CASE STUDY
IMPROVING RELIABILITY

S&C ELECTRIC COMPANY
Excellence Through Innovation

Switching Transient Analysis: Transients Damage Adjustable-Speed Drives at Industrial Plant

S&C Featured Solution: Power System Studies

Location: Northwest US

Customer Challenge

A large industrial customer in an area served by a major northwestern utility reported extensive damage to adjustable-speed drives (ASDs) in their plant. The same customer also experienced frequent occurrences of nuisance tripping of ASDs. Concerned about their customer's experiences, the utility approached S&C's Power Systems Solutions Division to perform transient studies to determine the likely causes of damage to the ASDs. The utility was also interested in determining the levels of transient overvoltage resulting from the energization of a 20.8 kV grounded-wye capacitor bank at its distribution substation in the affected industrial customer's area. Furthermore, the utility also wanted to evaluate the effectiveness of vacuum switches with controlled closing to mitigate transients during energization of this capacitor bank.

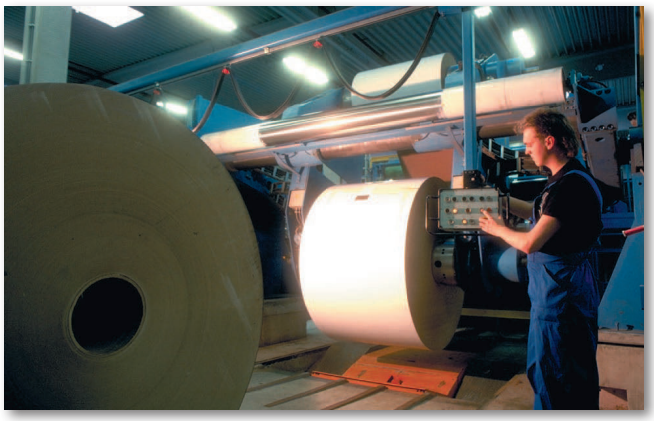
S&C Solution

The industrial customer reported that there was a brief power outage just prior to the reported incident in which ASDs in the plant were damaged. Damage to ASDs included damage to diode bridge rectifiers, metal oxide varistors, and power supply cards, as well as blowing of fuses. The reported sequence of events suggested that the damage to the equipment may have been the result of transients generated during the restoration of power.

In addition to the reported incident, the customer also experienced frequent tripping of ASDs. The tripping of the ASDs was traced to be directly related to the energization of the utility's 20.8 kV capacitor bank in the distribution substation.

Results

S&C developed an equivalent circuit model of the utility's subtransmission and distribution systems in the vicinity of the affected plant. Then transient overvoltages during line re-energization and during capacitor bank energization were simulated using this model in the Electromagnetic Transients Program (EMTP). Simulation results indicated that significantly higher-than-normal phase-to-ground and phase-to-phase overvoltages can occur at transformer secondary buses (480-volt) in the industrial plant during line re-energization following a brief power outage. These overvoltages may precipitate phase-to-phase flashovers in ASDs which have reduced insulation withstand capabilities due to contamination or insulation degradation. In addition, inrush currents into larger horsepower ASDs during restoration of power were high enough to result in damage to ASD components. These inrush currents were particularly large if the DC bus voltage of the ASD was only slightly higher than the undervoltage trip level. Component damage in an ASD can also occur due to arc voltages resulting from fuse operation in an adjacent ASD.



The arc voltages generated during the fuse operation, combined with the associated inrush currents due to lower-than-normal ASD DC bus voltage levels, were determined to be the most likely cause of cascading operation of fuses in adjacent ASDs. Simulations indicated that 3% AC line chokes would significantly reduce inrush currents into ASDs under the same conditions. The chokes would also minimize any increase of bus voltages at the 480-volt bus as a result of arc voltages due to ASD fuse operation.

The transients generated by the energization of the 20.8-kV capacitor bank were found to be severe enough to cause tripping of ASDs if no transient mitigation is applied. When transients are mitigated using commercially available mitigation devices, the transient overvoltages on the DC bus of the ASDs can be reduced significantly. However, the addition of 3% AC line chokes for additional mitigation at the input to a few ASDs in the plant was still required. If no mitigation was applied at the substation, AC line chokes would be required at more than 100 ASDs used in the plant.

The overall result of the transient studies was two satisfied customers! Both parties were able to explain the likely causes of the equipment damage, understand the phenomena involved, and determine the most economical solution to prevent reoccurrence of damage or nuisance tripping of ASDs!