



Fault Detection, Isolation, and Service Restoration

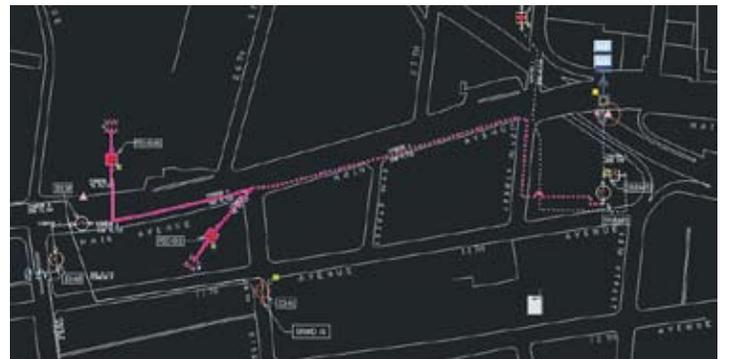
GE Energy's Fault Detection, Isolation, and Service Restoration (FDIR) application is a key building block for any utility's Smart Grid solution. FDIR enables utilities to significantly improve their distribution network reliability and reap economic benefits resulting in considerable cost savings.

Why choose FDIR?

FDIR ensures:

- **Minimized outage areas:** Intelligent algorithms restore the maximum number of customers after fault occurrences.
- **Minimized outage duration:** FDIR offers an optimized restoration algorithm that ensures minimized outage periods as well as the efficient use of field crews. For instance, FDIR recommends the minimum number of switching operations and avoids switching devices in areas marked 'difficult crew access.'
- **All safety precautions and rules are followed.** For example, opened switches and grounding network sections under work are automatically tagged. As a result, FDIR promotes a safer working environment for field crews.

- **All available equipment information and field data are considered when analyzing faults.** FDIR can carry out complex network configurations that would be difficult to do manually.
- **Implemented recommendations will not adversely effect the network,** i.e.: will not cause such things as equipment overload.

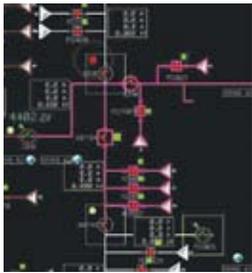


Graphical highlighting of affected equipment.

The fault detection mechanism makes use of available SCADA circuit breaker and fault detector statuses. In addition, it accounts for any relevant devices along the fault path, such as reclosure relays, when evaluating network conditions. Suspect fault conditions are highlighted on graphical network displays.

Smart fault management

When put to the test on DMS systems deployed around the world, FDIR has emerged as an extremely reliable and effective advanced fault-management system. GE Energy is a world leader in intelligent fault management and optimized restoration switching applications.



Highlighting of faulted zones, fault detectors, and switching recommendations.

FDIR is a state-of-the-art application offering an adaptive, model-based approach. This approach allows FDIR to instantaneously detect both feeder and substation faults and take immediate action, isolating faulted equipment and restoring any un-faulted network sections. Throughout this process all relevant DMS information (such as connectivity and equipment

modelling) and SCADA data are considered in providing optimal restoration recommendations. Schematics and geographical maps used in conjunction with integrated reporting displays offer both visual and analytical feedback to users to further their understanding of the fault incident scope and proposed corrective measures.

Users can also manually assign equipment faults and set fault detectors, a feature that is particularly valuable when working on network sections where telemetry is either unavailable or non-existent.

Immediate detection and reporting

FDIR has the ability to manage concurrent faults during high-activity and storm conditions. In situations where a crew is assigned to multiple fault incidents within a single-geographical area, FDIR is able to make common restoration recommendations for multiple independent fault incidents.

Date	Fault Time	Connected Cuts (Bus, Phase)	Deconnected MV Amps	Open Switch	Location Path	Location Path	Location Path	Location Path	RTN Path
12/12/07	1:52:00	19 (2)	2.05 (2)	Grand FDR1 Centre CB	SD Executed	SD Created, not Executed	SD Created, not Executed	SD Created, not Executed	Analysis Not Done
12/12/07	2:02:00	12 (4)	5.45 (3)	Grand FDR2 Tap CB	SD Executed	SD Executed	SD Created, not Executed	SD Created, not Executed	Analysis Not Done
12/12/07	3:02:00	2 (0)	0.00 (0)	Grand FDR3 Tap CB	SD Executed	SD Executed	SD Executed	SD Executed	SD Created, not Executed
12/12/07	4:53:00	0 (0)	0.00 (0)	Grand FDR4 19V CB	SD Executed	SD Executed	SD Executed	SD Executed	SD Executed

High level display of unplanned outage occurrences.

The real-time electrical network is constantly monitored to detect and locate all potential fault occurrences. The fault detection mechanism makes use of all available SCADA circuit breaker and fault detector statuses. When evaluating network conditions, FDIR also accounts for any relevant devices along the fault path, such as reclosure relays. Suspect fault conditions are highlighted on graphical network displays.

Alarms are issued to alert users to faults and are also used as a historical record of the fault incident itself and all the associated corrective actions that followed.

```

21-10-08 18:14:50 A-1 GND_AD2 FDIR#G
21-10-08 18:14:50 A-1 GND_AD2 GND_AD2.IB10409
21-10-08 18:14:50 A-1 GND_AD2 GND_AD2.IB17965
21-10-08 18:14:50 A-1 GND_AD2 GND_AD4.IB38636
21-10-08 18:14:50 A-1 GND_AD2 GND_AD2.IB130
21-10-08 18:14:50 A-1 GND_AD2 GND_AD2.IB10409
21-10-08 18:14:49 A-1 GND_AD2 GRAND.CCTB_AD2
FDIR #G - FDIR recommends some loads to restore
FDIR #G - Faulted zone between: GND_AD2.IB10409 and GND_AD2.IB130.
FDIR #G - This fault detector did not see the fault: GND_AD2.IB17965
FDIR #G - This fault detector did not see the fault: GND_AD4.IB38636
FDIR #G - This fault detector did not see the fault: GND_AD2.IB130
FDIR #G - This fault detector saw the fault: GND_AD2.IB10409
FDIR #G - Circuit Breaker GRAND.CCTB_AD2 - V = 4.80 kV - trip number at lockout: 1
    
```

Sample alarming sequence upon fault detection.

Users can set configuration options directly impacting the proposed recommendations, such as specifying that only SCADA-controllable switches rather than non-telemetered switches are to be considered.

Once the fault is established, the suspect faulted zone is automatically calculated after a thorough consideration of all available data, including equipment modelling characteristics present in DMS, any reported SCADA information, and user-set faults where SCADA telemetry is unavailable. An integrated set of UI displays enables users to seamlessly locate and navigate through the highlighted faulted zone and recommend switching actions on both geographical maps and schematic displays.

Precise isolation

In order to isolate the fault, switching recommendations are issued immediately after a faulted zone is identified. Recommendation actions can be configured to issue either SCADA controls or switching orders. Users can set various other configuration options that directly impact proposed recommendations, such as specifying that only SCADA-controllable switches rather than non-telemetered switches are to be considered. To ensure immediate isolation and upstream restoration of any fault occurrence, utilities often configure FDIR to automatically issue isolation and upstream restoration recommendations using only telemetered switchable devices. These recommendations are automatically implemented via SCADA scripts.

Intelligent restoration

Restoration logic uses sophisticated processing to ensure that a number of pre-set constraints are respected. The following are examples of factors and priorities considered in determining an optimal load restoration strategy.

- Recommendations do not cause new overloads or violations beyond a user-specified tolerance when implemented.
- The priority is to restore entire de-energized islands. If it is unable to do that, FDIR attempts to restore the maximum load possible by splitting outaged islands.
- Recommendations will minimize switching actions.

- When transferring loads, feeders belonging to the same substation are prioritized. If this is not possible, transfers to feeders from other substations are considered.

Fault Record Detailed Display

- The priority is to transfer loads to immediately adjacent feeders (i.e.: first neighbour). If this is not possible without overloading adjacent feeders, transfers to second neighbours are possible.
- An available configuration option is to consider the estimated network loading for the next 24 hours when validating switching recommendations. This option guarantees that the recommendations are valid for that specified time frame.

Contact us to find out how you can benefit from the innovative FDIR application.



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