Proactive Management of Power Quality & Reliability of LV Distribution Networks using Transient Analysis

A Case Study presentation by

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***Abstract*-- Power Distribution companies (DISCOMs) often face the plight of disruptive failures in the low voltage (LV) distribution network due to oscillatory transients arising from switching operations, partial discharge, poor electrical contacts and fault events, which becomes manifest specially during Renewable Energy (RE) connections/ disconnections. This case study discusses the impact of these factors on power quality, safety and reliability of distribution systems, with a potential to interrupt supply to a large number of electricity customers. The study also examines the impact of transients and volatile RE connections on reliability indices, revenue, customer satisfaction and regulatory compliances, and provides recommendations to mitigate the problems.**

Keywords- Power Quality, Transient Analysis, Power Distribution, Network Analysis, Real-time monitoring, Grid stability, Grid Reliability)

I. INTRODUCTION

The Distribution Company (DISCOM) which is the subject of this case study was keen to implement a solution to identify the source of transient faults and be able monitor oscillatory transients on the LV Distribution network in real time to overcome supply disruptions, triggered by transient events. This was important to make the network more resilient, adaptive and fault-tolerant to bear the vagaries of integrating Renewable Energy (RE) sources to the Grid. At the same time, the DISCOM wanted the solution to be reliable, cost-efficient, non-invasive and easily retrofittable.

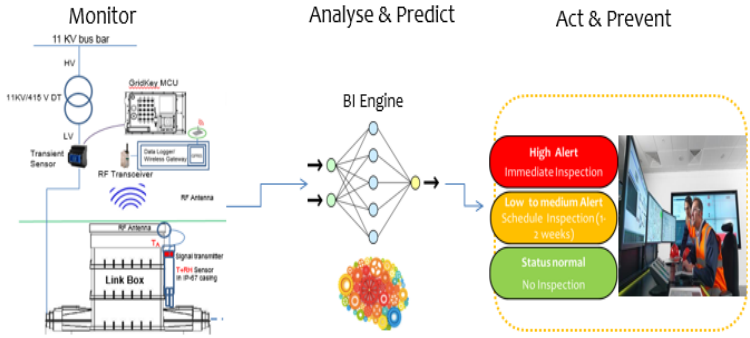
The DISCOM has faced issues in the past due to oscillatory transients arising from switching operations of large loads including RE sources, partial discharge, poor electrical contacts and other fault events. These factors not only led to supply interruptions to a large number of electricity customers, but also compromised power quality, safety and reliability of the network. The present case study analyses the measures adopted by the DISCOM to mitigate the network disturbances due to transient faults occurring in such volatile conditions. After implementing these measures, the DISCOM was able to improve the reliability indices.

II. SOLUTION OVERVIEW

The solution involved a combination of transient sensors, telemetry system and analytic dashboard to monitor the transient characteristics of the network arising from poor line conditions, switching operations, partial discharge, insulation breakdown, etc. The solution was non-invasive and did not need network shutdown to implement. Transients were centrally monitored in real-time and predictive algorithms were used to analyse transient waveforms, the sources of transients and corrective actions were taken even before major faults could develop. The solution was innovative in terms of technology and cost-effective in terms of investment.

III. DETAILS OF THE SOLUTION

To resolve the problem in a non-invasive way, the DISCOM used a combining of technologies. First, to measure the electricity transients at the point of common coupling (PCC) on the Distribution network, using Rogowski coils as sensors. Rogowski coils measures the rapid rate of change of voltages or currents, due to electrical disturbances. Second, to monitor the electrical transients due to emerging faults or disturbances in the network. Third to conduct predictive analysis on the disturbance data and correlate with emerging fault symptoms which can be diagnosed and rectified.



The heart of the solution is the Business Intelligence (BI) engine, which processes the electrical voltage and current

transients, measured by the sensors installed strategically across the LV distribution network, at pre-determined vulnerable points of common coupling. The transient data is analyzed in terms of magnitude, frequency, time and duration of occurrences.

The BI engine performs predictive analysis of incipient fault data and uses regression analysis of real time electrical transients, correlate them with historical fault data and then predict emerging fault and its probable location on the network. Any fault in the network due to partial discharge, poor contacts, insulation breakdown or fast switching of large inductive or non-linear loads will manifest itself in corresponding transient characteristics which can be measured using this method.

The BI dashboard uses algorithms to analyse fault patterns at user-selectable intervals and monitor the health of network sections, which helps to pre-empt catastrophic failures. The solution analyses multiple scenarios, symptomatic of an emerging fault, thus preventing the cause of disruptive failures of the network.

IV. BENEFITS TO THE DISCOM

Correlating the transient analytics data with historical events of similar faults enabled the DISCOM to be fore-warned of the emerging conditions in the network. This helped the DISCOM take informed decisions on proactive maintenance of the affected network sections. The DISCOM succeeded in preventing costly breakdowns, associated loss of revenue, improving asset life, increasing power quality and network reliability, and enhancing customer satisfaction.

The successful implementation of the solution enabled the DISCOM to identify impending faults on their LV network before they could become catastrophic. Real time analysis of transients and fault patterns could help identify the nature, source and magnitude of an emerging fault. Based on this data, the DISCOM were able to identify weaker sections in the network, prioritize maintenance schedule, defer asset replacements and prevent costly breakdowns.

The DISCOM saved almost 5% in CAPEX by prioritising the replacement schedule and deferring capital replacements of network assets, based on condition data. The DISCOM also saved between 9-10% on OPEX by timely taking timely preventive actions to prevent network breakdowns due to transient faults.

This resulted in the DISCOM achieving quantifiable benefits in terms of:

1. Reduction in breakdown costs (9-10%)
2. Deferment of asset replacement costs (5%)
3. Improving PQ and safety
4. Improving network reliability (CI/CML)
5. Enhancing customer satisfaction

V. CONCLUSION

This method provides a way for the DISCOM to proactively manage the Power Distribution network, keep the network healthy by real-time monitoring and prevent costly network breakdowns. Moreover, the method ensures safe operation and help maintain CI/ CML, as per regulatory standards. The solution itself is non-invasive and does not need any network downtime for its implementation. Also due to the falling prices of the sensors, telemetry and analytics infrastructure used for implementing this solution, it is quite cost-effective and value for money The investment pays back in reasonable time depending on the scale of implementation, typically in about 12 to 18 months.

In indirect benefits, the real-time proactive monitoring solution also promotes power quality of supply, network safety, reliability and regulatory compliance.