Proc. of Int. Conf. on Current Trends in Eng., Science and Technology, ICCTEST

Distribution Automation System: A Technology Revisited for the Modernisation of Bengaluru's Power Distribution Network

RekhaS[1], Nalini S[2]
[1]Student, Dr Ambedkar Institute of Technology, VTU, Bengaluru, India
Email: Rekhas.1234@gmail.com
[2]Associate professor, Dr Ambedkar Institute Of Technology, VTU, Bengaluru, India
Email: nalini_sha0803@yahoo.co.in

***Abstract*— Electrical Utilities are one among the key players for every country's economic progress. Increasing reliability and reduction of losses directly contribute to increase in GDP.Distribution Automation System (DAS) has been proven across world as an important tool to enhance reliability of the distribution system. The Bengaluru city's distribution network is undergoing transition towards automation. This paper provides an overview on the current distribution systemin Bengaluru and also the expected scenario after the implementation of DAS.**

***Index Terms*— Distribution Automation System, DAS, fault detection, power restoration, recloser.**

I. INTRODUCTION

Modernisation of the electric power system sector has been an ongoing trend worldwide, since its inception. With its huge network& diversified nature, changes in the Indian power sector is not only complex but also challenging to implement. Nevertheless, power sector in India has been upgraded time and now, through the introduction of Supervisory Control & Data Acquisition (SCADA), Energy Management System(EMS)etc.The distribution sector, however, has taken a backseat in this perspective, owing to its huge network. With the advances in automation, the emphasis on adoption of DAS has increasedhasincreased, persuading power distribution companies to automate their distribution network. A portion of the urban Bengaluru city with an area of approximately 8005 sqkms has been taken up for implementation ofDAS.Many companies across the world have adopted DAS in ways convenient to them such as application to particular feeder, the distribution network falling under a particular substation or the entire distribution gridetc[4]-[9]. The current approach in Bengaluru is to implement DAS for the 11 kV network alone, excluding the secondary sides of distribution transformers, refer figure 2.

II. DAS (DISTRIBUTION AUTOMATION SYSTEM)

Distribution automation system refers to a setup which enables monitoring and controlling of the electric power distribution network from a specific remote location [4]-[9]. It is a system which transforms a manually controlled network to a remotely operable one, accompanied with automatic decision making

Grenze ID: 02.ICCTEST.2017.1.188

ability. This is enabled by embedding Intelligent Electric Devices (IEDs) in the network at various points, through which the network data such as current, voltage, power, faults etc can be captured at different locations. The IEDs are coupled with radios for transmission and reception of command signals & data flow to & from a control centre facility and finally, a communication network for linking the devices with the control centre. The control centre houses the servers and systems necessary for data acquisition and monitoring. The distribution network will be monitored by a set of operators at the control centre, each allotted a part of the network. The entire network willbe projected on a video projection screen (figure 1). Controlling of the network, refers to switching off /on the devices, feeders, reconfiguring the feeders etc.

III. BENGALURU POWER DISTRIBUTION NETWORK

Bengaluru's distribution network is an open loop configured i.e., radial distribution type. Both Overhead (OH) & Underground (UG) lines are used, based on the load to be carried. Approximately 6000 MW load is catered in this network with over 1000 plus feeders from various substations. Traditional Ring Main Units (RMU), Group Operating Switches (GOS), Distribution transformers, Supporting poles form the major components of the network. The primary distribution voltage is 11kV and secondary distribution voltage is 433 V. The fault detection elements are the circuit breakers at the starting points of feeder lines and the fuses on the secondary side of the distribution transformers (11/0.433 kV)

IV. FDIR (FAULT DETECTION, ISOLATION& POWER RESTORATION) IN EXISTING NETWORK

Consider a fault occurring at any point on the feeder 'F2'in figure 2 i.e., the section between the substation and the HT side (High tension/ primary) of the distribution transformer. The first fault sensing element is the circuit breaker – relay arrangement at the outgoing node of the substation feeder 'F2'. Hence, all the loads connected to feeder 'F2' directly or through distribution transformers will lose supply of power when the circuit breaker trips, irrespective of the type of fault (i.e, temporary or permanent one).

A. Fault intimation:

Circuit breaker tripping will be communicated to the substation personnel via its own SCADA system. Also, the distribution company's call centre will start receiving complaint calls from consumers.

B. Response:

Re-engaging the tripped CB, which would be successful, provided the fault was a temporary one. In case of permanent fault, the CB refuses to re-engage.

C. Fault location identification(In case of permanent fault):

Investigation through patrolling. Starting from the substation end, the GOS switches would be opened and closedsequentially, checking on the status of the CB re-engagement. If the circuit breaker re-engages, it indicates that the fault is ahead of the GOS (i.e., away from the substation). When the circuit breaker fails to re-engage, inspite of opening the GOS, it indicates the fault was before the GOS (i.e., towards substation end). This way, the faulty section in the feeder line would be identified and isolated.

D. Power restoration:

All the loads connected ahead of the GOS would suffer power outage unless an alternate feeder line is connected (either in RMU or atchangeoverpoints).

E. Repair work:

Once the fault is cleared, which normally involves clearing of the tree branch, replacing of the conductors, if burnt out etc., the feeder is resumed to its earlier form.

If the fault is on the LT side (low tension/secondary) of the distribution transformer, the fault detecting element would be the fuse at the secondary side of the transformer. Hence the fault is isolated by design, by the virtue of the transformer function. The remaining section of the feeder remains undisturbed. This fault again, will have to be cleared and the fuse replaced to restore power to consumers connected via that distribution transformer.

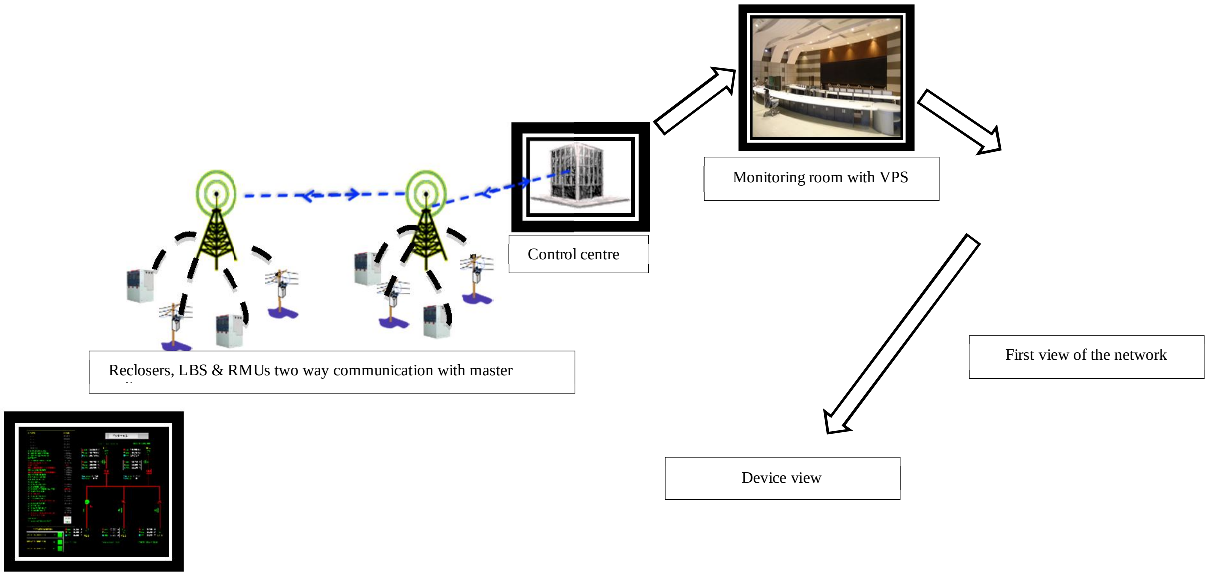


Figure 1: Pictorial view of DAS

V. Limitations Of Existing System

- The FDIR process explained above requires 25 to 65 mins depending upon the fault location. Hence, time consuming leading to longer power outage hours and loss of revenue to the company.
- Manually controlled and hence less reliable.
- No real time monitoring system. System managed based on estimation technique aided by the knowledge of past data.

VI. Changes Included For Implementation Of DAS

A. Inclusion of Monitoring devices i.e., IEDs in the network

Automatic Line recloser :
It plays the role of a circuit breaker, by tripping immediately on detection of fault current in the line but also has the ability to reclose itself after a pre-programmed duration of time without any manual intervention. Clearly, the reclosing feature aids in avoiding unnecessary power outage due to momentaryfaults. In case of permanent faults, the line recloser goes into a 'lockout phase' (end of reclosing attempts for that fault), after unsuccessful attempts (2, 3 or more, as per programmed value) to reclose.

Load break Switches:
Segmenting of a power line is the key control in isolating faulty section. As an advanced alternative to the GOS in the network, load break switches are used to isolate the faulty section from the rest of the network, from a remote location. They are basically switchgears used in medium voltage systems. Additionally, load break switches have the features of acting as a sectionaliser in coordination with the line recloser i.e., it can also operate automatically with the line recloser's unsuccessful reclosing attempts forming the input to trigger opening of the load break switch.
Both line reclosers and load break switches offered by many manufactures have Feeder terminal units (FTU), which is similar to a control box housing the electronics and software necessary for automatic &/or remote operation.

Ring main units :

Ring main units are again switchgear units but with feature of 'n' number of switchgears combined as a single compact unit. These are basically used at tapping points through underground lines.Although ring main units were existing in the network, they lacked the ability/ features to be a part of an automated system. RMUs which are compatible with the DAS are useful for feeder reconfiguration from remote location during exigencies as shown in figure 2 & figure 3 and hence replace the conventional ones. All the above three devices installed at various points/nodes in the 11kV network (i.e., excluding the LT section of distribution transformers) form the monitoring elements of the distribution network.

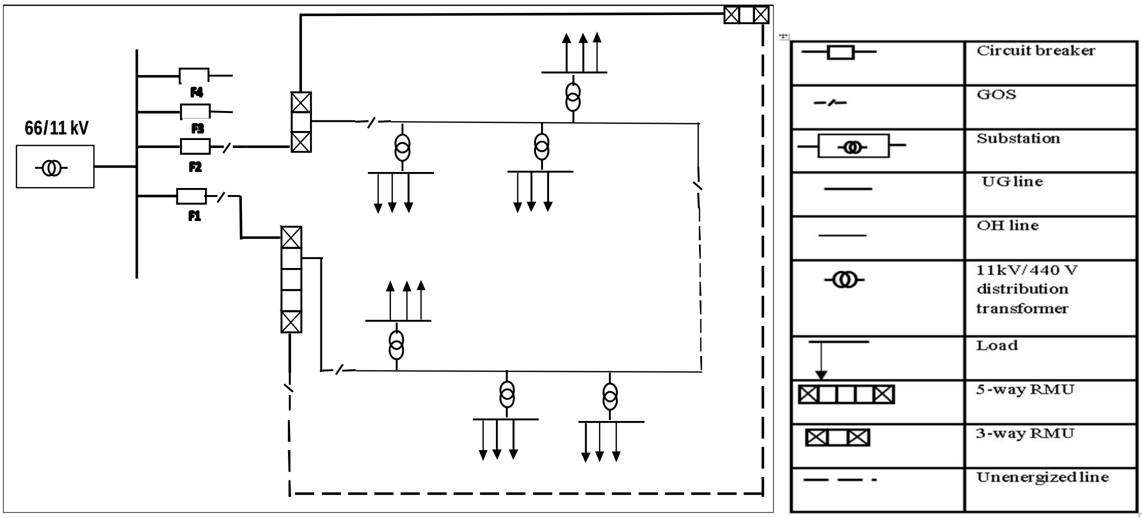


Figure 2: Conceptual single line diagram of distribution substation

B. Communication System

Flow of data can be supported by various technologies from optic fibres to radio communication to satellite communication. Along with the control system electronics, a radio and an antenna accompanies every device included in the network. The status of these devices i.e., the open/close condition, voltage, current, power values, on/off condition etc will be captured on real time basis at the control centre facility which houses all the hardware such as servers, controlling systems and also operators necessary for monitoring and controlling the network. Bengaluru has communication towers spread across, housing radios operating on UHF (Ultra High Frequency) along with DMBS (digital microwave backbone system) forming thepillar of the DAS system.The master radios with the DMBS system assosciated with eachtower interact with close to (120*3) IEDs inserted in the network. They also communicate with each other as shown in Figure 1.

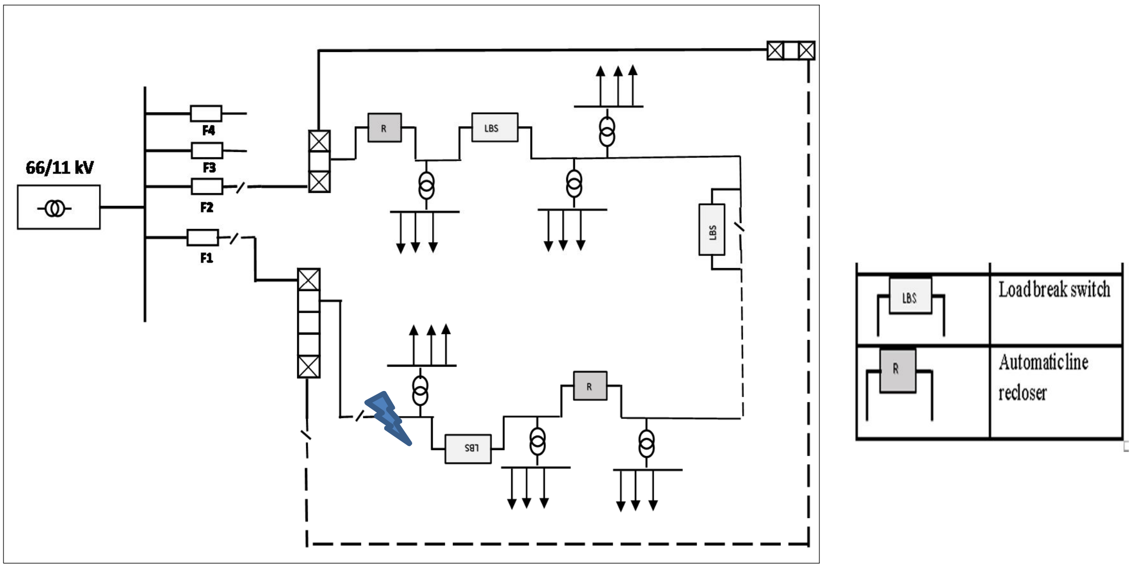


Figure 3: Conceptual single line diagram of distribution substation with inclusion of LRCs & LBS

VII. IMPROVED FDIR PROCESS

Consider a fault occurring in the Feeder F1with the Line reclosers and load break switches as shown in fig 3.

A. Fault intimation

Immediately seen in the DAS control centre in less than two minutes.

B. Response

The automatic recloser reacts by opening to cut-off the fault current flow. However, it would reclose after few milliseconds. If the fault current persists, it opens and recloses again. If the set attempts for lockout is '3', then at the 2nd unsuccessful attempt to reclose, the LBS in the line, close to the fault disconnects, isolating the fault current. The LBS action can be changed only through control centre or by manual changeover at the device location.

C. Fault location identification

Investigation through patrolling is not needed as the fault section will be seen on the DAS system in the control centre.

D. Power restoration

By closing the midpoint LBS between feeder F1 and feeder F2, which was normally open, power can be restored to the healthy sections of the feeder F1 but energised from F2

E. Repair work

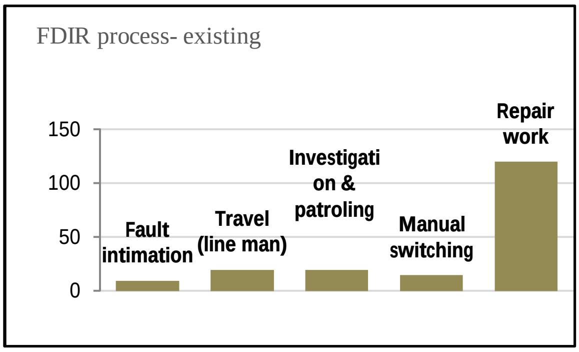
Once the fault is cleared, which normally involves clearing of the tree branch, replacing of the conductors, if burnt out etc., the feeder is resumed to its earlier form.
Thus , a considerable amount of reduction in time in the FDIR process is expected which would curtail the loss of revenue to the distribution company due to unscheduled power outages and also enhance the reliability of the network.

VIII. BENEFITS

Apart from the increase in revenue and reliability by the modified FDIR process alone, the latest DAS systems offered by the suppliers, also encapsulates various other DMS (Distribution Management System) functions such as Volt/VAR control, Distribution state estimation, Report generation, Calculation of Quality service indices (SAIFI, SAIDI, CAIDI & MAIFI), Load forecasting, Switching management, Crew management, Outage management etc. The accuracy of these will be superior since it would be based on real time data.

IX. INFERENCE

Clearly, the FDIR process improves by more than 72% by the adoption of DAS in the distribution network. The basic structure of a DAS system, its primary benefit by improvement in the FDIR process has been explained in reference to the earlier process, considering the Bengaluru scenario as an example.



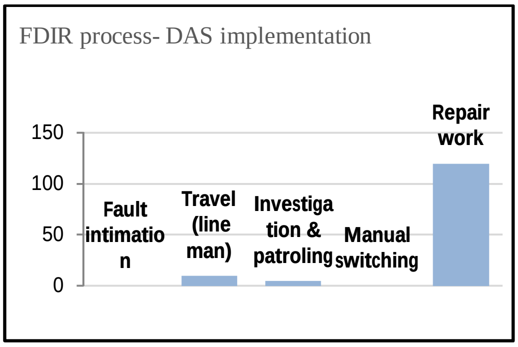


Figure 4 & 5 : Charts indicating the time consumed in FDIR process with & without DAS

X. SCOPE FOR FUTURE IMPROVEMENT

Extending the DAS to the LT side of the distribution transformer would support the trending 'Smart grid' concept implementation in Bengaluru. Also, reactive power control can be exercised through DAS by installation of capacitors in the network.

ACKNOWLEDGEMENT

We wish to express our gratitude to Prof V Keshav Murthy, Dr Sumangala B V and the entire staff of EEE department at Dr Ambedkar Institute of Technology, Bengaluru for their encouragement and support. We also thank Ms Sowbhagya and Mr Ajay Kumar, whose inputs have greatly helped in drafting this paper.

REFERENCES

[1] TuranGonen, 'Electrical Power Distribution Engineering', CRC Press, Third edition, 2014.
[2] Distribution Automation Handbook: Elements of power distribution systems, ABB, 2013.
[3] A manual on 'SF6 gas insulated Pole Mounted Load Break Switch' by Shinsung Industrial Electric,website: *http://www.ssiec.co.kr*
[4] Namhun Cho, Rajatha Bhat, Jung Ho, "Field Experience of Distribution Automation System (DAS) in KEPCO", IEEE
[5] Smart Electric Distribution Systems and Technologies (EDST), 2015 International Symposium.
[6] H. Asgeirsson, "Distribution Automation – The Foundation For the Smart Grid at DTE Energy", IEEE PES General meeting 2010.
[7] Dogan Gezer, SuleymanUludag"An MV Distribution Automation System and its Assessment in Light of the Smart Grid Vision", Fourth International Conference on Power Engineering, Energy and Electrical Drives (POWERENG), 2013.
[8] N Ozay, A N Guven, A Buyuksemerci, M Fettahlioglu, "Design & Implementation of a Feeder Automation System for Distribution Networks"
[9] Namhun Cho, Rajatha Bhat, Jung-Ho Lee, "Smart Fault Isolation and Service Restoration Under Consideration of Abnormal Conditions in Distribution Systems", 2015 IEEE
[10] H M Gill, "Smart Grid Distribution Automation for Public Power", 2010 IEEE.
[11] Bescom's official webpage: bescom.org/en/
[12] Power ministry of India website powermin.nic.in