

Workshop on Modeling and Analysis of Switching Transients Associated with Shunt Capacitors and Reactors

October 9-11, 2014

Venue: Bangalore

Background: Shunt capacitor banks provide additional VAR support to maintain the voltage at required level during heavy through-flow or during contingencies resulting in deficiency of reactive power support. The reactive support was traditionally provided by generators and transmission system and as the power system is continually getting more stressed, the need for shunt capacitors have increased over the past few decades as an economical alternative to adding rotating mass. Since the capacitor doesn't allow sudden change in voltage, switching of capacitors resulted in high frequency, high magnitude currents that had an impact on the switching devices and the grounding. Also, since the system is mostly inductive, addition of shunt capacitors have led to the generation of non-fundamental frequency transients that need a detailed analysis using PSCAD due to system complexity. The course focuses on transient and harmonic issues associated with capacitor banks. With detailed modeling of the system and shunt capacitors, transients studies focus on issues such as voltage magnification, harmonic resonance, phase to phase insulation on transformers terminated at the end of the lines connected to substations with shunt capacitor banks to name a few.

During light load conditions, system voltages exceed the maximum allowable limits due to excessive capacitance of the transmission lines. Shunts reactors absorb reactive power to maintain the system voltage within the accepted limits during light load periods. Shunt reactors are either directly connected to transmission lines or to tertiaries of transmission transformers. Since the reactor doesn't allow sudden change in current, transients produced during energization and de-energization have caused front-end insulation failures on shunt reactors and failures of switching devices. PSCAD provides a means to study these transients and use appropriate designs such as voltage controlled opening or opening with increased arcing time to mitigate failures.

Historically, shunt reactors were not switched very frequently and the problems/failures associated with shunt reactors were not significant though the phenomenon was well known. But, with the increased non-conventional generation such as wind that has high degree of variability, these shunt devices are switched more frequently than in the past and the industry is seeing more failures of shunt reactors and the switching devices. The course focuses on these issues and shows selection of mitigation methods and its effect on the Re-ignition and TRV of the switching devices.

- Topics:**
- Transient over voltages during energization – Mitigation methods such as synchronized closing , pre-insertion resistors/ inductors
 - Voltage magnification at lower voltage buses with capacitor banks
 - Phase to phase over voltages on transformer terminated at the end of the lines
 - Simultaneous energization of a capacitor bank and transformer
 - Breaker issues – Restrike
 - Harmonic resonance issues with shunt capacitor banks examples – tertiary connected capacitor banks, shunt capacitor is a weak system during contingencies
 - RRRV issues associated with breakers clearing faults on capacitor banks with reactors
 - Sizing of inrush/outrush current limiting reactors – Latest development in the industry.

Instructor: **Mr. Pratap Mysore** is with HDR, a consulting company, as System Protection Director in the Power Delivery group. He has over 35 years of experience in the power system industry in the areas of protection, control, system design and system studies. He has experience in power utilities with transmission system voltages up to 500 kV, relay manufacturing and consulting industry. Over the past 25 years, he has actively contributed to the industry in the development of standards and documents in the IEEE. Presently, he is one of the officers (secretary) of the Power System Relaying Committee under IEEE Power Energy Society involved in the development of IEEE/IEC documents related to power system Protection. He is an active member of the capacitor subcommittee involved in the development of documents related to shunt and series capacitors.

He is also an active participant in the Consortium of Universities for Sustainable Power (CUSP) program sponsored by the Department of Energy and led by University of Minnesota. CUSP is an effort to resurrect power programs in over one hundred universities in the USA by developing modules for power courses to be used by the faculty at various universities. Mr. Mysore is an adjunct professor at the University of Minnesota, where he gives lectures and teaches a graduate level course in power system protection in the spring (Jan-May) semester.

He has presented papers and tutorials at the local conferences and regularly provides training to utility engineers on protection philosophies. He has a professional Engineering License in the state of Minnesota.

Registration: Limited Seats Available! Please reserve your seat at your earliest by submitting the registration [form](#) before 20th September, 2014
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