



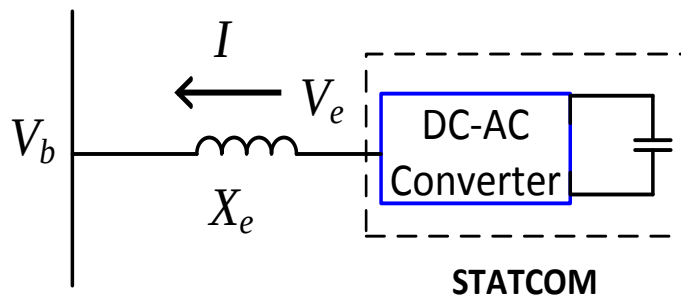
STUDY & ASSESSMENT OF DOMINION'S STATCOMS

11/15/2016

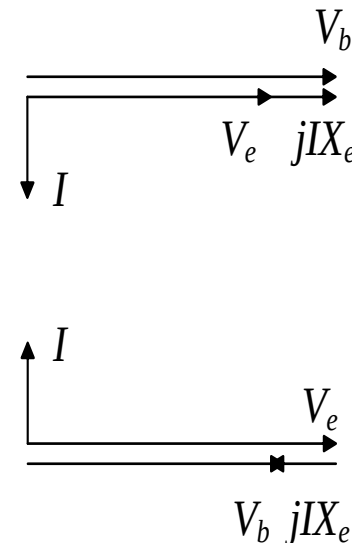
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What is a STATCOM?

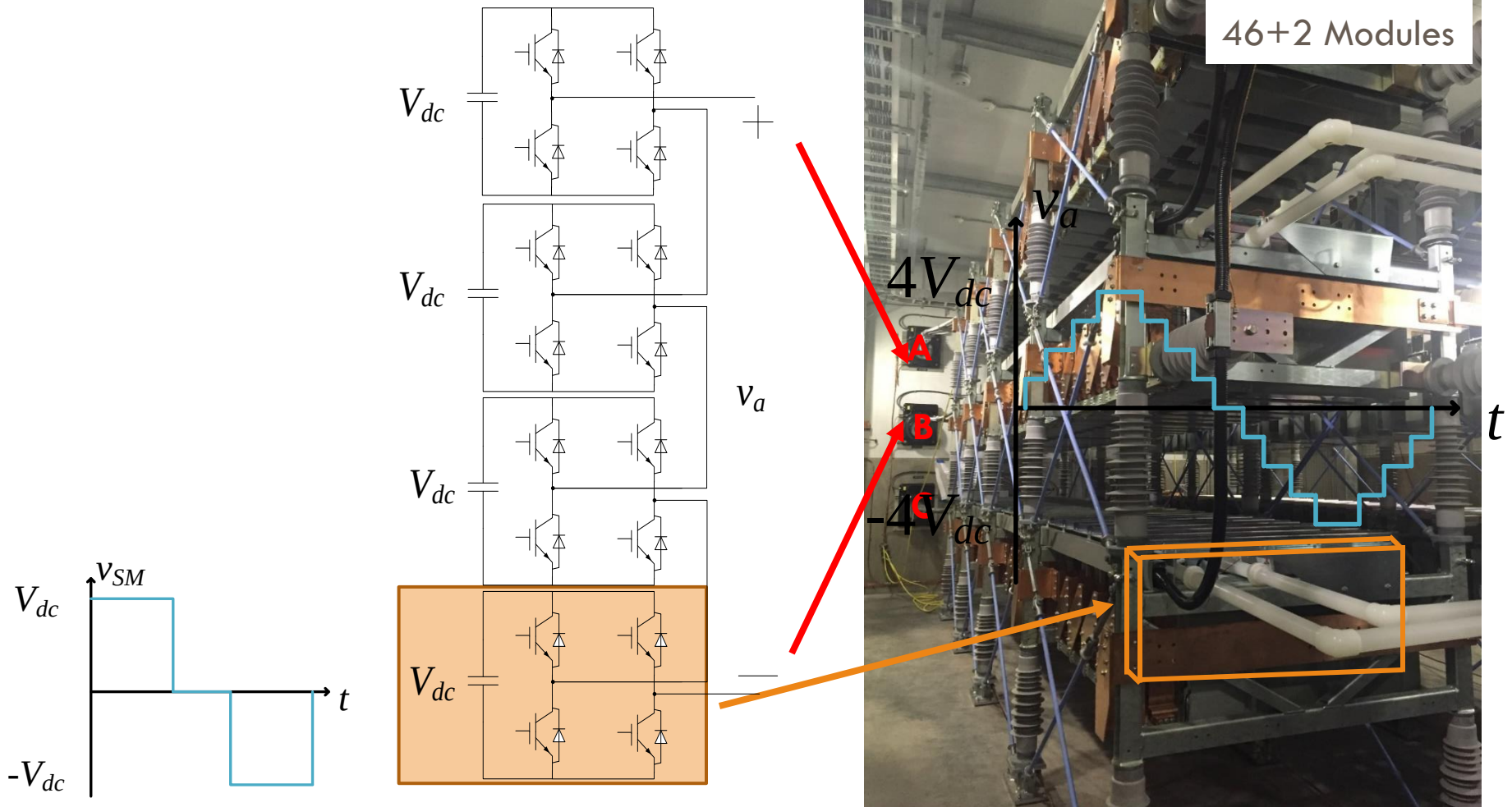
- Static Synchronous Compensator
 - A Flexible AC Transmission Systems (FACTS) device
 - Voltage source converter (VSC) power-electronics based
 - Compensates reactive power linearly with system voltage changes



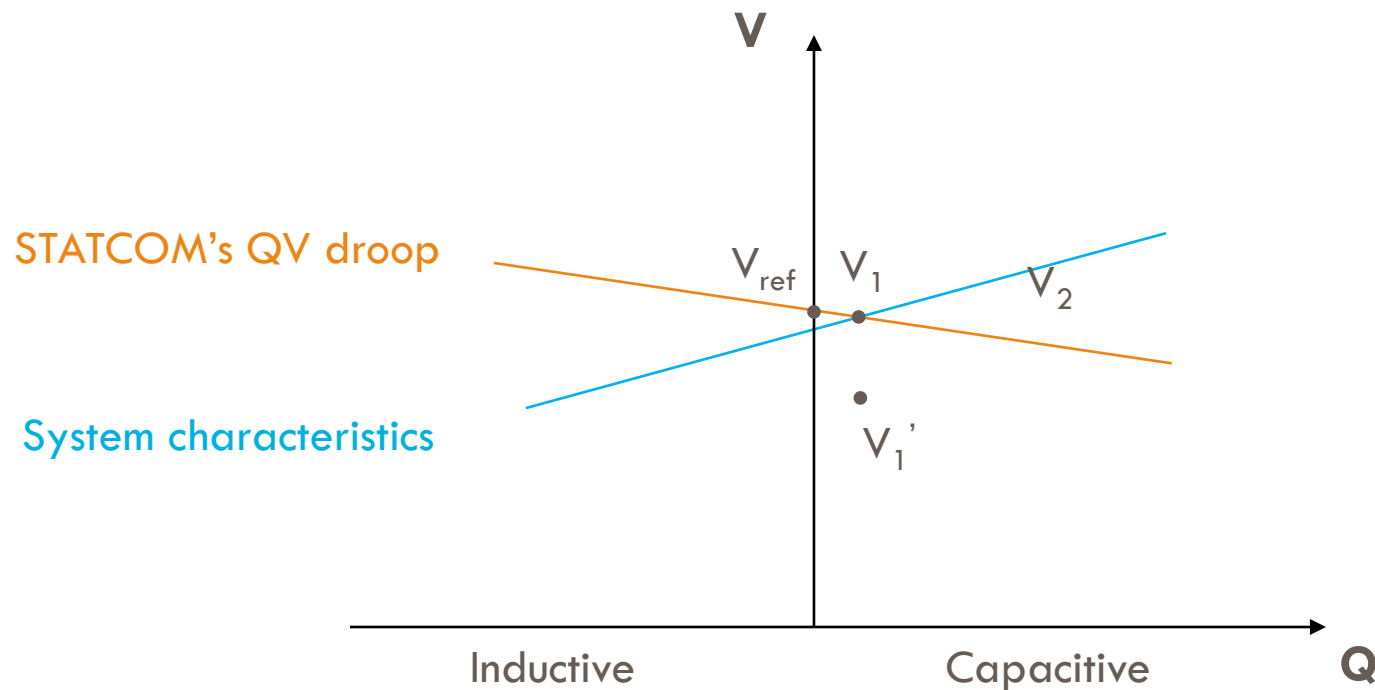
$$Q = \frac{V_b (V_e - V_b)}{X_e}$$



A Closer Look at the Converter



STATCOM's Basic Operation



Why STATCOMs?

Violations found for N-1-1 contingencies under future operating conditions, specifically related to:

- Generation Retirements

- Multiple power plants retiring during the same timeframe in the same local area due to Environmental Protection Agency regulations
- Retirements led to the need for both real and reactive power support

- STATCOMs selected for multiple reasons:

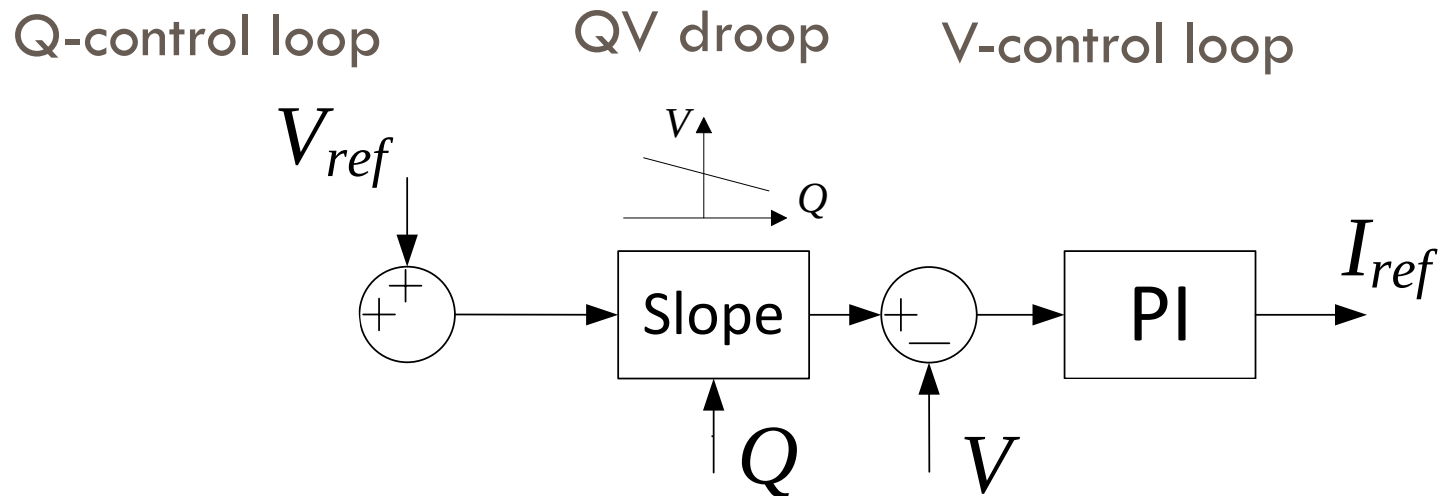
- Require less land to deploy, beneficial in this congested area
 - No filter banks
- Better performance during low voltage conditions (performs linearly with voltage)
- Equivalent reactive and capacitive support bands

Incorporating Resiliency into the STATCOM deployment

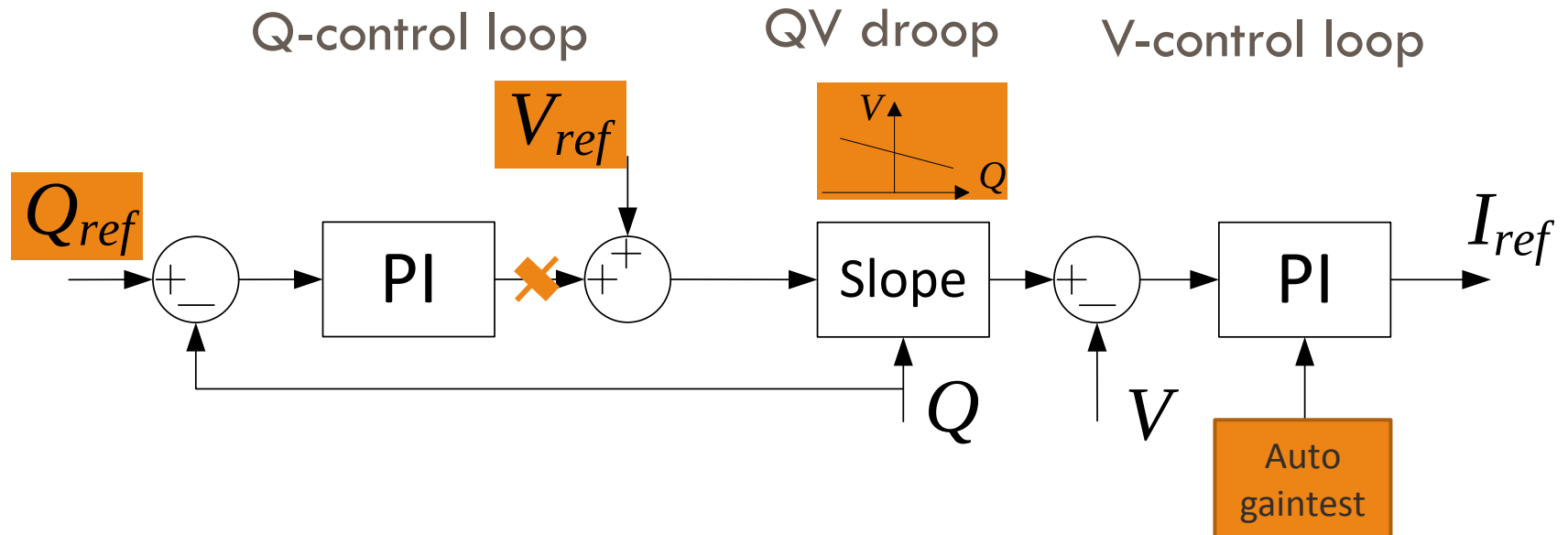
- Planning studies determined the need for 300 MVAR of *dynamic* reactive support
- Started with idea of one single 300 MVAR STATCOM
- Decided to increase resiliency by distributing STATCOMs around the transmission area
 - Deployed 4 smaller STATCOMs, all normally online
 - Enables an in-service spare unit



STATCOM's Controller



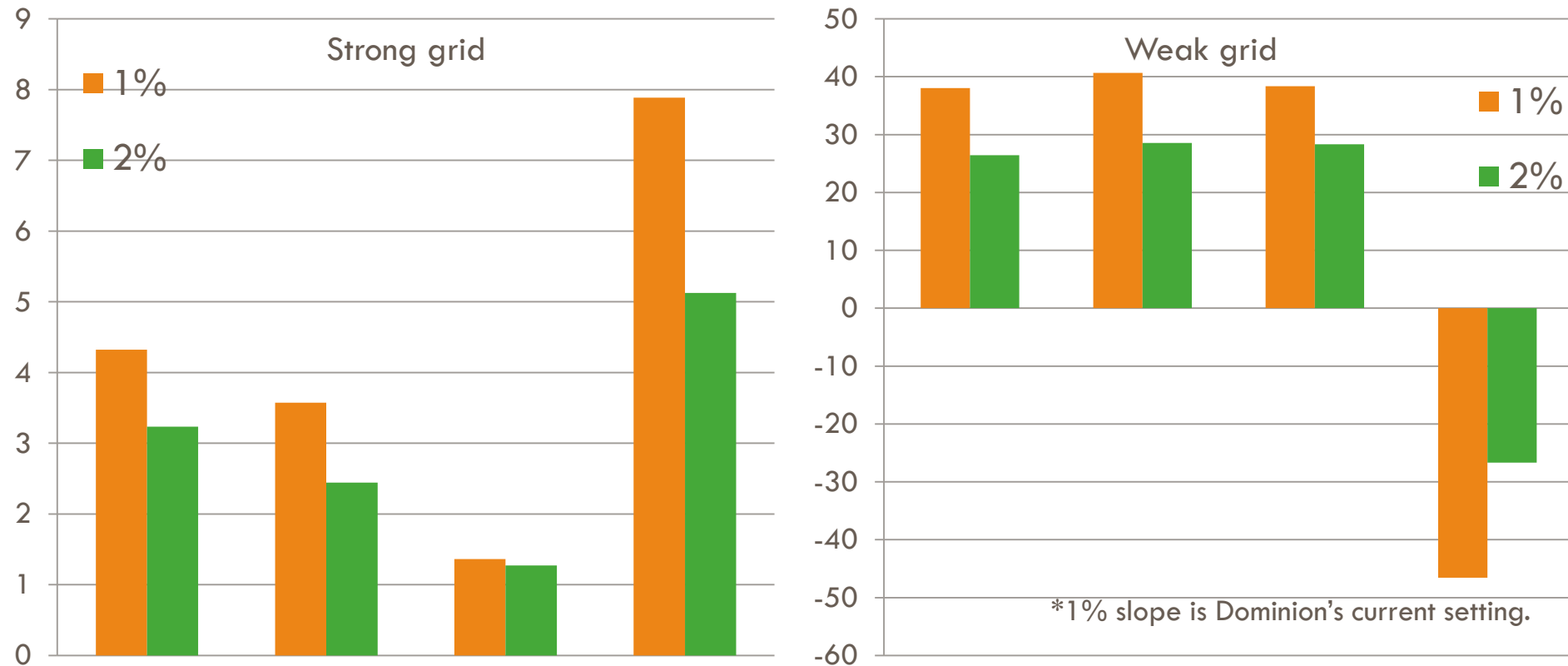
Assessment of Controller's Settings



- Inner current loop is not accessible, and not the focus.
- The PI parameters are not tunable.
- References, slopes and switch of Q-control and auto gaintest are accessible.

Effects of QV Slope

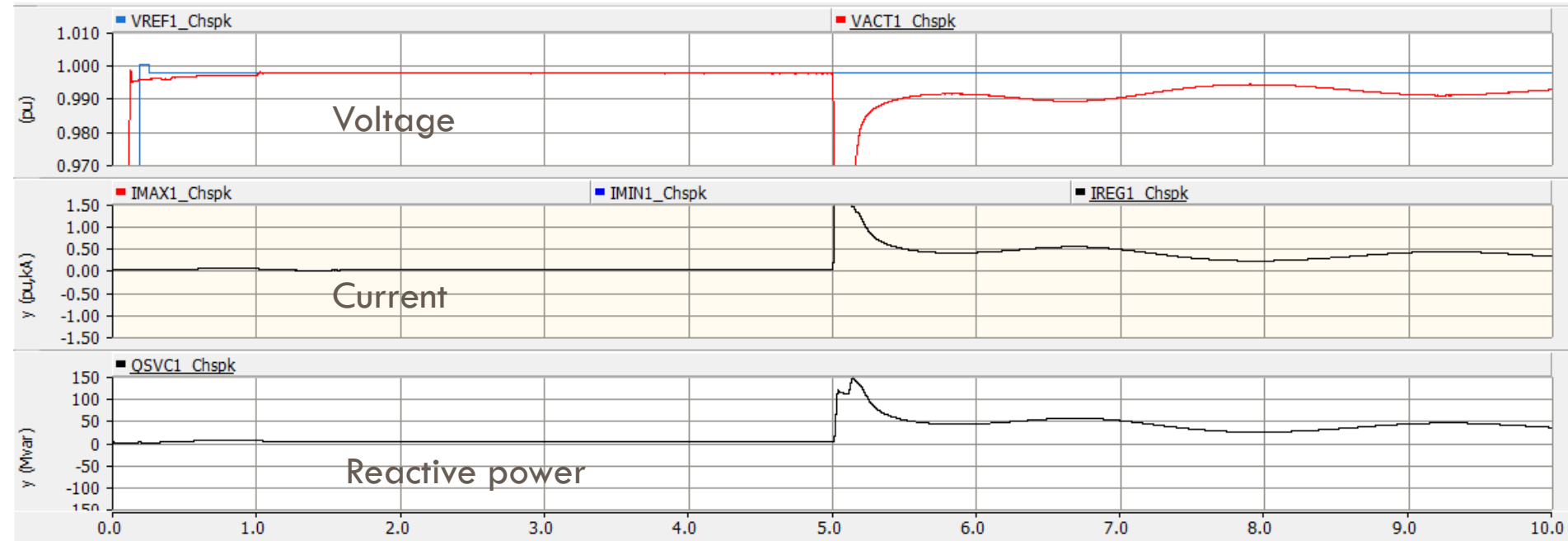
Steady-state Reactive Power in MVAR with Different Slopes



A steeper slope indicates less reactive power transferred with the grid, yet more voltage deviation from the set point.

Effects of QV Slope (Cont'd)

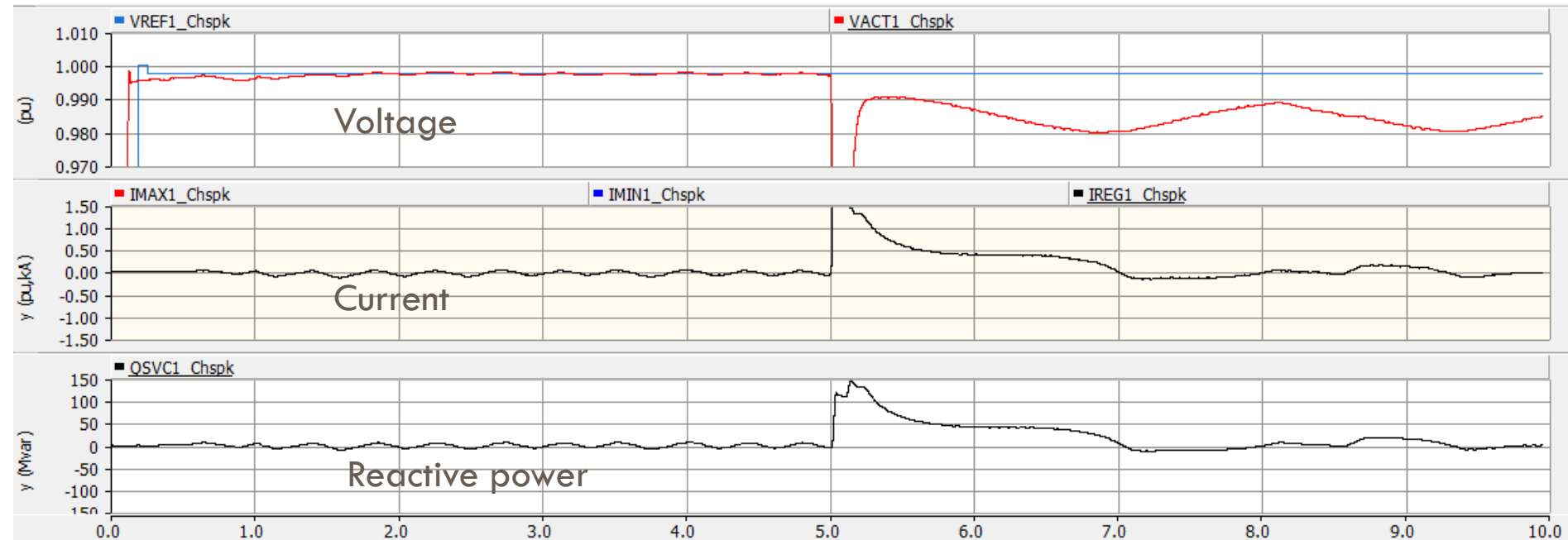
2%



Different slope shows little difference in dynamic responses, except for offsets due to different operating points.

Effects of Outer Q-loop

Q-loop off

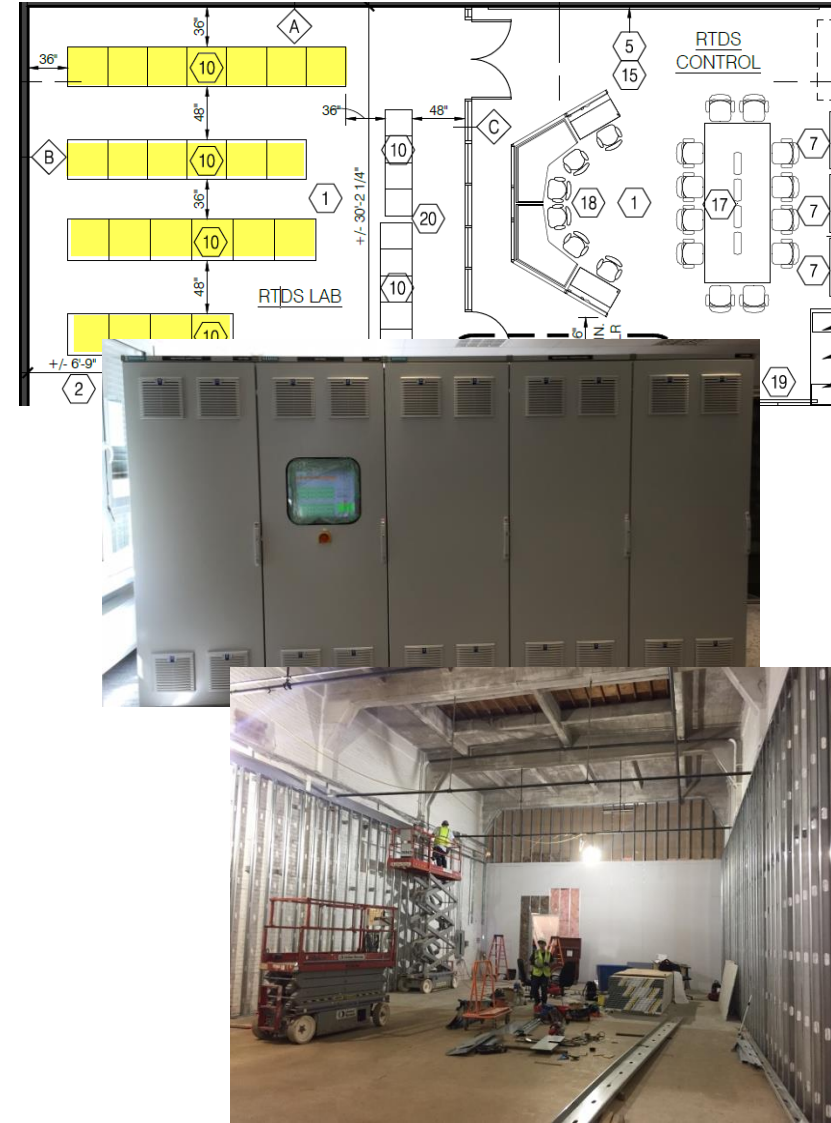


Activation of outer Q-loop results in:

- Steady-state oscillations at 3.3 Hz with 13.5 MVAR variation
- Less-damped oscillatory mode after fault
- Issues with computer model, working with vendor

Expanding Dominion's RTDS Lab for FACTS

- These new STATCOMs are critical components to the transmission system
 - Control systems are complex, with many settings and operation modes
- Expanding our RTDS lab to have spare, fully functional controllers for the different STATCOM models:
 - Training for engineers/technicians
 - Full evaluation/understanding of all settings/operation modes
 - Software/firmware testing
 - Additional spare components



Summary & Conclusions

- A STATCOM is a VSC-based compensator for reactive power support.
- Multiple STATCOMs have been deployed in Dominion's transmission grid for better voltage regulation, contingency response, and resiliency.
- The control settings of STATCOMs were evaluated to see if any negative interactions existed between the STATCOMs.
 - None observed to date



Thank you!