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Installation and Commissioning of Mitsubishi Electric's MMC STATCOM (SVC-Diamond™) at Dominion Energy's Colington Substation

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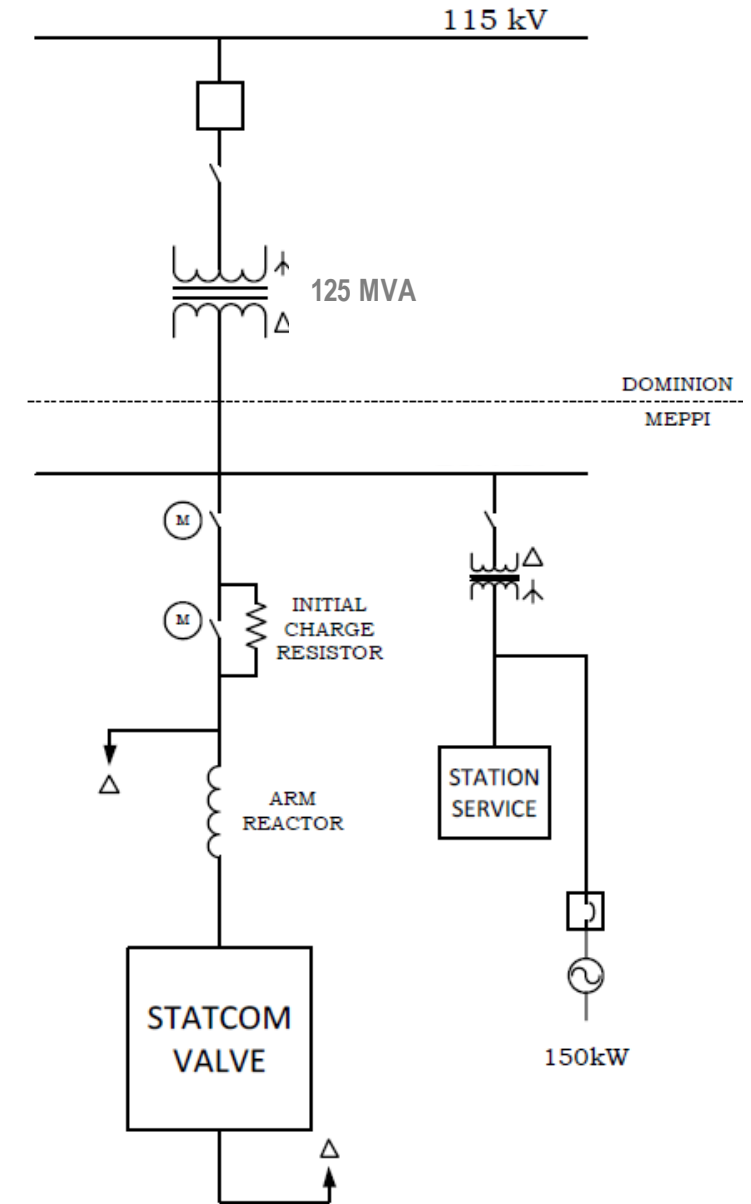
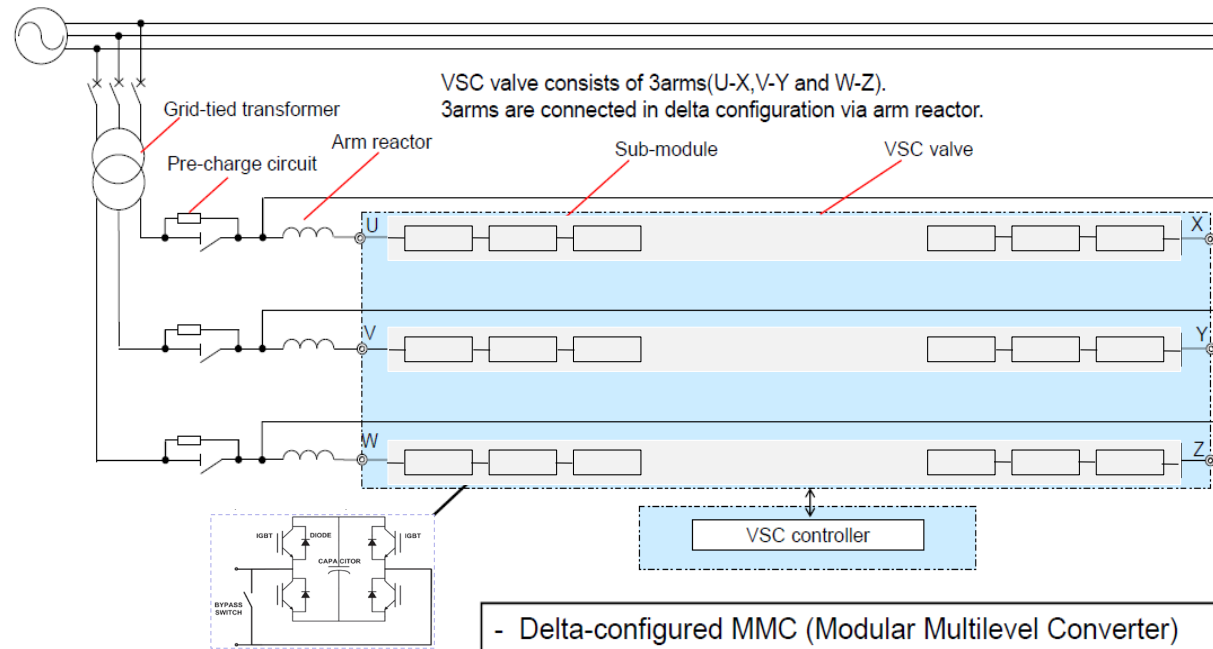
Project Background

- Dominion Energy's Colington STATCOM
 - +/-125 Mvar at 115 kV
 - Outer Banks, North Carolina
 - Commissioned June 2017
 - Replaces legacy SVC
- Dynamic Stability
 - Fault-Induced delayed voltage recovery (FIDVR)
 - Load fluctuations caused by the air-conditioning loads.



Project Overview

- The STATCOM system is connected to the 115 kV transmission system through a 125 MVA, 3-phase transformer and features Voltage Sourced Converter (VSC), Modular Multilevel Converter (MMC) topology with a continuous rating of +/-125 Mvar



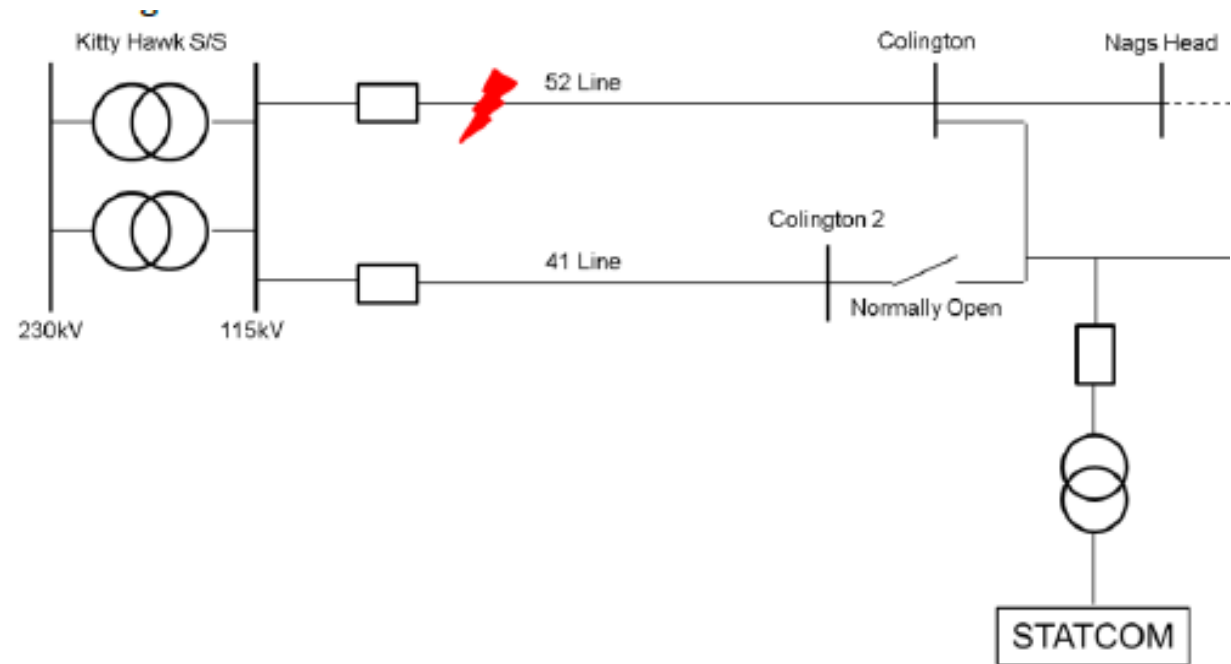
STATCOM Site and Arrangement

- The Colington STATCOM site is exposed to severe weather conditions, resulting in flooding or storm surge and heavy salt contamination.
- To address possible flooding or storm surge:
 - All main equipment, including control building, was elevated three feet above grade.
 - The raised platform around the building allowed for ease of maintenance while also requiring the use of OSHA compliant handrails.
- To address outdoor contamination issues associated with the coastal environment:
 - stainless steel was used for all outdoor control cabinets, enclosures, and heat exchangers.
 - Insulators and bushings were coated with a room-temperature-vulcanizing silicone (RTV) and specified with additional creepage length (44kV/mm).
 - The control building included a resin-based coating on its exterior, and the outdoor yard steel structures included a heavy galvanized coating.
- STATCOM installation has less yard equipment



STATCOM Application on a Transmission Line

- With the STATCOM connected to the #52 transmission line, a single contingency on this line will result in a complete loss of voltage at the STATCOM connection point and operation would be suspended until voltage is restored.
- Dominion Energy employs a 10 second reclose scheme on the #52 transmission line.
- Weather related contingencies
 - Often successfully restored after the reclose.
 - The time period for these contingencies also has the highest demand for capacitive var support.
- STATCOM design considerations:
 - Available for at least one reclose attempt
 - Automatic restore function
 - Backup generator



STATCOM Application on a Transmission Line

- Monitoring of internal converter voltage in coordination with the undervoltage logic to ensure the STATCOM can remain available for one reclose attempt if the line trips due to various 1-LG, 2-LG, and 3-LG faults.
- Automatic restore function to place the STATCOM back in service when the 138 kV transmission line voltage has been restored.
- During complete loss of AC station service a backup propane generator automatically starts and runs the critical AC loads (e.g., converter cooling system) for up to 48 hours. Once the 52 line is restored, and therefore system voltage, the automatic restore function detects the system voltage and automatically restarts the STATCOM.

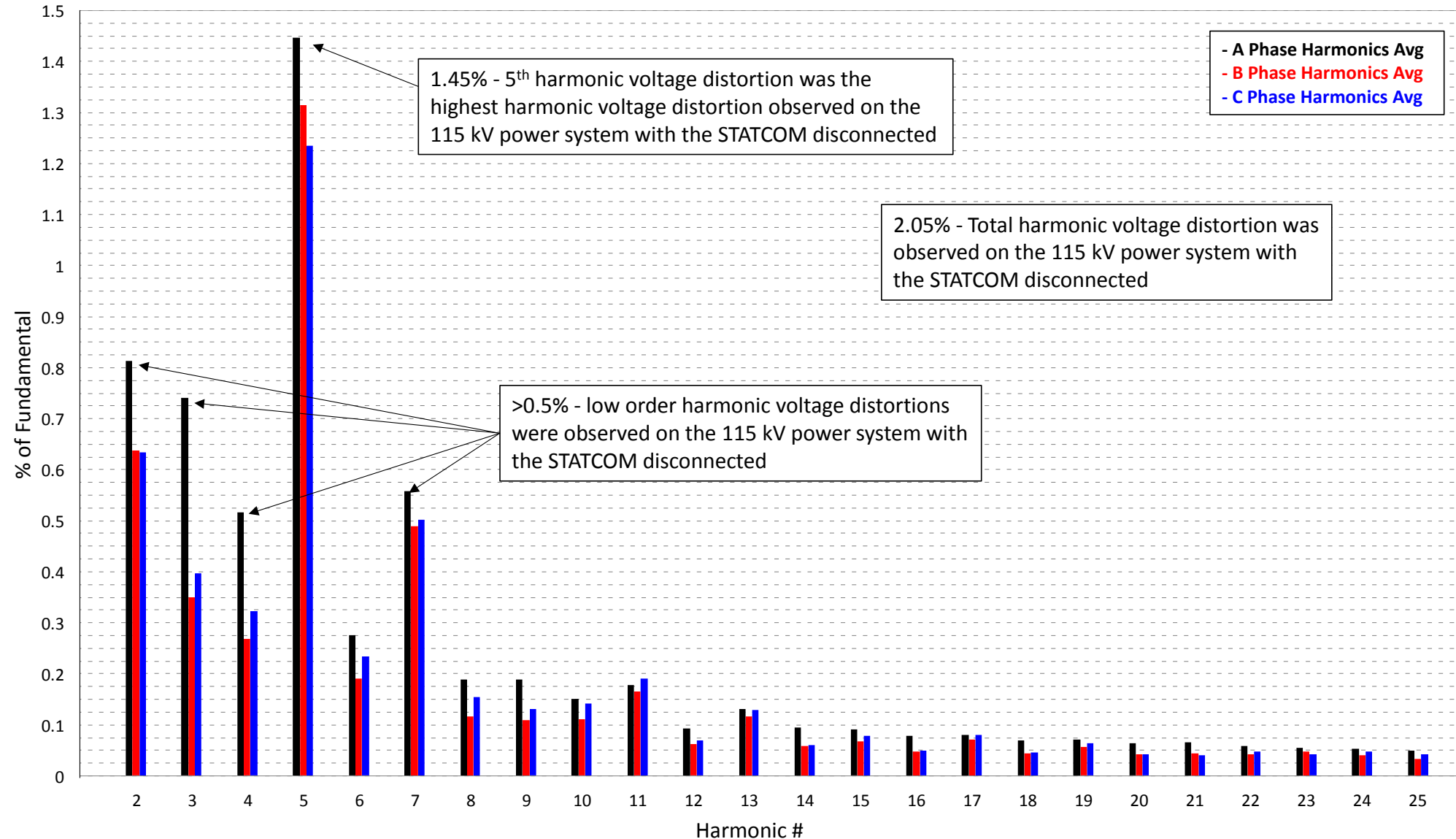
Case example of re-close ride-through

- On August 8th, 2017 the Dominion Energy system experienced a single phase, B-phase to ground contingency on the #52 transmission line due to a -99kA lightning strike calculated to be less than 3.5 miles from the STATCOM.
- The #52 transmission line protection executed a trip and successful reclose.
- The Colington STATCOM rode through this event as designed, remained available through the event, and was immediately available post reclose for Var support during recovery.

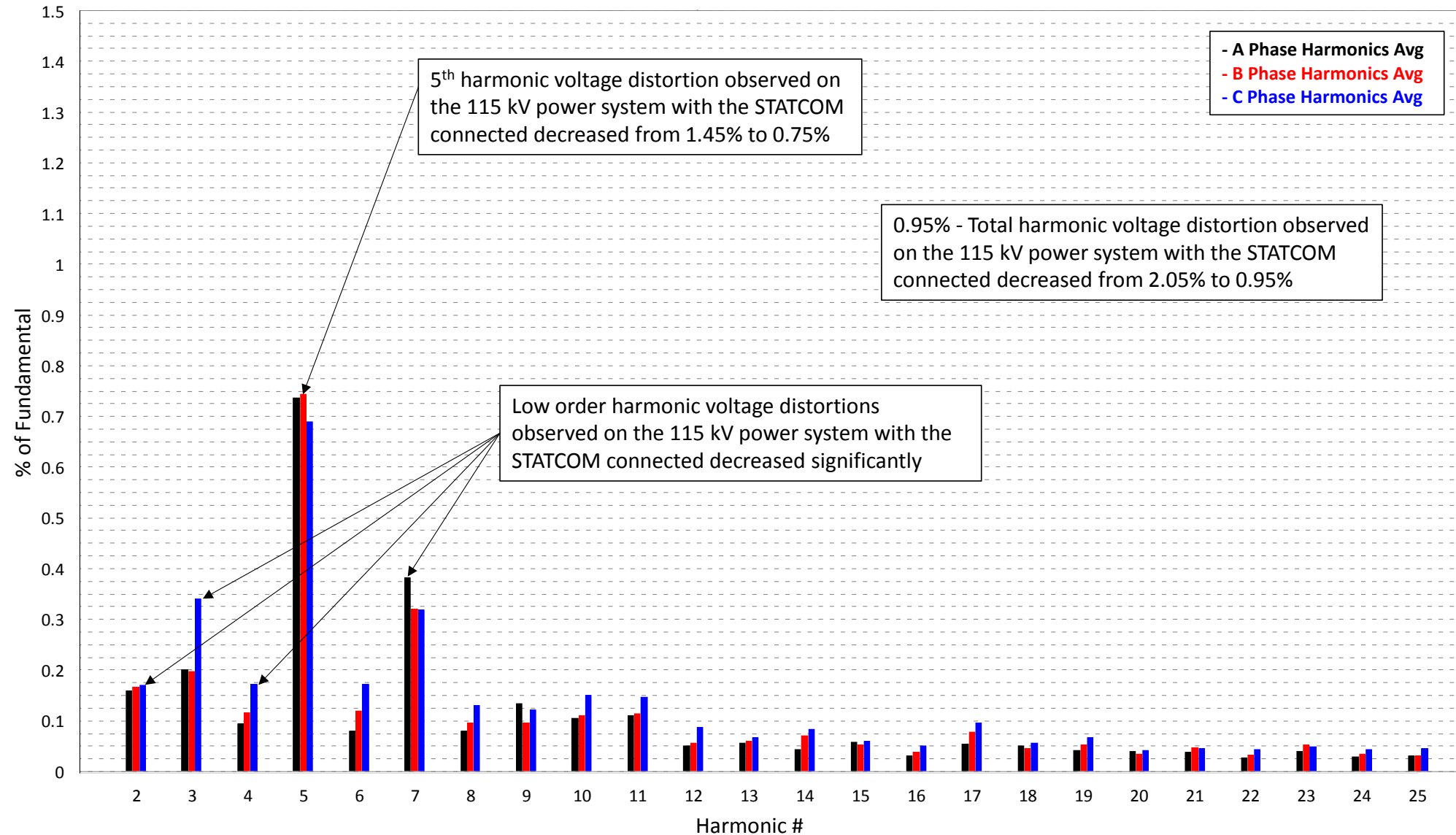
STATCOM Harmonic Measurement Observations

- Harmonic distortion is a major design consideration for all FACTS and HVDC technologies both for equipment rating and for system performance.
- The power system characteristics around Colington has an impact on the harmonic performance of the STATCOM and includes two key factors:
 - Impedance, determined by a frequency scan analysis
 - Background harmonic content, determined by measuring voltage distortion over an extended period of time.
- With all the aforementioned factors considered, the STATCOM design was confirmed via calculation to meet all the specified criteria.
- At the time of commissioning the validity of the design was further proven with actual measured data.

STATCOM Harmonic Measurement Observations



STATCOM Harmonic Measurement Observations



Conclusion

- Dominion Energy's Colington STATCOM
 - +/-125 Mvar at 115 kV
 - Outer Banks, North Carolina
 - Commissioned June 2017
 - Replaces legacy SVC
- The *SVC-DiamondTM* design
 - Power system needs for dynamic reactive power control FIDVR events in the Outer Banks area
 - Voltage Sourced Converter (VSC)
 - Modular Multilevel Converter (MMC) topology
- Colington STATCOM Additional Considerations
 - Site and environmental conditions
 - Transmission line application
 - Harmonics