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Enhancement Of Iraqi Power Distribution System Performance

A project

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Partial Fulfillment of the Requirements for the Degree of Higher
Diploma in Electrical Engineering.**

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ
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رَبِّكَ ذِي الْجَلَالِ وَالْإِكْرَامِ ﴾

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Dedication

To my family ... who always give me support and love .

To my husband ... who courage me .

To my friends... who share my sadness before my joy.

To my professors ... who gave me knowledge.

To all those ,I dedicate this work.

Zainab Mohsin
2022

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Abstract

This project presents a method to improve the Iraqi power distribution networks performance in terms of voltage profile and reduce power losses using an optimal capacitor placement strategy. Minimizing the power losses represents the proposed objective with considering the system constraints. In order to find the optimal capacitor placement (location and size), an efficient optimization method, using the genetic algorithm (GA), is also proposed in this paper. The proposed method is based on the natural genetic operations. The goal of the study being presented here is to improve the system voltage and reduce the losses. The proposed methodology is presented to solve a real-world problem in Iraqi distribution system. The suggested approach was developed in a MATLAB / Simulink environment program and evaluated on two separate test systems. The first test is performed on (a distribution system with 69 buses), while the second test is a realistic sample obtained from the hilla distribution network of the distribution system with 99 buses. The results of many tests indicate that GA is an appropriate algorithm for use as an optimization approach since it is very accurate and steers clear of local minimums [1]. As a result, the findings of the research point to a method that is both effective and practical for addressing the issue of capacitor placement in the power distribution system.

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List of Symbols

Symbol	Definition
I	Number of buses
v_{max}	Maximum value of the bus voltage .
v_{min}	Minimum value of the bus voltage .
v_s	Voltage source
I	Current
S_n	Apparent power
v_n	Voltage at each node
p_n	Active power at each node
Q_n Q_{ci}	Reactive power at each node Injected reactive power at bus- i .
v_2	Voltage on bus 2
Z_1	Impedance of branch 1
NB	Number of buses
ϵ	Tolerance for voltage mismatches has been set at this point
Q_{G-i}^{CB}	Capacitor with reactive power
NV N	Size Number of variable
V_i^k, V_i^{k+1} :	two consecutive bus voltage repetitions on the bus

List of Abbreviations

Symbol	Description
CB	Capacitor Bank
GA	Genetic Algorithm
SA	Simulated Annealing
DSA	Direct Search Algorithm
BFA	Backerium Foraging Algorithm
ABC	Artificial Bee Colony
PGSA	Plant Growth Simulation Algorithm
TLBO	Teaching learning Based Improvement
PSO	Particle Swarm Optimization
OF	Objective Functions
CX	Cycle Crossover
UX	Uniforme crossover
OX	Order Crossover
SVCs	Static Var Compensators
ANN	Artificial Neural Network

Chapter One

Introduction

1.1 Introduction

In recently years, the electrical power demand in Iraq has increased significantly, due to the increase in economic growth and population. Moreover, in certain agricultural fields near the cores of Iraqi cities, irregular residential buildings that is not considered in future planning produced by Iraq's General Directorate of Urban Preparation, have proliferated during the previous 20 years. These buildings were fed electrical power from the nearest electrical distribution feeders without prior planning. As a result, most of the feeder lines that supply the aforementioned buildings are overloaded and have a poor voltage profile, causing consumer electrical equipment to fail. Furthermore, due to the existence of inadequate cable diameters for the load current, power losses in these feeders were increased. Electric power distribution utilities in Iraq have offered numerous solutions to improve the power distribution system in order to overcome this problem. The following are the most common traditional strategies used :

- Increase the cable size of the feeder lines that are overburdened.
- Shunt capacitors are installed along the distribution feeder to compensate for load inductive power. Shunt capacitors modify the characteristic of an inductive load by drawing a leading current that counteracts some or all of the lagging components of the inductive load current at the point of installation. By using of shunt capacitor to the distribution feeder, the magnitude of the source current can be reduced; the power factor improved, and reduces the voltage drop between the sending end and the load end[2].

- Optimal feeders reconfiguration.

Globally, the use of capacitors to supply distribution networks with compensating reactive power has become widespread in recent years. They are used to reduce power losses and to maintain the voltage profile within acceptable parameters.

The advantages of using such compensation are highly dependent on the manner in which the capacitors are installed on the system, namely the placement of capacitors as well as their size. Because there are so many possible permutations in the solution space, finding a solution to this optimization problem can be difficult and time consuming.

In this project, efficient optimization method is used to find the optimal capacitors location and size in distribution system.

1.2 Problem Definition

The placement of capacitors in the distribution network at strategic points and the appropriate size of the capacitors themselves help to cut down on the system losses. In addition, the voltage profile can also be improved, and the current of the feeders and the amount of money invested in the network can be reduced. However, there is a possibility that they will not do the job for which they are designed if they are located in an area that is not the most advantageous imaginable. Therefore, it is vital to use an optimization method to find the optimal capacitors location and sizes in the distribution system with considering the system constrains.

1.3 Literature Review

The installation of capacitors in the distribution network at ideal places and the size of capacitors may both help to decrease losses. The capacity of feeders is increased as a result of this, as is the voltage profile, which results in a reduction in network investments [3,4]. The amount to which the advantages occur is dependent on the location, size, and kind of capacitors used. A lot of researchers are working incredibly hard to find a solution to the issue of optimum capacitor placement in the power distribution network. Optimal capacitor placement is a difficult combinatorial optimization issue with many variables to consider. To get the best possible location of the capacitor, several optimization strategies and algorithms have been developed [5].

A genetic algorithm (GA) is used in conjunction with the ETAP software to solve the optimal capacitor placement problem presented in [3].

The 2/3 rule, which was the first technique for optimal capacitor placement, had been used for capacitor placement assuming a uniformly distributed load on the distribution feeder [4]; however, the major drawbacks of this method are that it does not produce the optimal solution, it is extremely time-consuming, and it is unrealistic for large networks.

Particle swarm optimization (PSO) using operators based on Gaussian and Cauchy probability distribution functions was used in reference [5] to determine the ideal capacitor location using the particle swarm optimization technique.

Using the fuzzy-based approach, Bhattacharya and Goswami [6] were able to identify plausible capacitor nodes in a radial distribution system, while the simulated annealing (SA) methodology was employed to finalize the selection of capacitor sizes.

Etemadi and Fotuhi-Firuzabad [7] employed the PSO method to discover the best capacitor location with independent goal functions. The conventional objective function of the optimal capacitor placement consists of the total cost of losses and investments. Since capacitors supply reactive loads locally, they improve the load-carrying capability of the lines and therefore play the same role as redundant lines. Thus, optimal capacitor placement can also improve the reliability indices of a distribution system. Therefore two new objective functions are defined here. The first one is defined as the sum of reliability cost and investment cost. The second is defined by adding the reliability cost, cost of losses and investment cost. The latter is a comprehensive objective function which is the resultant of the conventional and reliability-based objective functions.

Raju and colleagues [8] proposed the direct search algorithm (DSA) to determine the ideal positions and sizes of fixed and switched capacitors in order to maximize net savings while minimizing active power loss, they were able to demonstrate that it was feasible.

Tabatabaei and Vahidi [9] came up with an original approach for determining the best place to put shunt capacitors in radial distribution systems as well as the ideal size of such capacitors. This approach makes use of a novel evolutionary mechanism, and it is predicated on a fuzzy kind of decision-making. In a methodical and step-by-step process, the installation node was chosen via the use of fuzzy reasoning, which was

backed by the theory of fuzzy sets. Additionally, an evolutionary technique called the bacterium foraging algorithm (BFA) is applied in the process of solving the objective multivariable optimization problem and determining the ideal node for capacitor placement.

Reddy and Veera [10] developed a two-stage system based on the fuzzy approach and GA to determine the ideal placements and sizes of capacitors, respectively.

In [11], a loss sensitivity technique is utilized to determine the ideal positions of capacitors in radial distribution networks; the suggested algorithm, which takes into account the influence of load increase, is evaluated on a 38-bus distribution company system in the United Kingdom.

In [12], the authors offer a viable strategy for solving the capacitor placement issue using a graph search algorithm; the stated approach lowers the running cost while imposing certain limitations on the technological limits.

In [13] Sallam et al employed shunt capacitors in distribution systems for the first time to increase reliability indices. They proved that a shunt capacitor may increase the dependability of a distribution system by improving the load-carrying capabilities of the feeders by managing the reactive power flow, utilizing the state-space technique and Markov process. As a result, shunt capacitors serve the same purpose as redundant lines in terms of system security and dependability.

1.4 Project Objective

The objective of this project is to minimize the power losses and improve the voltage profile with considering the current-carrying capacity of the system branches. In order to determine the optimal capacitor allocation (size & location), an optimization method based on the genetic algorithm is used. The proposed method is based on the Darwinian principle of selection and survival of the fittest. It is a search algorithm that uses natural genetic operations for instance crossover and mutation.

1.5 Project Organization

This project is organized into five chapters, which are the introduction, an explanation of the losses of the distribution system and the traditional solutions, a discussion of the method of optimization by using capacitor placement and size based on the genetic algorithm, the analysis of the Iraqi distribution system, the results, and the conclusion.

Chapter One

This chapter provides an introduction to the capacitor in the distribution system, and a general review of the previous investigations that engage with the optimal capacitor placement problem, and an explanation of the purpose of the project.

Chapter Two

This chapter contains a synopsis that serves as an introduction to the Genetic Algorithm. The definition and principle of workings of Load flow and optimization method by adding capacitor placement and genetic Algorithms are discussed in detail.

Chapter Three

This chapter presents the GAs program that has been used effectively to solve the capacitor placement and size problem. The design variables in this problem are the capacitor sizes and location at the selected sites. The problem has been successfully solved using this program.

Chapter Four

In this chapter, the obtained results are presented and discussed to verify the effectiveness of proposed method.

Chapter 5

This chapter presents the project conclusion and the future work.

Chapter Two

Theoretical Background

2.1 Introduction

losses in Iraqi distribution system increases and the system voltage deteriorates due to the continuous increasing of the load demand [14]. Numerous solutions, such as placement of distributed generator, capacitors and system reconfiguration and other measures can be devised to help decrease these losses [14,15]. While the Iraqi distribution systems are created as weakly meshed networks, they are operated as radial networks, with the switches positioned at the ends of each branch.

As mentioned before, the proposed method is based on placement of capacitors in the system to decrease the losses and increase the voltage. In this chapter, the optimization approach based on genetic algorithm is presented. In addition, this chapter demonstrates how the installation of the ideal capacitor arrangement contributes to the resolution of the aforementioned issues.

2.2 Distribution And Transmission Line Losses

Generally speaking, the distribution sector is regarded as the weakest link in the whole power system. Transmission losses account for around 17 % of total losses, whereas distribution losses account for approximately 50 % of total losses. Losses in transmission and distribution system are classified into two types [16] which are technical and Non-technical Losses.

- i. **Technical losses:** arise as a result of power dissipation (as I^2R) in components of power systems such as lines [17,18]. These losses are also observed in transformer windings and cores.
- ii. **Non-technical losses:** Rather than being caused by technical failures, non-technical losses result from actions taken by the power system's external actors. These actions include non-payment of utility bills and stolen electricity by using illegal connections [19].

These connections can result in malfunctioning and overloading and system equipment, that can have a negative impact on the revenue of utility providers as a result of the unexplained power consumption .

2.3 Load Flow Analysis of Power Systems

A power flow analysis is a tools to determine the system variables at the steady-state such as current, power and voltage. For many decades, researchers have been studying how to make this software operates as quickly, efficiently, and accurately as possible. It is necessary to match the characteristics of the source and the load in order to solve the load-flow issue using the circuit rules imposed by the transmission lines in order to solve the problem. Regulation is used to keep the voltage output of power plants consistent. Consequently, power supplies are often treated as constant voltage sources in the load-flow program to account for this.

Figure (2.1) depicts a simple circuit architecture for a single customer load that is linked to a generator through a transmission line.

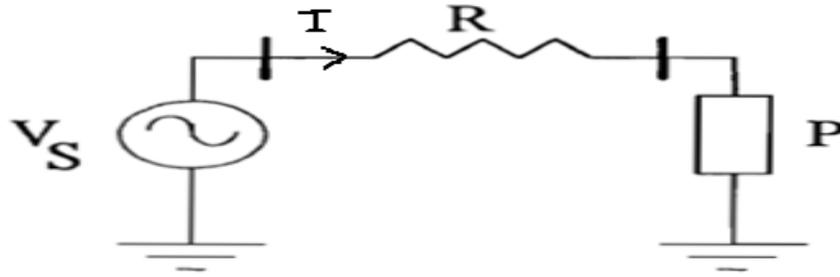


Figure (2.1): Circuit model for load Flow.

It is necessary for the source voltage to match the voltage across the transmission line plus the voltage across the load according to the requirements of circuit theory. As a result of Ohm's Law, it is possible to represent the voltage across a transmission line as a product of the current flowing through the line multiplied by the line impedance. There is a linear connection formed as a consequence of this.

$$V_s = IR + V_L \quad \dots\dots\dots (2.1)$$

Where V_s is a constant quantity, V_L represents a voltage across the load may be used to define a constant power load as follows.

$$P = V_L * I \quad \dots\dots\dots (2.2)$$

P represents a constant power load .

Figure (2.2) depicts a visual representation of the solution of these two relationships for the model shown in Figure (2.1). It Must be noted that this straight forward case may be solved in closed form. However, if the number of generators, loads, and transmission lines in the system grows, a numerical technique will be necessary in order to find a solution to the problem . The intersection of the constant power curve and the linear

relationship arising from the circuit equations represents the solution to the load-flow issue. As demonstrated in Figure (2.2), the curves may come together in more than one place. However, for a power system, only the location with the maximum load voltage is a feasible answer. It is conceivable that the curves do not cross, in which case there is no solution [20].

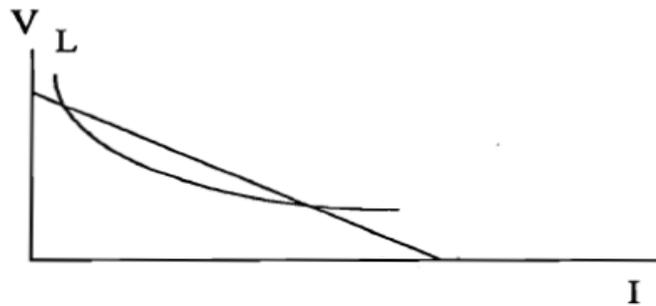


Figure (2.2): Load flow solution

The Gauss-Sidle, Newton-Raphson, and ladder load flow techniques are the most often used methods for determining load flow. In this project, we will make use of the ladder load flow method since it has a number of benefits over algorithms that were built especially for transmission analysis. Probably the most notable feature of the Ladder Method is that it can be written down without the need for matrix operations. For big systems, matrix operations cost a significant amount of time and memory. The connection of the system is represented by "points" in this version of the Ladder Load-Flow Method. Such a strategy boosts the speed of execution while also organically dealing with the sparsity of the system's data structure [20].

2.4 Ladder Load Flow

It is one of the techniques used to calculate the total load that is being carried by the system. This method is divided into two phases, namely, pull-back and sweep-forward [19]. In the process of solving the problem of optimum capacitor placement, the power flow plays a vital and effective role as it is used as a sub-measure in each iteration. Accordingly, the power flow technique must be computationally efficient and robust. In numerical terms to provide better performance in practice. Therefore, the forward-to-back-scan strategy, or the so-called peaceful repetition approach, is adopted, as it can be implemented directly and is a reliable method for radial feeders [19].

The following equation used to calculate the load current at each node:

$$I_n = \left(\frac{S_n}{V_n}\right)^* = \left(\frac{P_n + jQ_n}{V_n}\right)^* \quad \dots\dots\dots(2.3)$$

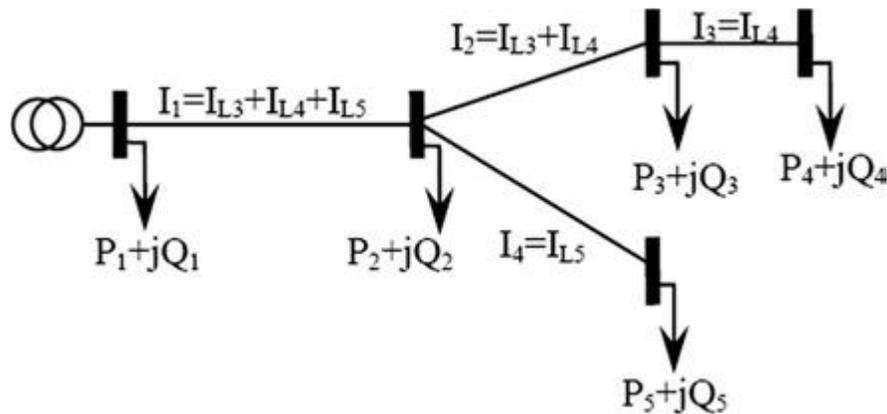


Figure (2.3): Sample distribution feeder

Assuming a voltage of one p.u for each bus, Kirchhoff's current equation is used to compute the branch currents during the first backward sweep. To update bus voltages in the forward sweep, Kirchhoff's voltage law is used in conjunction with the overall current flowing during all branches. Each bus's voltage drop is calculated by starting at the source bus and working outwards, using the previous backward sweep as a beginning point for each bus's voltage drop. For instance, the voltage on Bus 2 is calculated as follows :

$$V_2 = V_1 - Z_1 I_1 \quad \dots\dots\dots(2.4)$$

Where -:

Branch 1's impedance is Z1

With updated bus voltages each time, repeatedly rerun the backward sweep in order to reach the convergence requirement, and the procedure will continue until this is achieved.

$$\text{Max} | V_i^k - V_i^{k+1} | < \varepsilon \quad i=1,\dots\dots\dots,\text{NB} \quad \dots\dots\dots(2.5)$$

Where: -

V_i^k and V_i^{k+1} : are two consecutive bus voltage repetitions on the bus

NB: is the number of buses.

ε : Tolerance for voltage mismatches has been set at this point.

The steps of the backward /forward sweep (BFS) algorithm to find the radial distribution system load flow are shown in Figure.(2.4)

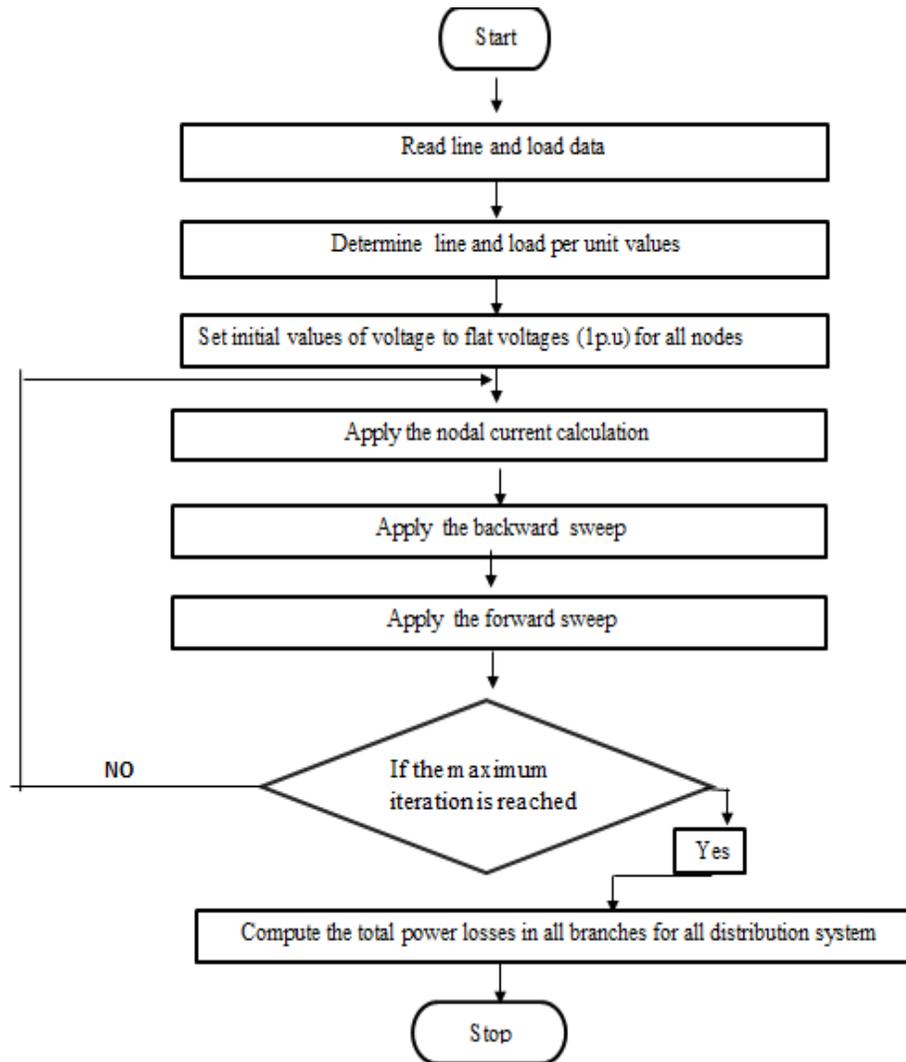


Figure (2.4): Flowchart of Load flow.

2.5 Optimal Capacitor Placement

Capacitors have long been used in distribution networks to compensate for reactive power. The purpose of these devices is to reduce power losses and maintain voltages within acceptable limits, as well as to raise the released thermal capacities of distribution lines and transformers and improve power factors. It is more common for capacitors to be put on distribution systems in a three-phase configuration rather than a single phase arrangement, a single unit, or in a bank series or shunt configuration. At the site of installation, An inductive load's characteristic is altered by drawing a leading current that neutralizes the trailing components of the inductive load current. It is possible to lower the amount of the source current by connecting a shunt capacitor to the distribution feeder. The power factor has been enhanced, and the voltage drop between the transmitting end and the receiving end has been reduced [21]. Therefore, the ideal placements and sizes of capacitors in distribution networks may be treated as a restricted optimization issue. To tackle this problem, optimization techniques are utilized such as Heuristic meta such as artificial bee colony (ABC), Plant Growth Simulation algorithm (PGSA), Teaching Learning Based Improvement (TLBO), particle crowd optimization (PSO), genetics Algorithm (GA), Precision Genetic Algorithms and Approaches (MGA) [22-23]. Genetic Algorithms are different from normal optimization and search methods in four ways: 1. GAs work with coding of the parameter set, not the parameters themselves. 2. GAs search from a population of points, not a single point. 3. GAs use payoff (objective function) information, not derivatives or other auxiliary knowledge. 4. GAs use probabilistic transition rules, not deterministic rules [24].

2.6 Installation Of Capacitor Bank Into Load Flow

For an example, let us assume that a distribution feeder with N buses and the substation connected at bus-1. If the capacitor with reactive power ($Q_{G_i}^{CB}$) is installed at bus- i along the radial feeder, reactive current will flow in the feeder branch altering the reactive component of the branch current and decreasing the inductive current .

In load flow algorithm, it is necessary to modify the reactive power demand at each node to include the capacitor reactive power. At the i -th bus at which a capacitor bank unit is installed, the reactive power demand is updated as follows:

$$Q_{D-i}^{\text{withCB}} = Q_{D_i}^{\text{with outCB}} - Q_{G_i}^{CB} \dots\dots\dots(2.6)$$

$$[S] = [S_{Di}] - [S_{CB-i}] \dots\dots\dots(2.7)$$

2.7 Genetic Algorithm

John Holland was the first to provide the theoretical basis of genetic algorithms [24] .An optimization issue can be solved using the GA, which is a global search approach that was inspired by Darwin's natural law and the concepts of genetics, but which can also be used to tackle other problems.

The genetic algorithm is a type of heuristic algorithm that has been used widely to solve optimization issues for a variety of difficulties [21].The GA

approach is based on the creation of a randomly generated solution to an optimization problem to produce a population of persons (or individuals). As a result, using the objective function, these individuals are ordered according to the value of their return on assessment. Figure (2.4) depicts the procedure of using a genetic algorithm.

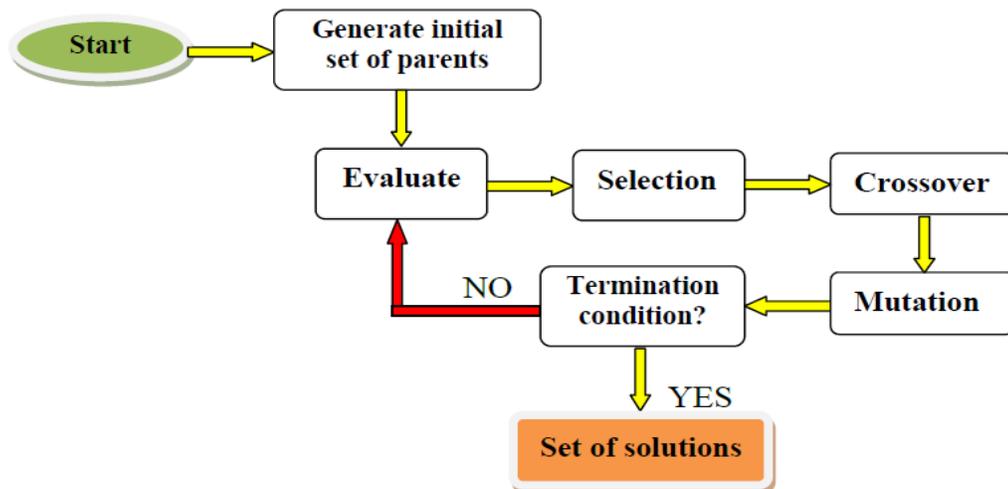


Figure (2.5): Process of genetic algorithm.

The following are the most prominent words associated with the GA [21]:

An individual's situation: Individuals can be considered for the point at which an objective functions (OF) is put into effect. In this case, it is a set of variables' values for which the optimization function is to be performed. Individuals are referred to as "scorers" because they have certain OF value. Individuals are regarded to be the vector entries that are associated with the genes of a genome.

Population: There are many different people in the population. According to mathematics, if N is the size of the population, and NV is the number of variables in the OF, the population may be represented mathematically by a matrix of size $N \times NV$, in which each row corresponds to a unique individual.

Generating: Is the first step of a process. A number of calculations are performed on the existing population at each iteration, with the results of these computations being utilized to construct a new population (as explained in the following sections). The new generation refers to the succeeding populations that have been formed.

Children and their parents are included: The GA picks a number of individuals from the existing population, known as parents, in order to form the next generation. Individuals of the following generation, known as children, are created from the genetic material of this generation.

2.7.1 Genetic Operators

Genetic Operators are a type of genetic operator that may be used to change the genetic makeup of a population of an organism. As a starting point, the terms outlined above are used to describe the genetic operators that are often used on parents to produce offspring for the next generation [25].

- **Selection.** Selecting the fittest individuals from the present population to be employed in the generation of the next population is accomplished by this method.

- Crossover.** This operator permits genetic information to be exchanged between pairs of people when the operator is used. Crossover children are youngsters who have crossed over from one group to another. Two randomly chosen chromosomes from the middle generation are chosen for further study. Afterward, a random number (n) is chosen from 1 to the length of a chromosome, and pairs of selected chromosomes from the n-th gene to later genes are exchanged with each other to form new chromosomes. This procedure is repeated for each gene. Figure (2.6) show example of crossover operation

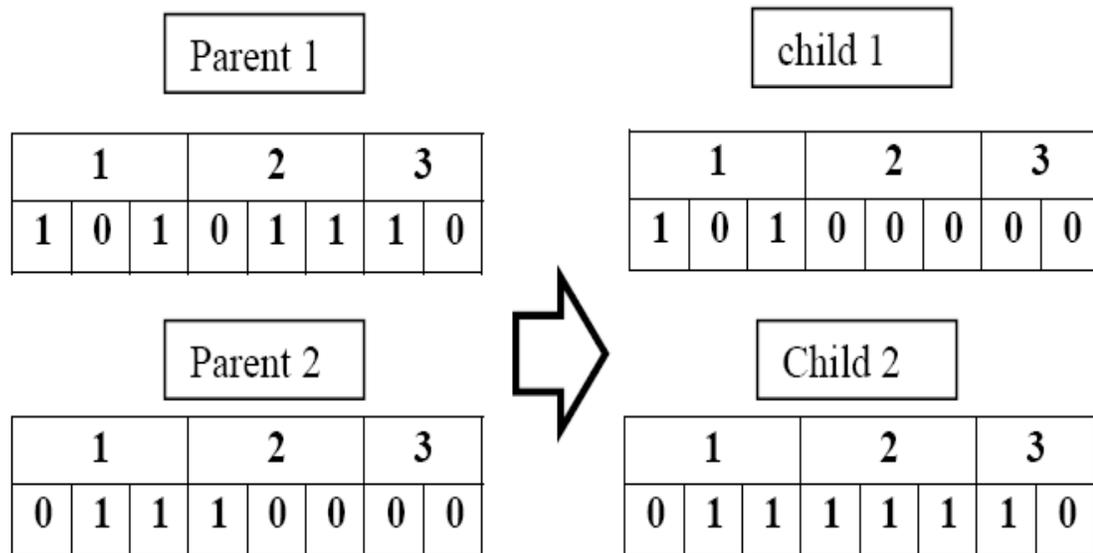


Figure (2.6): Crossover operation

- Mutation.** Is a term used to describe the process of changing something. Individual genomic representations necessary to be

modified as a result of the mutation are altered in accordance with a set of probabilistic principles. Some solutions are also randomly updated in order to evaluate the fitness of each element and to prevent the algorithm from reaching a local optimum. So, a chromosome is chosen at random from a pool of candidates. Then some of its genes are replaced with a random number generated by the computer. A mutation is a term used to describe the random variation of a gene in each category.

Figure (2.7) show the scheme of new generation production.

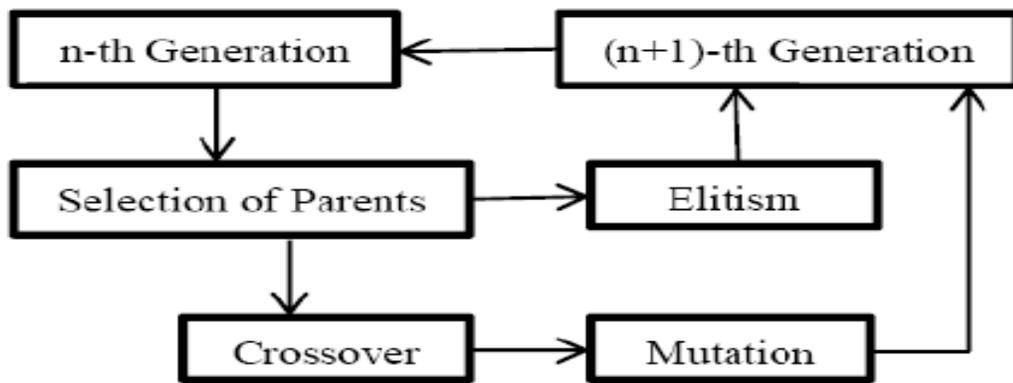


Figure (2.7): New generation production

Algorithm the following is a proposal, the proposed approach for obtaining the optimal position and placement of selective capacitors in distribution systems is based on multi-objective optimization techniques [26]:

Step 1: Prepare the line, load the data into it, and then deliver it to the user as an input parameter.

- Step 2: Calculate the flow of the loads and calculate the delivery mechanism.
- Step 3: Create a random beginning population and set the iteration count to zero before starting the simulation.
- Step 4: Determine the CB 's maximal size and location (no. of the bus).
- Step 5: If the bus voltage does not fall within the chromosome's authorized range, the chromosome is deemed infeasible and should be removed from the experiment altogether.
- Step 6: Figure out how much each chromosome is worth in terms of the fitness function, which corresponds to how much the objective function of is worth in this case (5).
- Step7: From lower to higher, arrange the objective function values in descending order, discarding the values that are unsuitable while retaining the values that are the fittest.
- Step8: To generate a new set of chromosomes, utilize the preserved chromosome to carry out Mutation and Mating procedures on the other chromosomes.
- Step 9: To find out how to fit each of the newly generated chromosomes is, use the fitness values.
- Step 10: Boost the number of iterations by one and repeat steps 5 through 9 before the number of iterations exceeds the limit.

The standard procedure of GA is shown in flowchart as shown in Figure 2.8

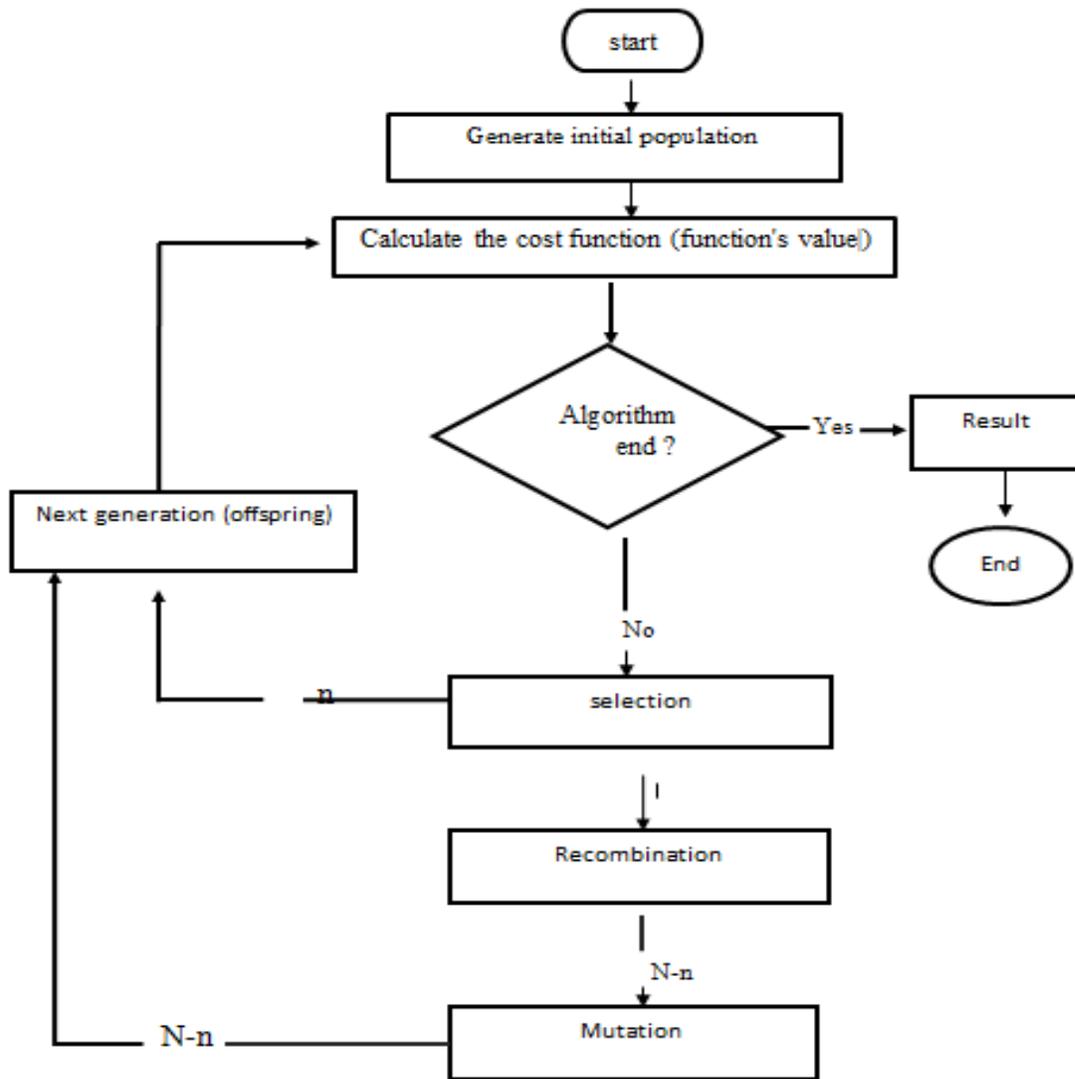


Figure (2.8): Flowchart genetic algorithm.

2.8 Types of Crossover

The crossover operator will take a population, split it up into pairs of people, and then recombine the genes of those individuals with a certain amount of likelihood [27]. Immediately after the processes of selection and reproduction comes the process of crossover. And it is used to combine the pairs of chosen strings (Parents) in order to develop new strings that have the potential to have more excellent fitness than either of their parents. It is often done using a probability that is termed the crossover probability (P_c), and this probability is typically selected to be close to one in order to keep some of the nice strings that were identified in the past. Take note that the value of the bits will not change as a result of this operation. The crossover may be accomplished in a number of different ways such as [21, 28]:

1. The One - Point Crossover.
2. Two -Point Crossover.
3. Order crossover (OX).
4. Cycle crossover (CX).
5. Uniform crossover (UX).

One-Point Crossover 2.8.1

Single point intersection is one of the most basic types of intersection operators and one of the most popular types of intersection operators. It is also one of the simplest intersection operators. In the course of this method, the cutoff point will be selected randomly. The next step is to create children for each parent's chromosome by adhering to the procedures described below. In order to facilitate understanding of the concept, the two parental chromosomes were shown in Figure. (2.9) The cutoff point, which is placed between genes 6 and 8 of parent 1 as well as between genes 3 and 2 of parent 2 was determined by a stochastic process and placed there. The remaining gene pathway can be determined in the order in which nodes on a chromosome or offspring are found after the primary node is finally spliced

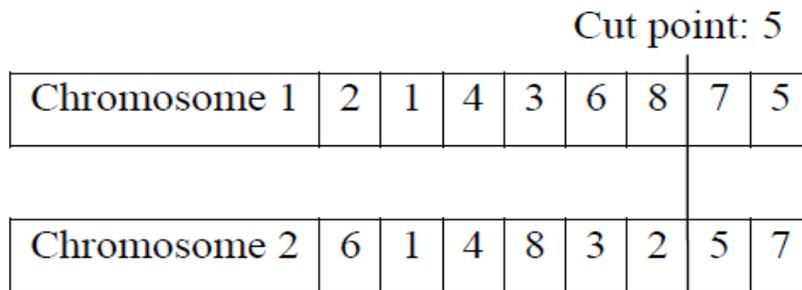


Figure (2.9): father chromosomes with a cut at the gene's location

Every single one of the cut points has an equal probability of being achieved. The new kid will inherit genes from their first parent up to the cut point, as well as non-repeating genes from the beginning of their second parent [29].

- i. It is recommended that random sampling be used to determine the cut points between any two genes. A cut point is referred to as an empty rectangular area for the purpose of simplicity throughout this research. In Figure. (2.10), this may be observed. Consequently, each parent chromosome has two distinct substrings, one before and one after the cut point..
- ii. It is necessary to copy and paste the starting segment from Parent 1 into the string that represents Offspring 1.
- iii. Copy each gene from Parent 2 one at a time and put them one at a time into the Offspring 1, deleting the repeated values to prevent duplication.
- iv. In order to produce offspring 2, the roles of the parents are switched around.

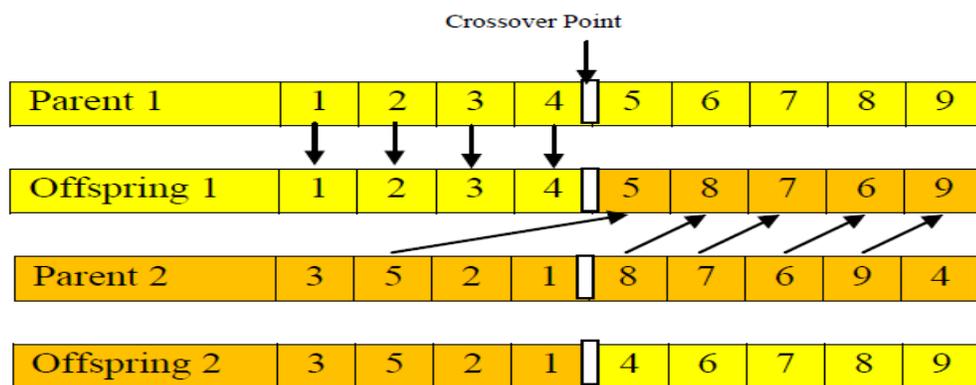


Figure (2.10): A graphical illustration of a crossover at a single point.

2.8.2 Two-point crossover

The functioning of a two-point crossover is quite similar to that of a one-point crossover. To create two offspring rather than just one, two random cut spots are randomly selected at the same locations in two parents.

- i. Randomly choose two places in the list of genes from each parent that divide them into two distinct individuals.
- ii. Figure 8a demonstrates how to transfer the substring from Parent 2 to Offspring 1 by selecting it between the two cut marks..
- iii. The remainder of the data is taken directly from the first parent and placed into Offspring 1 precisely as they were. , with the exception of any repeated values. For example in Figure. (2.11), genes 1 and 8 have already been inserted in the center of the Offspring 1 population. As a result, they are excluded by virtue of being copied to it. For the remaining values, just copy and paste them from Offspring 1's first parent

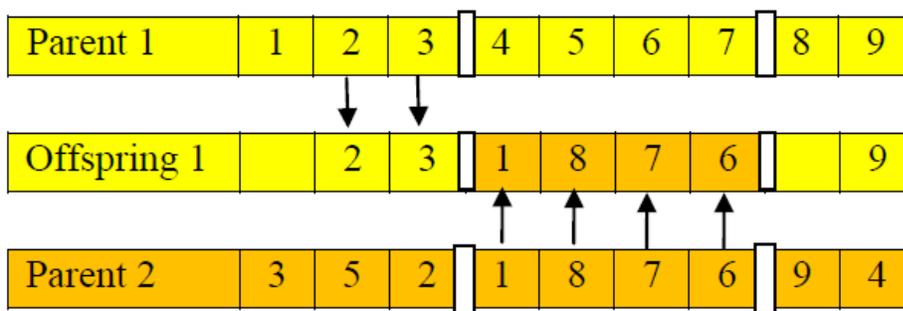


Figure (2.11): Two-Point Crossover Diagram Exemplified

- iv. Genes that were not present in the first parent are present in the Offspring 1, but in the same order as they occur in the second parent after the second cut point, as seen in Fig 8b in the first offspring (Since gene 4 is shown after a second cut point of the Parent 2, it is placed first in the Offspring 1 followed by gene 5.).
- v. By swapping the roles of the parents, it is possible to develop Offspring 2, which is indicated by the symbol Offspring 2 in Figure.(2.12).

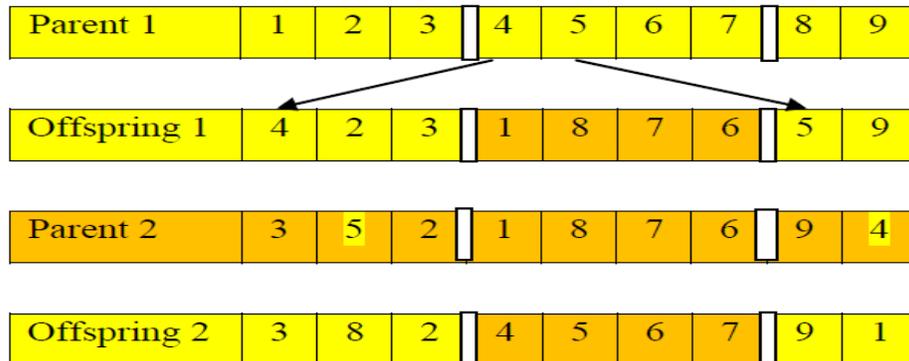


Figure (2.12): An example of a Two-Point Crossover diagram.

2.9 Benefits Of using Genetic Algorithms

- Because genetic algorithms don't start from a single design but rather from a collection of designs, their odds of discovering a more optimal solution are significantly increased by this search strategy
- Because genetic algorithms only employ fitness values, they do not need derivatives; hence, they do not require extra knowledge about

the objective function; consequently, they are insensitive to regional optimal points, to which mathematical optimization approaches are sensitive.

- Because of the variation operators (selection, recombination, and mutation) that they utilize to access the parameter search space, they are also resistant to premature convergence. This is due to the fact that these variation operators are what allow them to fully explore the parameter space.
- Genetic algorithms are applicable to the great majority of engineering design problems because they can work with both discrete and continuous parameters. The "Optimal Capacitor Placement Problem" may be solved using a genetic algorithm because of the discrete character of the optimization problem.
- Genetic algorithms are entirely parallelizable, which means that the assessment of chromosomes may be done separately from one another. Furthermore, since the created population of solutions is the result of a wholly random process, there is no reliance between generations of solutions.
- Due to the aforementioned properties, genetic algorithms are resilient because they are able to modify their chromosomes in response to changes in their surroundings in the same manner as their biological analogs do.

2.8 Application of GA in Power System:

1. The genetic algorithm (GA) may be used to find the combination of generating units in the Economic Load Dispatch issue that will result in the lowest possible overall operating expenses. The Genetic Algorithm is able to locate a global (or sub-optimal) combination of generation units in the global solution space for this particular issue. The solution generated by the Genetic Algorithm encodes each generation unit as a binary string. The fitness function takes a string and changes it into a real number. This real number represents the entire cost of particular power distribution across units [30].
2. Two stages of a solution technique based on GA were developed in order to give large-scale unbalanced power distribution systems a realistic idea of capacitor placement, replacement, and control. There are several advantages to using this two-stage process, including speedy sensitivity-based search and wide search with GA. [30].
3. An strategy that uses a genetic algorithm (GA) to solve the optimization issue of link phase arrangement between distribution transformer banks and the main feeder that has a radial topology. [31].
4. The GA can be used to dispatch sources of reactive power in a variety of different system settings. The allocation of reactive power sources is made easier with the assistance of GA, which helps to ensure that the required degree of safety is maintained.

The suggested evolutionary algorithm makes use of transformer tap changers, static capacitors, static Var Compensators (SVCs), and generator terminal voltages as its reactive power sources [28].

5. When applied to the issue of loss-minimum reconfiguration, the GA is shown to be a viable algorithm as an optimization strategy, and the researchers discovered that it is possible to attain an approximate global optimum using this method [28,32]. And in other study, an algorithm for the distribution system reconfiguration issue was developed using the Genetic Algorithm (GA) for optimization and the Artificial Neural Network (ANN) for recognition; the GA optimized the system-switching pattern [33].
6. The GA is used in the process of resolving issues with the allocation and management of capacitors in electrical distribution networks. The suggested method draws its inspiration from the daily load fluctuation curve in order to pinpoint the most advantageous sites for fixed and switched shunt capacitors [34].

Chapter Three

Proposed methodology for the Optimal Capacitors Sizing and Placement

3.1 Introduction

In this chapter, the proposed optimization algorithm for finding the optimal capacitors location and size in distribution network to improve the voltage profile and decrease the system losses is presented. The algorithm is broken down into two stages: the load flow solution stage, and the genetic algorithm stage which is utilized to determine the optimal sizes and locations of capacitors.

3.2 Proposed Methodology

The proposed method for addressing the capacitor placement and size in distribution system is based on genetic optimization algorithm. Traditional optimization approaches such as nonlinear programming, which have limits in looking for completely optimum solutions and may get caught in a local minimum, are being replaced by GA to address these issues. In contrast, the suggested technique has the novel benefit of simultaneously determining the ideal size as well as the optimal location of the capacitors banks.

3.2.1 Objective Functions and System Constrains

The proposed objective function is based on minimizing the system losses (P_{Loss}) which is mathematically defined as:

$$\text{Min (OF)} = (\sum_i^{NL} P_{Loss}^{with CB}) \dots\dots\dots (3.1)$$

The following system constrains are considered in the proposed optimization method:

(i) Bus-voltage constraint

$$V^{min} \leq V_i \leq V^{max} \quad \forall i = \text{numberofbus} \dots\dots (3.2)$$

(ii) Branch thermal limit constraint

$$I_i \leq I_{max} \quad \forall i = \text{numberofbranch} \dots\dots (3.3)$$

(iii) Capacitor size constraint

Capacitor must be within their possible minimum and maximum limitations for reactive power injection, which are as follows:

$$Q_c^{min} \leq Q_{C,i} \leq Q_c^{max} \quad \forall i = \text{numberofbus} \dots\dots\dots (3.4)$$

Where $Q_{C,i}$: Injected reactive power at bus- i .

(iv) Reactive power constraint

The total capacitive power (Q_C^{Total}) installed in the system must be lower than or equivalent to total reactive power of the system loads (Q_L^{Total}) as \therefore .

$$Q_C^{Total} \leq Q_L^{Total} \dots\dots\dots (3.4)$$

3.2.2 Optimization algorithm

i. Initialization

The initialization is the process of creating a population. There are two optimization factors (locations, size) in each chromosome of this population as shown in figure (3.1). The starting population is produced at random and comprises these two variables. The resulting value for each choice variable is determined using a random number generator. CBs of various sizes (kVA) are to be installed at the load nodes, with the exception of those connected to the substation buss.

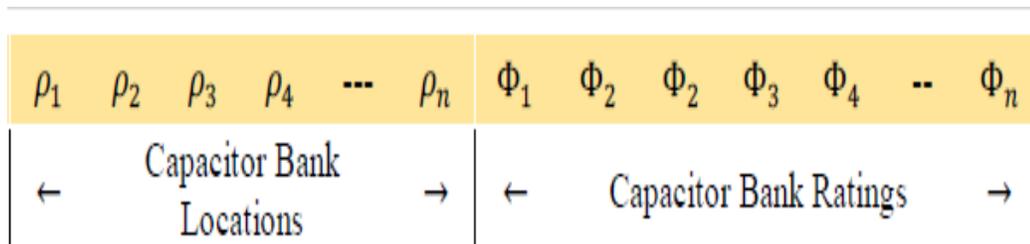


Figure (3.1): Proposed chromosome structure.

ii. Fitness Function

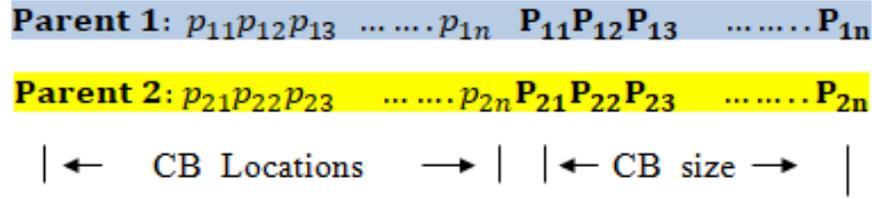
The fitness function or objective function represents the minimizing of the system losses as mentioned before. The losses is determined using ladder load flow algorithm discussed in Chapter-2.

iii. Reproduction

In this step, the program randomly selects the best pair of chromosomes found where the number of chromosomes was 100 chromosomes and 10 per chromosome length (5 for size and 5 for location) for a system of 69-bus and 200 chromosomes with a length of 20 per chromosome, for a system of 99-bus to mate and form a new generation. After that Perform Load Flow Algorithm to evaluate power losses for each chromosome.

iv. Crossover

After the random selection of the parents, single _ point crossover was used, where it divides the two parental chromosomes in a crossing site that is randomly selected by the program. Figure (3.2) shows an example to illustrate the crossover operation on the chromosome that we built with length 10. After that Perform the load flow algorithm to evaluate power losses for each offspring.



Then, as seen below, a single offspring is created.

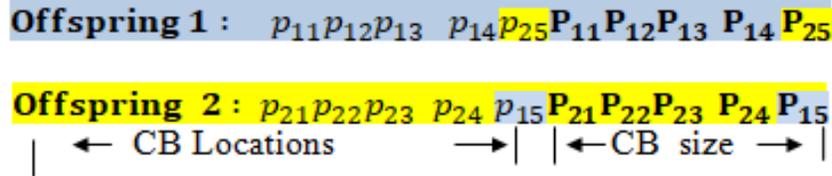


Figure (3.2): Example of the GA crossover operation.

v. Mutation

An unexpected change was observed in the chromosomal variable, i.e. in the location and size of the capacitors, and we interpret this change as a mutation. The mutation location may be in position 5. Outcross: In the example, a random value was created using the mutation site's given value (xx) as shown in figure (3.3). Mutation helps GA get a better answer. Depending on the user's mutation chance, mutation may occur throughout evolution. After that Perform Load Flow Algorithm to evaluate power losses for each offspring obtained by mutation.

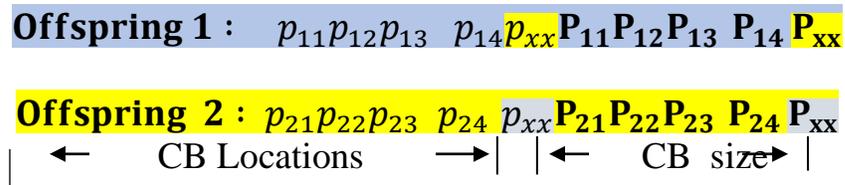


Figure (3.3): Example of the GA mutation operation.

vi. Elitism

By crossing and mutating, a new group may lose its best chromosome. Elitism involves replicating the best chromosomes to a new population. GA has the remaining population. Elitism improves GA performance by not abandoning a superior solution.

3.2.3 Proposed algorithm Flowchart.

The proposed optimization approach using Genetic Algorithm to find optimal location and size of CB in radial distribution system is shown in Figure (3.4)

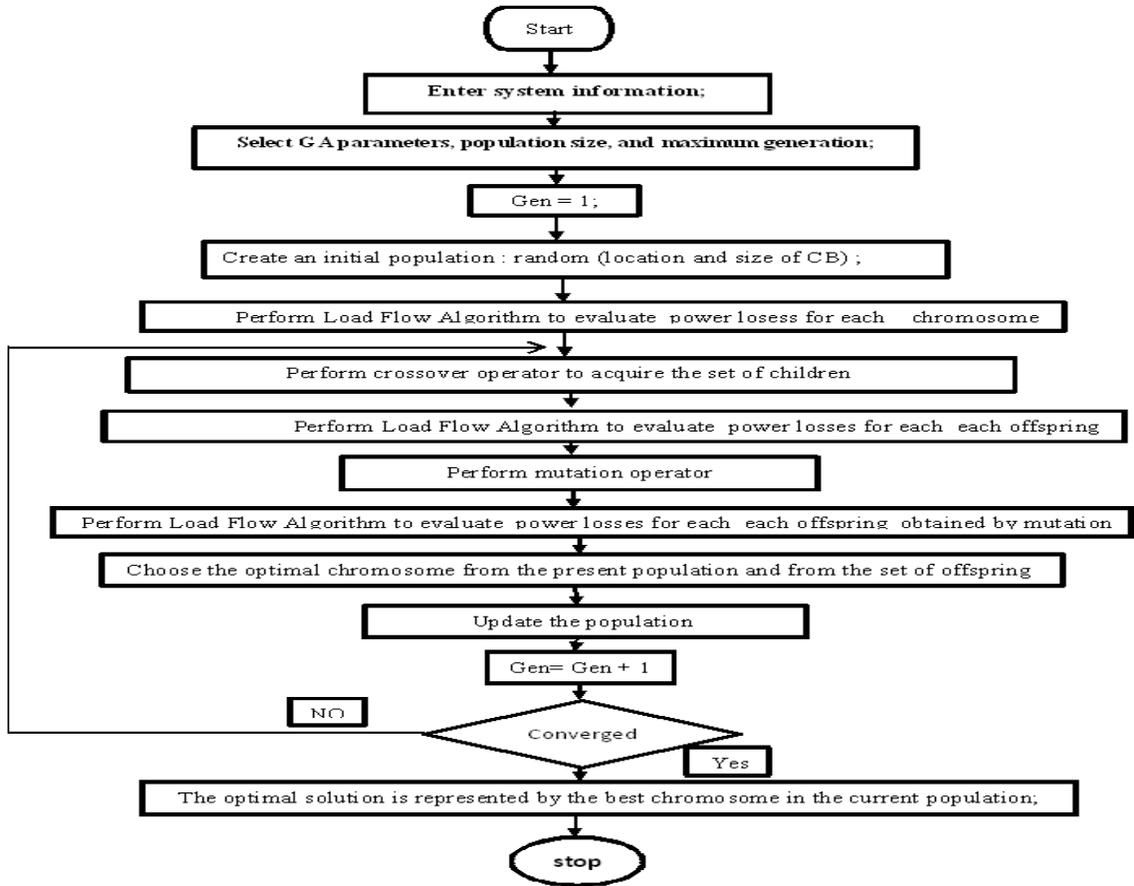


Figure (3.4): Proposed algorithm Flowchart

Chapter Four

Result and Discussion

4.1 Introduction

As mentioned before, in order to solve the issue of CB placement, an effective optimization method is necessary to determine the best position and size for CBs. In this chapter, two test cases which are the 99-bus real feeder from Iraqi distribution network and the IEEE 69-bus feeder are utilized to evaluate the proposed method. The obtained results are also discussed. The computer program of the proposed method is developed using MATLAB program.

4.2 Test Systems

In this project, two test systems are utilized to evaluate and the method effectiveness. The system details for the two test cases will be illustrated in the following subsections.

4.2.1 IEEE 69-bus System

This system consists of 69-bus and 68-branch as shown in figure (4.1) [35]. It has only one substation, which has a voltage magnitude of 1p.u., and the rest of the buses of the network are load buses. According to the data from the system, it was discovered that the active load power is varied from (0 to 1244kW), and reactive power is varying from (0 to 888kVAR). More details are presented in Appendix-A.

4.2.2 99-bus Iraqi distribution system

The 99-bus Iraqi system is an actual feeder from distribution network of Hilla city, in Iraq. The system has one substation named AL-Shaoy substation, which has a voltage magnitude of 1p.u., and the other buses of the network are loads. The system configuration is presented in figure (4.2). More details are presented in Appendix-B.

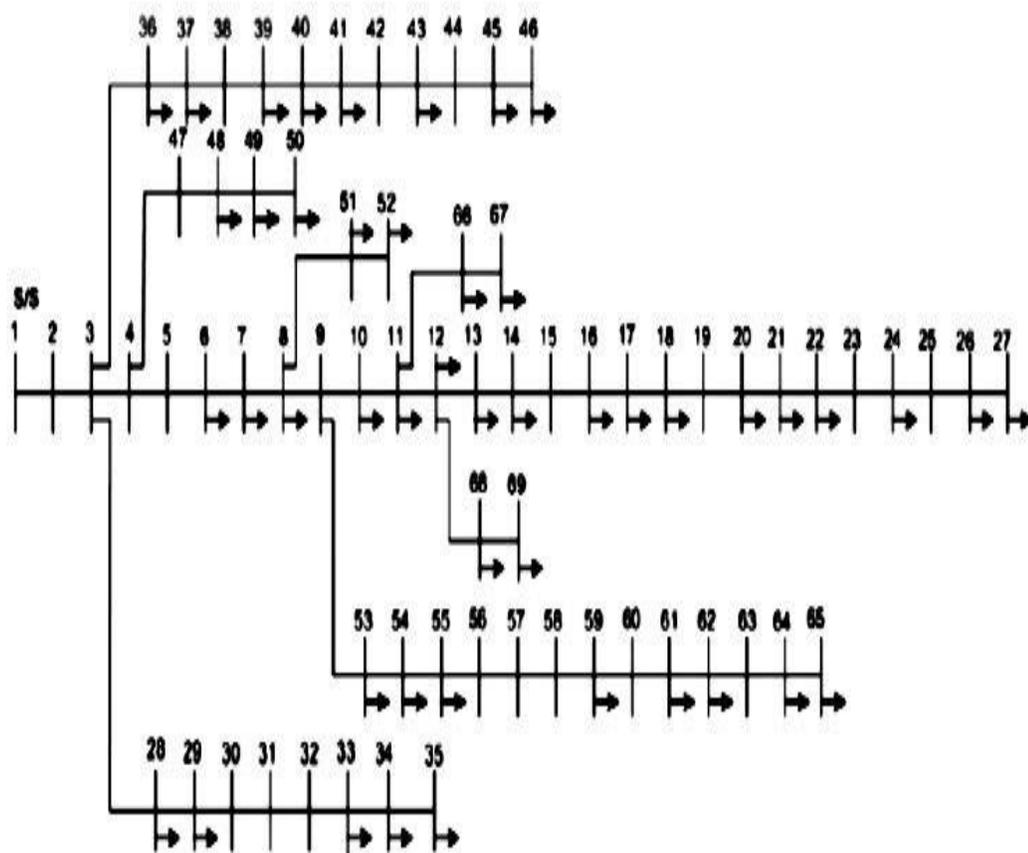


Figure (4.1) IEEE 69-bus System [35]

4.3 Simulation Results

4.3.1 IEEE 69-bus system

In order to test the method presented in this project, the system of IEEE 69-bus is utilized as the first case. The results of the base case which represents the distribution system performance without using the placement of the capacitors in the system and the results of adding the capacitors will be discussed. The results are presented in Figures (4.3)-(4.6). From the results, five optimal locations (buses) are obtained which are [61 18 11 50 62] whereas the size of the capacitors utilized in the mentioned buses are [500 300 300 300 900] kVAR. In this case, the power loss is decreased to 144 kW whereas the loss in the base case was 225kW. This result showed the proposed method efficiency to decrease the power losses. Figure (4.3) shows the comparison of the branch system losses between the two cases.

Moreover, the use of capacitors bank in the distribution system improve the system voltage which increases from 0.9092 to 0.9311 p.u (percentage of improvement is 2.4 %), as shown in figure (4.4).

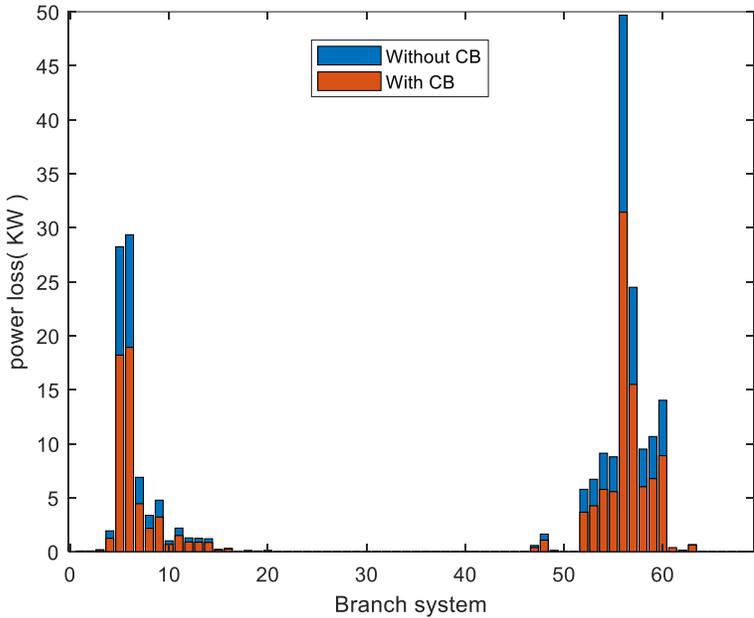


Figure (4.3):69-bus power losses.

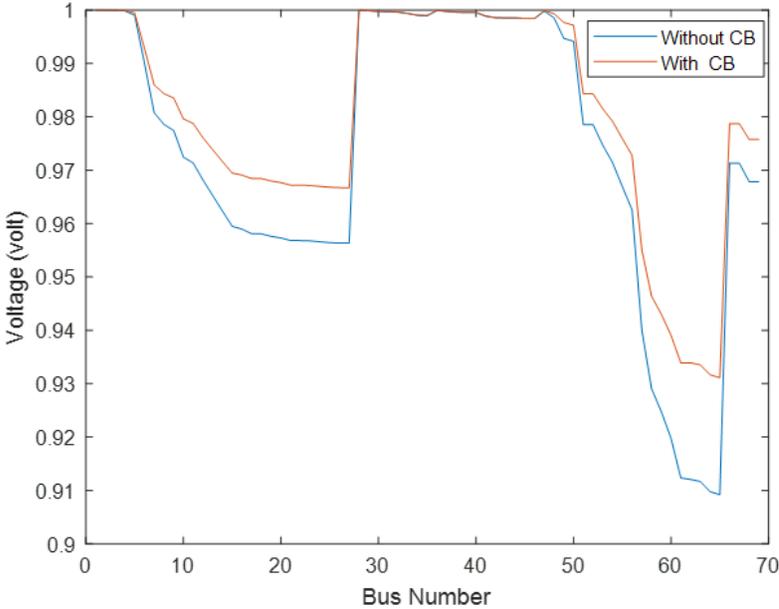


Figure (4.4):69-bus voltage.

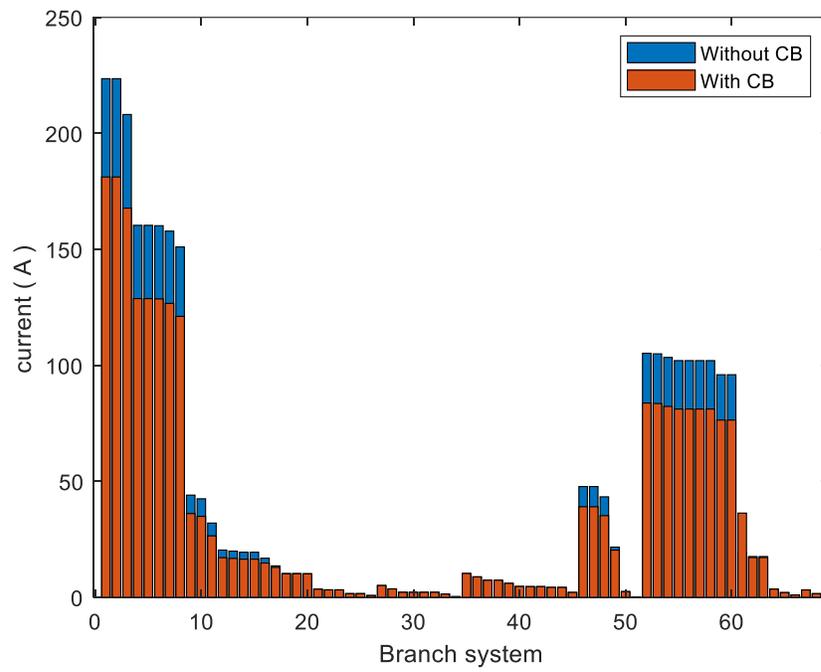


Figure (4.5):69-bus current

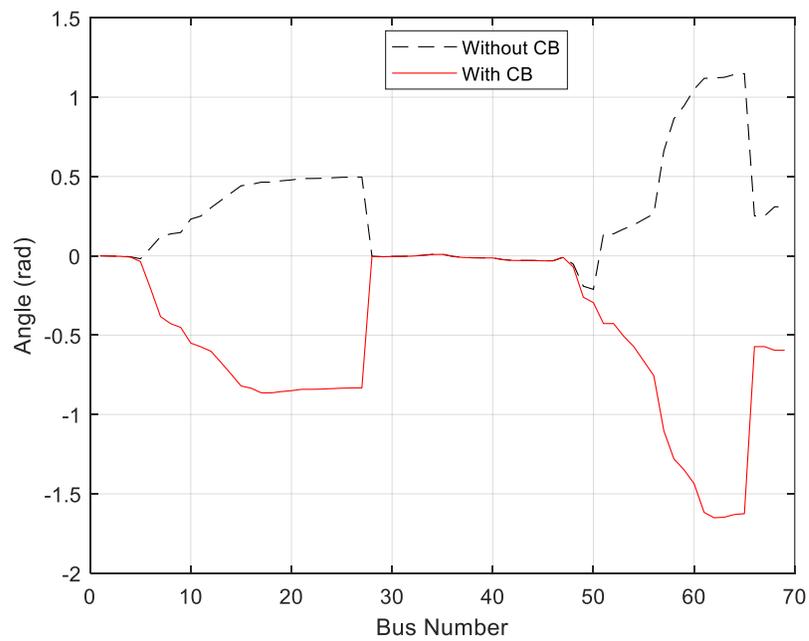


Figure (4.6):69_ bus Angle.

4.3.2 Simulation Results of Iraqi 99-bus system

The same procedure used with 69-bus system will be utilized in this section to evaluate the method proposed in this project with 99-bus real distribution system and the results are presented in figures (4.7)-(4.10). From the results, ten optimal locations (buses) are obtained which are [73 65 16 31 7 66 34 92 57 44] whereas the size of the capacitors utilized in the mentioned buses are [300 300 1500 1500 1200 600 900 600 300 1200] kVAR. From table 4.1 the power loss is decreased to 600 kW whereas the loss in the base case was 784.5kW. This result showed the proposed method efficiency to decrease the power losses. Figure (4.7) shows the comparison of the branch system losses between the two cases.

Moreover, the use of capacitor bank in the distribution system improves the system voltage which increases from 0.9133 to 0.95 p.u. (percentage of improvement is 4.01 %), as shown in figure (4.9). The overall results are presented in Table (4.1).

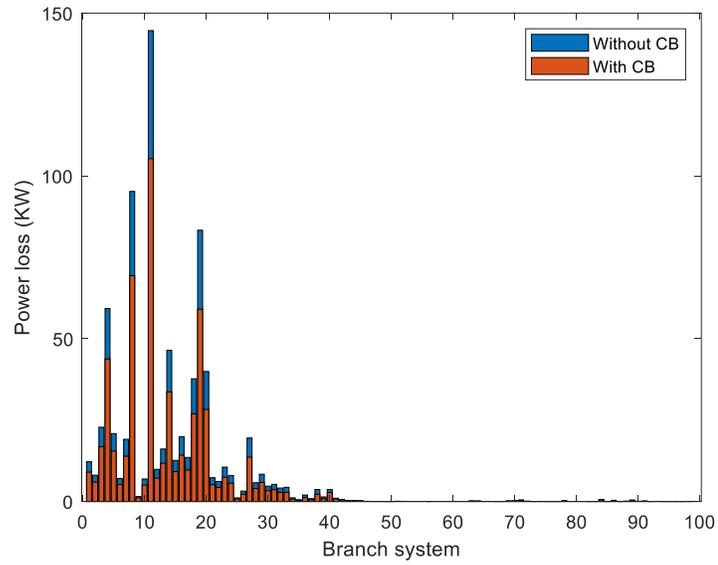


Figure (4.7):99-bus power losses.

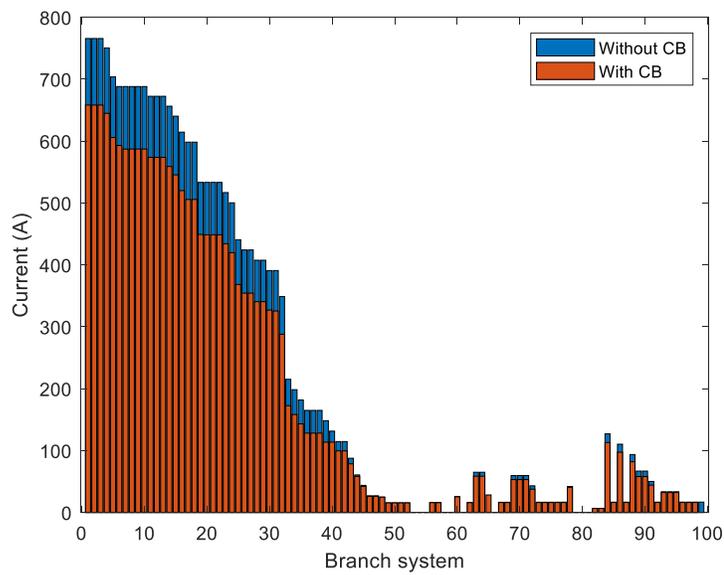
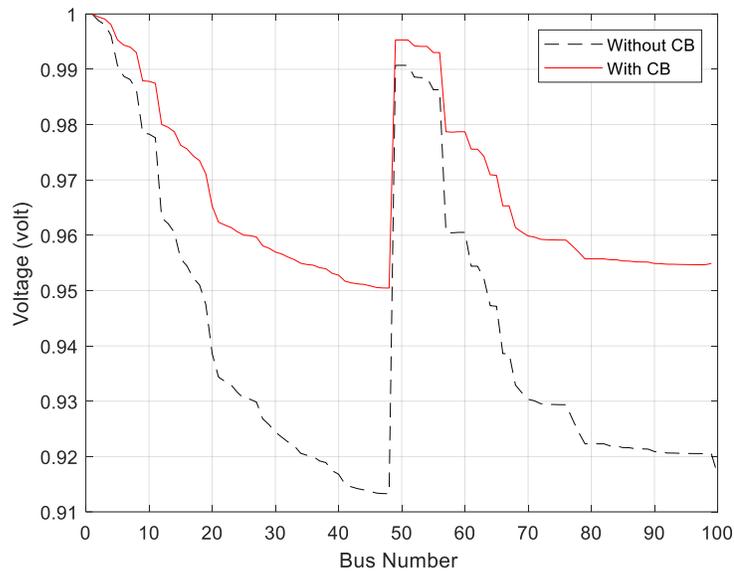
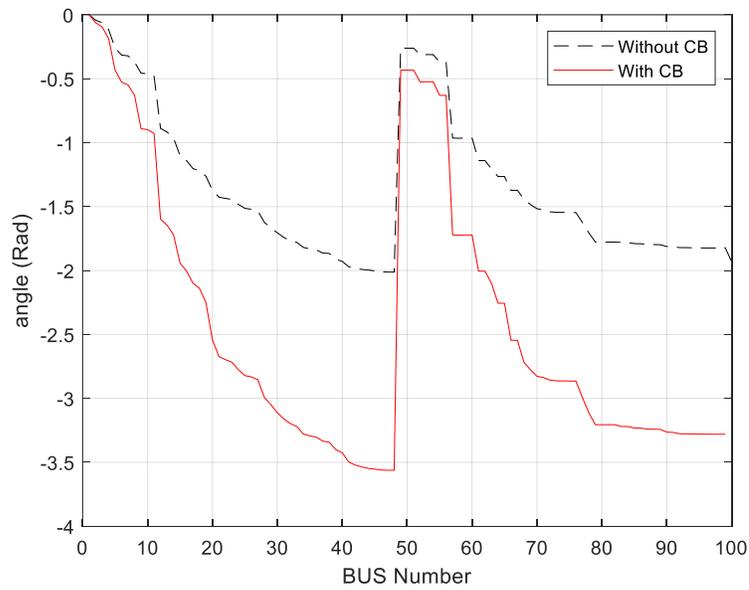


Figure (4.8):99- bus Branch current.



.Figure (4.9) :99_bus voltage.



.Figure (4.10): 99_bus voltage.

Table (4.1): Simulation results of 69 and 99 bus systems with and without capacitor bank.

Cases	Location	size (KVAR)	Ploss (kW)	Vmax (p.u)	Vmin (p.u)
Base case(69)	---	---	225	1	0.9092
Case 1	[61 18 11 50 62]	[500 300 300 300 900]	144	1	0.932
Base case (99)	---	---	784.5	1	0.9133
Case 1	[73 65 16 31 7 66 34 92 57 44]	[300 300 1500 1500 1200 600 900 600 300 1200]	600	1	0.95

Chapter Five

Conclusions and Future Works

5.1 Conclusions

Most important conclusions from this study are:

- 1- This project presented an optimal capacitors allocation in distribution systems to enhance the performance of Iraqi power distribution systems.
- 2- The objective of the proposed method was to minimize the active power losses by satisfying the system constraints
- 3- The 69 bus test system and an actual distribution system selected from the Hillah city network were used to evaluate the performance of the proposed.
- 4- Test results verified the ability of the method to minimize the power losses, improve the voltage profile, and contributed to solving the problem of the overloaded branch in the Hilla power distribution system.
- 5- It was also observed that there was an improvement in the voltage value after adding the capacitor to the system.

5.2 Suggestions for Future Works

1. The optimal reconfiguration method can be combined with the addition of capacitor to reduce network losses.
2. Also distribution generator can be combined with the optimal capacitor placement to reduce losses and enhance voltage profile.

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الخلاصة

يقدم هذا المشروع طريقة لتحسين أداء شبكات توزيع الطاقة العراقية باستخدام استراتيجية وضع المكثف الأمثل. يمثل تقليل فقد الطاقة الهدف المقترح مع مراعاة قيود النظام. من أجل العثور على الوضع الأمثل للمكثف (الموقع والحجم) ، تم اقتراح طريقة تحسين فعالة باستخدام الخوارزمية الجينية في هذا البحث. تعتمد الطريقة المقترحة على العمليات الجينية الطبيعية. الهدف من الدراسة المقدمة هنا هو تحسين جهد النظام وتقليل الخسائر. تم تقديم المنهجية المقترحة لحل مشكلة حقيقية في نظام التوزيع العراقي . حيث تم تطوير النهج المقترح في برنامج MATLAB المتخصص وتم تقييمه على نظامي اختبار منفصلين. تم إجراء الاختبار الأول على (نظام توزيع ذو 69 ناقل) ، بينما الاختبار الثاني هو عينة واقعية تم الحصول عليها من شبكة توزيع الحلة لنظام التوزيع (ذو ال 99 ناقل) . تشير نتائج العديد من الاختبارات إلى إن GA هي خوارزمية مناسبة للأستخدام كنهج أمثل نظراً لأنها دقيقة للغاية وتبتعد عن الحدود الدنيا المحلية. نتيجة لذلك، تشير نتائج البحث إلى انها طريقة فعالة وعملية على حد سواء لمعالجه مسأله وضع المكثف في نظام توزيع الطاقه.



جمهورية العراق
وزارة التعليم العالي والبحث العلمي جامعة بابل
كلية الهندسة / قسم الهندسة
الكهربائية

تحسين أداء نظام توزيع الكهرباء العراقي
بحث

مقدم الى كلية الهندسة في جامعة بابل كجزء من متطلبات نيل درجة
الدبلوم العالي في الهندسة الكهربائية.

من قبل:

زينب محسن نعمه

أشرف:

أ.م. د. شمم علوش

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Appendix

Appendix (A):69 bus system data.

Appendix (A_1):line data.

Appendix (A_2):load data.

Appendix (B):99 bus system data.

Appendix (B_1):line data.

Appendix (B_2):load data.

Appendix A

Table A.1: The 69-node radial distribution networks Line data.

Node A	Node B	R(ohms)	X(ohms)
1	2	0.0005	0.0012
2	3	0.0005	0.0012
3	4	0.0015	0.0036
4	5	0.0251	0.0294
5	6	0.366	0.1864
6	7	0.3811	0.1941
7	8	0.0922	0.047
8	9	0.0493	0.0251
9	10	0.819	0.2707
10	11	0.1872	0.0619
11	12	0.7114	0.2351
12	13	1.03	0.34
13	14	1.044	0.345
14	15	1.058	0.3496

15	16	0.1966	0.065
16	17	0.3744	0.1238
17	18	0.0047	0.0016
18	19	0.3276	0.1083
19	20	0.2106	0.069
20	21	0.3416	0.1129
21	22	0.014	0.0046
22	23	0.1591	0.0526
23	24	0.3463	0.1145
24	25	0.7488	0.2475
25	26	0.3089	0.1021
26	27	0.1732	0.0572
3	28	0.0044	0.0108
28	29	0.064	0.1565
29	30	0.3978	0.1315
30	31	0.0702	0.0232
31	32	0.351	0.116
32	33	0.839	0.2816
33	34	1.708	0.5646
34	35	1.474	0.4873

3	36	0.0044	0.0108
36	37	0.064	0.1565
37	38	0.1053	0.123
38	39	0.0304	0.0355
39	40	0.0018	0.0021
40	41	0.7283	0.8509
41	42	0.31	0.3623
42	43	0.041	0.0478
43	44	0.0092	0.0116
44	45	0.1089	0.1373
45	46	0.0009	0.0012
4	47	0.0034	0.0084
47	48	0.0851	0.2083
48	49	0.2898	0.7091
49	50	0.0822	0.2011
8	51	0.0928	0.0473
51	52	0.3319	0.1114
9	53	0.174	0.0886
53	54	0.203	0.1034
54	55	0.2842	0.1447

55	56	0.2813	0.1433
56	57	1.59	0.5337
57	58	0.7837	0.263
58	59	0.3042	0.1006
59	60	0.3861	0.1172
60	61	0.5075	0.2585
61	62	0.0974	0.0496
62	63	0.145	0.0738
63	64	0.7105	0.3619
64	65	1.041	0.5302
11	66	0.2012	0.0611
66	67	0.0047	0.0014
12	68	0.7394	0.2444
68	69	0.0047	0.0016

Table A.2: The 69-node radial distribution networks load data.

Node	Vbus (V)	PG (kW)	QG(kvar)	PL (kW)	QL(kvar)
1	1	0	0	0	0
2	1	0	0	0	0
3	1	0	0	0	0
4	1	0	0	0	0
5	1	0	0	0	0
6	1	0	0	2.6	2.2
7	1	0	0	40.4	30
8	1	0	0	75	54
9	1	0	0	30	22
10	1	0	0	28	19
11	1	0	0	145	104
12	1	0	0	145	104
13	1	0	0	8	5
14	1	0	0	8	5.5
15	1	0	0	0	0
16	1	0	0	45.5	30

17	1	0	0	60	35
18	1	0	0	60	35
19	1	0	0	0	0
20	1	0	0	1	0.6
21	1	0	0	114	81
22	1	0	0	5.3	3.5
23	1	0	0	0	0
24	1	0	0	28	20
25	1	0	0	0	0
26	1	0	0	14	10
27	1	0	0	14	10
28	1	0	0	26	18.6
29	1	0	0	26	18.6
30	1	0	0	0	0
31	1	0	0	0	0
32	1	0	0	0	0
33	1	0	0	14	10
34	1	0	0	19.5	14
35	1	0	0	6	4
36	1	0	0	26	18.55

37	1	0	0	26	18.55
38	1	0	0	0	0
39	1	0	0	24	17
40	1	0	0	24	17
41	1	0	0	1.2	1
42	1	0	0	0	0
43	1	0	0	6	4.3
44	1	0	0	0	0
45	1	0	0	39.22	26.3
46	1	0	0	39.22	26.3
47	1	0	0	0	0
48	1	0	0	79	56.4
49	1	0	0	384.7	274.5
50	1	0	0	384.7	274.5
51	1	0	0	40.5	28.3
52	1	0	0	3.6	2.7
53	1	0	0	4.35	3.5
54	1	0	0	26.4	19
55	1	0	0	24	17.2
56	1	0	0	0	0

57	1	0	0	0	0
58	1	0	0	0	0
59	1	0	0	100	72
60	1	0	0	0	0
61	1	0	0	1244	888
62	1	0	0	32	23
63	1	0	0	0	0
64	1	0	0	227	162
65	1	0	0	59	42
66	1	0	0	18	13
67	1	0	0	18	13
68	1	0	0	28	20
69	1	0	0	28	20

Appendix B

Table B.1: The 99-node radial distribution networks Line data.

Node A	Node B	R(ohms)	X (ohms)
1	2	0.00693	0.01155
2	3	0.00459	0.00595
3	4	0.01296	0.0168
4	5	0.0351	0.0455
5	6	0.01404	0.0182
6	7	0.00495	0.00385
7	8	0.01344	0.0168
8	9	0.06705	0.05215
9	10	0.00108	0.0014
10	11	0.00486	0.0063
11	12	0.10665	0.13825
12	13	0.00729	0.00945
13	14	0.01188	0.0154
14	15	0.03591	0.04655

15	16	0.01026	0.0133
16	17	0.01755	0.02275
17	18	0.0126	0.0098
18	19	0.0351	0.0273
19	20	0.09765	0.07595
20	21	0.0468	0.0364
21	22	0.00855	0.00665
22	23	0.0072	0.0056
23	24	0.01316	0.01645
24	25	0.01064	0.0133
25	26	0.00189	0.00315
26	27	0.00588	0.00735
27	28	0.03612	0.04515
28	29	0.01155	0.01925
29	30	0.0168	0.021
30	31	0.01029	0.01715
31	32	0.01148	0.01435
32	33	0.01131	0.01015
33	34	0.03136	0.0392
34	35	0.00952	0.0119

35	36	0.00546	0.0091
36	37	0.02436	0.03045
37	38	0.0108	0.0084
38	39	0.04508	0.05635
39	40	0.02128	0.0266
40	41	0.07095	0.07525
41	42	0.02541	0.02695
42	43	0.01551	0.01645
43	44	0.01386	0.0147
44	45	0.02409	0.02555
45	46	0.03762	0.0399
46	47	0.01782	0.0189
47	48	0.0045	0.0035
5	49	0.00741	0.00665
5	50	0.00621	0.00805
50	51	0.00594	0.0077
6	52	0.06808	0.01295
52	53	0.046	0.00875
53	54	0.01485	0.01155
8	55	0.01482	0.0133

55	56	0.06669	0.05985
14	57	0.00486	0.0063
57	58	0.02772	0.0294
57	59	0.0099	0.0077
59	60	0.00864	0.0112
16	61	0.0126	0.0098
61	62	0.0171	0.0133
17	63	0.02268	0.0294
19	64	0.01485	0.01155
64	65	0.01258	0.00595
20	66	0.01215	0.00945
66	67	0.00594	0.0077
23	68	0.00294	0.0049
24	69	0.01008	0.0126
25	70	0.01755	0.01575
70	71	0.02324	0.02905
71	72	0.04347	0.05635
72	73	0.01485	0.01925
73	74	0.00594	0.0077
74	75	0.00891	0.01155

75	76	0.00308	0.00385
28	77	0.00609	0.01015
30	78	0.00693	0.01155
32	79	0.03976	0.0497
79	80	0.00616	0.0077
80	81	0.00273	0.00455
81	82	0.01848	0.0231
33	83	0.01482	0.0133
83	84	0.00962	0.00455
33	85	0.01242	0.0161
85	86	0.00504	0.0084
85	87	0.00972	0.0126
87	88	0.00567	0.00945
87	89	0.00297	0.00385
89	90	0.03348	0.0434
90	91	0.00399	0.00665
91	92	0.01998	0.0259
92	93	0.00231	0.00385
92	94	0.00729	0.00945
94	95	0.00294	0.0049

95	96	0.00252	0.0042
96	97	0.00225	0.00175
97	98	0.00336	0.0056
34	99	0.01782	0.0189
40	100	0.04095	0.03185

Table B.2: The 99-node radial distribution networks Load data.

Node	Vbus (V)	PG (kW)	QG(kvar)	PL (kW)	QL (kvar)
1	1	0	0	0	0
2	1	0	0	0	0
3	1	0	0	0	0
4	1	0	0	225	108.9725
5	1	0	0	90	43.58899
6	1	0	0	0	0
7	1	0	0	0	0
8	1	0	0	0	0
9	1	0	0	0	0

10	1	0	0	0	0
11	1	0	0	225	108.9725
12	1	0	0	0	0
13	1	0	0	0	0
14	1	0	0	0	0
15	1	0	0	225	108.9725
16	1	0	0	0	0
17	1	0	0	0	0
18	1	0	0	0	0
19	1	0	0	0	0
20	1	0	0	0	0
21	1	0	0	0	0
22	1	0	0	0	0
23	1	0	0	0	0
24	1	0	0	0	0
25	1	0	0	0	0
26	1	0	0	225	108.9725
27	1	0	0	0	0
28	1	0	0	0	0
29	1	0	0	0	0

30	1	0	0	0	0
31	1	0	0	0	0
32	1	0	0	0	0
33	1	0	0	0	0
34	1	0	0	0	0
35	1	0	0	225	108.9725
36	1	0	0	225	108.9725
37	1	0	0	0	0
38	1	0	0	0	0
39	1	0	0	225	108.9725
40	1	0	0	0	0
41	1	0	0	225	108.9725
42	1	0	0	0	0
43	1	0	0	360	174.356
44	1	0	0	360	174.356
45	1	0	0	225	108.9725
46	1	0	0	225	108.9725
47	1	0	0	0	0
48	1	0	0	360	174.356
49	1	0	0	360	174.356

50	1	0	0	0	0
51	1	0	0	225	108.9725
52	1	0	0	0	0
53	1	0	0	225	108.9725
54	1	0	0	0	0
55	1	0	0	0	0
56	1	0	0	0	0
57	1	0	0	0	0
58	1	0	0	225	108.9725
59	1	0	0	0	0
60	1	0	0	0	0
61	1	0	0	360	174.356
62	1	0	0	0	0
63	1	0	0	225	108.9725
64	1	0	0	0	0
65	1	0	0	900	435.8899
66	1	0	0	0	0
67	1	0	0	0	0
68	1	0	0	225	108.9725
69	1	0	0	225	108.9725

70	1	0	0	0	0
71	1	0	0	0	0
72	1	0	0	225	108.9725
73	1	0	0	360	174.356
74	1	0	0	0	0
75	1	0	0	0	0
76	1	0	0	225	108.9725
77	1	0	0	225	108.9725
78	1	0	0	225	108.9725
79	1	0	0	567	274.6106
80	1	0	0	0	0
81	1	0	0	0	0
82	1	0	0	0	0
83	1	0	0	0	0
84	1	0	0	90	43.58899
85	1	0	0	0	0
86	1	0	0	225	108.9725
87	1	0	0	0	0
88	1	0	0	225	108.9725
89	1	0	0	360	174.356

90	1	0	0	0	0
91	1	0	0	225	108.9725
92	1	0	0	0	0
93	1	0	0	225	108.9725
94	1	0	0	0	0
95	1	0	0	0	0
96	1	0	0	225	108.9725
97	1	0	0	0	0
98	1	0	0	225	108.9725
99	1	0	0	225	108.9725
100	1	0	0	225	108.9725
				10467	5069.399