Closed Loop Automation Solution for Ship Locks

G&W Products: LaZer Automation Solution utilizing PNI switches and SEL-451 relays.

Issue: A major seaway located near Niagara Falls installed a new ship stabilization technology to aid in the moving of ships through the locks. For this technology to function properly, an uninterrupted supply of power provided by a resilient power distribution system was required. This system needed to provide the least downtime in the event of a fault on the power lines running underneath the ship locks. It also needed to be able to seek a live power source if the primary source was lost.

Solution: G&W designed, tested, and delivered a state-of-the-art LaZer Automation Solution that includes six (6) padmount PNI switches (4-way units) in a Closed Loop Fault Location, Isolation, and Restoration (FLISR) and Loss Of Voltage (LOV) scheme. The loop is fed from two feeders, with Line 2 being the primary source and Line 1 being the backup source. The single line diagram in Figure 1 shows the layout for the medium voltage power system at the lock.

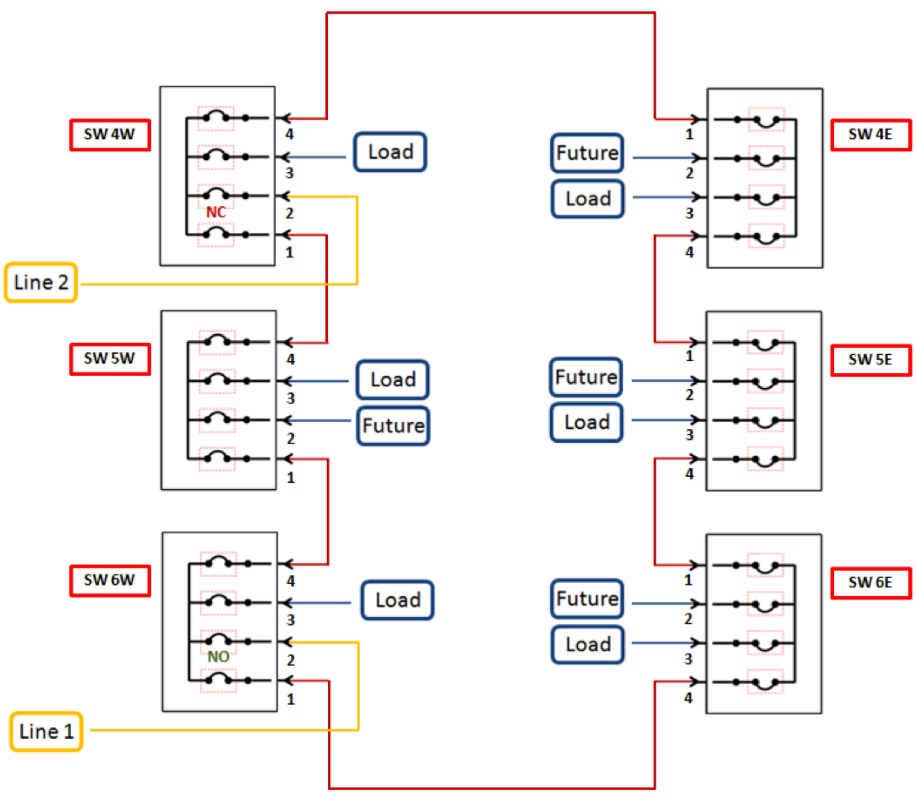

Figure 1

Switchgear Layout:

Each 4-way PNI switch is equipped with fault interrupters on all four ways and two SEL-451 relays, located in a low voltage enclosure that is attached to the switch, for protection and control. Ways 1 and 4 are protected and controlled by one relay, while ways 2 and 3 are protected by a second. Voltage sensing is provided on all four ways for each of the six (6) PNI padmount switches. Four (4) of the switches include provisions for motor operators on both the line and load ways for future use. Two (2) switches are connected to the substation sources and include motor operators on the respective feeder way. The upstream substation breakers/reclosers are coordinated with the two feeder ways to participate in a Loss Of Voltage (LOV) Source Transfer Scheme. Those breakers/reclosers also participate in the Closed Loop FDIR/LOV scheme by sending a direct trip signal so that the LOV scheme can proceed with no inherent delay.

Communication Layout:

Each padmount PNI switch establishes communication with its adjacent switch by utilizing a fiber optic communication ring. This ring is established by connecting both SEL-451 relays to a managed Ethernet switch which is located in the low voltage enclosure along with the two relays. The managed Ethernet switch is then connected to the Ethernet switch of the adjacent padmount switch to form the ring. A ring communication layout was selected to enhance the communication reliability as it allows all communication to continue if a single fiber optic cable is lost. Figure 2 shows the communication layout of one padmount switch including the relays and Ethernet switches.

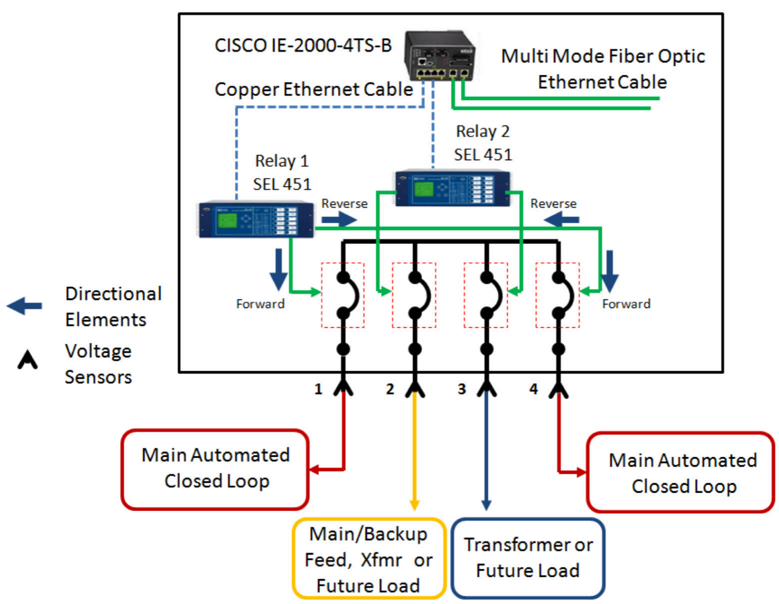

Figure 2

Closed Loop FLISR Protection Scheme using POTT and DCB (Main Loop):

The primary protection for the main loop cables between the switches is achieved by utilizing a Permissive Overreaching Transfer Trip (POTT) scheme. The POTT scheme works by comparing the fault direction at each end of a line. The relays communicate via IEC 61850 Generic Object Oriented Substation Event (GOOSE) messaging to send the fault directional information in form of a "permissive" signal to the relay at the other end of the line. If the relays at each end see the fault in the direction of the line the fault location is determined to be on the line between the two relays. Therefore the relays can trip immediately and isolate the fault since they do not have to coordinate with any upstream protection devices. As described, the POTT scheme requires information from the other end of the line and will only work when the adjacent relay is in service and good communication is established. If the communication network or adjacent relay is out of service the POTT scheme is backed up by a secondary protection scheme.

This backup is accomplished by utilizing a Directional Comparison Blocking (DCB) scheme with inverse time overcurrent characteristics. A similar DCB scheme is also used to protect against a fault inside the PNI switches. The DCB scheme is similar to the POTT scheme in that it uses the direction of the fault from two relays to determine if the fault is in the protected zone. It differs in that the relay sends a "blocking" signal via IEC61850 GOOSE messaging if it detects the fault is outside the zone to prevent the inverse time overcurrent protection from operating. In this application, the DCB scheme will block the inverse time overcurrent protection on ways 1 and 4 (see Figure 1) when the fault is not inside the PNI switch or on the adjacent lines.

In the unlikely event of both a communication (POTT scheme inactive) and DCB scheme failure, additional backup is provided by utilizing inverse time overcurrent elements at the upstream substation relays to interrupt the fault.

Source Protection and Loss of Voltage Source Transfer:

As stated above, the loop in this application is fed from two feeders, with Line 2 being the primary source and Line 1 being the backup source. The two sources themselves are radially fed and protected by the customer's substation switchgear and overhead reclosers. Two of the PNI padmount switches in the loop (SW 4W and SW 6W, see Figure 1) participate in an automatic source transfer on loss of voltage of one of those two feeders. If the upstream breaker trips or is opened it will send a signal to the relay located at the downstream PNI switch. The relay will execute a LOV scheme with no inherent delay as soon as it receives the signal from the breaker. As a backup, a timed LOV scheme is incorporated should the communication between the upstream breaker and the padmount switch be lost.

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