NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Lesson Learned
Protective Relaying Digital Input Board Loading Resistance

Primary Interest Groups
Transmission Owners (TO)
Transmission Operators (TOP)
Transmission Service Providers (TSP)

Problem Statement
The digital input board in a relay circuit that protects a main circuit transformer was overly sensitive to transient signals, noise, or high resistance contact bridging from outdoor mounted relay devices, resulting in a false trip of a transmission line breaker.

Details
On two separate occasions and at two different stations, protective relay actions associated with power transformers resulted in false tripping of the main circuit breaker. Both incidents were initiated by outdoor mounted protective relaying devices. While the protection systems responded correctly and in accordance with design to isolate equipment, the protective trip was triggered by voltages at the digital input board that were not produced from an actual closure of a protective relay trip contact. The resulting trip of the main circuit breaker was determined to be false in nature and unnecessary.

Protective relaying devices and circuitry that protect outdoor power equipment (e.g. transformers or capacitors) are periodically exposed to severe weather conditions throughout their service life and are specifically designed to withstand harsh environments. One of these incidents was preceded by an extended period of bad weather but the protective trip occurred after the weather cleared while the second incident occurred during a period of good weather. As a result, it was concluded that there was no obvious correlation with either poor weather or wet conditions.

Thorough analysis showed that one of the protection circuits that produced a false trip was associated with a sudden gas pressure relay and the second with oil temperature monitoring. Although these are entirely different relay mechanisms with essentially no common parts or equipment, they both provide information to the protection system via a digital input circuit board installed in the control room. There are multiple inputs to the digital input circuit boards, and the boards are failsafe such that a failure of the board itself would not result in a protective signal being generated. Investigation and field testing of the control cables and protection systems involved verified that the equipment was operating within specifications.

All evidence collected during field inspections, circuit analysis and subsequent monitoring supported the conclusion that the protective trips were caused by the protection digital inputs being too sensitive to voltages from transient signals, signal noise, or high resistance contact bridging across the trip contacts on outdoor mounted protective devices.

Corrective Actions

Field modifications were performed on the protective relaying digital input circuit boards to introduce loading resistors in order to de-sensitize (dampen) the voltage signals to the digital input digital circuit boards. The loading resistors are installed across the digital input to lower the input resistance and limit the voltage level from transient signals, signal noise and contact bridging. The loading resistors have minimal impact on the voltage applied to the digital input from an actual protective trip contact closure. During approximately six months of operation after the modifications had been made, there have been no protective trips initiated from transients, signal noise or contact bridging. This period of time saw a number of severe weather events that included lightning storms through the summer, a hurricane, and a snow storm during the late fall. There were numerous nearby transmission level faults during these weather events which were seen by the protection systems and handled correctly. Continued monitoring of the modified digital input boards performance will be documented for further analysis.

Lesson Learned

Outdoor mounted protective relays and circuitry have the potential to be exposed to a wide range of disturbances that may disturb the voltage across a digital input in the control room. Modern digital relaying and control systems may be subjected to mechanical shocks, vibrations and other signal or noise interference events which, in turn, may cause transients to be detected as a full contact closure by the protection circuit digital input boards. The digital inputs associated with the protection of outdoor mounted devices should be designed or modified as necessary to reduce their sensitivity to voltages from transients, signal noise or high resistance contact bridging.

Methods to reduce the sensitivity to these voltages are:

- Add a loading resistor to the input of the digital input circuit board.
- Tightly twist the insulated send and return wires together to prevent induced voltages from picking up digital inputs. This makes the circuit more immune to any other voltage being induced from an outside source.
- Use interposing relays to electrically separate the input board from other devices. This requires more wiring but provides a solution to the problem where there are many cables located which may provide spurious signals near the protection circuit digital input board.

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For more Information please contact:

NERC – Lessons Learned (via email)	John G. Mosier (via email) or (212) 840-1070

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