World Academy of Science, Engineering and Technology
International Journal of Energy and Power Engineering
Vol:12, No:03, 2018

Neuro-Fuzzy Approach to Improve Reliability in Auxiliary Power Supply System for Nuclear Power Plant

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Abstract : The transfer of electrical loads at power generation stations from Standby Auxiliary Transformer (SAT) to Unit Auxiliary Transformer (UAT) and vice versa is through a fast bus transfer scheme. Fast bus transfer is a time-critical application where the transfer process depends on various parameters, thus transfer schemes apply advance algorithms to ensure power supply reliability and continuity. In a nuclear power generation station, supply continuity is essential, especially for critical class 1E electrical loads. Bus transfers must, therefore, be executed accurately within 4 to 10 cycles in order to achieve safety system requirements. However, the main problem is that there are instances where transfer schemes scrambled due to inaccurate interpretation of key parameters; and consequently, have failed to transfer several critical loads from UAT to the SAT during main generator trip event. Although several techniques have been adopted to develop robust transfer schemes, a combination of Artificial Neural Network and Fuzzy Systems (Neuro-Fuzzy) has not been extensively used. In this paper, we apply the concept of Neuro-Fuzzy to determine plant operating mode and dynamic prediction of the appropriate bus transfer algorithm to be selected based on the first cycle of voltage information. The performance of Sequential Fast Transfer and Residual Bus Transfer schemes was evaluated through simulation and integration of the Neuro-Fuzzy system. The objective for adopting Neuro-Fuzzy approach in the bus transfer scheme is to utilize the signal validation capabilities of artificial neural network, specifically the back-propagation algorithm which is very accurate in learning completely new systems. This research presents a combined effect of artificial neural network and fuzzy systems to accurately interpret key bus transfer parameters such as magnitude of the residual voltage, decay time, and the associated phase angle of the residual voltage in order to determine the possibility of high speed bus transfer for a particular bus and the corresponding transfer algorithm. This demonstrates potential for general applicability to improve reliability of the auxiliary power distribution system. The performance of the scheme is implemented on APR1400 nuclear power plant auxiliary system.

Keywords : auxiliary power system, bus transfer scheme, fuzzy logic, neural networks, reliability
Conference Title : ICEPGS 2018 : International Conference on Electric Power Generation and Sources
Conference Location : Paris, France
Conference Dates : March 15-16, 2018