



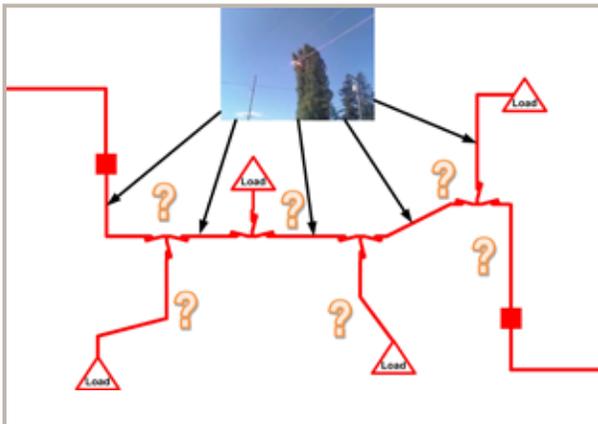
Smart Tap[®]

Fault Location and Load Restoration in Transmission Networks

Low or high current location and load restoration in transmission networks.

Faults on lines with multiple taps between substations can result in significant outage times and customer dissatisfaction. Commonly used substation based fault locating solutions for tapped transmission lines can be problematic when trying to locate the fault. Using Smart Tap technology, the fault location information is reported through the SCADA system allowing the system operator to determine which line segment has experienced the fault.

In addition, the Smart Tap provides an estimate of the distance to the fault from the node. For momentary and permanent faults, the SCADA fault information can assist crews in the location and elimination of the source of these faults. For permanent faults, the operator can quickly isolate the faulted section and minimize outage times and reduce SAIDI minutes.



In a transmission network with four taps, there are nine possible fault section locations.

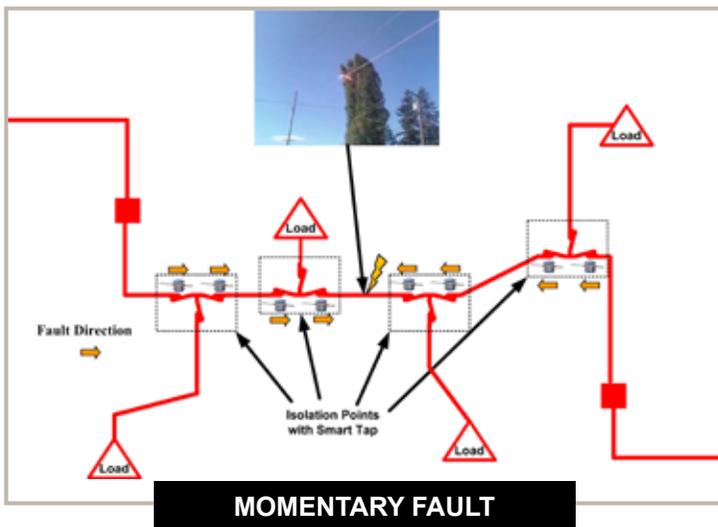
- If a fault occurs, it is not possible to identify the faulted section
- Trial and error approach required to clear fault
- Based on experience of operators or line crews
- For permanent faults, breakers are reclosed into fault if first try is not successful
- The trial and error approach repeated until proper section is identified
- For trip and hold momentary faults, location cannot be identified by section
- Fault distance cannot be accurately estimated from substation with line taps

KEY FEATURES

- Detects over current and high impedance faults
- Detects magnitude and direction of permanent and momentary faults
- Works on looped transmission lines with radial load taps
- Waveform capture and event logs
- Diagnostic logic and reporting
- Direction indication points to faulted section
- Provides estimate of fault location position on the line
- Reports information to SCADA operator
- Configurable for automatic sectionalizing and partial restoration

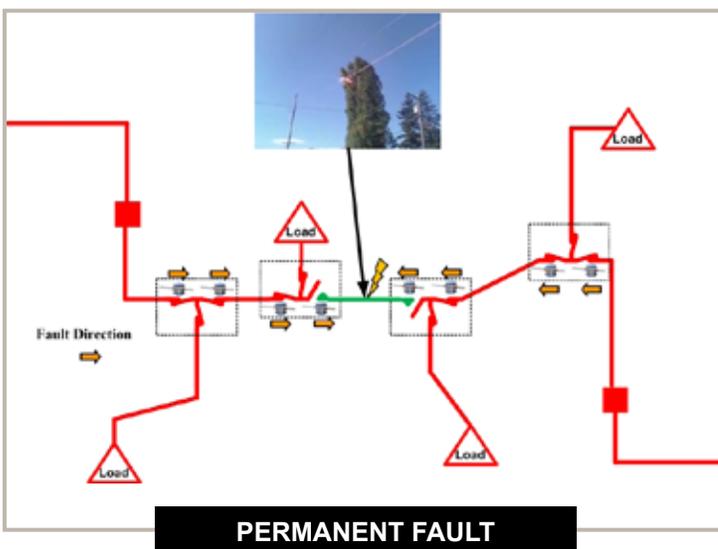
FAULT SENSING WITH SMART TAP

Momentary low current faults can trip the breaker and be cleared on the instantaneous reclose operation. Smart Tap detects the direction of these faults and provides information to the investigative team on the section where the fault occurred. The detection of the direction of these kinds of faults is very sensitive due to pre-fault compensation. Small changes in ground current are detected and the direction of the fault is calculated. This information is not reported unless the substation circuit breaker trips and a momentary outage exists.



Line fault between two taps. Smart Tap generates fault direction flags at each sensing point. These flags can be sent to the SCADA system and displayed on the operators single line diagram. These direction indicators represented as arrows on this diagram point to the faulted line segment.

Permanent overcurrent faults can be detected with sudden changes in line current. These direction indications are only reported if the substation breaker trips out the line.



In the case of a permanent fault, The SCADA operator can open the switches which will isolate the faulted section after the breakers have locked out for the remote controlled switches. If the switches are manually operated the crews can be dispatched to the proper section to isolate the fault without the guess work of trying several locations before the proper location is identified. The power to the customer can be quickly restored while the crews are clearing the source of the fault.

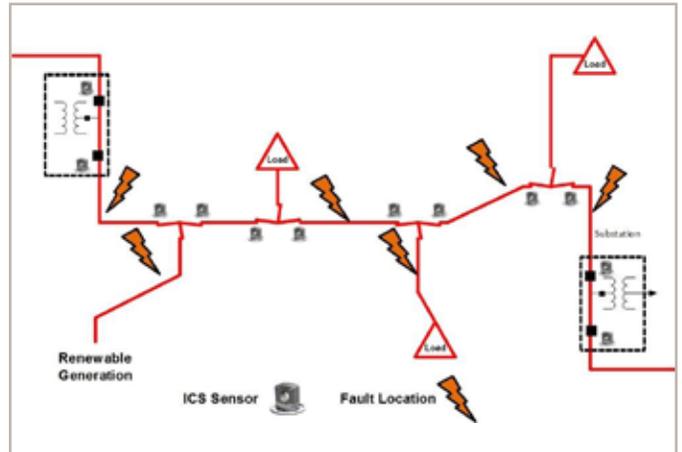
FAULT SENSING WITH SMART TAP

Fault Sensing Scenarios

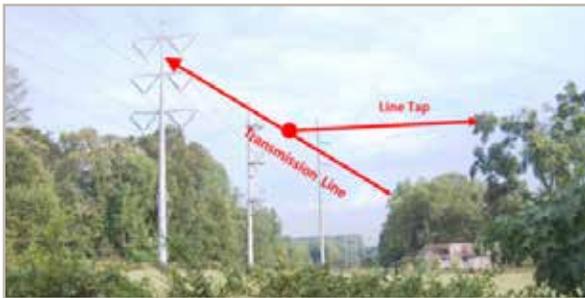
- Fault on Loop Transmission Line during normal operation
- Fault on Loop Transmission Line operating in Radial mode (breaker open on one end)
- Fault on Loop Transmission Line with both ends operating in Radial Mode (Isolation switch/breaker open in Line)
- Closing into a pre-existing fault when energizing a Transmission Line or Line Segment
- Disconnecting Distributed Generation (DERs, renewables, etc.) on transmission line taps when a fault is present on the transmission line
- Fault status during Recloser Operations

Fault Sensing Capability

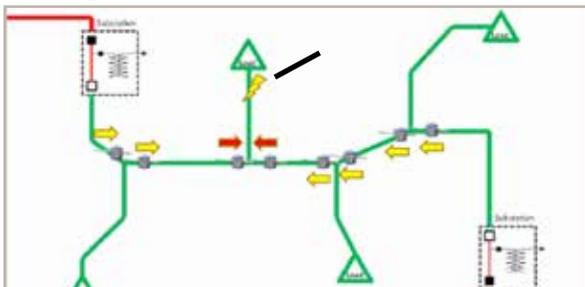
- Phase to Phase (3 phase fault or 2 phase fault)
- Phase to Ground (single phase to ground, 2 phase to ground)



FAULT SENSING CHARACTERISTICS OF SMART TAP



Smart Tap is able to estimate the distance to the fault from the measurement node with innovative patent pending current phasor algorithms.



Distance to fault 22 miles +/- 1 mile from tap.

SYSTEM INTEGRATIONS

Smart Tap provides direction information to SCADA through local RTU and SCADA communication network. Direction indicators can be displayed on the SCADA diagrams and to provide information to the operator to guide the sectionalizing switching steps.



Southern States **ICS**[®]



Control Center SCADA Display with Fault Direction Indication

Intelligent Circuit Sensor - **ICS**[®]

High voltage Sensing Technology

- 2.4 GHz Radio
- Energy harvesting - no batteries or solar panels at high voltage
- Single receiver per 3-phase set
- Redundant radio channels on each phase
- Minimum startup current 10 Amps
- Startup time: less than 1/4 cycle

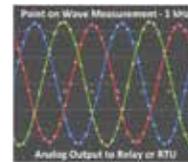


Patented Electronic **Current Sensor** requires no batteries, sealed for life



Real Time Measurement

- Current & voltage
- Phase angle
- Fault detection
- Fault direction
- Fault distance estimation



Real Time Waveform Capture

APPLICATIONS



Substations and Switching Stations



Manual and Remote Controlled Switches



Circuit Switchers