

Introduction to Static Var Compensator (SVC) and Static Synchronous Compensator (STATCOM)



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WHAT ARE FACTS, SVC, AND STATCOM?

- **Flexible AC Transmission Systems (FACTS)**

- IEEE Definition: *“Alternating current transmission systems incorporating power-electronic based and other static controllers to enhance controllability and increase power transfer capability.”*



- Static Var Compensator (SVC)
- Static Synchronous Compensator (STATCOM)
- Thyristor Controlled Series Compensator (TCSC)
- Static Synchronous Series Compensator (SSSC)
- Unified Power Flow Controller (UPFC)

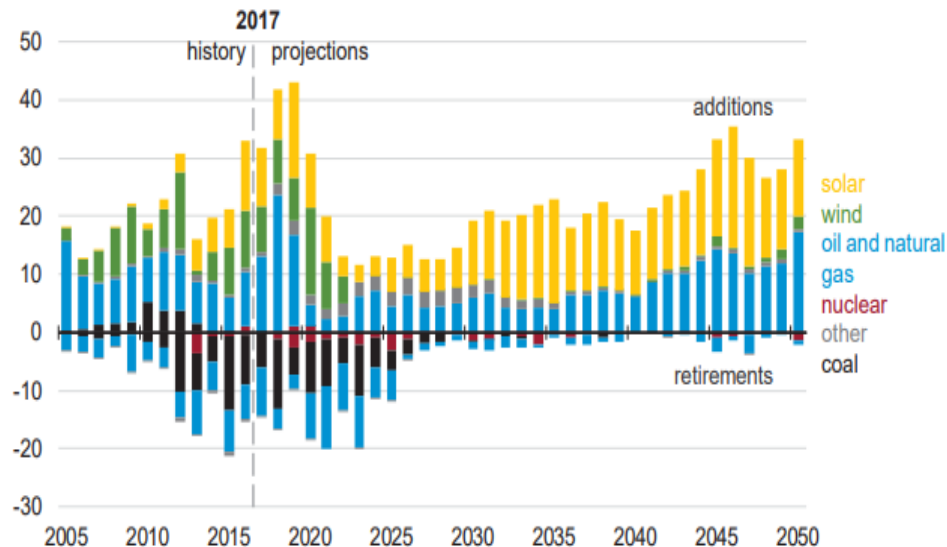
WHAT IS DRIVING THE NEED FOR FACTS?

Renewable
Integration

Coal Plant
Retirements

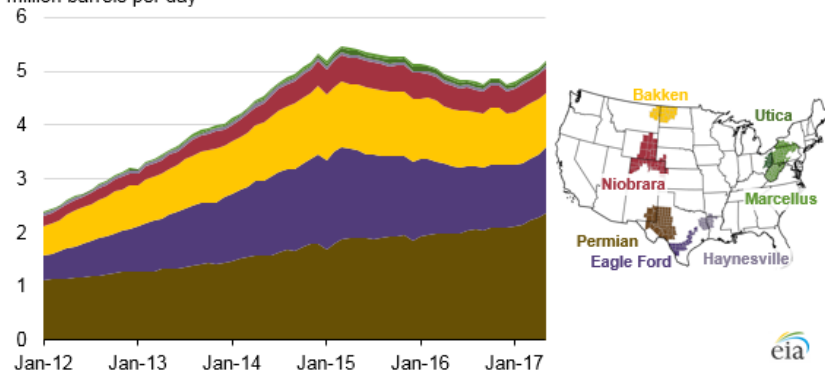
Regional Load Variation

Annual electricity generating capacity additions and retirements (Reference case)
gigawatts



Source: Annual Energy Outlook 2018, <https://www.eia.gov/outlooks/aeo/pdf/AEO2018.pdf>

Monthly oil production in selected regions (Jan 2012 - May 2017)
million barrels per day



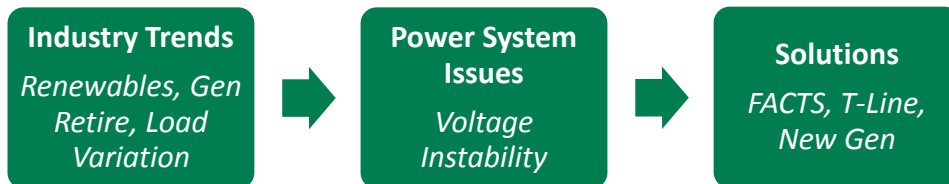
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POWER SYSTEM ISSUES AND SOLUTIONS

Power System Issues

- Separation distance of Load from Generation source
- Variation or change in load (regional)

This creates potential for voltage instability



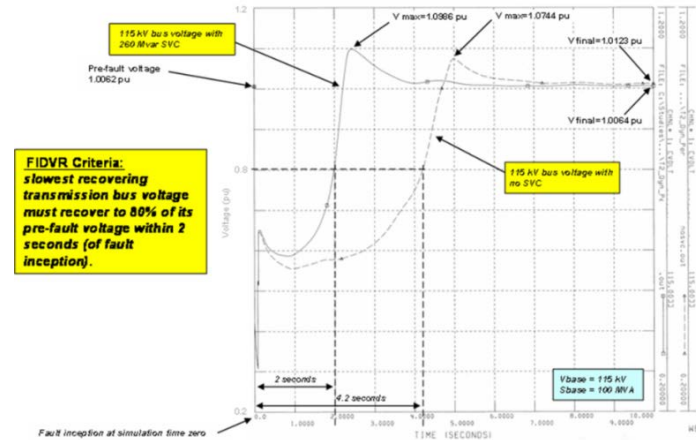
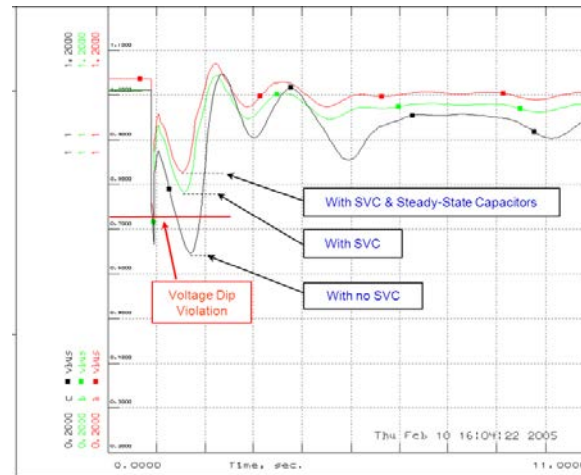
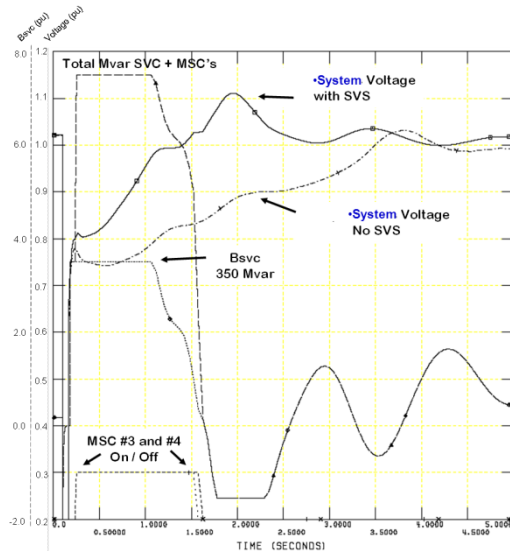
Solutions

- FACTS technologies such as SVC and STATCOM

SVC & STATCOM POWER SYSTEM SOLUTION

Purpose of SVC and STATCOM

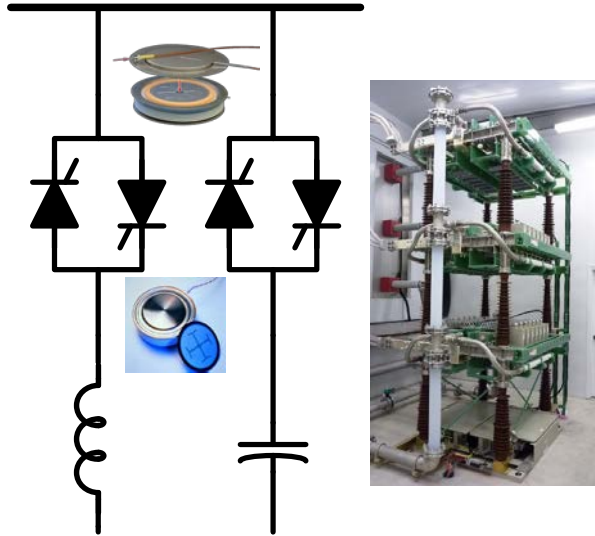
- Provide rapid insertion or removal of VARs to support power system voltage during and immediately following system disturbances
- Avoid voltage collapse or slow voltage recovery following system disturbances (FIDVR)
- Provide steady-state voltage regulation



Source: Sullivan, D.J., Pape, R., Birs, J.J., Riggle, M., et al, "Managing Fault-Induced Delayed Voltage Recovery in Metro Atlanta with the Barrow County SVC," Facts Panel Session, IEEE PES Power Systems Conference and Exposition, Seattle Washington, March 2009

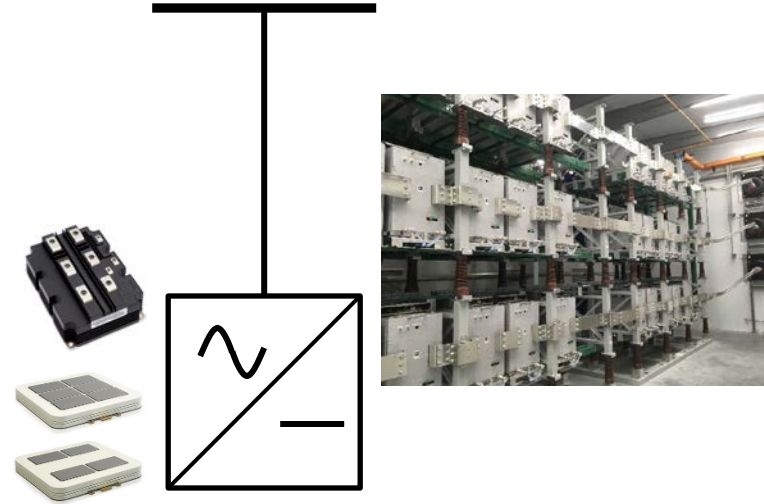
SVC & STATCOM – TECHNOLOGY CHOICES

SVC
(fast & repeatable)



Thyristor Controlled

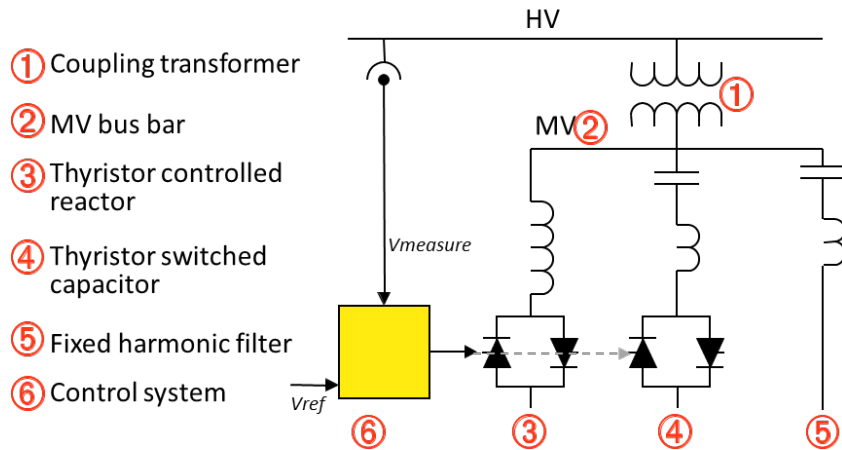
STATCOM
(fast & repeatable)



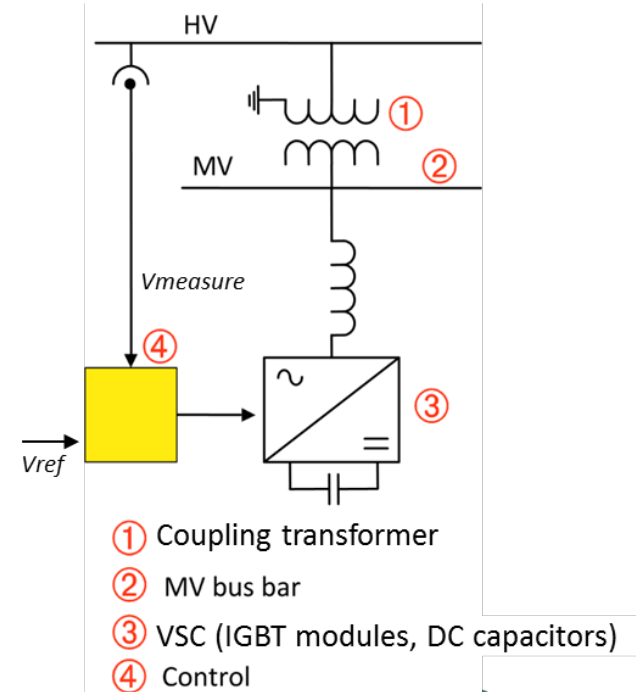
IGBT Controlled
Voltage-Sourced Converter (VSC)

TECHNOLOGY FUNDAMENTAL CONFIGURATIONS

Example SVC Configuration

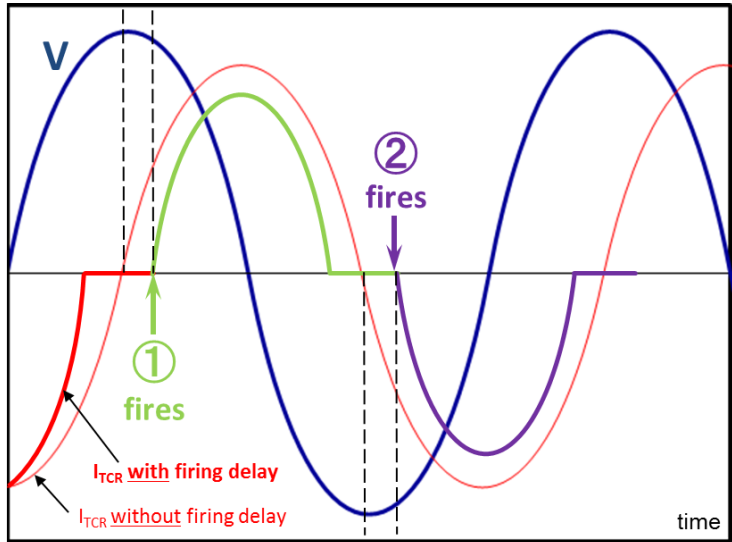


Example STATCOM Configuration

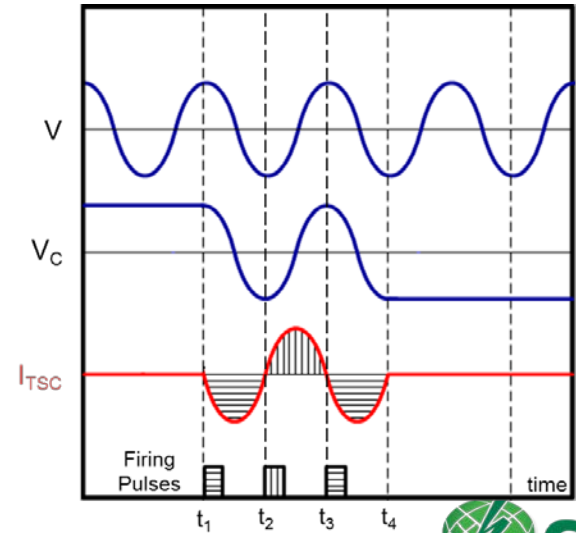
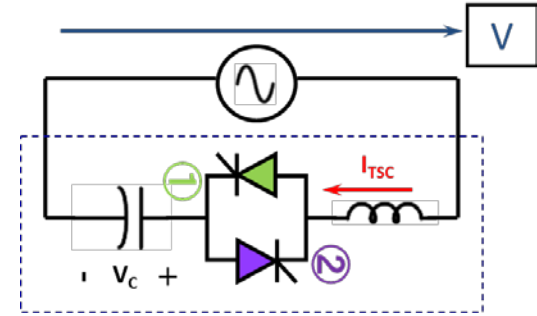


Source: IEEE/PES Substation Committee (I4 & I5 WG) "Tutorial on Shunt Compensation" – 2018 PES T&D Conference and Expo, Denver, CO

Thyristor Controlled Reactor (TCR)



Thyristor Switched Capacitor (TSC)



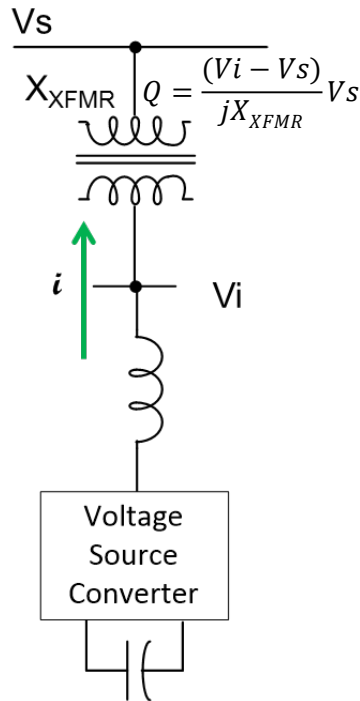
SVC INSTALLATION (-35 / +100 at 138 kV)



Reference: Sullivan, D.J., Paserba, J.J., Reed, G.F., Croasdaile, T., Westover, R., Pape, R., et. al., "Voltage Control in Southwest Utah With the St. George Static Var System," Facts Panel Session, IEEE PES Power Systems Conference and Exposition, Atlanta Georgia, October 2006

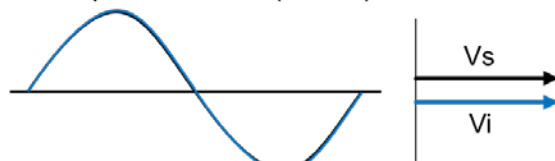
STATCOM - PRINCIPAL OPERATION MODES

Simplified STATCOM 1-line

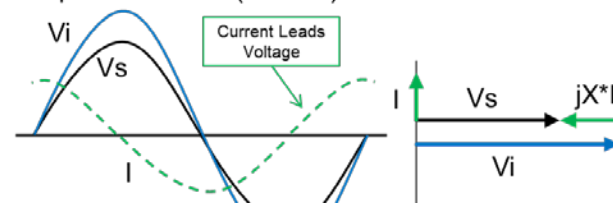


Fundamental STATCOM Operation

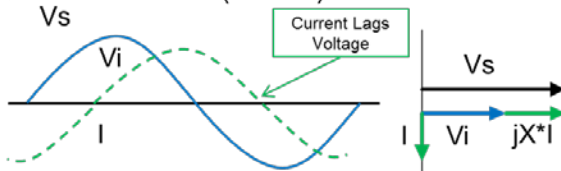
→ Idle Operation Mode ($V_i = V_s$)



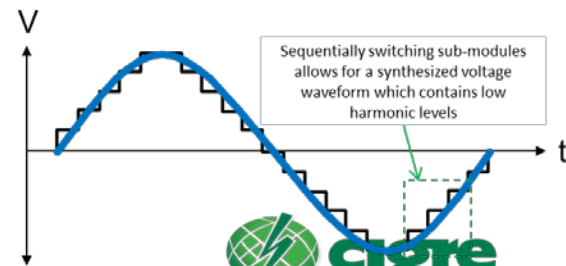
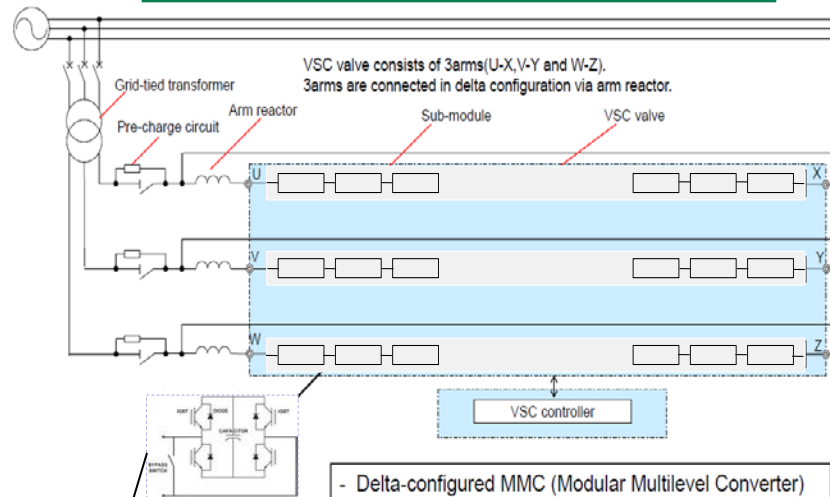
→ Capacitive Mode ($V_i > V_s$)



→ Inductive Mode ($V_i < V_s$)



STATCOM Converter Configuration



STATCOM INSTALLATION – Dominion Energy's Colington Statcom

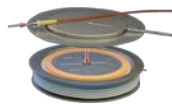


Reference: Sullivan, D, Buterbaugh, B, Allison, R "Installation and Commissioning of Mitsubishi Electric's MMC STATCOM (SVC Diamond™) at Dominion Energy's Colington Substation," CIGRE US National Committee 2018 Grid of the Future Symposium, Washington DC, USA, Oct, 2018.

SUMMARY OF SVC & STATCOM

SVC and STATCOM

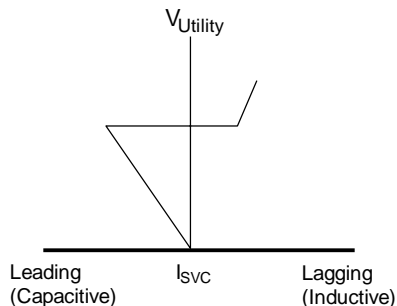
- Provide rapid insertion or removal of VARs to support power system voltage during and immediately following system disturbances
- Avoid voltage collapse or slow voltage recovery following system disturbances (FIDVR)
- Provide steady-state voltage regulation



- **SVC**
- Classic Thyristor-based system

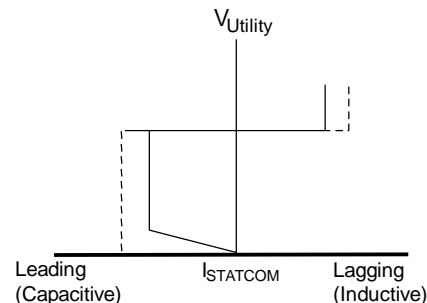


SVC
Proportional to Voltage Squared (50% Voltage = 25% output)
Requires Filtering
100% (more outdoor eq)
2 to 3 cycles
>2



Reactive Power
Harmonics
Installation Space
Speed of Response
System Strength (SCR)

STATCOM
Proportional to Voltage (50% Voltage = 50% Output)
Usually None
50 % to 60 % (less outdoor eq)
1.5 to 2 cycles
>1

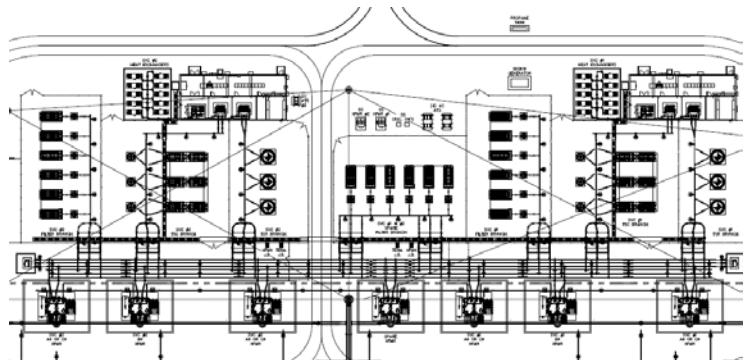
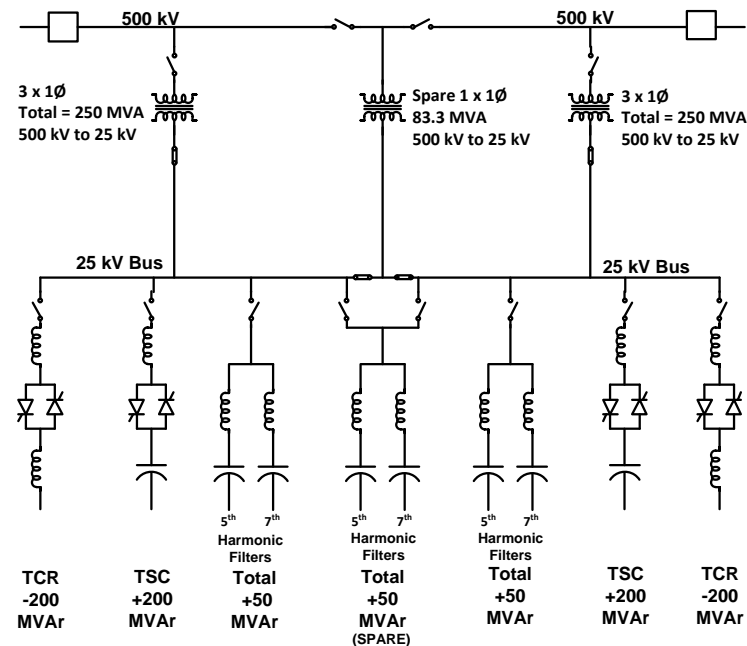


- **STATCOM**
- Voltage Source Converter (VSC) system
- Modular Multilevel Converter



DOMINION ENERGY'S MOSBY SVCs

- **Commissioned In-Service :**
 - July, 2014 in Catharpin, VA
- **Ratings: (each)**
 - -150/+250 MVar @ 500 kV
- **TCR+TSC+FC SVC Base Design: (each)**
 - 1 x TCR Branch, rated 0 to -200 MVar
 - 1 x TSC Branch, rated +200 MVar
 - 1 x Harmonic Filter Branch (5th & 7th), rated +50 MVar total
 - 1 x Harmonic Filter Branch (5th & 7th), rated +50 MVar (single shared spare)
- **Application:**
 - Dynamic Voltage Control
- **Availability:**
 - 98.5 %



Thank You



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