECT : LA VÉRENDRYE**

1 SVC, 3 Substations and IREQ
> **SVC Control Equipment:**
- Multi-Functionnal MBPSS.
- Control the SVC voltage setpoint.
- Power limitation algorithm.
- IREQ Simulink development.
- Partnership with ABB.

> **Substation Control Unit (UCP)**
- Detection logic algorithm.
- Adjust the MF-MBPSS output with ramp signal.
- IREQ Simulink development.
- Partnership with ABB.

Legend:
- Green circle: Phasor Data Concentrator (PDC Cooper SMP16)
- Green line: Telecommunication
- Yellow square: Phasor Measurement Unit (PMU)
- Blue hexagon: Open Line Detector (DLO)
- Red square: Control equipment connected to SVC
R&D Pilot Project – Challenges

> Multidisciplinary project:
  - Involving 12 teams and more than 30 people.

> Combine technologies:
  - Synchrophasors, telecommunication, substation engineering, SVC control, grid operation, real-time simulation, algorithms and hardware development.

> Real-time test bench:
  - Complete replica of the system
  - Close-loop real-time tests using Hypersim.
  - More than 3600 reliability and security tests.
Wide-Area Voltage Control System replica on Hypersim, IREQ
Voltage at SVC substation is normal: does not observe the drop voltage at Load area

Impact of control on voltage at SVC substation

Impact at Load area:
- Increase of voltage
- Voltage collapse avoided

Voltage drop at Load area

Moment of application of control signal to substation’s SVC

End of test: Back to initial state

Release of control
Field test: Controlled voltage drop at Chenier

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Conclusion

- Successful R&D project leading to full WACS deployment.
- Voltage profile improved for extreme contingencies.
- Major gains on power flow limitations.
- Low-cost and robust solution using synchrophasors.