Power Factor Correction and Voltage Control in Industrial Systems

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Abstract

Electrical loads are expected to operate at power factor close to unity or above a utility specified value, which is typically 0.9. Low power factor causes the efficiency of power distribution to diminish and losses to become large. Operation of a power system at a low power factor is costly for the utility due to the increased current required to be sent over the lines to provide the same real power at the loads. Utilities therefore impose penalties on customers which operate their load at power factor below the specified values. In industrial environments lagging reactive power is drawn due to various types of loads such as induction motors, arc furnaces, etc., which can cause operation at a low power factor. Thus, reactive power compensation is required to maintain acceptable power factor at industrial sites. This project aims at designing, developing and validating a Static VAr compensator (SVC) model for load compensation (power factor correction). The first part of the project deals with the development of a lab scale model (16VAC, single-phase) equivalent to an industrial distribution system (27.6kVAC, three-phase) to examine realistic results of reactive power control with hardware. The SVC provides desired amount of capacitive reactive power for load at different power factors. The SVC controller is developed using a PIC which reads four inputs – voltage and current signals (analog input) and voltage zero crossing and current zero crossing signals (digital input). Using these inputs the associated power factor can be determined and an appropriate output pulse created to trigger the SVC. In the second part of the project, the actual distribution system is simulated on the electromagnetic transients software PSCAD/EMTDC. Using the software, 15km to 60km distribution lines are modeled to simulate the associated voltage drop experienced in typical distribution systems. At 27.6kVAC, the system is loaded with various parallel loads to simulate an industrial system with inductive loads being switched in. With these variations to the system, the model demonstrates the effective use of an SVC to compensate for low power factors and sudden voltage drops. Using PSCAD, the theoretical lab model and real system model are analyzed and compared to validate the load compensation results of the lab-scale model.

Key Words: Power factor correction, Load compensation, Reactive power control, Static VAr compensator, power system modeling and simulation