Lesson Learned

Bus Differential Power Supply Failure Causes Loss of Load

Primary Interest Groups
Transmission Operators
Transmission Owners

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 has an 115kV Single Breaker Double Bus configuration with 10 elements is protected by a B90 Bus differential scheme. The scheme consists of 7 IED (individual electronic devices) 3 differential relays (one per phase), a tripping IED, Control IED and Bus Selector SW IED. 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 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, this caused the reference voltage used in the A/D converter to provide erroneous current and voltage values 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 resulted in erroneous voltage values used in the differential element supervision. This version of the relay does not monitor the power supply internal logic voltages and therefore the relay did not take itself out of service. The double bus trip resulted in a sustained loss of over 58,000 customers.
**Corrective Actions**

- The affected 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 increased 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 provide input into the A phase bus differential relay. A subsequent A phase bus fault causes low A phase voltage which is being monitored by B & C elements which are providing an input into A phase, allowing the bus differential element to operate. The inter-relay communication is being provided “Direct Input/Output digital bits” that is not affected by DC power supply degradation (Refer to Figure -3).
Bus Differential Scheme
Voltage Supervision

Figure -2 Original Bus Differential Voltage Supervision

Figure -3 Revised Bus Differential Voltage Supervision
• The location of similar installation and similar relays were determined through the services 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 3 days prior to installation to ensure there were no “infant mortality” issues. All 10 at risk bus differential schemes were modified within 3 months of the originating event.

Lessons Learned

• The importance of independent device supervision - 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 inherent 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 must consider increased security of the scheme when applied. The next bus differential design will have additional security and segregation between the Bus 1 and Bus 2 protective elements.

• 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.