IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Impact Factor: 6.252
Volume 2, Issue 2, July 2022

To Study of Machine Learning Enabled Steady – State Security Predictor as Deployed For Distribution Feeder Reconfiguration

Prof. Prajakta Kasulkar[1] and Shilpa Damle[2]
Assistance Professor, Ballarpur Institute of Technology, Ballarpur, India[1]
PG Scholar, Ballarpur Institute of Technology Ballarpur, India[2]

Abstract: *Reconfiguration is an indispensable method for loss reduction in power distribution systems and is also used to restore loads in out-of-service areas in case of a fault. This thesis focuses on reconfiguration of radial distribution networks to optimize the power distribution process in the feeders and for voltage profile improvement. Feeder reconfiguration is done to minimize losses for the existing and new topology of the feeder system and for the purpose of maintenance in the distribution system. Distribution network reconfiguration is one of the well-known and effective strategies in the distribution networks which performs by the status management of the network switches in order to obtain a new optimal configuration for the feeders. This study formulates multi-objective distribution feeder reconfiguration along with optimal sizing of distributed generators and capacitors. The prevalent objective functions in the network reconfiguration studies comprise of power loss and voltage deviations that are considered as the main objectives for traditional distribution systems, however, less attention has been paid to the objective functions of reliability and network voltage security in the previous literature. Therefore, the main objective of this study is to improve the reliability and network voltage security by solving the distribution network reconfiguration problem. To this end, the energy not supplied and voltage stability index are defined as the objective functions of reliability and voltage security. A modified gravitational search algorithm is suggested to solve the complex and non-convex optimization problem.*

Keywords: Machine Learning

I. INTRODUCTION

Power system is a complicated inter-connection of different electricity carrying equipments. Some important components of this complex interlinking are: generating stations, transmission lines, substations, feeders and distribution system. Each component of this entire system can be technically monitored, examined and operated to obtain the maximum benefit out of it. To make a power system operate efficiently and in a reliable manner, we require efficient techniques and methodology.

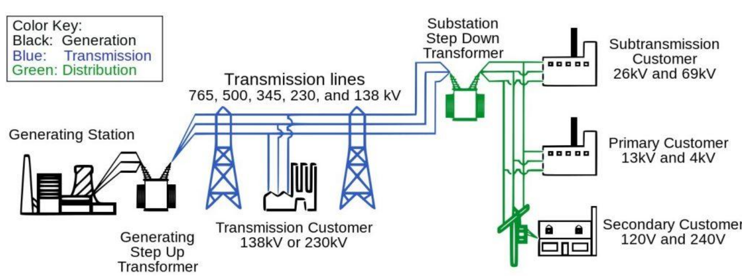


Fig.1.1 Basic structure of power system

Power systems include three rudimentary subsystems.

- Generation subsystem
- Transmission subsystem
- Distribution subsystem

The part which adjoins the EHV and HV transmission systems with the distribution system is known as transmission subsystem. These subsystems can be individualized depending on their operating voltage levels:

- Generation (Level: 11kV-30 kV)
- EHV Transmission (Level: 500kV-765kV)
- HV Transmission (Level: 230kV-345kV)
- Sub-transmission (Level: 69kV-169kV)
- Distribution (Level: 120V-35kV)

1.1 Overview of Distribution System

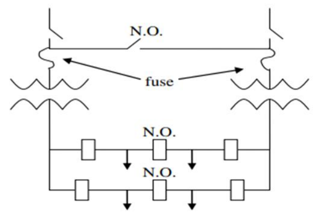
In this case our task is to elucidate the distribution system. Of the total expenditure in the power systems, the generation and distribution segments account for 40% each and the remaining 20% is given in transmission. Further sub categorization of distribution system results in three subsystems:

- Distribution substation
- Primary distribution system
- Secondary distribution system

A. Distribution Substations

The distribution substation is provided power at any required transmission or sub-transmission voltage level by the transmission or sub transmission lines, which is forwarded to multiple distribution feeders originating in the substation. This comprises the primary distribution system. Several feeders originate radially from the substation in order to supply the load. Functions of the distribution substation can be given as follows:

- **Transformation of voltage**: Several transformers are located within the substation for stepping down voltage level as acceptable to the primary distribution voltage level. The configuration of these transformers would either be three phase or three single phase transformers connected as three phase banks. The primary distribution voltage standards are 4.16kV, 7.2kV, 12.47kV, 13.2kV, 14.4kV, 23.9kV, and 34.5kV.
- **Protection and switching:** Various types of switchgear are located at the substation and can have the following components: Switches: These are those devices which connect/ disconnect different parts of a network and can also carry or obstruct normal load currents.
- **Circuit breakers:** These devices work in a similar fashion to switches, in addition to which they can interrupt short-circuit current. These devices are often paired with relays which can sense short-circuit conditions using potential transformers and current transformers.
- **Reclosures**: These devices have the ability to- reclose after opening, open again, and reclose again, repeating this cycle a predetermined number of times until they lockout. These are somewhat similar to circuit breakers. Fuses: These devices have the capability of carrying a fixed load current without any hindrance and also obstruct a pre-defined fault current. on both sides. Special substation designs to achieve high reliability may utilize multiple circuit breakers. As shown in Figure 1.2, multiple circuit breakers may be employed in specially designed substations to achieve high reliability. As shown in Figure 1.3, the cost effective designs may employ protection only in series with the feeders. In the mentioned figures, circuit breakers and switches are normally closed unless there is a “N.O.” indicated beside it. Figure 1.2 indicates that all feeders can remain supplied for a transformer or a sub-transmission outage. The low voltage scheme of Figure 1.2 is called “breaker and a half”, given that it requires 3 breakers to protect 2 feeders.
- **Regulation of voltage**: The feeder will cause a voltage drop IZ volts per unit length, owing to the current I flowing from source to load along the feeder length and a finite impedance Z per unit length. Thus, loads connected over the length of the bus will see varying voltage levels with the farthest load seeing the lowest voltage of all.



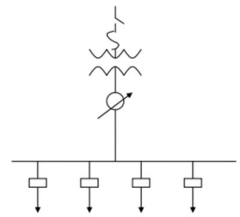


Figure 1.2 High reliability design Figure 1.3 Low reliability design

This is illustrated by the solid line in Figure 1.3. It is notable, that the voltage at the substation end of the feeder is 1.02 p.u. However, the voltage at feeder far-end is about 0.97 p.u. If the load were to increase, the far-end voltage would drop to an even lower value. As a result, voltage regulation along the feeder is a must, as the load varies. Different ways to achieve this include substation bus voltage regulators or substation feeders, line voltage regulators, load tap-changing transformers, and switched or fixed shunt capacitors. 4. Metering: Several substations have some sort of metering device that record, minimum existing current and current peaks and falls that have occurred in the last time period (say, 1 hour). Digital recording which is capable of recording a large amount of substation operational information is also heavily employed.

B. Power Distribution Networks

Power Distribution networks are overgrowing and becoming more complex and complicated systems. Power generation is defined as the process used to produce electricity, normally at a central power plant. The transmission term is the process of transporting electricity to the customers at high voltages. Distribution is defined as the process of transforming electricity to lower voltages and transporting it shorter distances to individual consumers. The traditional power system is fundamentally the interconnection of different power system components, such as synchronous machines, power transformers, transmission lines, transmission substations, distribution lines, distribution substations, and different types of loads. They are placed far away from the power consumption area, and electric power is transmitted through long transmission lines. Nowadays, the distribution system is neither traditional nor complex system because it has become smart systems. A smart system is a modern form of the traditional power grid which provides a more secure, reliable and dependable electrical service. It is, in fact, two-way communication between the utility and the electricity consumer. In addition, the distribution term now is divided into two types. One-Way distribution in which the power can only be distributed from the central plant using traditional energy infrastructure. The second type is the two-way distribution, while power still provided from the essential power plant, in a smart system, power can bi-directional and flow back to the transmission lines from a secondary power provider. These providers can be small or large scale individuals who have access to alternative power sources, such as wind turbine or solar panels, that can send energy back into the grid. The smart grid is capable of providing data and information of all the events in real time. The components of a smart grid include smart meters, smart substations, smart appliances, and advanced synchrophasor technologies. The utilities have the least controllability of the customer connected devices which is also where most of the change is occurring. The result is a set of challenges associated with further integrating of Distributed Energy Resource (DERs). To meet these challenges, an integrated approach for planning DERs is needed. In the late years, there has been a notable influx of DERs onto the grid particularly on the distribution system, either at the medium or low-voltage level. Specifically, installations of solar photovoltaic (PV) systems are growing rapidly. PV systems are known as distributed generators (DGs) and also defined as an on-site generation or a decentralized energy source. Nowadays, there are a massive amount of the connected DGs units onto the grid. This shift alters the manner in which electricity is being generated, transmitted, and managed, thus necessitating a change in how utilities plan and integrate this resource. DERs conflicts have already risen between distribution systems designed for one-way power flow and DERs that want to force power flow in the opposite direction. Screening methods exist to avoid adverse impacts due to DERs, but this addresses the abundance of DERs interconnection requests and can result in higher overall costs if the resource is not fully integrated and located appropriately. For instance, let's consider designing the voltage regulator for a feeder. Without DERs, the network planner designs for a voltage drop from the substation to the feeder extremities. If the voltage is projected to drop too low during the peak demand periods, a capacitor bank or voltage regulator is added to boost the voltage level. Feeder voltage control is designed to yield voltages within ANSI C84.1. For the grid with DERs, the planner must also design for the voltage rise resulting from DER power output and must consider time(e.g., the impact of solar generation (at the bigging of the day or during the day)) in the analysis. An example of the time and location is the evaluation of PVs on a distribution feeder. Therefore, DERs are required to coordinate and approve when the DER are allowed to actively participate in regulating the voltage by changes its real and reactive output power. Besides, DERs must be coordinated with the protection devices when connected to the grid. A meshed system may better support DERs but requires an entirely different planning paradigm for distribution. New types of line equipment would be required to protect a new system configuration. Since the grid is becoming more complex, utility planning needs to change. Also, they need a new planning method that can accommodate the more integrated system. While the planning functions of the DERs do not change, additional critical items should be considered to integrate DERs better and to quantify the overall impact of such sources more precisely. The main factors that need to be considered in a proactive planning approach with DERs are the size and location, distribution systems response characteristics, and DER technologies. Part of this research is aiming to optimally determine the location of the planned DERs using Differential Evolution Algorithm DEA. The distribution feeder response characteristics attention is to determine the hosting capacity of the feeder. The hosting capacity of a feeder is defined as the amount of DERs a feeder can support under its existing topology, configuration, and physical response characteristics. If the hosting capacity is appropriately done then it will provide a range of information such as, how many DERs can be accommodated without system upgrades, what issues arise at the hosting capacity limits, the location of the DERs so that problems can be avoided, and the location where additional DERs are likely to cause issues on the grid. The third crucial item of integrating the DERs is the DER technologies. Different generation such as solar and wind can have widely varying impacts on voltage and capacity value compared with the dispatchable generation. The difference primarily comes from the timing in which the electricity is generated and the character of the energy output. Distribution system assessment for DERs must focus on incorporating DERs while maintaining established standards of reliability and power quality. When planning a distribution system the first step to be considered is to establish the distribution feeder 's ability to host DERs that is to determine its hosting capacity. Hosting capacity is to determine the number of DERs that feeder can accommodate under current grid conditions without affecting power quality or reliability.

C. Loss Minimization

There are a number of ways to reduce transmission and distribution losses. Some of the options to reduce technical losses include: One of the main benefits of applying capacitor is that they can reduce distribution line losses, replacing incorrectly sized transformers, improving the connection quality of conductors (power lines), and increasing the availability of reactive power by installing capacitor banks along transmission lines. To reduce nontechnical causes, policymakers can target theft by making it harder to steal power from lines.

- **Fixed technical losses**: The fixed losses in the distribution lines account for between a quarter and a third of the total technical losses. These are usually in the form of heat and noise and occur whenever the
- transformer is energized. The fixed losses are not influenced by the amount of load current flowing, but rather by The leakage current losses Open circuit losses Corona losses Dielectric losses.
- **Variable technical losses:** The variable losses are proportional to the square of the load current and accounts to between 2/3 and ¾ of the technical losses in a distribution system. The variable losses arise due to the line impedance, contact resistance and the joule heating losses.
- **Causes of technical losses:** Inefficient equipment such as the transformers, pumps, electrical machines and industrial loads Inadequate size of conductor in the distribution lines ,Long distribution lines ,Load imbalance among the phases , Low power factor.
- **Commercial(non-technical)power losses:** The non-technical losses, also referred to as commercial losses, are those related to unmetered supplies, incorrect billing, untimely billing, wrong tariff, defective meters and energy thefts. The unmetered supplies are those that may be left out when estimated amounts are used to calculate the amount of power to bill for. In addition, some consumers may tamper with the meters to make them indicate less power than what is actually used. The energy theft may occur when consumers tamper with the metering, or collude with the utility personnel to make illegal connections.

D. Power System Stability

Power system stability is defined as the property of a power system that enables it to remain in a state of equilibrium after being subjected to a disturbance.

Disturbances can be small or large - 1) Small Disturbances Incremental changes in load Incremental changes in generation. 2) Large Disturbances Loss of a large generator or load Faults on transmission lines.

Steady-state Stability: Steady-state stability relates to the response of synchronous machine to a gradually increasing load. It is basically concerned with the determination of the upper limit of machine loading without losing synchronism, provided the loading is increased gradually.

E. Objectives

- Implementation of three different methods for reconfiguration based on exhaustive search.
- Loss minimization in radial distribution network through reconfiguration.
- Comparison of voltage profiles and power loss reduction in these methods.

II. LITERATURE REVIEW

[1]Civanlar, Grainger, yin and Lee , uses an expression in the real power losses to know if a switching option produces an increase/reduction in losses. In this, the expression filters out those switching options that would not yield loss reduction. A switch exchange operation corresponds to the selection of a pair of switches, one for opening and the other for closing. The switch exchange operation becomes very time consuming and it does not ensure near an optimum solution.

[2]Baran and Felix F. Wu presented an alternate branch exchange algorithm with a filtering mechanism applying two approximate power flow methods with varying degree of accuracy viz., simplified method and backward & forward update of distribution flow. The methods are computationally attractive and in general, give a conservative estimation of loss reduction

[3]Qiuyu Peng and Steven H. Low proposed an optimal branch exchange algorithm where some loads are transferred from one feeder to another feeder while maintaining the radial structure of the network. It uses an AC power flow model and is based on the recently developed convex relaxation of optimal power flow. This algorithm gives an optimal solution when the voltage magnitudes are the same on all buses.

[4]Carlos et. al., reported an efficient reconfiguration algorithm based on loss change estimation method proposed by Civanlar . The algorithm establishes switching operations to reduce power loss with minimum computational effort. The results obtained show that the method is very robust, in spite of its simplicity.

[5]Shri mohammadi and Wayne Hong used a robust heuristic method developed based on the idea presented in , (Merlin Back). This method uses an optimal power flow and converges to the near-optimum solution and the final solution is independent of the initial status of the network switches.

[6]Goswami and Basu reported a power flow based heuristic algorithm for determining the minimum loss configuration. The algorithm is based on the concept of optimum flow pattern which is determined by solving the KVL and KCL (Kirchhoff's voltage and current laws) equations of the network. The optimum flow pattern of a single loop formed by closing a normally open switch is found out and the flow pattern is established in the radial network by opening a closed switch. This process is repeated till the minimum loss configuration is obtained.

[7] Mortaza Afsari developed a method based on sequential switch opening. In his thesis a power-based method is used where there is no need to convert the nodal powers to currents at different stages, thus saving a few power flow runs. The switch carrying minimum active power is opened to convert the loop into a radial form. This is continued till all the switches are exhausted and the system comes to minimum loss radial configuration.

[8]Huddleston Charles. T, et. al.,developed a quadratic loss function in which multiple switching pairs are considered simultaneously with linear current balance equations as constraints. This method has the advantage of solving multiple switching options.

[9]McDermott et. al., proposed a non-linear constructive method for reconfiguration problem of distribution networks. This reconfiguration algorithm starts with all operable switches open, and at each step, closes the switch that results in the least increase in the objective function. The objective function is defined as incremental losses divided by incremental load served. A simplified loss formula is used to screen candidate switches.

[10]Joel Jose and Anupama Kowli presented a path-based mixed integer quadratic programming (MIQP) formulation of distribution feeder reconfiguration (DFR) for loss minimization and reliability enhancement. The proposed path-to-branch incidence matrix results in linear expressions for the reliability indices and power flow equations. These linear models are suitably deployed in a flexible DFR optimization framework wherein reliability can feature in either via objectives or constraints.

[11] Song et al. derived a fuzzy controlled EP (FCEP) based approach for reconfiguration. The mutation fuzzy controller adaptively adjusted the mutation rate during the simulated evolutionary process. The status of each switch in distribution systems was naturally represented by a binary control parameter 0 or 1. The length of string was much shorter than those proposed by others. A chain-table and combined depth-first and breadth-first search strategy was employed to further speed up the optimization process. The equality and inequality constraints were imbedded into the fitness function by penalty factors which guarantee the optimal solutions searched by the FCEP were feasible.

[12] Jeon and Kim ,showed that simulated annealing; tabu search and a hybrid algorithm of the two methods with some adaptations had been applied and compared. Numerical examples demonstrated the validity and effectiveness of the proposed methodology using KEPCO's distribution systems.

[13] Huang developed an enhanced genetic algorithm (EGA)-based fuzzy multi-objective approach to solve a network reconfiguration problem. Maximizing the fuzzy function satisfied multiple objectives of minimizing power loss, voltage violation, current constraints and switching number, while subject to a radial network structure in which all loads must be

[14] Fan et al. indicated that the single-loop optimization approach actually originates from the same technical principle as the simplex method. This paper also presented a simple and effective scheme to efficiently determine the switch exchanges within a loop for minimum line losses, and proposed a heuristic scheme to develop the optimal switch plan with minimum switch operations in order to accomplish the transition from the initial configuration to the optimal configuration.

[15] Gohokar et al. described the formulation of the reconfiguration problem using network topology approach. Algorithm developed could be used in general to radial system with any number of bifurcations. A modified iterative load flow method was also discussed. Simple and efficient technique was described to detect the loops formed during reconfiguration process. Formulation of single loop optimization problem was implemented to obtain network reconfiguration under normal operation.

[16] Su and Lee proposed an improved mixed-integer hybrid differential evolution (MIHDE) based method to reduce power loss and enhance the voltage profile. This research recognized beneficial load transfers to minimize power loss and ensure prescribed voltage limits. The proposed method determined the proper system topology that reduced the power loss according to a load pattern.

[17] Venkatesh and Ranjan reconfigured an RDS under the umbrella of SCADA to achieve the best voltage profile and minimal kW losses amongst several objectives. That problem required the determination of the best combination of feeders from each loop to be switched out such that the resulting RDS gave the optimal performance in the chosen circumstance. The problem had a discontinuous solution space and certain problem variables assume discrete values of zero or one. Fuzzy adaptation of EP was necessitated while considering optimization of multiple objectives.

[18] Hsiao elucidated a multi-objective evolution programming method for distribution feeder reconfiguration in a practical system. The multiple objectives were minimizing power losses, ensuring voltage quality, service reliability assurance, and minimizing switching operations. Generally, the attributes of the above four objectives were not the same and operators' judgment must be involved in trading off between these objectives. Accordingly, this investigation presented an interactive fuzzy algorithm for obtaining a compromise solution. Furthermore, the solution algorithm was implemented in C++ with man-machine interactive procedures and tested on a Tai-Power 102-bus system with very promising results.

[19] Su et al. introduced ant colony search algorithm (ACSA) to solve the optimal network reconfiguration problem for power loss reduction. The ACSA applied the state transition rule, local pheromone-updating rule, and global pheromone-updating rule to facilitate the computation. Numerical results showed that the proposed method was better than genetic algorithm and simulated annealing.

[20] Prasad et al. developed a method based on a fuzzy mutated genetic algorithm, which overcame the combinatorial nature of the reconfiguration problem and dealt with non continuous multi-objective optimization. The attractive features of the algorithm were: preservation of radial property without islanding any load point and an efficient convergence.

III. PROBLEM FORMULATION

The objective function of the network configuration problem in this paper is to minimize the total power loss as:

$$\text{Minimize } Z = \sum_{n=1}^{N_t} \sum_{k=1}^{l} \left| I_{k,n} \right|^2 R_k \quad (1)$$

The objective function is subjected to the following constraints. - Power flow equations:

$$P_{i,n} = \sum_{j=1}^{N_B} \left| Y_{ij} V_{i,n} V_{j,n} \right| \cos(\theta_{ij} + \delta_{j,n} - \delta_{i,n}) \quad (2)$$

$$Q_{i,n} = -\sum_{j=1}^{N_B} \left| Y_{ij} V_{i,n} V_{j,n} \right| \sin(\theta_{ij} + \delta_{j,n} - \delta_{i,n}) \quad (3)$$

Bus voltage limits:

$$V^{\min} \leq V_{i,n} \leq V^{\max} \quad (4)$$

Current transfer capability of feeders:

$$I_{k,n} \leq I_k^{\max} \; ; \; k \in \{1,2,\ldots,l\} \quad (5)$$

IV. METHODOLOGY

4.1 Distribution Feeder configuration

The objective of "Distribution Feeder Reconfiguration" can be a part of distribution automation. The configuration management is done at the time of service maintenance or service testing. The configuration of this radial distribution system can be changed by changing the status of switches. Here the normally close sectionalizing switches are opened and same numbers of normally open tie-switches are closed. This is called reconfiguration. In new topological structure, the tree shape of radial distribution is maintained. The procedure can be said as the part of "Distribution Management". Here, reconfiguration is done to obtain minimum loss path for the load feeding configuration of this radial distribution system can be changed by changing the status of switches. Here the normally close sectionalizing switches are opened and same numbers of normally open tie-switches are closed. This is called reconfiguration. In new topological structure, the tree shape of radial distribution is maintained. The procedure can be said as the part of "Distribution Management". Here, reconfiguration is done to obtain minimum loss path for the load feeding.

4.2 Service Restoration in Distribution System

Service restoration is a process of restoring power flow immediately after any kind of disturbance in the power system. This disturbance may be due to the fault in the distribution system and in this case, some portions of the distribution system may run out of power. To establish the connection, some tie-switches have to be closed maintaining the radial structure. Here already some sectionalizing switches are off-line. Service restoration happens in the same procedure like feeder reconfiguration. For a complex distribution feeder system, it is quite cumbersome to restore an ample amount of power from a distant control center. There are varieties of loads in the distribution system such as industrial, commercial and residential loads. If there is less power available at the feeding point, the control center restores the service depending upon the priority of the customers.

4.3 Islanding

Power system islanding is closely related to the micro-grid islanding. It means isolation of one or more than one node at the time of power distribution due to faulty power controlling operation. As power flow is totally dependent on the status of the existing switches in the tree structure, bad controlling or an invalid sectionalizing and tie-switches combination can lead to islanding of the whole or a single region. Islanding hampers the reliability of the power system. This islanding should be eliminated quickly after any outage.

4.4 Customer Feeding and Reliability Restoration

Customers of electricity are of three types such as industrial, commercial and residential. On the priority basis the electrical system is chosen to supply at the time of outage to these customers. In industrial hub, outage of electricity for one hour may cause serious loss of raw assists. In general, if a load point in feeder section is heavily loaded then there will be chance of voltage dipping. As stated earlier, reconfiguring the structure, the heavily loaded portion of the feeder can be transferred to lightly loaded feeder portion. By doing this, some nodes in the feeder system may lead towards the verge of voltage collapsing situation. Overloading can reduce the capacity of feeder line and life span of distribution transformers connected to the system. Apart from this, if configuration is changed by altering more number of switches in the system, the power system can suffer from the ill effect of the switching surge.

Feeder reconfiguration in a distribution system is an operation in configuration management that determines the switching operations for many purposes such as decreasing network loss, balancing system load, and improving bus voltages or system reliability. The configuration may be varied via switching operations to transfer loads among the feeders. Two types of switches are used: normally closed switches (sectionalizing switches) and normally open switches (tie switches) . There are a number of closed and normally open switches in a distribution system. The number of possible switching actions makes feeder reconfiguration become a complex decision-making process for system operators. . A flowchart for feeder reconfiguration algorithm is shown in Figure 4.4.1

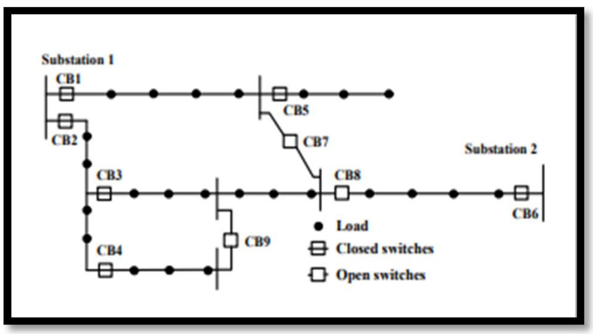


Fig.4.4.1 Schematic Diagram Of a Distribution System

Figure 4.4.1 shows a schematic diagram of a simplified primary circuit of a distribution system. In the figure, CB1-CB6 are normally closed switches that connect the line sections, and CB7 is a normally open switch that connects two primary feeders. The two substations can be linked by CB8, while CB9, when closed, will create a loop.v

4.5 Radial Configuration Format – No Load Point Interruption

Feeders are used for the transmission of electricity; it is the power line in which electricity is transmitted in power systems. It does the transmission of power from the generating station or substation to the distribution points. There is no intermediate tapping and by that, the flow of current will be the same for the sending and the receiving section. Feeders are the conducting device which is used for the transmission of power to the main load center. We could get constant voltage from the feeder. There are four distribution feeder systems are used

4.5.1 Radial
4.5.2 Parallel feeders
4.5.3 Ring main
4.5.4 Interconnected systems

4.5.1 Radial Feeders

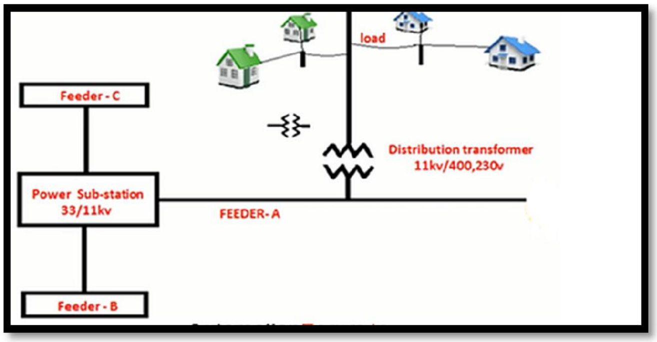


Fig.4.5.1 Radial Feeder

It is used for many distribution processes. It is really cheap and simple; it is only used when the substation or the generating stations are located at the center of the consumers. This type feeder will radiate from the generating stations or substations and it will reach the distributors at one end. Thus the power flow is in one direction.

4.5.2 Parallel feeder

There is a disadvantage in radial feeders if there is any fault occur during the transmission there will be no supply for many customers so this can be changed by using parallel feeder if there is any fault occurs only one line of the feeder will be affected the other will do the work the cost is high due to increase in feeder number it can be used to transfer heavy loads.

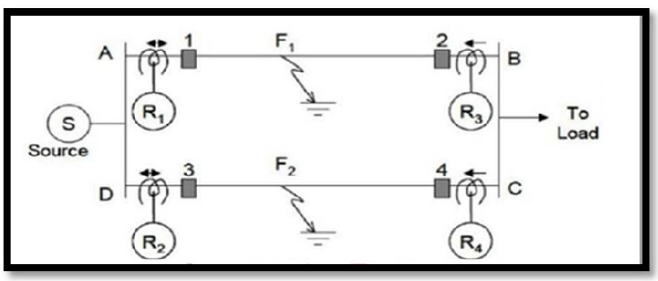


Fig.4.5.2 Parellel Feeder

4.5.3 Ring Main:

In this type of feeder system, we could get reliability as much as in a parallel system This type of feeders are used in urban and industrial environment in this type the distribution transformers are connected with two feeders cabling has done for many routes starting and finishing is in the same location the power is delivered to the substations if there is any fault In the ring it will be isolated by circuit breaker and the supply will continue by using ring feeder there will be few fluctuations in the customer section there is always an alternative path if any fault occurs.

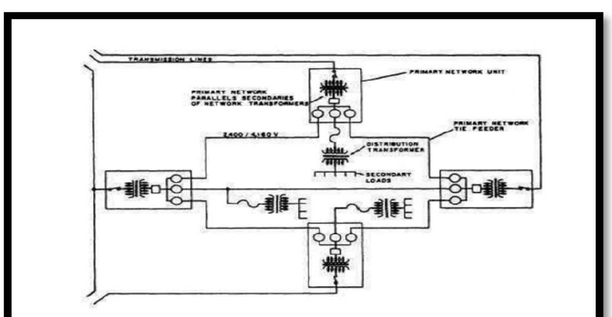


Fig.4.4 Ring Main

4.5.4 Interconnected Systems

In this type the ring feeder is energized by more than one substation or generating station it is an interconnected distribution in case of transmission failure the system doesn't stop it continues and it does the load transmission

Classification Of DFR Method

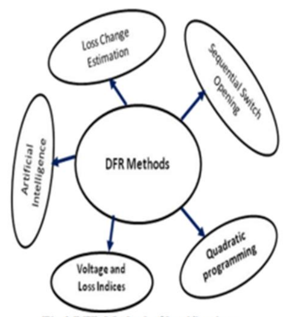


Fig.2 DFR Methods Classification

A distribution system is designed to operate economically and reliably. Corresponding DFR objectives reflect these goals. This section describes commonly used DFR objectives.

Power Loss Reduction

Power Loss reduction is a main objective of DFR because the reduction in system losses brings down the unnecessary operational cost to the profit-driven utilities. System losses are affected by many aspects, such as load imbalance, low voltages, and long distribution lines.

Load Balancing

DFR for load balancing determines an optimum radial distribution system configuration to balance loads among distribution feeders. The optimal load balancing switching operation enables appropriate transfer of loads from heavy-loaded feeders to light loaded feeders, in order to maintain sufficient load transfer margin and consequently enhance operational efficiency Load balancing can mitigate equipment overloading to avoid unnecessary system losses and faster equipment aging that will cause even more losses.

Mitigation of Voltage sags

Distribution feeder emanates radially from the substation to supply the loads and thereby the voltage drops along the distribution lines from the substation. To maintain the node voltage profiles within operating limits, various control strategies have been implemented, including voltage regulators and reactive power support. In order to achieve a better voltage profile, DFR alters the network topology and therefore power flow magnitudes and directs to avoid overloads and long distribution paths that will cause a significant voltage drop.

Service Restoration

The goals described above are commonly targeted for normal conditions of a distribution system. Service restoration, however, is a group of objectives in emergency conditions such as fault, when switches are opened to isolate part of the system. The isolation can lead to loss of loads and/or distributed generators (DGs). DFR for service restoration redirects the power flow to regain the service to loads and DG connections to the network while considering the objectives for normal conditions and special requirements, such as minimum restoration time, maximum restored load and minimum switching operations.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 2, July 2022
IJARSCT
Impact Factor: 6.252

Block diagram

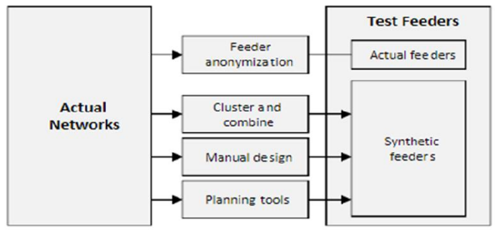
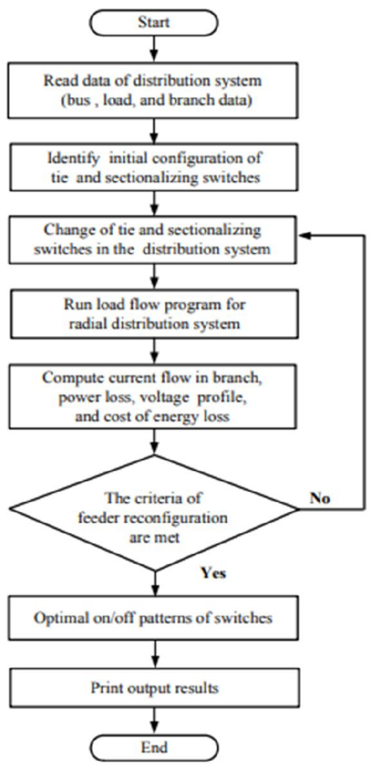


Figure 2. Test feeders building procedures.

Fig. 4.7.1 Test Feeder Building Procedures

Flow chart:



4.9 Working

In our Proposed System we divided the section into two parts. One is Distribution feeder reconfiguration and steady state security assessment. The voltage stability index & the losses of particular structure, Could not be predicted so we used a regression model with the help of machine learning to find the values of voltage stability index active and reactive losses. The Proposed System was fed with the switching configuration of the unknown network & predicted the class of network regression by using machine learning. After implementing the 12 iteration to test security prediction new model. After Reconfiguration 2 to 12 buses will be checked for security as compared to old data. This will increase the efficiency of the system.

Programme :

```
clc
linedata=xlsread('Blinedata.xlsx');
busdata=xlsread('Bbusdata.xlsx');
linedata(:,3)=linedata(:,3)./(1.602756);
linedata(:,4)=linedata(:,4)./(1.602756);
busdata(:,3)=busdata(:,3)./(100000);
busdata(:,4)=busdata(:,4)./(100000);
nbus=length(busdata);
Vbase=12.66; % In kv
Kleng=length(linedata);
sectionlizer=[1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1];
tie=[0 0 0 0 0];
baseTop=[sectionlizer,tie];
InMAT=baseTop;
newlinedata=NewDataMake(InMAT,linedata);
radial=radialChek(newlinedata,nbus);
[Tloss V IL]=powerflow(newlinedata,busdata,nbus,Vbase);
baseTLoss=Tloss;
Fin=baseTLoss;
Open=length(tie);
brch=nbus-2;
%% Making Population
pup=1;
Osave=0;
popsize=13;
lim=round(popsize/Open);
for k=1:length(tie)
  npup=0;
  while (npup<lim)
    Sec=sectionlizer;
    Ti=tie;
    Ti(k)=1;
    Osec=ceil(brch*rand+1);
    if (Osec==Osave)
      Osec=ceil(brch*rand+1);
    end
    Osave=Osec;
    Sec(Osec)=0;
    InMAT=[Sec,Ti];
    newlinedata=NewDataMake(InMAT,linedata);
    radial=radialChek(newlinedata,nbus);
    if (radial==1)
      pup=pup+1;
      npup=npup+1;
      pupMAT(pup,:)=InMAT(1,:);
    else
      npup=npup+1;
     pupMAT(pup,:)=InMAT(1,:);
```

```
        end
    end
end
%% Scrounger
ScrPop=InMAT;
ScrPercent=0.4;
ScrSize=round(ScrPercent*size(pupMAT,1));
Randpop=randperm(size(pupMAT,1));
pro=find(Randpop==1);
Randpop(pro)=[];
Xp=pupMAT(1,:);
for k=1:ScrSize
ScrMAT(k,:)=pupMAT(Randpop(k),:);
end
Scounter=0;
for k=1:ScrSize
Xsc=ScrMAT(k,:);
DEl=xor(Xp,Xsc);
r3=ceil((brch/2)*rand+1);
r4=r3+ceil((brch/2)*rand+1);
m=Xsc;
for kk=r3:r4
if (DEl(kk)==1)
m(kk)=Xp(kk);
end
end
radial=0;
newlinedata=NewDataMake(m,linedata);
radial=radialChek(newlinedata,nbus);
mm=m;
kkk=0;
while (radial~=1 && kkk<length(m))
mm=m;
kkk=kkk+1;
if (mm(kkk)==0)
mm(kkk)=1;
newlinedata=NewDataMake(m,linedata);
radial=radialChek(newlinedata,nbus);
end
end
if (radial==1)
Scounter=Scounter+1;
ScrPop(Scounter,:)=mm(1,:);
end
end
%% Ranger
RangPercent=0.9;
RangSize=round(RangPercent*popsize)-1;
RangCounter=0;RangMAT=[];
```

```
for k=ScrSize+1:length(Randpop)
    RangCounter=RangCounter+1;
    RangMAT(RangCounter,:)=pupMAT(Randpop(k),:);
end
RangRand=randi(RangSize,length(tie));
Rcounter=0;
for k=1:RangSize
    RangMAT=RangRand;
    Zcounter=0;
    for kk=1:length(tie)
        if (RangMAT(5,kk)==1)
            Zcounter=Zcounter+1;
        end
    end
    Ycounter=0;
    for kk=1:5
        if (RangMAT(5,kk)==0)
            Ycounter=Ycounter+1;
        end
    end
    if (Zcounter>Ycounter)
        radial=0;
        xo=0;
        while (radial~=1 && xo<25)
            RangMAT2=RangMAT;
            for kk=1:(Zcounter-Ycounter)
                uu(kk)=ceil(brch*rand+1);
            end
            RangMAT2(k,uu)=0;
            InMAT=RangMAT2(k,:);
            %newlinedata=NewDataMake(InMAT,linedata);
            radial=radialChek(newlinedata,nbus);
            xo=xo+1;
        end
        if (radial==1)
            Rcounter=Rcounter+1;
            Rangpop(Rcounter,:)=RangMAT2(k,:);
        end
    end
end
%% Power flow

    InMAT=pupMAT;
    %newlinedata=NewDataMake(InMAT,linedata);
   % [Tloss V IL]=powerflow(newlinedata,busdata,nbus,Vbase);
    LossMAT=Tloss;

[LossMAT index]=sort(LossMAT);
pupMAT=pupMAT(1,:);
```

```
Fin=[Fin LossMAT(1,1)];
iter=0;
teta=length(Ti);
maxiter=50;
tic
while (iter<maxiter)
   iter=iter+1;
   %% Combine
   Rangpop=length(RangMAT2);
   for k=1:size(ScrPop,1)
      newlinedata=NewDataMake(ScrPop(k,:),linedata);
      %[Tloss V IL]=powerflow(newlinedata,busdata,nbus,Vbase);
      SCLossMAT=Tloss;
   end
   for k=1:size(Rangpop,1)
      %newlinedata=NewDataMake(Rangpop(k,:),linedata);
      %[Tloss V IL]=powerflow(newlinedata,busdata,nbus,Vbase);
      RANGLossMAT=Tloss;
   end

   LossMAT22=[LossMAT;SCLossMAT;RANGLossMAT];
   [LossMAT22 index]=sort(LossMAT22);

   LossMAT=LossMAT22;
   Fin=[Fin LossMAT(1,1)];

end

tempdata1=(complex(newlinedata(:,3),newlinedata(:,4)));
tempdata2=(complex(linedata(:,3),linedata(:,4)));


figure(1)
plot(Fin,'r','Linewidth',2.5)
title(['Total Loss = ',num2str(min(Fin))]);
grid on
xlabel('Iteration')
ylabel('Loss [Kw]')
pause(0.0001)
figure(2)
pareto(abs(tempdata1))
grid on
title('NEW DATA');
figure(3)
pareto(abs(tempdata2))
grid on
title('OLD DATA  ');
olddata=[linedata(:,1) linedata(:,2) linedata(:,4)];
newdata=[newlinedata(:,1) newlinedata(:,2) newlinedata(:,4)];
```

```
yfit = trainedModel5.predictFcn(newdata);
yfit1 = trainedModel5.predictFcn(olddata);
sol=(yfit1./transpose(yfit))*100;
figure(4)
plot(yfit,'g')
xlabel('Bus')
ylabel('Security Predictor')
title('MACHINE LEARNING BASED PREDICTION NEW DATA');
grid on
figure(5)
plot(yfit1,'b')
xlabel('Bus')
ylabel('Security Predictor')
title('MACHINE LEARNING BASED PREDICTION OLD DATA');
grid on
```

4.10 System Requirement

4.10.1 Hardware Requirement

4.10.1.1 CPU I3 processor
4.10.1.2 RAM 4GB
4.10.1.3 OS window 8
4.10.4.4 ROM 250 GB

4.10.1.1 CPU I3 processor

A central processing unit (CPU), also called a central processor, main processor or just processor, is the electronic circuitry that executes instructions comprising a computer program. The CPU performs basic arithmetic, logic, controlling, and input/output (I/O) operations specified by the instructions in the program. This contrasts with external components such as main memory and I/O circuitry,[1] and specialized processors such as graphics processing units (GPUs).

4.10.1.2 RAM

Random-access memory (**RAM**; /ræm/) is a form of computer memory that can be read and changed in any order, typically used to store working data and machine code.[1][2] A random-access memory device allows data items to be read or written in almost the same amount of time irrespective of the physical location of data inside the memory, in contrast with other direct-access data storage media (such as hard disks, CD-RWs, DVD-RWs and the older magnetic tapes and drum memory), where the time required to read and write data items varies significantly depending on their physical locations on the recording medium, due to mechanical limitations such as media rotation speeds and arm movement.

4.10.1.4 ROM

Read-only memory (ROM) is a type of non-volatile memory used in computers and other electronic devices. Data stored in ROM cannot be electronically modified after the manufacture of the memory device. Read-only memory is useful for storing software that is rarely changed during the life of the system, also known as firmware. Software applications (like video games) for programmable devices can be distributed as plug-in cartridges containing ROM.

4.11 Software Requirement

MATLAB

MATLAB (an abbreviation of "Matrix Laboratory") is a proprietary multi-paradigm programming language and numeric computing environment developed by MathWorks. MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages.

Although MATLAB is intended primarily for numeric computing, an optional toolbox uses the MuPAD symbolic engine allowing access to symbolic computing abilities. An additional package, Simulink, adds graphical multi-domain simulation and model-based design for dynamic and embedded systems.
As of 2020, MATLAB has more than 4 million users worldwide. They come from various backgrounds of engineering, science, and economics.
MATLAB was invented by mathematician and computer programmer Cleve Moler. The idea for MATLAB was based on his 1960s PhD thesis. Moler became a math professor at the University of New Mexico and started developing MATLAB for his students as a hobby. He developed MATLAB's initial linear algebra programming in 1967 with his one-time thesis advisor, George Forsythe.This was followed by Fortran code for linear equations in 1971.
In the beginning (before version 1.0) MATLAB "was not a programming language; it was a simple interactive matrix calculator. There were no programs, no toolboxes, no graphics. And no ODEs or FFTs."
The first early version of MATLAB was completed in the late 1970s. The software was disclosed to the public for the first time in February 1979 at the Naval Postgraduate School in California. Early versions of MATLAB were simple matrix calculators with 71 pre-built functions. At the time, MATLAB was distributed for free to universities. Moler would leave copies at universities he visited and the software developed a strong following in the math departments of university campuses.
In the 1980s, Cleve Moler met John N. Little. They decided to reprogram MATLAB in C and market it for the IBM desktops that were replacing mainframe computers at the time.[23] John Little and programmer Steve Bangert re-programmed MATLAB in C, created the MATLAB programming language, and developed features for toolboxes.[24]

4.12 Features

MATLAB combines a desktop environment tuned for iterative analysis and design processes with a programming language that expresses matrix and array mathematics directly. It includes the Live Editor for creating scripts that combine code, output, and formatted text in an executable notebook. It extends its functions and developments of all kinds of discipline through a set of characteristics called toolbox.

4.13 Toolbox

5G Toolbox: Simulate, analyze, and test 5G communications systems

- Aerospace Toolbox: Analyze and visualize aerospace vehicle motion using reference standards and models
- Antenna Toolbox: Design, analyze, and visualize antenna elements and antenna arrays
- Audio Toolbox: Design and analyze speech, acoustic, and audio processing systems
- Communications Toolbox: Design and simulate the physical layer of communications systems
- Deep Learning Toolbox: Design, train, and analyze deep learning networks
- DSP System Toolbox: Design and simulate streaming signal processing systems
- Financial Toolbox: Analyze financial data and develop financial models
- LTE Toolbox: Simulate, analyze, and test the physical layer of LTE and LTE-Advanced wireless communications systems
- GPU Coder: Generate CUDA code for NVIDIA GPUs
- MATLAB Compiler: Build standalone executables and web apps from MATLAB programs
- Radar Toolbox: Design, simulate, and test multifunction radar systems.
- RFPCB Toolbox: Perform electromagnetic analysis of printed circuit boards.
- Satellite Communications Toolbox: Simulate, analyze, and test satellite communications systems and links.
- SerDes Toolbox: Design SerDes systems and generate IBIS-AMI models for high-speed digital interconnects.
- Signal Integrity Toolbox: Simulate and analyze high-speed serial and parallel links.
- Signal Processing Toolbox: Perform signal processing and analysis.
- Statistics and Machine Learning Toolbox: Analyze and model data using statistics and machine learning.
- Symbol has the same field names. In addition, MATLAB supports dynamic field names[41] (field look-ups by name, field manipulations, etc.).

4.14 Function

- c Math Toolbox: Perform symbolic math computations
- Wavelet Toolbox: Analyze and synthesize signals and images using wavelets
- In addition to these, you can develop applications for all kinds of industries, with more than 100 Toolboxes for Matlab and Simulink.[35]

4.15 Structures

MATLAB supports structure data types.[40] Since all variables in MATLAB are arrays, a more adequate name is "structure array", where each element of the array When creating a MATLAB function, the name of the file should match the name of the first function in the file. Valid function names begin with an alphabetic character, and can contain letters, numbers, or underscores. Variables and functions are case sensitive.[42] gb Image = imread('ecg.png'); gray Image = rgb2gray(rgbImage); % for non-indexed images level = gray thresh(gray Image); % threshold for converting image to binary, binary Image = im2bw(gray Image, level); % Extract the individual red, green, and blue color channels. Red Channel = rgb Image(:, :, 1); green Channel = rgb Image(:, :, 2); blue Channel = rgbImage(:, :, 3); % Make the black parts pure red. redChannel(~binaryImage)= 255; greenChannel(~binary Image) = 0; blueChannel(~binaryImage) = 0; % Now recombined to form the output image. rgbImageOut = cat(3, redChannel, greenChannel, blueChannel); imshow(rgbImageOut);

V. RESULT

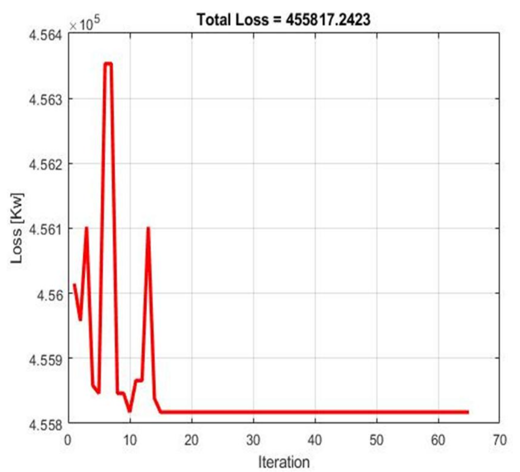


Fig 5.1.1 Total loss

Fig 5.1.1 Shows the Total loss of the system Basically this is a preliminary data when we put line data & bus data in IEEE topology model this graph is shown which is down to 65 iteration which happens from machine learning iteration, which shows voltage stability assessment in machine learning, so that we reconsigned the system to minimize losses it will remove errors in transient steady state stability so that system will stable.

IJARSCT
ISSN (Online) 2581-9429
IJARSCT
Impact Factor: 6.252
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 2, July 2022

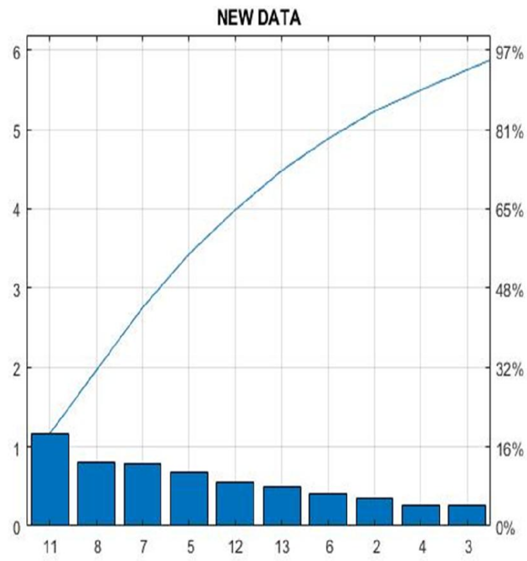


Fig .5.1.2 New Data

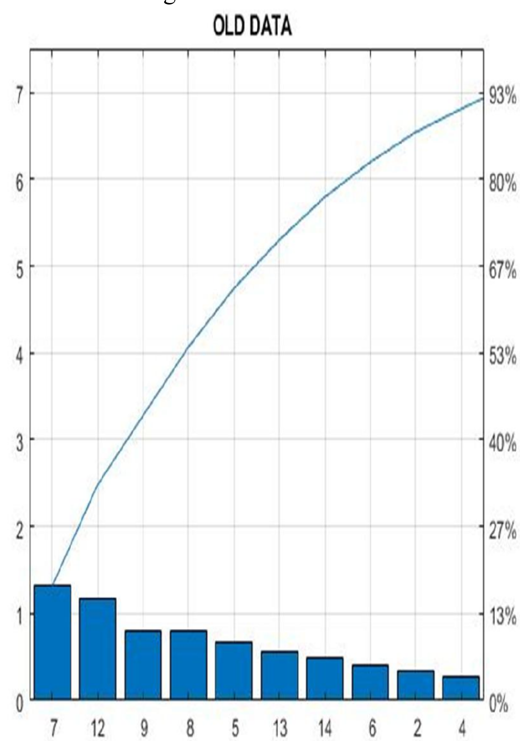


Fig 5.1.3 Old data

Fig 5.1.2 & Fig 5.1.3 shows the pantograph in old data we see that the efficiency is 93% because of power losses when we implement new data efficiency will increase to 97% after the recognigral in machine learning.

Fig 5.1.4 Machine learning based predicting new data

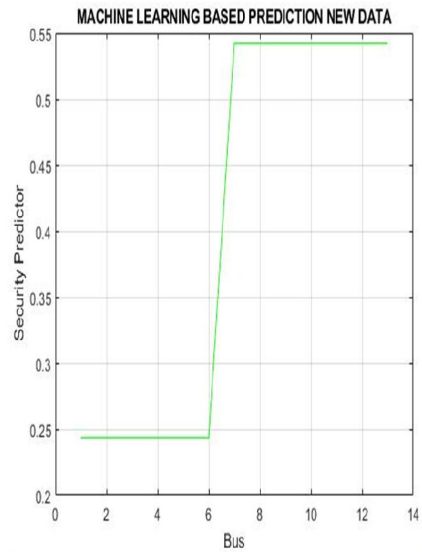


Fig 5.1.5 Machine learning based old data

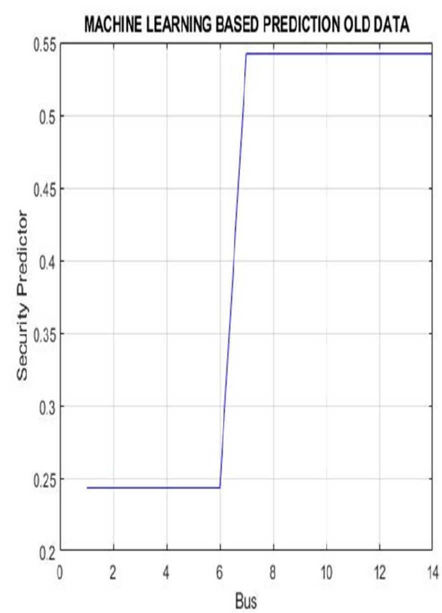


Fig 5.1.4 & Fig 5.1.5 shows machine learning based prediction new & old data. In fig 5.1.5 there are 14 iterations to test security prediction as we set the configuration. And in new data prediction (fig no. 5.1.4) shows the 12 iteration to test security prediction after implementing new data after the reconfiguration 2 to 12 bus will be checked for security as compared to old data. In old data we have to reconfigure two extra switches with their implementation & after the implementing new data we have only reconfiguration even switches this will increase system efficiency.

VI. CONCLUSION

This paper presents a review of developments on distribution feeder reconfiguration. In this paper different feeder reconfiguration techniques have been discussed. Their objectives and constraints have also been reported. As the demand for electricity increases day by day, the distribution system becomes complicated and its control becomes difficult. Several intelligence techniques are used for feeder reconfiguration to reduce power losses and improve voltage profile and reliability. Intelligent switchgear is now used in feeder reconfiguration to enhance accuracy and reliability with the advancement in the field of automation. It is difficult to select a single method/solution that could satisfy the requirement of all operational aspects, including computational efficiency and operational constraints. In the case of faulty conditions, the comprehensive off-line studies can well address the uncertainties in contingencies and operating conditions, knowledge-based heuristics are the most reliable and efficient. It is preferred to reasonably integrate some of the solution methods to make use of their merits and avoid their disadvantages for normal conditions.

6.1 Advantage

- voltage regulation.
- increasing reliability.
- loss reduction.
- avoiding congestion in cables.
- facilitating use of distributed generation.

6.2 Disadvantage

- proper selection of distribution transformers
- Feeders
- proper re-organization of distribution network
- placing the shunt capacitor in appropriate places
- theft control
- adoption of upgraded technology
- replacing incorrectly sized transformers
- increasing the availability of reactive power by installing capacitor banks along transmission lines

6.3 Application

- Virtual Personal Assistants.
- Predictions while Commuting.
- Videos Surveillance.
- Social Media Services.

VII. FUTURE SCOPE

- Future scope of Study , that proposed system ,machine learning (ML) approach for classifying configuration states and adopts the decision tree technique to interpret the online applications in the feeder reconfiguration.
- With the ongoing advancements in the field of machine learning, we can expect more robots in manufacturing premises in the near future. Among many other benefits, using machine learning in manufacturing can reduce costs, enhance quality control and improve supply chain management.
- The scope of Machine Learning is not limited to the investment sector. Rather, it is expanding across all fields such as banking and finance, information technology, media & entertainment, gaming, and the automotive industry.

REFERENCES

[1]S. Civanlar, J.J. Grainger, H. Yin and S.S.H. Lee(2021), "**Distribution feeder reconfiguration for loss reduction**", IEEE Trans. on Power Delivery, Vol. PWRD-3, No. 3, pp. 1217-1223.

[2]M.E. Baran and F.F. Wu(2021), **"Network reconfiguration in distribution systems for loss reduction and load balancing"**, Trans. on Power Delivery, Vol. PWRD-4, No. 2, pp. 1401-1407.

[3]Qiuyu Peng and Steven H. Low(2019), **"Optimal branch exchange for Feeder reconfiguration in Distribution Networks",** 52nd IEEE conference on Decision and Control, December 10-13, Florence, Italy.

[4]Carlos A. Castro, JR. and Andre A. Watanabe(2018), **"An efficient Reconfiguration algorithm for loss reduction of distribution systems",** Electric Power Systems Research, 19 (2018), pp. 137-144.

[5]D.Shirmohammadi and H.W. Hong(2018), **"Reconfiguration of Electric Distribution Network for Resistive Line Losses Reduction",** IEEE Transactions on Power Delivery, Vol. 4, No. 2, April 2018, pp. 1492-1498.

[6]S.K. Goswami and S.K. Basu(2020), **"A New Algorithm for the Reconfiguration of Distribution Feeders for Loss Minimization",** IEEE Transactions on Power Delivery, Vol. 7, No.3, July 2020, pp. 1484-1490.

[7]Mortaza Afsari(2020), **"Improved algorithm for power flow and reconfiguration of distribution networks",** Ph.D. thesis, Electrical Engineering Department, I.T., B.H.U., Varanasi, 2020.

[8]C.T. Huddleston, R.P. Broadwater, and A. Chandrasekaran(2018**), "Reconfiguration Algorithm for Minimizing Losses in Radial Electric Distribution Systems",** Electric Power Systems Research, Vol. 18, 2018, pp. 57-66.

[9]T.E. McDermott, I. Drezga and R.P. Broadwater(2018), **"A Heuristic Nonlinear Constructive Method for Distribution System Reconfiguration"**, IEEE Transactions on Power Systems, Vol. 14, No. 2, May 2018, pp. 478-483.

[10] Joel Jose, Anupama Kowli(2018), **"Reliability constrained distribution feeder reconfiguration for power loss minimization",** 2018 National Power Systems Conference (NPSC), IEEE Conference Publications.

[11] R. Taleski and D. Rajicic(1997**), "Distribution network reconfiguration for energy loss reduction",** IEEE Transaction on Power System, Vol. 12, No. 1, pp. 398-406.

[12] Y. H. Song, G.S. Wang, A. T. John, P. Y. Wang(1997), **"Distribution network reconfiguration for loss reduction using fuzzy controlled evolutionary programming",** IEE Proceedings - Generation, Transmission and Distribution, Vol. 144, Issue 4, pp. 345-350.

[13] Jeon Young-Jae and Kim Jae-Chul(2000), **"Network reconfiguration in radial distribution system using simulated annealing and Tabu search",** IEEE Power Engineering Society Winter Meeting, Vol. 4, pp. 2329-2333, 2000.

[14] Y. C. Huang(2002), **"Enhanced-genetic-algorithm-based fuzzy multi-objective approach to distribution network reconfiguration",** IEE Proceedings - Generation, Transmission and Distribution, Volume 149, Issue 5, p. 615 – 620.

[15] Fan Ji-Yuan, Zhang Lan and J. D. McDonald(2002**), "Distribution network reconfiguration: single loop optimization",** IEEE Transaction on Power Systems, Vol. 11, No. 3, pp. 1643-1647.

[16] V. N. Gohokar, M. K. Khedkar and G. M. Dhole(2003), **"Formulation of distribution reconfiguration problem using network topology: A generalized approach",** Electric Power Systems Research, Elsevier, pp. 305-310, 2003.

[17] Su Ching-Tzong, Lee Chu-Sheng(2003**), "Network reconfiguration of distribution systems using improved mixed-integer hybrid differential evolution",** IEEE Transactions on Power Delivery, Vol. 18, No.3, pp. 1022-1027.

[18] B. Venkatesh and Rakesh Ranjan(2003**), "Optimal radial distribution system reconfiguration using fuzzy adaptation of evolutionary programming**", International Journal of Electrical Power & Energy Systems, Vol. 25, Issue 10, pp. 775–780.

[19] Y. Hsiao(2004), **"Multi-objective Evolution Programming Method for Feeder Reconfiguration"**, IEEE Transactions on Power Systems, Vol. 19, No. 1, pp. 594-599.

[20] Su Ching-Tsong, Chang Chung-Fu and Chiou Ji-Pyng(2005), **"Distribution network reconfiguration for loss reduction by ant colony search algorithm",** Electric Power Systems Research- Elsevier, Volume 75, Issues 2–3, pp. 190–199.