Lesson Learned
DC Grounds and AC Tied to DC Cause Multiple Relay Misoperations

Primary Interest Groups
Generator Owners (GOs)
Generator Operators (GOPs)
Transmission Owners (TOs)
Transmission Operators (TOPs)

Problem Statement
A dc ground coupled with an ac voltage tied to the 125 VDC battery system caused false breaker status indications on a line relay, and this resulted in a relay misoperation. Also, a high-speed auxiliary relay misoperated momentarily to introduce 125 VDC due to the extremely small air gap in the normally open contacts.

Details
The concurrent misoperation of six relays associated with multiple 525 kV breakers is the context of this lesson learned.

According to event records from the line relays, the breaker status in a line relay momentarily changed state, indicating an open breaker. The line relay then keyed a breaker-open transfer trip to the remote end due to this false breaker-open status.

At approximately the same time the line relay misoperated, six high-speed auxiliary relays configured to trip associated generation unit breakers operated. In this switchyard, each of the 525 kV yard breakers had a 352 breaker failure relay installed. If a protective trip is issued to a breaker, an input to the breaker failure relay is energized as a breaker fail initiate. In the case of these six 525 kV breakers, each breaker had two trip coils. Thus, there are two breaker failure initiate inputs to each 352 relay. Event records were uploaded from each of the breaker failure relays. Based on review of the event recorders, it was concluded that the six 525 kV breakers that operated were tripped by the high-speed auxiliary relays.

Initial investigation of the event indicated a strong negative ground on the 125 VDC system. Upon further investigation, an inadvertent connection between a 24 VDC battery circuit and the station annunciator 125 VDC common was identified. Once this connection was removed, the ground disappeared. System protection engineers believed this dc ground, along with a momentary ac voltage tied to the 125 VDC battery system (discussed below), caused the breaker status change in the line relay, resulting in a “breaker-open” or “inadvertent open” transfer trip to the remote station.

High-speed auxiliary relays are very fast, even when compared to other similar equipment. One manufacturer has developed a high-threshold version that requires a minimum of 70 volts, which should prevent it from operating on system grounds. The auxiliary relays in question were this high-threshold version.
Multiple event records taken from the breaker failure relays show indications of an ac signal on the breaker trip bus and breaker status input. (See Figure 1, which shows the alternating pick-up and drop-out of the relay input IN101, corresponding to 60 cycle voltages impressed on the relay input.) If 120 VAC is momentarily tied to a 125 VDC battery system, the peak voltage on the dc system could rise to $120 \times \sqrt{2} + 135 \text{ VDC} = 305 \text{ Volt peak}$.

![Figure 1: Breaker Fail Relay Event Record](image)

The normally open contacts had an extremely small gap (0.018 to 0.023 inches). It is postulated that if the ac voltage was momentarily tied to the 125 VDC battery system, the auxiliary relay contacts could have arced due to the extremely small gap and the large peak voltage applied, causing dc tripping current to flow, tripping the breaker and picking up the auxiliary relay's target/seal-in unit. The target/seal-in units of the six breakers were indeed found targeted, indicating that tripping current went through the auxiliary relays even though none of the protective relays that pick up these tripping auxiliaries operated. Despite thorough investigation, it is not currently known how the ac voltage was momentarily tied to the 125 VDC battery system.
Corrective Actions
The entity is investigating replacing the auxiliary relays with fiber-optic contact-transfer-tripping auxiliaries and running fiber between the unit tripping relays located in the unit control rooms and the switchyard control house. This will eliminate the high-threshold auxiliary relays and prevent similar events in the future. Also, the entity is in the process of implementing a system-wide modification of the relay settings of all relays similar to the line relay that misoperated to prevent a dc ground from causing a similar misoperation. The modification is to add a two-cycle delay to the “breaker open” transfer trip in order to override a transient false input to the relay.

Lesson Learned
A dc ground can cause a line relay to have a false-breaker-status indication, resulting in a relay misoperation. This lesson learned is an aggregate and similar to published Lessons Learned LL20120301 and LL20140501.

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Source of Lesson Learned:  
Western Electricity Coordinating Council

Lesson Learned #:  
20161001

Date Published:  
October 4, 2016

Category:  
Relay and Protection Systems

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