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Title of Abstract:

Report on Design, Testing, and Commissioning of 100% Stator Ground Fault Protection at Dominion Energy Bath County Pumped-Storage Station

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Abstract (not to exceed 300 words)
Cradled in Virginia's rugged Allegheny Mountains, the Bath County Pumped Storage Station, which went into operation in 1985, is jointly owned by Dominion and the operating companies of the Allegheny Power System, and managed by Dominion Generation. The facility, which includes six 530 MVA rotating machines, has a peak generating capacity of approximately 3,000 MW. Several years ago the plant began upgrading their static excitation systems along with protection systems for each of the six machines. Each machine can operate as synchronous generator as well as synchronous motor. The scheduled operation of the units is based on grid demand and changes daily. Typically, during peak demand hours, several machines will be operating as generators at the same time. Conversely, during non-peak hours, the several machines will be running as motors pumping thousands of gallons of water back to the upper reservoir some 1200 ft above the powerhouse. The machines have a rated voltage of 20.5 kV which is stepped-up to 500 kV for transmission. The plant utilizes nine single-phase GSU transformers, each shared by two machines on the 20.5 kV side. The machines are high-impedance-grounded through single-phase neutral grounding transformers. The upgrading of the existing protection system consisted of replacing single-function electromechanical relays with redundant microprocessor-based generator protection relays. Sensitive Rotor Ground Fault protection (ANSI # 64R) and 100% Stator Ground Fault (SGF) protection (ANSI # 64S) were two of the primary enhancements made to the protection. This paper will focus on the 100% SGF protection. This system uses a sub-harmonic 20 Hz signal injecting into the neutral grounding transformer, monitoring the stator ground resistance to detect stator ground faults. A 20 Hz AC signal generator coupled to the secondary of the neutral grounding transformer through a 20 Hz bandpass filter, drives an alternating current into the starpoint of the generator. The digital relays monitor the 20 Hz voltage and current and calculate the complex impedance from those two metered values. Due to the high ground capacitance of these machines, it is imperative that the protection system is able to differentiate between the capacitive and resistive components of the 20 Hz ground current. The settings for the trip and alarm stages of the 100 % SGF protection are based on resistance thresholds rather than current thresholds, leading to high reliability. The main advantage that this method offers over the conventional method of evaluating the 3rd harmonic of the neutral voltage is the ability to detect ground faults in the stator

windings prior-to and during start-up of the machines. The conventional method is strictly dependant on generator operating conditions. By using the sub-harmonic signal injection, the measurement of the complex ground impedance of the stator windings can be done independently of generator operating conditions. This feature is ideal to Dominion Generation since they require that the stator ground resistance be measured prior to starting any machine. Before start-up, the 20 Hz injector is started for 30 seconds to ensure no grounds exist in the system. Once system integrity is verified, the machine is started. This paper will discuss in detail the design, testing and commissioning of the 100% SGF protection. There are several operating conditions which needed to be considered in the design of this system. The machines are started using Static Frequency Converters (SFC's) in most cases, but in some cases are started in "back-to-back" mode. In this mode one machine acting like a generator is connected to another machine being started as a motor. The generating machine provides the power to bring the motor to a certain frequency and then the two machines are isolated and the motor is powered by its normal source voltage taken from the 500 kV transmission network. The 100% SGF protection must be adaptive through all these different conditions and not mis-operate, resulting in unwanted tripping of the unit. The system has proven reliable during commissioning and now into its second year of operation.

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