

Open Phase Class 1E Protection Design

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Presentation Overview

- Basis for the Class 1E Design
 - Operating Experience Investigation
 - Conceptual Studies
- Voltage Unbalance Protection Design
- Settings for Voltage Unbalance Relays
- Voltage Unbalance Relay Logic
- Pros & Cons
- Clarifications Needed

Basis for the Class 1E Design

Drawing on investigations by the ETAP Nuclear Utility Users Group, the NEI industry task forces, and IEEE working groups, and several utilities, an open phase (OP) design was developed that focused on the goal of ensuring Class 1E electrical functions.

Operating Experience Investigation

- INPO IER L2-12-14 and NRC Information Notice 2012-03 required determination of vulnerabilities from the effects of an open phase fault.
- Industry OE shows two general results: (a) no operating effect or (b) loss of equipment functionality with no equipment damage.

Basis for the Class 1E Design (cont.)

Conceptual Studies:

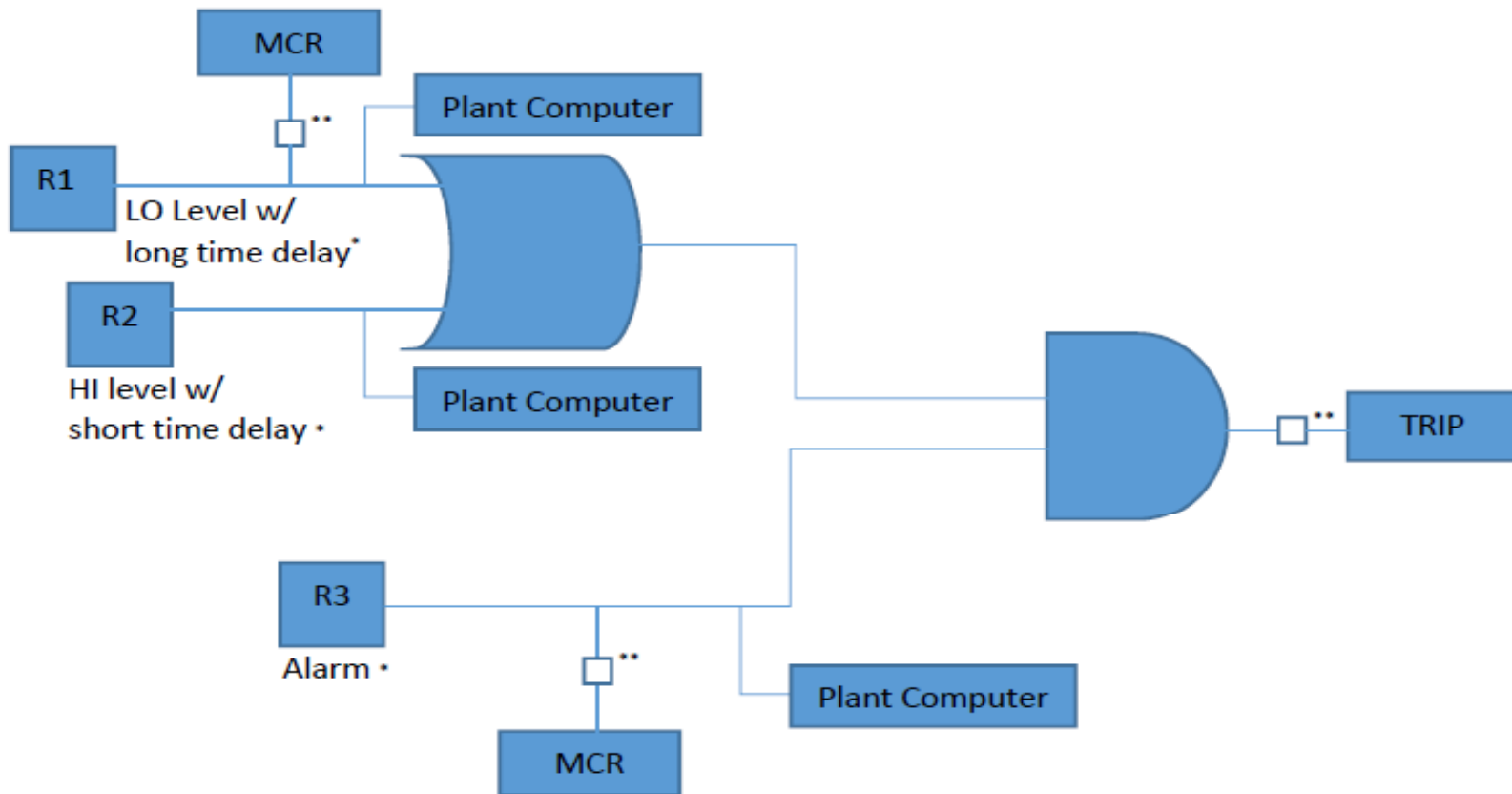
- detailed power system modeling, analysis and study varying the system loading and open phase grounding (unbalanced load flow)
- understand required regulatory parameters for the station
- The parameter of concern is voltage unbalance:
 - determine the amount of voltage unbalance Class 1E equipment could be subjected to
 - determine the amount of voltage unbalance that is acceptable or damaging
 - auxiliary power system voltage unbalance response at various load levels and configurations

Voltage Unbalance Protection Design

Piggy-back Degraded/Loss of Voltage Relay Connections:

- monitor bus voltages at the same point
- use existing voltage relay trip circuit
- use existing control room annunciation

Voltage Unbalance Relay Logic



* Setpoint documents required (after monitoring period)

** Procedure and/or licensing changes required prior to activation

Protection Design (cont.): Settings for Voltage Unbalance Relays

Alarm relay

- set slightly above "normal maximum" % voltage unbalance
- short time delay (supervises the trip function)

Low Unbalance relay

- set to maximum % voltage unbalance with no loss of functionality
- time delay ensures accident analysis time requirement is met

High Unbalance relay

- set at maximum % voltage unbalance setting on relay
- short time delay to coordinate with protective devices

Pros & Cons

Pros

- Protects Class 1E system from the negative effects of an open phase fault (equipment damage, loss of function).
- Protects the Class 1E system from sustained voltage unbalances caused by other types of malfunctions.
- Provides train-separated protection even for power system designs with a common offsite circuit for multiple trains.
- Addresses concerns of an OP fault between offsite transformer and the Class 1E system
- Trips only buses whose equipment functionality is being compromised, rather than tripping an offsite circuit affecting the entire plant.
- ABB 60Q phase unbalance relays are existing, Appendix B qualified technology.

- Piggy-backing existing voltage relay connections provides simple installation
- No new single point failure or common failure
- Creates no cyber security concerns
- Detects all open phase faults on the offsite circuit (any that create greater than normal unbalance on the Class 1E system)
- Provides universal voltage unbalance protection regardless of the cause

Cons

- A standby offsite source not normally connected to a protected Class 1E bus may need separate open phase detection for availability.

Clarifications Needed

- With Class 1E electrical functions protected, will the BTP require additional detection on the transformers to detect an Open Phase Fault of any magnitude. If so, the basis for the detection should be provided.

Questions