

EXPERIENCE SHARING: FEEDER AUTOMATION PILOT FROM ONE OF THE GLOBALLY LARGEST URBAN DISTRIBUTION NETWORK IN INDIA

Shrinjoy Bagchi¹, Vijay Shah², Rajkumar Rastogi¹, Sachin Mishra²

¹*Distribution Protection and Automation, Tata Power-DDL, Delhi, India*

²*Electrification Business, ABB India Ltd., Nashik, India*

shrinjoy.bagchi@tatapower-ddl.com; vijay.shah@in.abb.com; rajkumar.rastogi@tatapower-ddl.com;

sachin.mishra@in.abb.com

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Abstract

Tata Power Delhi Distribution limited (TPDDL), is one of the progressive utility catering to electricity supply to part of Delhi, National capital & hub for all political and administrative affairs of India. As a part of its ambitious smart grid journey, it has undertaken many new initiatives and ABB is also one of the proud partners in this journey, supporting TPDDL with different technological solutions. Deploying ABB reclosers in TPDDL distribution network is one of such activity that is jointly carried out by TPDDL and ABB. This paper contains detail experience sharing of overhead recloser deployment in suburban network, which helps TPDDL to automatize its fault detection, isolation and power restoration for critical feeders by effective deployment of reclosers, configured either as sectionalisers or as reclosers. Description includes details of implemented schemes, incorporating wireless communication architecture and highlights performance achieved post deployment with respect to pre-installation scenario. Various apparently trivial but quite significant aspect of solution robustness for delivering sustained performance in harsh ambient outdoor conditions, are also covered. Features about re-configurability of control logic, while handling dynamic system / installation conditions triggered upgrade needs are also touched upon. Finally, the paper concludes after sharing of the results from given deployment.

1 Introduction

As mobile, computers and all variety of electronic objects become mainstay of today's day to day living & businesses, non-acceptability for power system outages continue to heighten. Further, COVID-19 linked challenges and evolving new way of living & working, has forced increased dependency on good quality of uninterrupted power, which forms the backbone for communication linked connectivity apart from serving as principal source of operational energy for variety of elements in eco-system. For progressive utility offering complete solution to power quality conscious customers, it is equally important, not only to sustain but also exceed its benchmark performance indices SAIDI (System Average Interruption Duration Index), SAIFI (System Average Interruption Frequency Index) etc. Further, increasing concerns on climatic change driving emphasis on greener energy sources even in underdeveloped and developing countries, makes electric network dynamically evolving with rapid rise of photovoltaic generation & integration. To meet the above challenges, utilities across the globe have been adopting different hierarchy of measures by keeping close watch on customer load requirements versus its own generation, transmission & distribution capacity and then ensuring dynamically gentle mix of local

distributed generation integration as well as deploying novel FDIR schemes. TPDDL, a member of Global Intelligent Utility Network Coalition (GIUNC), is one such progressive utility catering to electricity supply to part of Delhi, national capital & hub for all political and administrative affairs of India. It has consumer base of over 1.76 million, with operations span in an area of 510 sq. kms, delivering peak load beyond 2GW & over 4345 circuit kilometres of 11kV distribution network [1].

1.1 Smart Grid Initiatives

As a part of ambitious Smart Grid roadmap (Figure 1) TPDDL during last decade, has undertaken, for implementation, various Distribution Automation projects based on systems such as GIS (Geographical Information System), ADMS (Advanced Distribution Management System) and OT's (Operation Technologies), GSM based Street Lighting System, SMS based Fault Management System and Automatic Meter Reading (AMR). Use of modern technologies such as HVDS (High Voltage Distribution System) and LT aerial bunch conductor have also been deployed to curb power theft which had been prevalent in the region. AMR based auto demand response programme, to manage grid stress and peak demand have also been initiated.

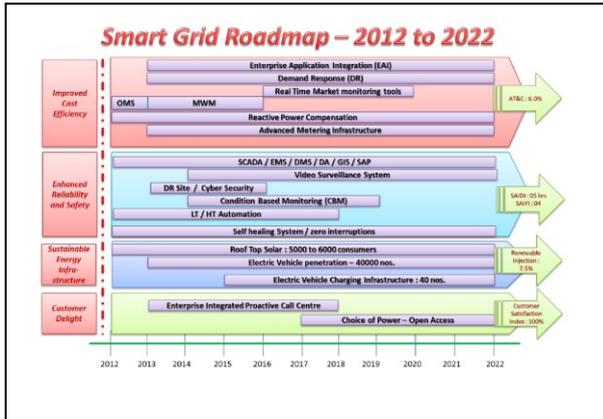


Figure 1 TPDDL Smart Grid Roadmap

1.2 Achievements during last decade

After taking over the electricity distribution business from erstwhile Delhi Vidyut Board in 2002, one of the major operational challenges in front of TPDDL was to improve the reliability of power supply. The entire inherited network was in an extremely dilapidated condition resulting in frequent blackouts and brownouts. With the help of above initiatives, TPDDL has achieved considerable improvements. To highlight a few, Aggregate Technical & Commercial (AT&C) losses have shown a record decline from 53% in July 2002 to 7.79% in April 2020.[1] The reliability indices of July’2002 stood at an all-time high with SAIFI close to 55 Nos. and SAIDI close to 110 hours as against 4.38 Nos. and 5.92 hours getting achieved during early part of last decade[2].

However, certain challenges, as described in the next sub section had remained, which restricted in further improvement of SAIDI, SAIFI indices.

1.3 Open challenges

15% of network in TPDDL has bare conductor and it contributes majority of the transient faults in TPDDL power network. These bare feeders as a part of densely populated suburban area, are feeding majority of the domestic and industrial load, with multiple T-off going in to the downstream from the main feeder. The major reason of such transient faults is due to vegetation growth in close vicinity of the power line, apart from unauthorized construction near the power network, combined with severe environmental operating conditions including heavy wind flow. As an eventuality of these faults, complete feeders trip out from the grid and the power supply to large number of consumers are impacted. This also causes frequent operations of grid breaker and thereby increase its operation count, eventually resulting in reduction of useful life of the grid assets.

2 FDIR programme

To enhance reliability of the network in suburban distribution network and to establish a rapid self-healing of the distribution network, TPDDL installed 142 ABB make auto reclosers in the critical feeders.

2.1 Objective

The main objective of FDIR programme had been to establish auto reclosers and sectionalisers combinations where main line are protected through auto reclosers and t-off sections are protected through sectionalisers. Protection co-ordination of upstream breakers had been set in such way that breaker closest to fault only trips and upstream breaker auto-reclose the healthy network. There is dedicated protection scheme that coordinate auto reclosers and sectionalizer during fault. So, in this way consumer interruption per tripping reduces and SAIFI, SAIDI are further improved [3].

2.2 Solution Description

Solution involves deployment of overhead reclosers, which are configured either as sectionalisers or as reclosers with adaptive recloser duty cycle (typical O-0.5s-CO-10s-CO-10s-CO). Each recloser controller’s architecture apart from integral battery backup, incorporates wireless communication functionality by making use of wireless controllers which are communicating with wireless M2M Gateway in the nodal control center. Communication linkage over complete channel involves IEC-104 protocol, with control operating on GPRS (4G LTE) technology, exploiting virtual private network connectivity. The traffic from M2M Gateway is further routed to ADMS through DCU (Data Concentrator Unit). There is also additional firewall security at M2M and DCU level to ensure data integrity. The controllers are time sync on periodic interval through ADMS [4]. Apart from remote on-off of recloser, downloading of logged data from remote is also implemented. Solution architecture from field device level to ADMS end is depicted in Figure 2.

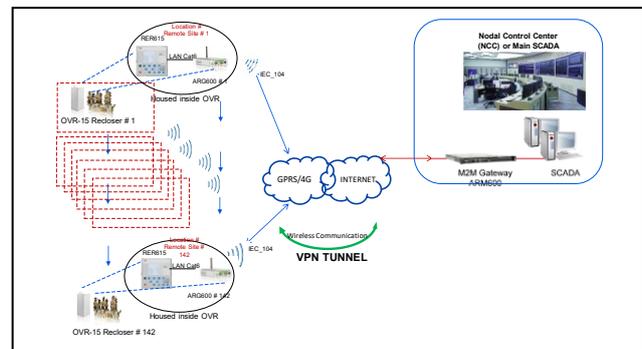


Figure 2 FDIR- Wireless communication Architecture

3 Key challenges and resolution

3.1 Technical challenges

The critical aspect was to develop logic for AR (Auto Reclose). The first challenge had been, if auto reclosing happens over permanent fault, the fault current will increase which can lead to accidents in such dense urban installations, apart from other side effect of such high fault current damaging the network elements or causing reduction of the asset life. The second challenging aspect had been, if the case involves any conductor parting, reclosing can complicate the situation with tremendous risk for public safety.

3.1.1 High current lockout scheme: to address the first challenge, the high current lock out scheme has been implemented. Feeder wise trend of fault current and nature of fault for the last five years were studied to understand the network characteristics. Accordingly, logic was defined in Reclosing controller (relay) memory, that in case of fault current >3 kA the AR should not make any try. This, logic reduces the possibility to make a try on dead short circuit fault.

3.1.2 Broken conductor protection scheme: to address the second challenge, broken conductor protection scheme has been enabled and it has ensured that, if the AR trip on broken conductor element, it will not make any try. So, these features ensure that there is no unwanted auto reclosing in case of conductor parting and public safety should not hampered.

3.2 Operative challenges

Further to the technical performance front, from operation perspective, solution robustness is equally an important factor. Being outdoor installation, recloser system sees apparently trivial but quite significant aspect of harsh ambient outdoor conditions for delivering sustained performance.

- As Delhi region sees high pollution during part of the year with AQI (Air Quality Index) hovering from poor to hazardous category [5]
- The average temperature in summer going beyond 40deg.C with max upto 50deg.C but in winter the temperature is falling towards near zero degrees.
- Further this region is seeing moderate to heavy rains during monsoon & beyond 700mm of average yearly rainfall with humidity varying from 0 to 100%
- During monsoon also frequent water logging & flooding incidents.

- Further, certain localities in this region, have also history of tampering and proximity of urban residential establishments to distribution lines, creating safety threats.

So, not only robust design solution but safety as well as tamper proof aspects of design remains implied need for installation.

The above needs are fulfilled with the solution making use of

- Poles from HCEP insulators for housing VI's and creepage suitable for very high pollution severity (31mm/KV)
- Painted HV cabinet of SS202 and unpainted LV Cabinet of SS316 type and offering IP55 degree of protection,
- Further, recloser controller incorporates state of art ABB Relion IEDs with conformal coating, which increase resistibility against moisture and corrosive agents.
- Additionally, pad lock and brackets, with mechanical manual emergency tripping with sensitive earth fault protection and double earthing as per IS 5613 following TPDDL Standard, facilitates the tamper proofing and safety aspects pertaining to end use application.
- Use of IEC 104 communication interfaces provide seamless transmission of recloser linked events with nodal center SCADA connectivity, resulting in real-time supportive actions and quick intervention of mobile crew when anticipated [3].

3.3 Reconfiguration needs

Further, with additional focus on increased penetration of distributed generation along with household solar roof top-based renewal integration, recloser controller parameters also need to be adopted in accordance with evolving network [6].

Availability of different setting groups within recloser controller simplifies the field usage and adaptive configurability for given point of application and directional feeds. This also helps during critical load shedding under severe power outage conditions, from centralised control room intervention.

Uniform type of control cabinet (HV & LV) hardware across recloser & sectionalizer functional application, help to have minimal spares for any eventual needs. Thus, with standard recloser hardware architecture, one can very easily adopt varying network configuration simply through software configuration uploads.

4 Results

Deployment of the FDIR solution has helped significantly in improving performance indices. Post deployment, as illustration during October 2020 to January 2021, there are 137 number of successful auto-reclosing, over transient faults, which in turn saved .613 million units. Along with that there are 174 lock out operations owing to permanent fault. So, in total for 311 times where fault has been arrested in the downstream breaker and interruption avoided in grid breaker. In addition, 174 lock out operation for permanent fault, helped in arresting tripping at downstream. So, supply of the consumers only for the affected portion got impacted and power supply for rest of the consumers in the upstream of the faulty network remained uninterrupted. Clearly, this has helped in significant improvement for SAIFI and SAIDI indices.

4.1 Typical power restoration with and without FDIR scheme

Figure 3 shows typical power restoration without FDIR where after outage event, post travel of crew & identification of fault, on healthy section power is restored by manual switching after isolating faulted section, while faulted section sees restoration on successful repairs.

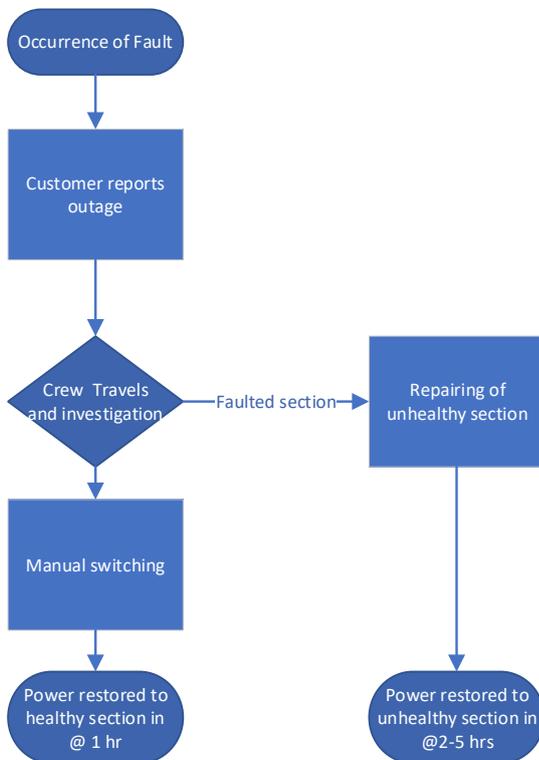


Figure 3 Power restoration without FDIR

However, with FDIR implementation, post automatic isolation of faulted section, power is restored on healthy section within few power cycles while locked out section sees comparatively faster restoration due to quicker intervention possibility by the crew. This is depicted in figure 4.

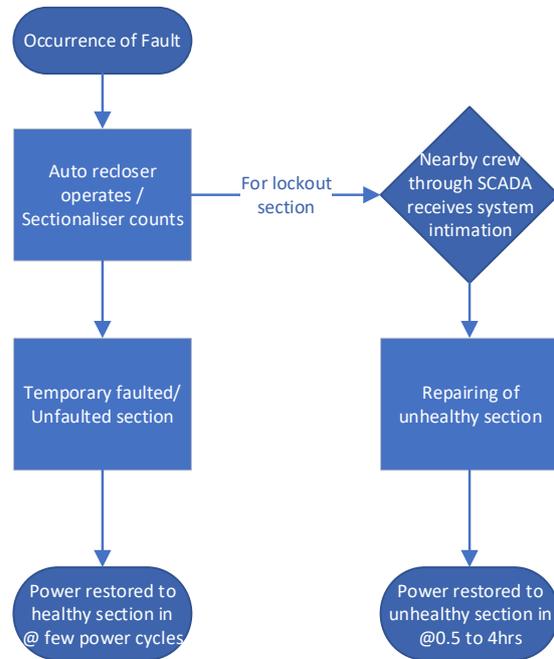


Figure 4 Power restoration with FDIR

4.2 Supportive Data Analytics

Further, every morning automated report from oracle server (which is integrated with ADMS) is generated, which contains total operation count of previous day of the auto reclosers along with fault current and lock out operation data. Periodical summary of same gets shared to internal functions & thereby helps field team in initiating smart preventive feeder maintenance actions, vegetation management etc. based on number of operations. Planning team, by viewing number of operations of auto recloser in subsequent months review post maintenance effectivity too. As a forward measure, network engineering group also use the data for additional load segregation, focussing on high tripping section, so that less consumers are impacted in case of power outage of upstream network.

Finally, the improvement in reliability also boost up the confidence of consumers which leads to customer delight through reliable power supply.

5 Conclusion

Feeder automaton pilot thus has resulted in manifold advantages for improving the performance indices for suburban network involving bare overhead lines. Positive improvements has also led to further FDIR implementation

consideration in different distribution utilities run under parenting of Tata Power such as TPCODL (Tata Power Central Orissa Distribution Limited) as well as in Western Electricity Supply Company of Odisha (WESCO) and Southern Electricity Supply Company of Orissa (SOUTHCO) which are recently acquired by Tata Power.

Thus, a sound FDIR programme with integrated safety measures and incorporating sound communication & computing backbone, not only improve power availability to end users, but also helps to analyse and process interruption events with fault current, operations counts data etc in real time. Followed analytics then eventually aids TPDDL in achieving high performance efficient network with only need driven intervention cum maintenance & thereby raising operational efficiency.

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7 References

Conference Paper

[3] Fahrudin M., Ken A., Cleber A., et al.: ‘Fault detection isolation and restoration on the feeder (FDIR): pick your technology’, 21st Int. conf. on Electricity distribution, CIRED, Frankfurt, 6-9 June 2011, paper 0366.

[4] Shrinjoy B., Rajkumar R., ‘An overview of Distribution Automation in TATA Power DDL and it’s effective contribution for power sector reform in North and North West Delhi.’ International Conference on Electrical, Electronics and Computer Engineering, UPCON, Aligarh Muslim University, Aligarh, Uttar Pradesh, Nov 08-10, 2019.

[6] Shrinjoy B., Rajkumar R., ‘A holistic approach to develop a robust distribution network with integrated protection and automation system for a next generation electric utility,’ IEEE International Conference on Power Energy, Environment & Intelligent Control, PEEIC2018, G. L. Bajaj Inst. of Technology and Management Greater Noida, U. P., India, Apr 13-14, 2018

Websites

[1] <https://www.tatapower-ddl.com/corporate/our-company/company-profile>, accessed 15 February 2021

[2] A compendium ‘TPDDL Case Study_COMPLETION OF 10 YRS.pdf’ at https://www.tatapower-ddl.com/Editor_UploadedDocuments/Content/TPDDL%20Case%20Study_COMPLETION%20OF%2010%20YRS.pdf, accessed 15 February 2021

[5] <https://www.aqi.in/dashboard/india/delhi>, accessed 15 February 2021