CIGRE-IEC 2016 Colloquium on EHV and UHV
Montréal, QC, Canada, May 9-11, 2016

# WIDE-AREA CONTROL OF NEW YORK STATE POWER GRID WITH MULTI-FUNCTIONAL MULTI-BAND POWER SYSTEM STABILIZERS

D. Rimorov[1], A. Heniche[1], I. Kamwa[1],
G. Stefopoulos[2], S. Babaei[2], B. Fardanesh[2]
[1]IREQ, CANADA [2]NYPA, USA

Hydro Québec
Institut de recherche

New York Power Authority
Generating more than electricity

Paper ID100



# Outline

- Project description
- Controller design
- Results
- Conclusions



## Project description

- Application of methodology and technologies developed by Hydro-Québec to NYS system
- Objectives : Dynamic behavior improvement of New York State Grid
  - frequency response
  - oscillation damping
- Solution
  - Using FACTS devices
  - Both objectives do not interfere or conflict – separate tuning
  - Local and/or Wide-area control
  - Enabling technology: Multi-Functional Multi-Band Power System Stabilizer (MF-MBPSS)
    - Capable of processing remote signals



## Controller design methodology

- Sensitivity analysis
- Simulation-based metrics
- System identification methods for linear model development
  - Low order models built from simulation data
    - Pulse probing of reference signals
    - Recorded response used to reconstruct low order state space model
  - Useful for linear analysis and controller model-based design
    - Modal analysis
    - Control loop signal selection
    - Controller setting



## Controller design for primary frequency control

- Utilization of load voltage sensitivity
- Siting determined by sensitivity analysis
  - Large plants and FACTS devices
- Average PMU frequency used as input
  - Actual 24 PMUs installed in NYS
- Using just low band is sufficient
- Controller performance
  - Large disturbances – nonlinear simulations
- Conclusion:
  - 3 plants and one SVC



## Controller design for oscillation damping

- Control loop signal selection based on
  - Observability/controllability and modal analysis
  - Available PMU signals on NYS
- Conclusion
  - STATCOM in NYS grid found to be best
  - Local signal (STATCOM bus frequency deviation) performs best compared to considered remote signals from PMUs installed to NYS

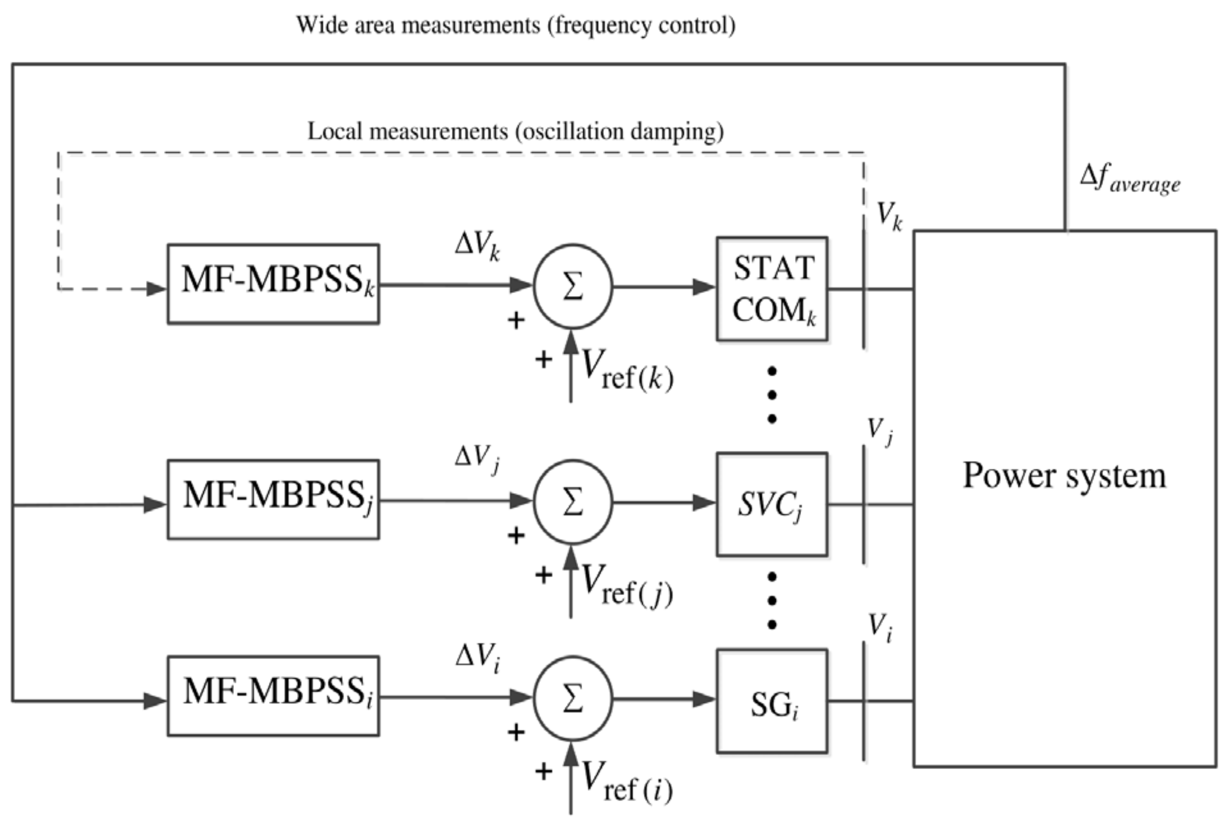


## Controller design for oscillation damping

- Controller tuning
  - Model-based design
  - Nonlinear constrained optimization
    - Objective function
      - Function of the area under the envelopes of oscillatory modes
    - Constraints
      - Minimum damping
      - Robustness metrics
      - Limits on MF-MBPSS parameters
- Controller performance
  - Testing with small-signal and large disturbances – nonlinear simulations

# Results : control strategy for oscillation damping and frequency response improvement

- Frequency control: 3 plants and 1 SVC
- Oscillation damping: STATCOM



## Results

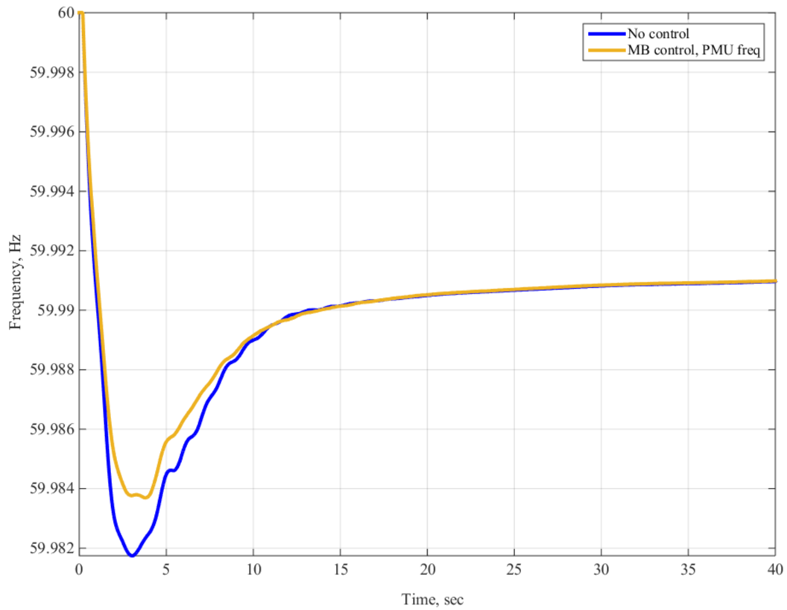
- Controller settings (simplified tuning) : band central gain (G) and central frequency (F) values

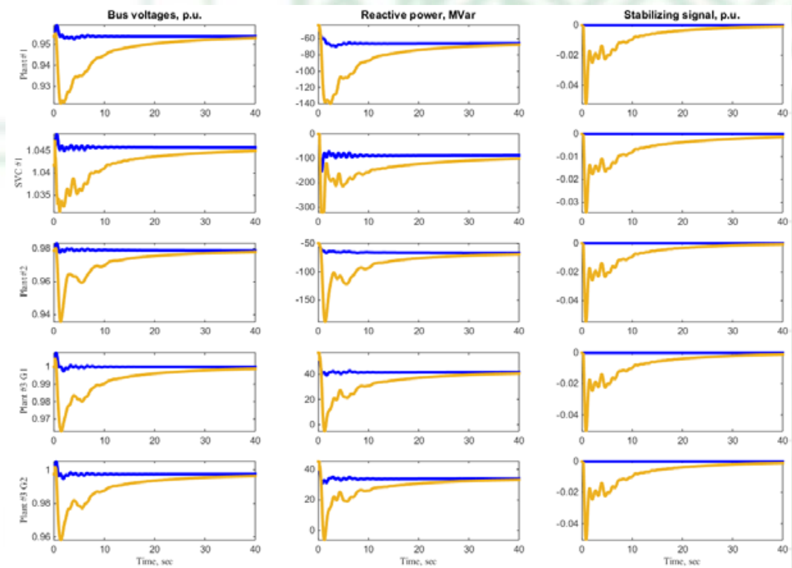
| Device | Objective | R | Low | | Intermediate | | High | |
|---|---|---|---|---|---|---|---|---|
| | | | F | G | F | G | F | G |
| Plant #1 | Frequency | 0.01 | 0.08 | 92 | - | - | - | - |
| SVC #1 | Frequency | 0.01 | 0.061 | 65 | - | - | - | - |
| Plant #2 | Frequency | 0.01 | 0.085 | 95 | - | - | - | - |
| Plant #3 | Frequency | 0.01 | 0.075 | 90 | - | - | - | - |
| STATCOM | Damping | 1.2 | 0.0457 | 120 | 0.8871 | 180 | 1.736 | 280 |



# Results

- Impact on frequency : Contingency: loss of ~ 1GW




- Frequency metrics

| Control | Min frequency | Nadir-Based Frequency Response (NBFR) | | |
|---|---|---|---|---|
| | Hz | MW/0.1Hz | MW gain | Gain, % |
| No control | 59.982 | 5586.3 | 667.78 | 11.95 |
| MF-MBPSS | 59.984 | 6254.1 | | |



## Results

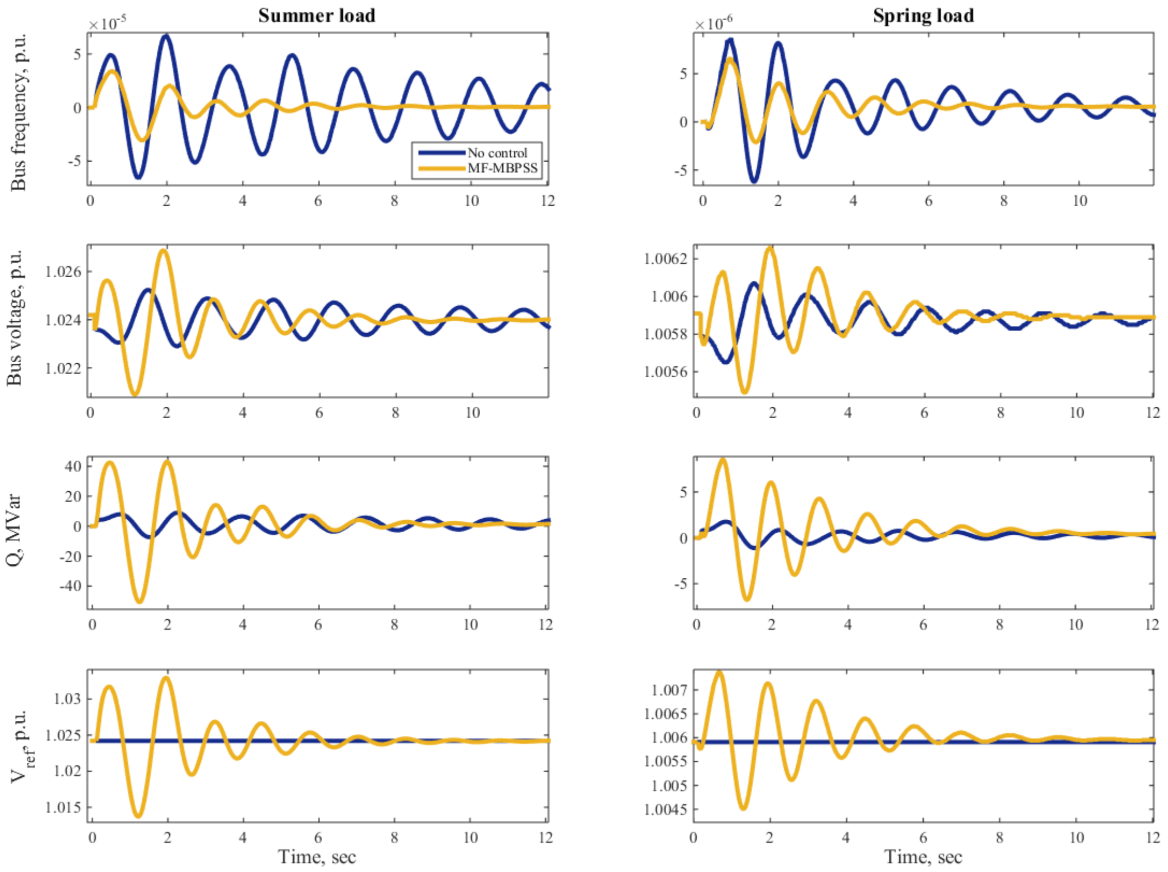
- Oscillatory stability: linear analysis, different load scenarios

| **Case** | **Inter-area mode #** | **Frequency, Hz** | | **Damping ratio** | |
|---|---|---|---|---|---|
| | | Open-loop | Closed-loop | Open-loop | Closed-loop |
| Spring | 1 | 0.979 | 0.951 | 0.0572 | 0.089 |
| | 2 | 0.804 | 0.823 | 0.0788 | 0.198 |
| Summer | 1 | 0.9506 | 0.913 | 0.0863 | 0.143 |
| | 2 | 0.754 | 0.812 | 0.1145 | 0.314 |

CIGRE-IEC 2016 Colloquium on EHV and UHV
Montréal, QC, Canada, May 9-11, 2016

## Results

- Large disturbance test, different load scenarios



## Conclusions

- Observable impact on frequency response can be achieved with limited reactive power
- System-wide damping improvement with little modulation
- Developed tuning procedures and methodologies useful for very large systems



# THANK YOU!

- QUESNTIONS?



# Controller topology