Substation Based FDIR/FLISR - Fault Detection, Isolation, & Restoration

Reliability Challenges
When faults occur on the distribution network, utility protection and control schemes normally shut down power on the feeder thus disrupting service to many customers. The size of area affected by the outage will directly translate into the number of consumers inconvenienced and suffer some degree of economic loss.

Many distribution utilities are measured as to how well they are serving their customers and maybe subjected to regulatory penalties if the regulators feel their performance is not as good as it should be. There are several different measurement indices that are used to gauge utility reliability effectiveness including:

- CML - Measurements indicating number of Customer Minutes Lost per average 100 customer
- CI - Measurements indicating total number Customer Interruptions per average 100 customers
- SAIDI - The System Average Interruption Frequency Index measuring the average number of minutes of interruptions that a customer would experience
- SAI FI: The System Average Interruption Frequency Index measuring the average number of interruptions that a customer would experience
- CAIDI: The Customer Average Interruption Duration Index measures the average outage duration that any given customer would experience

What FDIR can provide
Fault Detection, Isolation & Restoration (FDIR) schemes, also known as Fault Location Isolation and Supply Restoration (FLISR) or Circuit Reconfiguration Schemes, will greatly enhance distribution grid reliability by quickly restoring power to as many customers as possible. By quickly isolating faults and rerouting power from alternate sources to customers on health parts of the network, utilities can greatly reduce the number of customers affected by outages thus reducing their measurement indices and any penalties that may be associated with them.

Methods of performing FDIR
There are two main methodologies used to accomplish circuit reconfiguration:

- Centralized schemes that utilize a system wide Distribution Management Systems (DMS) that analyzes the entire network to identify the best way to reconfigure the network to restore power after a fault.
- Decentralized or Substation based schemes that analyze smaller sections of the network and does not require information about the larger distribution network to reconfigure local sections of the grid that are experiencing outages due to faults.

D400 FDIR
The D400 FDIR is a substation based Fault Detection, Isolation and Restoration solution that can quickly and cost effectively be integrated by Distribution utilities to drastically improve the reliability of their distribution networks. With this scalable substation based solution, utilities can prioritize the circuits they wish to automate and thus gain the maximum reliability improvements possible with the amount of investments they have available.

High Degree of Reliability
Through implementing a the D400 Substation based FDIR scheme, communications needed for monitoring or reconfiguring the network only need to extend from the field Reclosers and switches to the substation where the D400 is located. While communications can be sent back to Control Centers for SCADA management, the complete reconfiguration of the network can be done without a backhaul communications infrastructure. When large scale events occur that can cause multiple utility wide problems, the D400 Substation based FDIR solution will continue to operate and reconfigure the network even if backhaul communications are lost.

Looped and Multi-ended Circuits
The D400 FDIR application can be used on both Loopled and Multi-Ended distribution circuits. On looped circuits, power to re-energize healthy parts of the circuit will come from up to only two source locations.

On multi-ended circuits, the power to restore the network circuits may come from multiple source locations. When the load to be added from a reconfiguration action is too large to be supported from one source, the D400 FDIR solution will create a network configuration that will utilize power from as many sources as are needed to back power to the maximum number of customers possible.

Saleable, Cost Effective Solution
This D400 FDIR solution provides a scalable solution for automating from as few as two and as many as twenty circuits or feeder segments with a single D400. With this scalability, utilities have a cost effective solution that can be incrementally rolled out feeder by feeder or just installed on circuits that are causing the most reliability problems. One D400 can automate these twenty circuits whether or not they are emanating from one substation or multiple substations, as long as the D400 can communicate to the controllers in the field.
Segments - Each D400 can monitor and automate up to 20 sectors. Each sector is defined as a segment of a feeder that can be monitored and separated from the rest of the network. The start and end of each Sector is defined by an isolating switching device such as a breaker, recloser, or switch.

The D400 that is monitoring a particular sector will be responsible to isolating that sector in the event of a fault has occurred on it. This same D400 will also be responsible for controlling the tie switches to other sectors in the event that more load will be added to it to restore adjoining dead sectors.

Devices Controlled - Each D400 can communicate with and control up to 100 devices found within the sectors it is monitoring. Devices interfaced with may include protection relays, recloser controllers, switch controllers, and fault circuit indicators.

Modes of Operation
The D400 has two main modes of operation for isolating and reconfiguring distribution networks: Automatic Reconfiguration and Operator Assisted reconfiguration.

Automatic Reconfiguration - In Automatic Reconfiguration mode, the D400 will identify outages on it’s monitored sectors and take action to restore power to the maximum number of customers as possible without any interaction required from system operators.

Operator Assisted Reconfiguration - In Operator Assisted Reconfiguration mode, the D400 will require confirmation that system operators agree with the recommended action before these actions are carried out. This mode of operation is often used by utilities for an initial trial period of time that wish to have their operators get comfortable with the D400 recommendation before going into full Automatic Reconfiguration mode.

Reconfiguration Triggers
While the D400 is monitoring its sectors, there are several sequences on it's sectors that will cause to initiate a reconfiguration action.

Protection Lockout - The operation of a protection function on a protection relay or recloser controller

Loss of Voltage - The voltage on a sector has dropped below the programmed voltage threshold for an extended period of time defined by the utility.

Loss of Voltage After Fault - An immediate loss of voltage after a downstream overcurrent detection.

Isolation on sectors with DG
When a fault occurs on a sector of the line, the D400 will open all of the available switches to completely isolate the fault. On radial feeders or laterals, if additional switches are located down of the fault, the D400 will also open those switches to prevent any other sources such as Distributed Generation that may backfeed the fault.

Restoration
Once the D400 has ensured any faults are isolated, it will attempt reconfigure the network to restore power to as many customers as possible.

When operating in Operator Assisted Mode, the D400 will first ask for confirmation from the operator before taking any action. If the operator does not agree with the recommended action, the D400 will calculate the next optimal scenario and proposes that to the operator.

Historical load modeling
To ensure that the source being used to reenergize a sector can support the additional load, the D400 calculates the short term power requirements based on a 15 minute sliding peak demand window with 1 minute resolution.

The D400 also identifies the long term load requirements using a 30 days sliding window with a 1 day resolution and a 15 minutes averaging period.

Network Topology Modeling and Segments Definition

Dead line verification
Before reconfiguring the network, the D400 will verify that the voltage on the dead sector is has dropped below configurable thresholds to ensure that the line is still not energized due to any residual distributed generation sources.

Alternate Protection Groups
Before reenergizing a line, the D400 will alter the setting groups on any recloser or switch controllers on the line so that the protection functions will be coordinate for the new loads and direction of power flow.

Configuration
The D400 has a built in configuration tool that enables modeling of the system and configuration of the Fault Detection, Isolation and Reconfiguration features. This drag-and-drop graphical tool is used for defining zones of feeder sectors and communications to field devices.

This configuration tool also allows for adding monitoring parameters that allow users to analyze power system values and status during commissioning and real-time monitoring phases.

The D400 FDIR system configuration tools is an easy-to-use online tool that allows for system modeling and FDIR sector configuration. When being used in Operator Assisted mode, this tool can be the operator interface for acknowledging or rejecting reconfiguration scenarios proposed by the D400 FDIR system.
Real-Time Monitoring

SCADA Integration

The D400 supports most standard SCADA protocols including DNP 3.0, IEC 60870-5-104 Modbus, for integrating into operator systems. Utilities can integrate commands for accepting FDIR action recommendations as well as other substation automation applications that are supported by standard D400 functions.

SCADA Integration

The

Protocols

Email notification

To SCADA Operators or field crews on their SMART phones

- When lockout occurs
- When isolated
- When as many customers as possible are restored

Order Codes

Note that the FDIR option in the D400 is currently only supported in the 3.1 version of firmware.