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# Network Reconfiguration Using Fuzzy Neural Network for Power Loss Minimization and Voltage Profile Enhancement in the Distribution Bus System

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**ABSTRACT:** The objective of power system operation is to meet the demand at all the locations within the power network as economically and reliably as possible. The traditional electric power generation systems utilize the conventional energy resources, such as fossil fuels, hydro, nuclear etc. for electricity generation. The operation of such traditional generation systems is based on centralized control utility generators, delivering power through an extensive transmission and distribution system, to meet the given demands of widely dispersed users. Nowadays, the justification for the large central-station plants is weakening due to depleting conventional resources, increased transmission and distribution costs, deregulation trends, heightened environmental concerns, and technological advancements. Location and size of the DGs before and after radial network reconfiguration are determined using a multi-objective particle swarm optimization technique. In an active distribution network, an ideal network layout with DG coordination eliminates power losses, elevates voltage profiles, and enhances system stability, reliability, and efficiency. A penalty component is also addressed when examining actual power system circumstances; this penalty factor is critical in minimizing total power loss and enhancing voltage profile.

**KEYWORDS:** power, Loss, optimization, network, DG

## I. INTRODUCTION

Distribution system provides a final link between the high voltage transmission system and the consumers. A radial distribution system has main feeders and lateral distributors. The main feeder originates from substation and passes through different consumer loads. Laterals are connected to individual loads [9]. Generally radial distribution systems are used because of their simplicity. Power loss in a distribution system is high because of low voltage and hence high current.

Electricity networks are in the era of major transition from stable passive distribution networks with unidirectional electricity transportation to active distribution networks with bidirectional electricity transportation. Radial distribution networks without any RECONFIGURATION units are considered passive since the electrical power is supplied by the national grid system to the customers embedded in the distribution networks. They become active when RECONFIGURATION units are added to the distribution system leading to bidirectional power flows in the networks [7,9].

In an active distribution network, the amount of energy lost in transmitting electricity is less as compared to the passive distribution network, because the electricity is generated very near to the load center. Active Distribution Network has several advantages like reduced line losses, voltage profile improvement, reduced emission of pollutants, increased overall efficiency, improved power quality and relieved T&D congestion. Hence, utilities and distribution companies need tools for proper planning and operation of Active Distribution Networks. The most important benefits are reduction of line losses and voltage stability improvement. These are crucially important in determining the size and location of RECONFIGURATION unit to be placed in the distribution networks.

In the past decades, there have been many advances in communications and data processing. There is an increasing trend to automate the distribution system. The automation can improve the reliability, efficiency and service quality of the distribution system. It has become possible to install distribution operating center to monitor and control the



distribution networks as well as reconfiguring the distribution system to reduce the power losses, improving the voltage profile and balance loads under normal operating conditions [13,19].

Distribution networks [28,39,40] have two types of switches, sectionalizing switches that are normally close and tie switches that are normally open. The distribution system has multi substations and multi feeders, so that any load in the system can be supplied more than one route. Accordingly, the distribution system can be reconfigured by changing the status of sectionalizing and tie switches. The reconfiguration is applied to achieve the following:

- Power loss reduction.
- Load balancing.
- Service restoration after fault occurrence.
- Voltage deviation minimization.

### 1. Distribution Systems Power Loss Minimization

As previously stated, among the many benefits of distributed generation, reduction in system line losses is one of them. Normally, the real power loss draws more attention for the utilities, as it reduces the efficiency of transmitting energy to customers. Nevertheless, reactive power loss is obviously not less important. This is due to the fact that reactive power flow in the system needs to be maintained at a certain amount for sufficient voltage level. Consequently, reactive power makes it possible to transfer real power through transmission and distribution lines to customers. System loss reduction by strategically placed RECONFIGURATION along the network feeder can be very useful if the decision maker is committed to reduce losses and to improve network performance (e.g., on the level of losses and/or reliability) maintaining investments to a reasonable low level [29,30,32,46]. This feature may be very useful in case of revenue recovered by distribution company (DISCO) which is not only based on the asset value but also on network performance.

#### 1.1.2 Distribution Systems Voltage Profile Improvement

In a power system, the system operator is obligated to maintain voltage level of each customer bus within the required limit [27,30]. To ensure voltage profiles are satisfactory in distribution systems, different standards have been established to provide stipulations or recommendations. For example, the American National Standards Institute (ANSI) standard C84.1 has stipulated that voltage variations in a distribution system should be controlled within the range of -13% to 7% [9]. Actually, in practice, many electricity companies try to control voltage variations within the range of  $\pm 6\%$ . One of the upcoming widely adopted methods for improving voltage profiles of distribution systems is introducing distributed generation (RECONFIGURATION) in distribution systems. The RECONFIGURATION units improve voltage profiles by changing power flow patterns. The locations and size of RECONFIGURATIONs would have a significant impact on the effect of voltage profile enhancement.

Andreas, et. al. [5] discuss the reduction of distribution losses representing a specific issue for each DSO, due to heterogeneous levels of both technical (TL) and non-technical (NTL) losses, but also due to differences on definition, measurement or regulation of losses. This reveals a real concern in proposing a global framework, which would be general enough to include all DSO situations about losses and specific enough to bring adapted answers to losses management. In order to tackle these questions, CIRED has engaged a Working Group on the reduction of distribution losses, which proposes a three steps approach for 1. Measuring, 2. Managing and 3. Mitigating distribution losses.

Ola Badran, et. al. [6] discuss the Network Reconfiguration technique is a method which helps mitigate power losses from distribution systems. However, the reconfiguration technique can only do this up to a certain point. Further power loss reduction may be realized via the application of Distributed Generation (RECONFIGURATION). However, the integration of RECONFIGURATION into the distribution system at a non-optimal location may result in increased power losses and voltage fluctuations. Therefore, a strategy for the selection of optimal placement and sizing of the RECONFIGURATION needs to be developed and at the same time ensure optimal configuration. Many heuristic and artificial intelligence methods have been proposed in the literature for optimal distribution network reconfiguration, RECONFIGURATIONs sizing, and location.

Joel Jose and Anupama Kohli [7] presents a path-based mixed integer quadratic programming (MIQP) formulation of distribution feeder reconfiguration (DFR) for loss minimization and reliability enhancement. Analytical expressions for standard reliability indices like SAIFI and EDNS are obtained by adopting standard assumptions regarding component failures. A path-based modeling framework is adopted to allow for easy evaluation of the reliability indices. 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. The proposed MIQP formulations are applied to different test systems to optimize network losses or reliability or both. Numerical results showcase the wide range of capabilities of the proposed formulations.

T.S.R. Prasanti et. al [8] presents a new approach in order to determine the optimal placement of capacitor in radial distribution system. The power loss is significantly high in distribution systems because of lower voltages and higher currents. Optimal capacitor placement results in system loss reduction, power factor correction, voltage profile improvement and additional feeder capacity can be released. The capacitor placement is done by considering parameters like Loss sensitivity factor and better Voltage profile. FUZZY NEURAL NETWORK (FNN) algorithm is used for determination of the location system capacitor placement. In the proposed algorithm depending upon loss sensitivity factor, number of iterations required for deriving better volage profile is possible to reduce. For, 25-bus three phase unbalanced and balanced system is considered for capacitive compensation. Three phase load flow solution is obtained by using topology-based load flow program in MATLAB environment and time required, accuracy has been found satisfying.

Julius Kilonzi Charles [9] aimed at solving this problem by proposing a hybrid of GA and IFUZZY NEURAL NETWORK (FNN) to optimize RECONFIGURATION location and size while considering both real and reactive power losses. Both real and reactive power flow and power loss sensitivity factors were utilized in identifying the candidate buses for RECONFIGURATION allocation. This reduced the search space for the algorithm and thus increased its rate of convergence. The suggested method was programmed under MATLAB 2011 software and tested using IEEE 30-bus test system, IEEE 33-bus test system and IEEE 57-bus test system by considering three types of RECONFIGURATIONs. The results obtained were compared to those obtained by other researchers. It was observed that GA-IFUZZY NEURAL NETWORK (FNN) method performed better in terms of reducing both real and reactive power losses as compared to Heuristic, GA, FUZZY NEURAL NETWORK (FNN) and IFUZZY NEURAL NETWORK (FNN) methods. For the IEEE 30-bus test system, the percentage reduction in real power loss was 35.46%, 35.82% and 35.21% while the percentage reduction in reactive power loss was 36.01%, 35.95% and 35.88% for type 1, type 2 and type 3 RECONFIGURATIONs respectively. The voltage profile of the networks after optimizing RECONFIGURATION locations and sizes using GA-IFUZZY NEURAL NETWORK (FNN) method were also found to be much improved with the lowest bus voltage improved to 1.01pu and 0.959pu for the IEEE 30-bus and 33-bus test systems respectively.

MM. Aman, et. al [10] present a very detailed overview of optimum SCB placement techniques. Six different approaches of optimum SCB placement based on minimization of power losses, weakest voltage bus approach and maximization of system load ability will be applied on four different radial distribution test systems. The results have been compared on the basis of power loss reduction, voltage profile improvement, system load ability maximization and the line limit constraint.

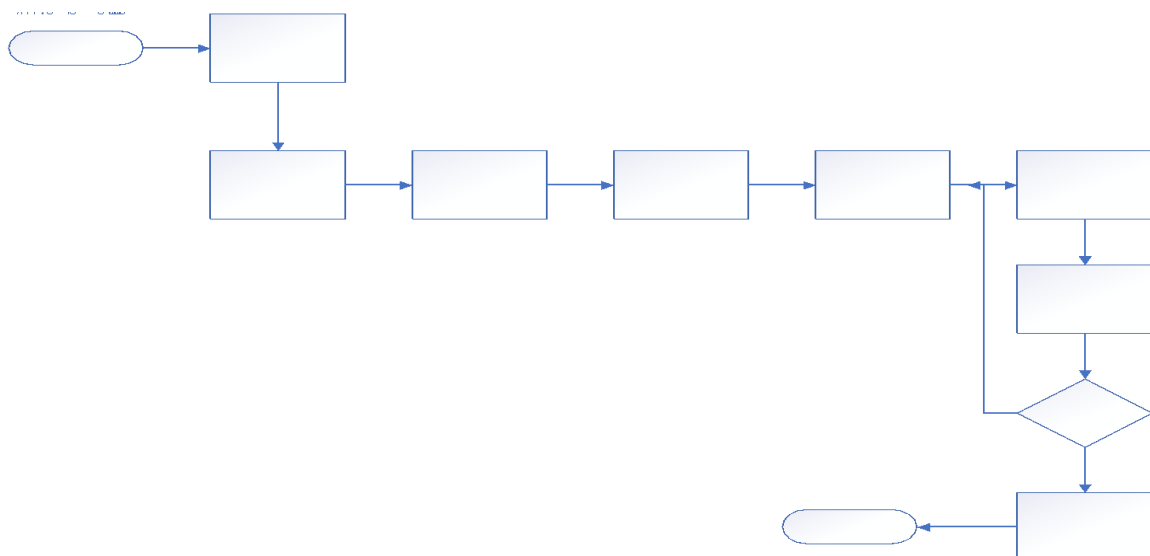


Fig.1 Proposed Flowchart



algorithm based on the gene and its purpose. In the genetic algorithm, the discovery, crossover and mutation procedure are the basis of the entire process for the best results. The optimization is based on the genes' fitness value. This algorithm supports the method of local optimization that is inadequate to achieve successful results. To address this dilemma, the present work proposes a hybrid approach. The Particle Swarm Algorithm for Optimization is a meta-heuristic algorithm based on swarm behaviour. This algorithm is used to solve the complex problem in order to obtain the best results. FUZZY NEURAL NETWORK (FNN) promotes the Global Optimization function and offers the best solution to the problem worldwide. In this work, FUZZY NEURAL NETWORK (FNN) and G.A work parallel to a better and optimal solution, as they are both optimized. In the section below, we clarify with the algorithm and flow map, the Genetic Algorithm (GA) and the Particle Swarm Optimization (FUZZY NEURAL NETWORK (FNN)). The flow diagram illustrates the technical execution of the algorithms in the step by step working an algorithm.

Steps for the approach suggested are shown as follows:

Phase 1: Load / Power initialization.

Stage 2: Initialize the Load Power generator.

Phase 3: Assign and measure the cost of generators.

Phase 4: Use the FUZZY NEURAL NETWORK (FNN) to optimize.

Phase 5: If FUZZY NEURAL NETWORK (FNN) performance is optimized, the convergence check otherwise begins with the following steps.

(a) Chromosome initialization.

(b) The junction of chromosomes.

(c) Add set of roulettes.

(d) Optimization check. If optimized, the convergence check otherwise runs until the target type is not obtained.

(e) Step 6: Convergence search. If converge then check the costs, restart the particles and repeat phase 5.

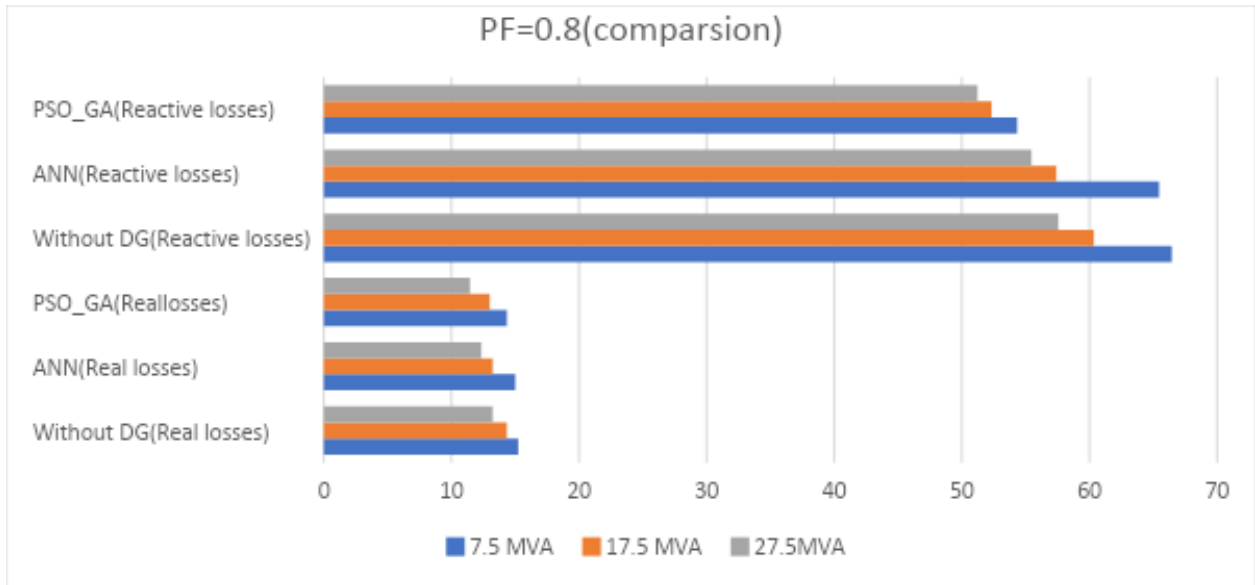
(f) Step 7: If costs are lower than C then stop.

In this paper, analysis of different approaches of congestion and loss reduction with or without Distributed generator has been considered. In table 1 and other experiment we have used IEEE30 bus system. Table 1 represents the PI sensitivity base congestion in 3- $\Phi$ , 6 lines of distributed system.

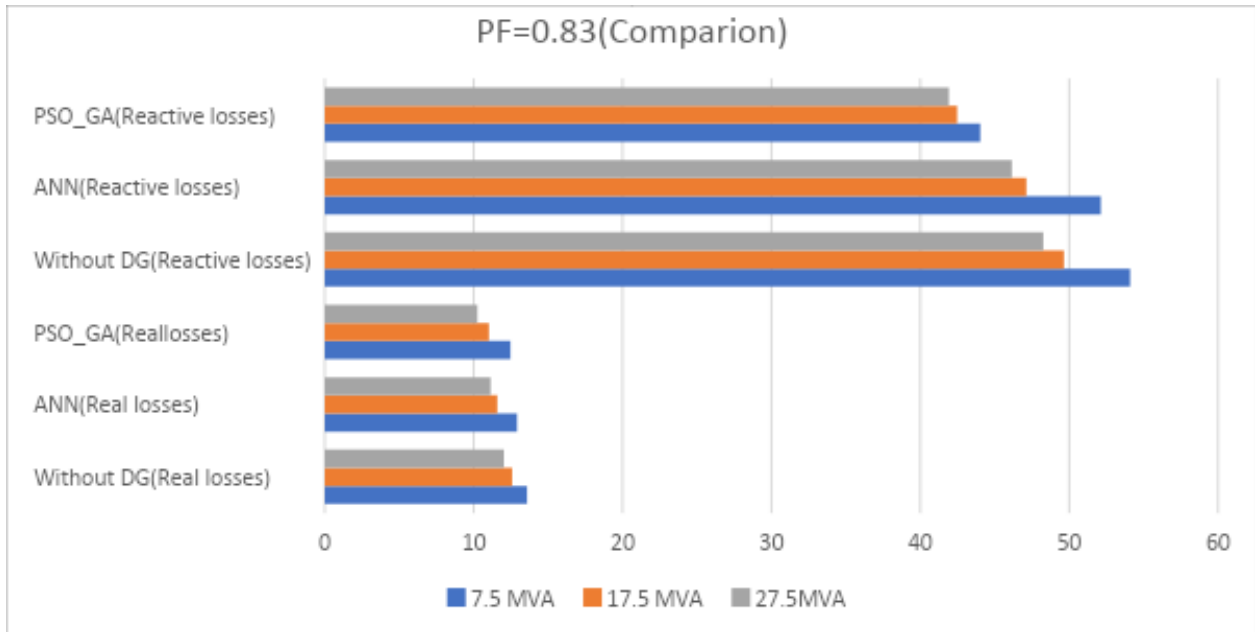
**Table 1. Congestion Lines**

FROM BUS	TO BUS	PI SENSITIVITY
5	7	-14.853
9	11	0
19	20	-6.457
24	25	-1.142
25	27	-4.694
8	28	-0.613

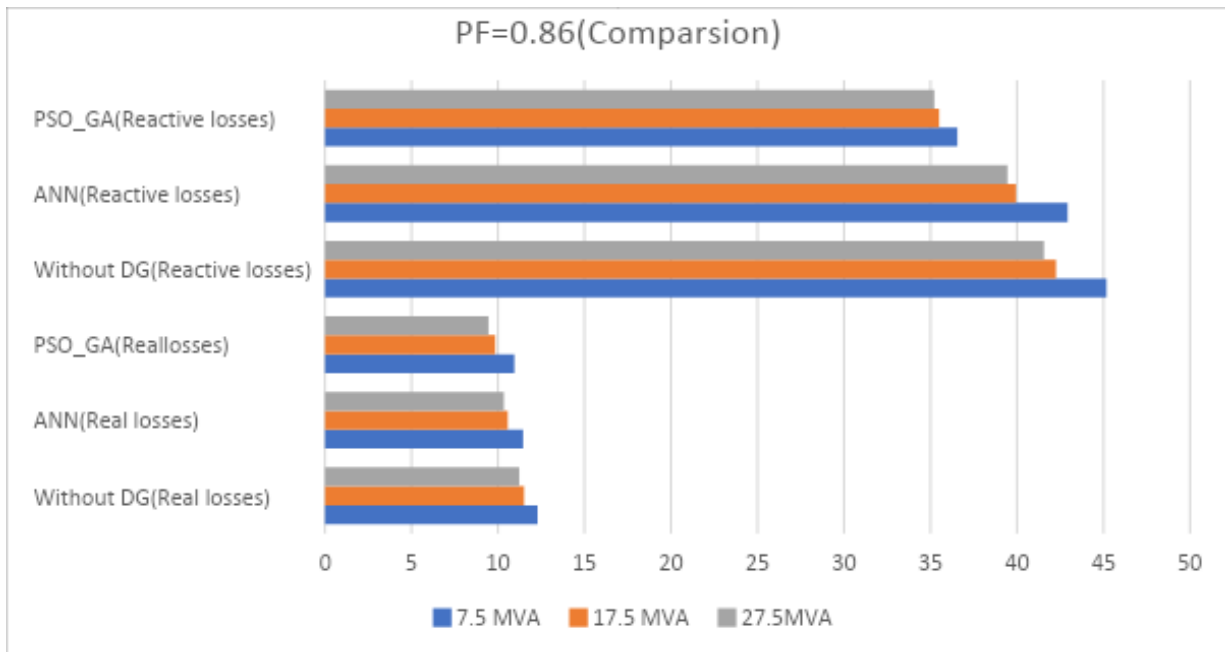
Figure 2, figure 3 and figure 4 represents the IEEE30 bus system on current, power and Voltage using the concept of Newton Raphson. It presents variation in every bus. Table 2 shows the real and reactive power losses using RECONFIGURATION and without RECONFIGURATION with different power factors. Figure below shows the comparison of real and reactive power loss. Both losses reduce when RECONFIGURATION is different.



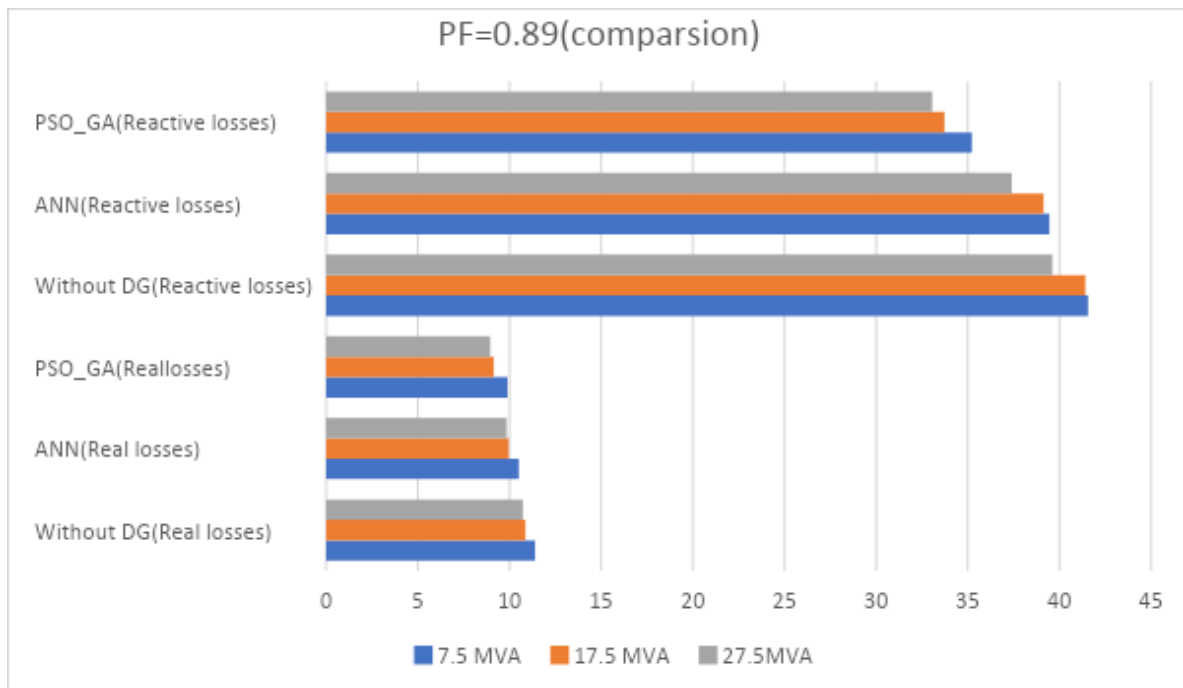
**Fig.2 Comparison of different power factor =0.8**



**Fig.3 Comparison of different power factor=0.83**



**Fig4 Comparison of different power factor=0.86**



**Fig.5Comparison of different power factor=0.89**

In fig 5 have been show the Power factor impact on Reactive losses and active of real losses with and without Distributed generator replacement. Losses Reduced when RECONFIGURATION replace in both cases. Its show optimal replacement of RECONFIGURATION effect on Losses.

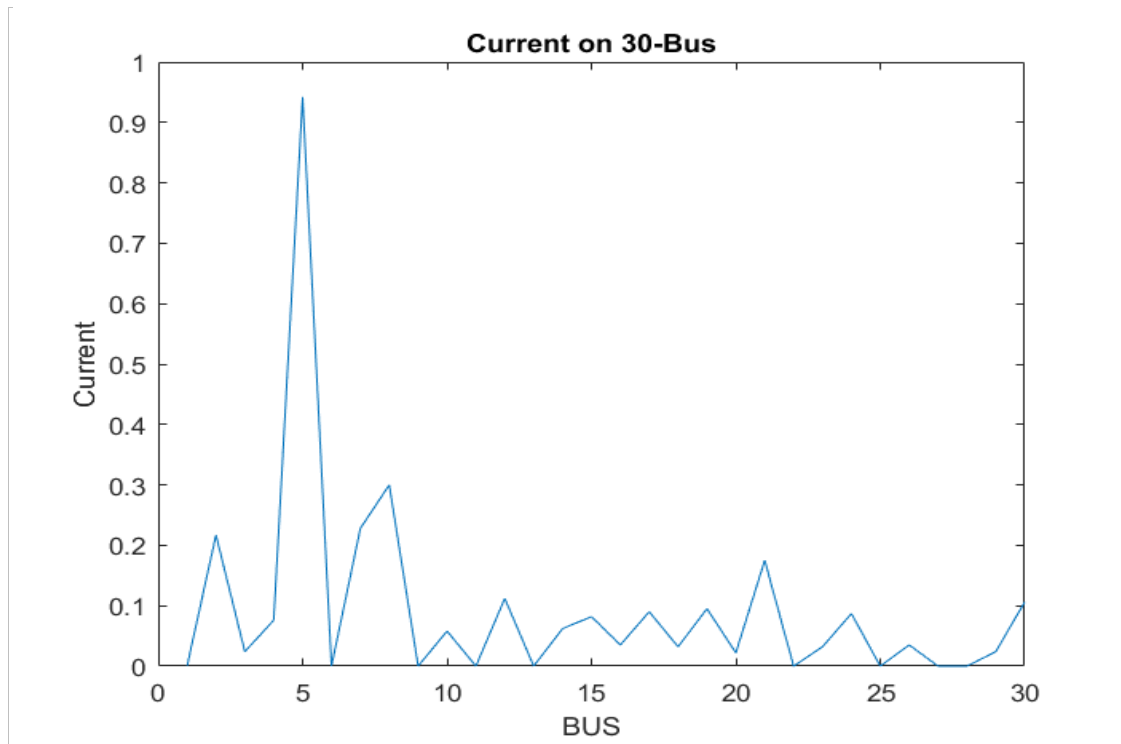


Fig.6 Current Distribution on 30-BUS

In fig 6 have been show the current distribution without RECONFIGURATION use in 30 BUS system. Its show current quality reduce because of losses Increases active and reactive.

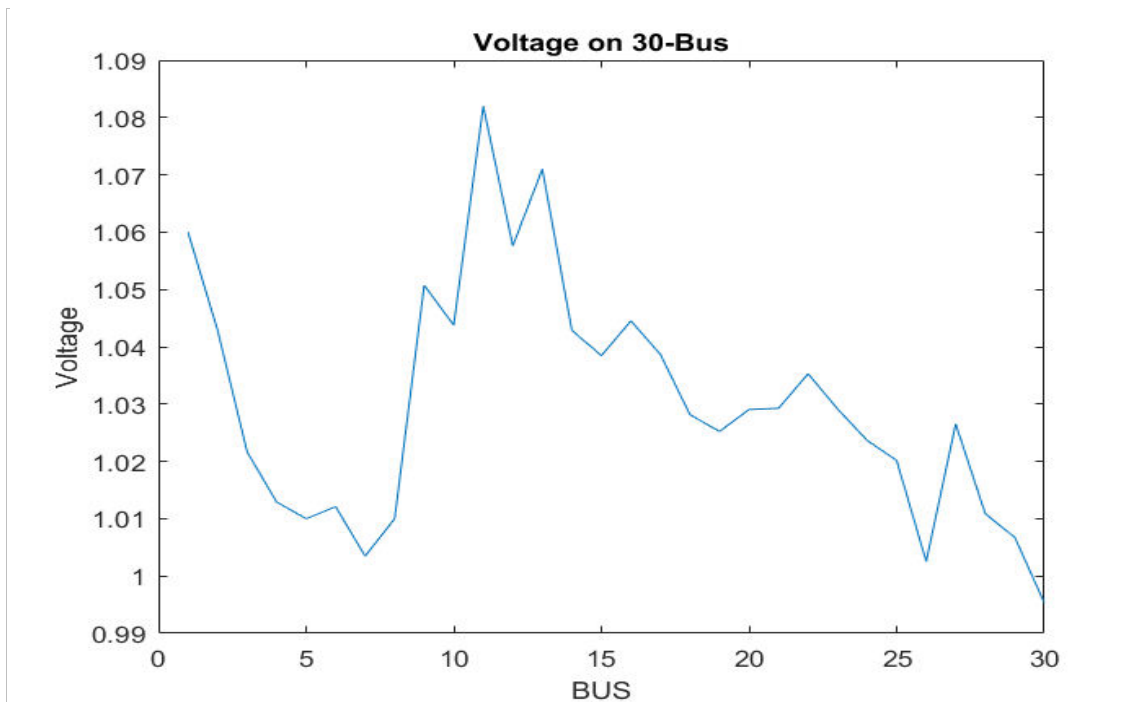


Fig.7 Voltage Distribution on 30-BUS



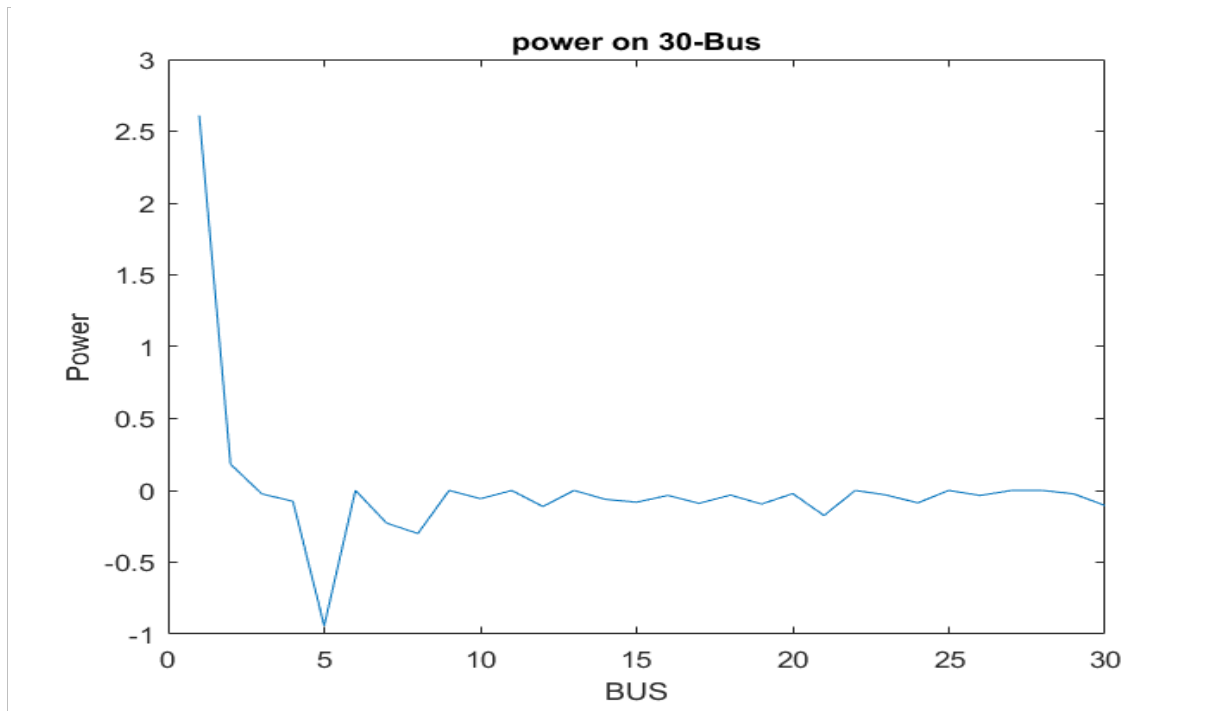


Fig.8 Power on a 30 bus

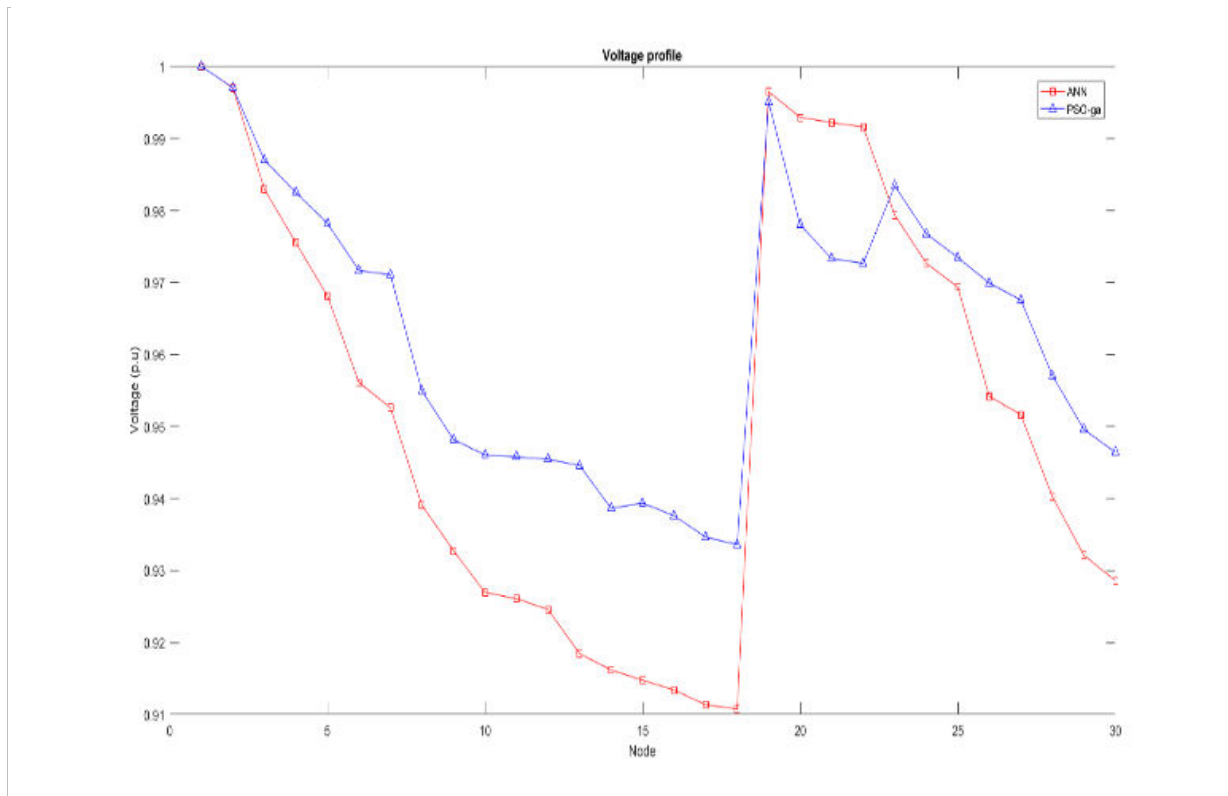


Fig.5.8 Voltage profile comparison

Table 5.2 shows the comparison of ANN and FUZZY NEURAL NETWORK (FNN) -GA base approaches for RECONFIGURATION placement in IEEE 30 bus system. Figure 5.6 represents the voltage profile after applying the techniques of FUZZY NEURAL NETWORK (FNN) -GA and ANN. FUZZY NEURAL NETWORK (FNN) -GA



helps in improving the power due to hybrid optimization process thereby improving the local and global degree of bus system but the technology of ANN focus over localized type of level. Hence, its effect on Voltage and the other parameters have been presented just like the losses and cost presented in figure 7 and figure 8, where the losses and cost of the system gets reduced in the methodology of FUZZY NEURAL NETWORK (FNN) -GA due to local and global approaches as discussed.

**Table 2. Location and losses comparison in proposed and existing**

PARAMETERS	ANN	FUZZY NEURAL NETWORK (FNN) -GA
LOCATION	[9 19]	[24 28]
LOSS	15.3422	12.333
COST	120	90
RECONFIGURATION SIZE	[10.23 7.45]	[7.23 6.45]

## II. CONCLUSION

RECONFIGURATION is optimally positioned in the distribution system that provides numerous advantages such as loss of power and harmonic minimization, enhanced voltage profile and stability, environmental friendliness and reliability improvement. In this paper, the Newton Raphson's power flow method with particle swarm optimization (PSO) algorithm hybrid with genetic algorithm is used for optimal placement of RECONFIGURATION in a distribution system. The method proposed is tested and validated in various bus test systems. The proposed optimal positioning of RECONFIGURATION units has proven resilient and provides improved efficiency for loss and THD minimization and voltage profile improvement. The research proposed aims to minimize power and voltage losses and also to reduce costs. The network's investment expense is the limited number of RECONFIGURATIONs of several smallest RECONFIGURATION sizes. The cost of this work per kVar which varies by size because the prices of large sizes are lower and the size optimum is less expensive. The index method and size of the RECONFIGURATION is used for the optimal placement of the RECONFIGURATION which is given by the proposed method and classical method PSO. The performance evaluation of the proposed work is done by comparing RECONFIGURATIONs and voltages, losses.

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