Lesson Learned

Bus Differential Power Supply Failure

Primary Interest Groups
Transmission Operators (TOPs)
Transmission Owners (TOs)

Problem Statement
A microprocessor bus differential relay scheme hardware failure initiated a double bus trip on the BES, resulting in a loss of 58,000 customers.

Details
The substation had a 115 kV single-breaker double-bus configuration with 10 elements, and was protected by a B90 bus differential scheme. The scheme consisted of: (1) seven intelligent electronic devices, including a tripping, a control, and a bus selector SW; and (2) three differential relays (one per phase). The scheme uses multiple zones of protection to identify and trip only the faulted bus. The zones are identified by “bus selector switch” inputs, which are used to place the breaker on bus-1 or bus-2. Internal logic places the breaker current transformer (CT) contribution in the bus-1 or bus-2 differential zone. Using this type of scheme, one bus differential scheme can protect two busses.

The “A” phase differential relay power supply capacitor started degrading, which caused the analog to digital converter to provide erroneous current and voltage values from the reference voltage used in the protection element calculations. This resulted in an “A” phase differential trip for bus-1 and bus-2; the voltage supervision was not effective since the degraded capacitor also provided erroneous voltage values used in the differential element supervision. This version of the relay does not monitor the power supply internal logic voltages, so the relay did not take itself out of service. The double bus trip resulted in a sustained loss of over 58,000 customers.

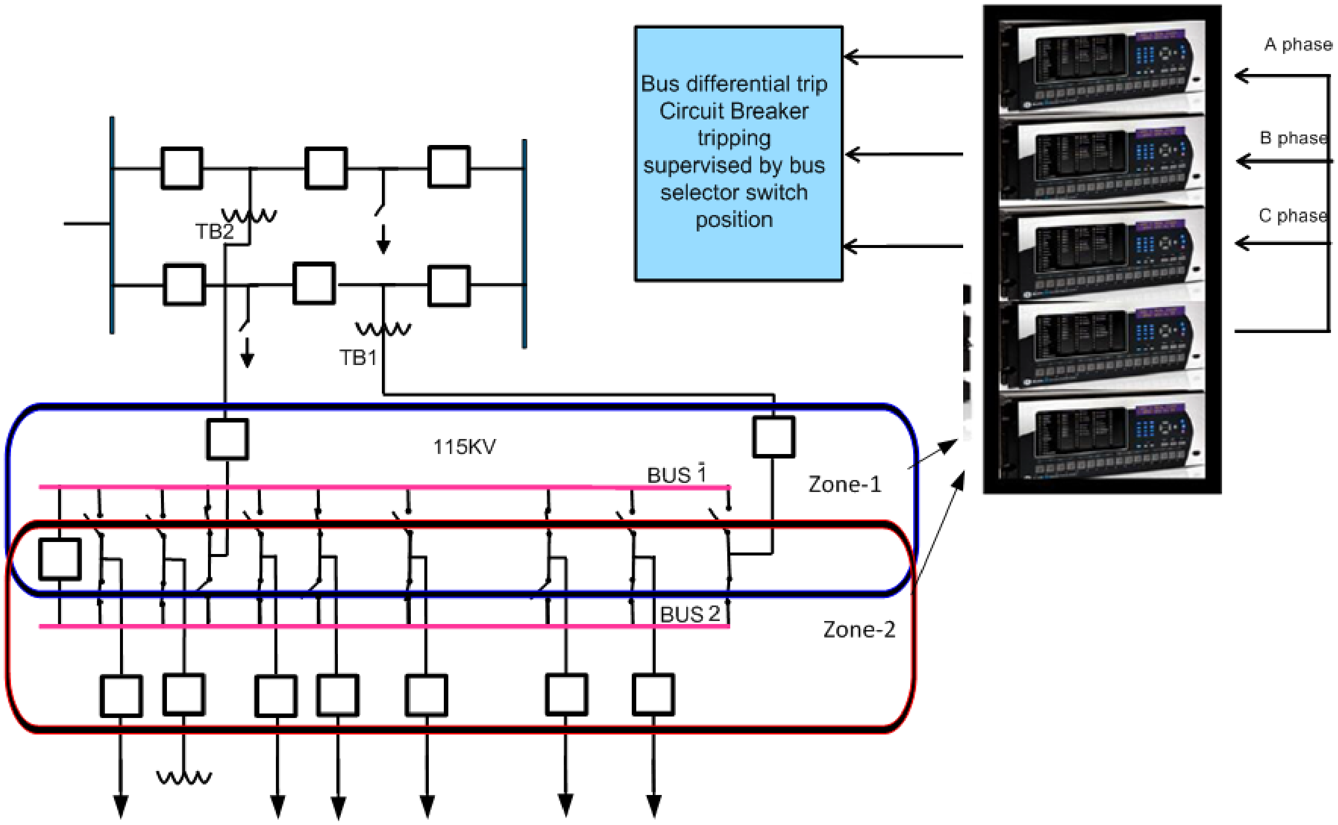

Figure 1: Substation Double Bus Single Breaker Bus Differential Scheme

Corrective Actions

The affected Direct Current (DC) power supplies were replaced with new versions of power supplies that incorporate additional self-monitoring on all seven IEDs for the bus differential scheme.

The security of the equipment was improved by adding independent supervision of the tripping elements. The adjacent phase bus differential relays were used to supervise the previous phase relay. For example, “B” and “C” phase differential relays are monitoring “A” phase bus voltage and providing input into the “A” phase bus differential relay. A subsequent “A” phase bus fault causes low “A” phase voltage. Since A phase voltage is being monitored by “B” and “C” elements, which are providing an input into the “A” phase relay, the bus differential element is allowed to operate. The inter-relay communication is being provided “direct input/output digital bits” that are not affected by DC power supply degradation (refer to figure 3).

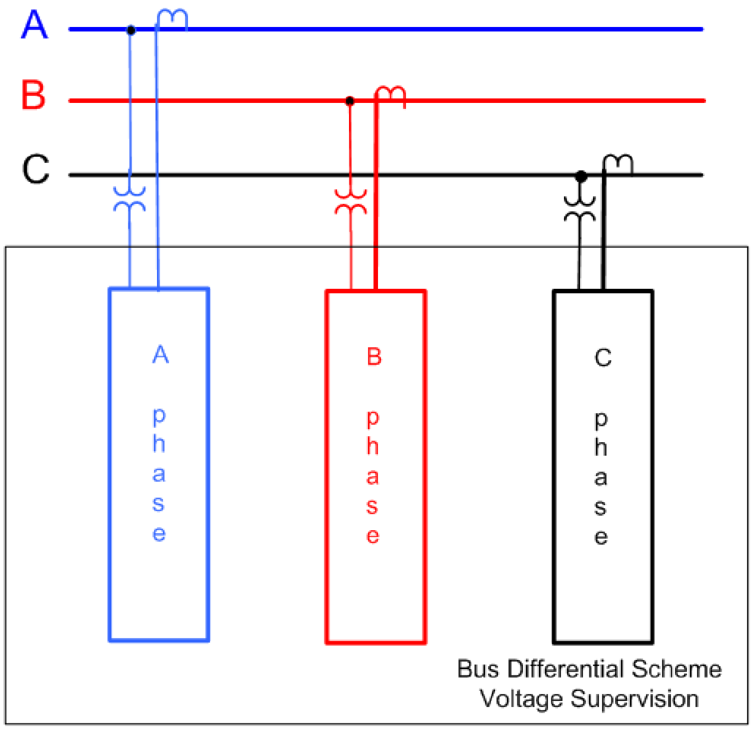

Figure 2: Original Bus Differential Voltage Supervision

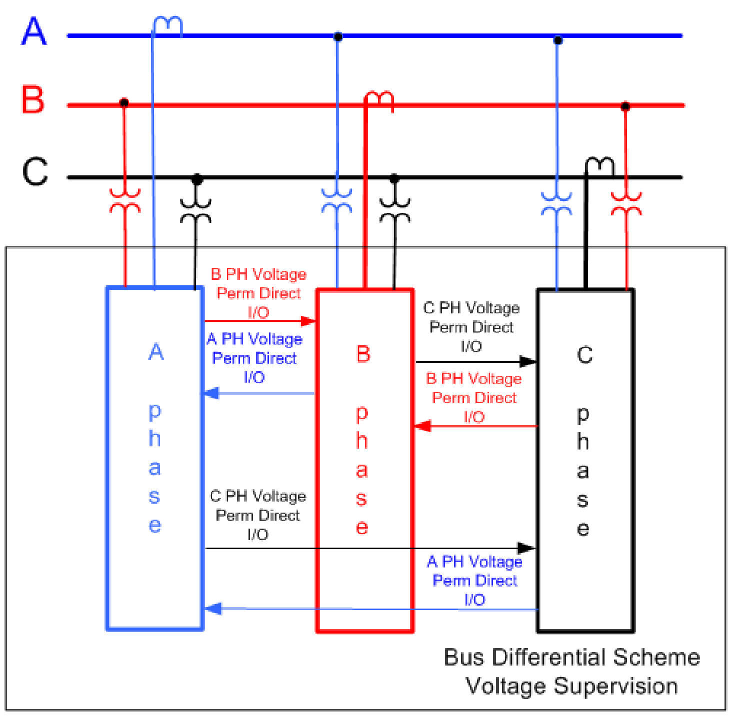

Figure 3: Revised Bus Differential Voltage Supervision

The location of similar installations and similar relays were determined throughout the service territory and prioritized based on the number of customers at risk for a bus differential misoperation. The replacement of DC power supplies, modified settings, functional testing, and drawing changes were staged ahead of time to minimize the amount of time the bus differential scheme was out of service. The new DC power supplies were energized for three days prior to installation to ensure there were no problems. All at-risk bus differential schemes were modified within three months of the originating event.

Lessons Learned

- For important and high-impact schemes, such as bus differential schemes using multiple zones in one relay, the supervision should be independent of the tripping device. In this case, the mode of failure affected the supervising element along with the tripping element (current) being measured.
- The design of this scheme, in which one scheme protects bus-1 and bus-2, thereby putting both busses at risk during a device failure or misoperation, should have involved increased security when applied.
- Relay manufacturers should ensure there is sufficient device self-monitoring to allow the device to be disabled prior to causing an unwanted trip. The manufacture must communicate the risks clearly to the owners and immediately when the problem is discovered.

NERC's goal with publishing lessons learned is to provide industry with technical and understandable information that assists them with maintaining the reliability of the bulk power system. NERC requests that you provide input on this lesson learned by taking the short survey provided in the link below.

Click here for: Lesson Learned Comment Form

For more Information please contact:

NERC – Lessons Learned (via email)	Paul Rice (via email) or (801) 883-6840
Source of Lesson Learned:	Western Electricity Coordinating Council
Lesson Learned #:	20141202
Date Published:	December 9, 2014
Category:	Relaying and Protection Systems