ENHANCED DC SYSTEM RELIABILITY AND COMPLIANCE IN DOMINION ENERGY'S SUBSTATIONS

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Abstract

Dominion Energy has developed a means to detect and alert on Battery Open Condition in our Substations. Battery Open Condition means that no battery system, neither primary nor back-up, is connected to the DC bus at the substation. Dominion has relied on float current readings measured at the battery and supplied by the battery monitor to detect Battery Open Condition (BOC). However, we became aware of a vulnerability where this method would be unreliable. If BOC occurs and goes undetected, then a catastrophic event could occur.

In addition to improving reliability, Dominion will also be able to demonstrate compliance with the 2 standards that pertain to the DC system, **NERC PRC-005-6** and **NERC TPL-001-5.1,** both of which require monitoring for open battery condition.
Other reliability improvements implemented alongside the monitoring of BOC include:

- determining normal load, which will allow us to run a daily automated check to ensure the charger(s) are sized correctly to fully recharge a discharged battery within 8 hours
- enabling redundant battery High/Low voltage operating alarm to our system operator
- monitoring AC Ripple Voltage, which is used to help determine the health of the battery charger and the AC noise on the DC system

Dominion hopes that through sharing our experiences with the above implementation, we can help others achieve similar success.

Introduction

Dominion Energy uses several methods to ensure that the backbone of our substations, the DC System, remains healthy and ready to perform its vital functions. Visual inspections, regular testing combined with diligent reviews of the results, and a large-scale battery monitoring program all combine to provide valuable insight into the health of the DC system. A critical condition requiring immediate attention is Battery Open Condition, where no battery system, neither primary nor back-up, is connected to the DC bus at the substation. Until now, Dominion has used the float current reading taken at the battery and provided by the battery monitor to determine whether BOC exists.

Compliance Requirements

There are two NERC standards pertaining to the DC system that utilities must comply with: **NERC PRC-005-6**[1] and **NERC TPL-001-5.1**[2]. These two standards overlap with some requirements and don't use the exact same terminology, but they both require monitoring for Battery Open Condition. PRC-005-6 specifies that "battery continuity" must be verified, and TPL-001-5.1 specifies monitoring for "open circuit" on station DC supply.

Reliability

Dominion Energy is committed to fully complying with the letter and intent of the requirements laid out by the NERC and other regulatory entities. However, we recognize the reason behind these regulations is of far greater importance than remaining audit-ready: ensuring reliability and grid stability. If Battery Open Condition occurs and goes undetected, a catastrophic reliability event could occur. Dominion believes BOC should be monitored continuously rather than by periodically checking readings during routine inspections.

Dominion has identified a vulnerability involving the use of temporary (trailer) batteries in a substation. It is common to have a battery trailer carry the substation when conducting performance testing, when the station battery is having an issue, or when replacing the battery string in a substation. When these activities occur, personnel will parallel the temporary battery with the station battery, disconnect the station battery, perform the testing/work, then parallel the station battery back and disconnect the temporary battery. Should personnel neglect to parallel the station battery back before disconnecting the temporary battery and leaving, there would be no DC at the station.

Solution

Dominion's goal was to develop a way to monitor the main current flow that would provide an alert in the event that there is no battery string connected to the station DC system. The decision was made to pursue an option where float current could be monitored at the DC bus in order to capture the primary, temporary or both battery systems. In this solution, the float current CT is moved beyond the point where a temporary battery would be connected, and will detect loss of float current if neither the station battery nor the temporary battery is connected to the DC bus.

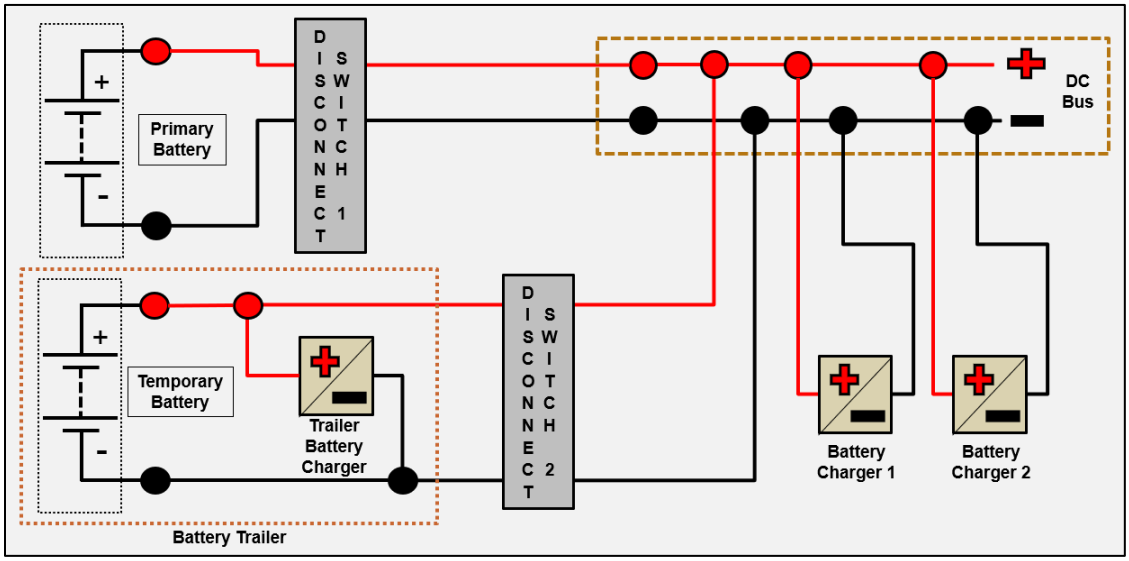

Figure 1. DC One Line
Original Configuration

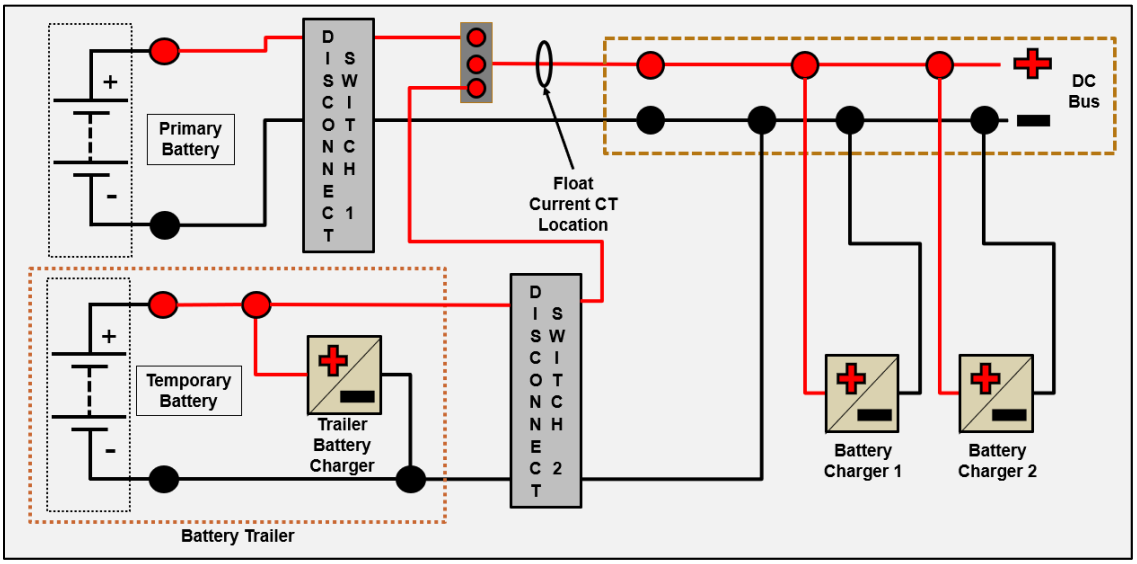

Figure 2. DC One Line After Addition of New Float Current CT And Positive Bus Connection

Dominion partnered with a vendor, and for two years worked with them to develop a real-time stand-alone device to monitor for Battery Open Condition. Care was taken to design the monitor so that it would reliably alert on BOC without also generating “nuisance” alarms. The vendor has a proprietary way of looking at the overall voltage, charging/float current, and the charger(s) supplied current to the DC system to identify the event is truly a Battery Open Condition. For example, although charger failure is a critical condition and certainly not a nuisance alert, we do not want the battery open condition alarm to be triggered during charger failure because we already have a real-time alarm for that condition. Additionally, there is user time-delay and threshold flexibility to avoid nuisance alarms because certain parameters used at one location might not be the best fit for another location.

Figure 3. New monitoring device, pictured over cells 3 and 4, is installed in Dominion Substation

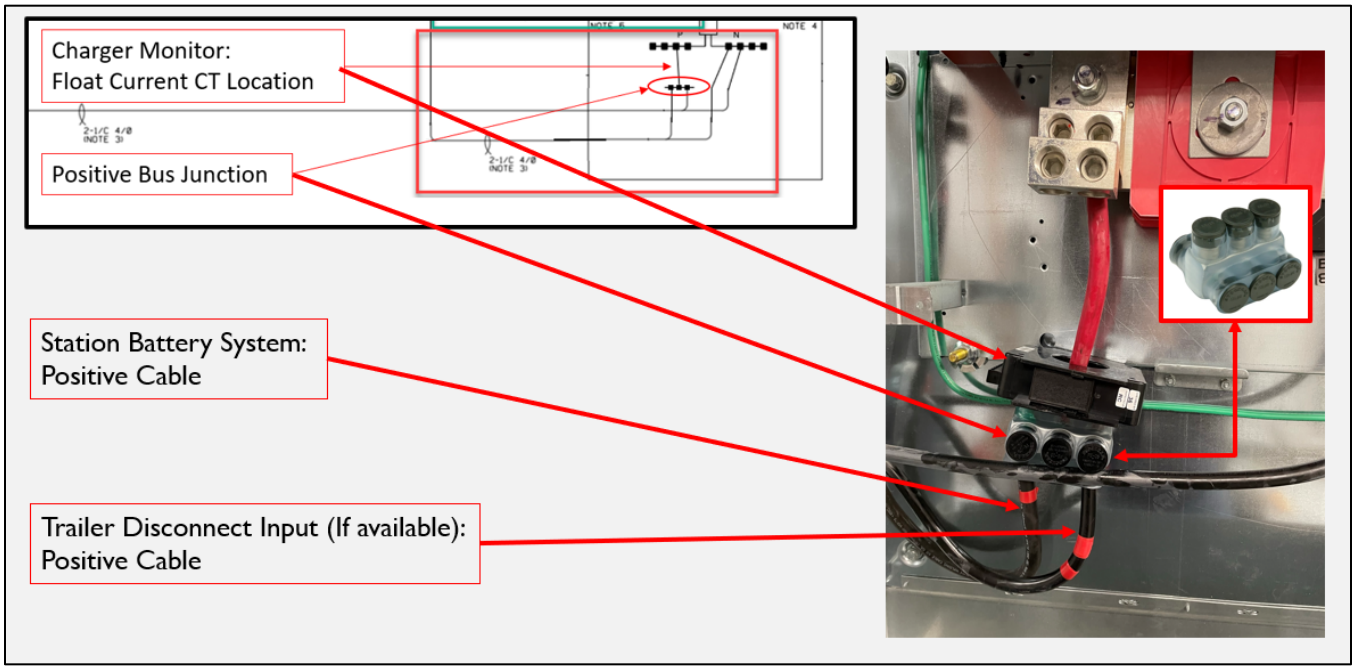

Figure 4. Placement of float current CT and positive bus junction at DC bus.

Other Monitored Points

In addition to the critical Battery Open Condition alarm, Dominion worked with our partner to have other points also monitored by the new device that will enhance our DC monitoring program:

- Substation DC Normal Load – monitored on each charger. Having this data will allow us to develop automation to perform a check that the charger is sized correctly. We will also use the battery and charger(s) nameplate data housed in our asset management database, as well as the station load returned from the monitor, to perform the calculation. Dominion's standard is to size chargers so that they can fully recharge a discharged battery within 8 hours. Because equipment in our substations is continually being added or replaced, we need to reassess charger size on an on-going basis.

- Ripple Voltage – measures AC on the DC system. Ripple voltage could be an indicator of the filtering capacitors in the battery charger decaying. Additionally, other components such as relays or converters tied to the DC system could also introduce AC noise.

- Hi/Low DC Voltage Alarm to System Operations Center – enabling redundant high/low DC voltage alarm to the system operator paralleling a contact through the new monitoring device with our traditional high/low DC voltage alarm.

Summary

Monitoring float current at the DC bus gives an effective way to generate a real-time alert on Battery Open Condition without the vulnerabilities presented by the use of temporary batteries in substations.

References

1. NERC, Standard PRC-005-6 – Protection System, Automatic Reclosing, and Sudden Pressure Relaying Maintenance, 2015.

2. NERC, Standard TPL-001-5.1 – Transmission System Planning Performance Requirements, 2018.