



**Daffodil International University  
Dhaka, Bangladesh**

**Thesis Report  
On  
Load Flow Analysis of Five Bus System Using MATLAB**

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This thesis has been submitted to the Department of Electrical and Electronic Engineering in partial fulfillment of the requirement for the degree of Bachelor of Science in Electrical and Electronic Engineering.



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## **APPROVAL LETTER**

This thesis report titled “**Load Flow Analysis of Five Bus System Using Matlab**”, submitted by Afikul Islam ID: 152-33-211, Md. Tamim Hasan ID: 142-33-154 to the Department of Electrical and Electronic Engineering, Daffodil International University has been recognized as a partial supplement to the postgraduate science phase of electrical and electronic engineering and confirmed as its style and material. The presentation has been held on 16 July 2019.

Board of Examiners:

## DECLARATION

We declare that this thesis is based on the results we receive. The work materials found by other researchers are referred by reference. This thesis is submitted to Daffodil International University for achieving BSc degree of Electrical and electronics engineering. This thesis has not been fully submitted for any degree prior to the degree.

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## **ACKNOWLEDGEMENT**

I will be compelled forever to the Daffodil International University, Bangladesh, Electrical Engineering Department for the degree to finish this endeavor, which is my B.T. The thesis is a major part of the program. My sincere gratitude to my efforts, Professor Dr. Md. Shahid Ullah and Md. Mahbub-Ud-Zaman Department of Electrical and Electronic Engineering. Daffodil International University has made it a compulsory effort for its practical initiative. It was his bearing and unending motivation over the range of vulnerabilities and questions. I must have really expressed gratitude The speaker of Mahbub-Ud-Zaman division of Electrical Engineering will express his support and support for his course. I am moreover grateful to the assets of the Electrical Engineering Department for offering their obliging hands over the range of our endeavor.

Taking everything into account, I have to perceive the responsibilities of my people, relatives, and my associates for their relentless and perpetual motivation.

## ABSTRACT

The foundations of the investigation and the structure of the power stream test intensity structure. They are fundamental for trade, intensity between measures, tasks, financial bookings, and utilities. Important information on the intensity flow investigation is the discovery of genuine and reactionary power streaming on the voltage and stage edges of each voltage and each transmission line. Power stream test is a significant device with numerical investigation of a number of power frameworks. In this test, repetitive methods are used because of the available diagnostic techniques to take care of the problem. To complete this test, there are strategies for numerical calculations that include many steps depending on the size of the structure. This method is annoying and takes a lot of time. The purpose of this work is to create a tool kit for the electricity flow test. I've used GAUSS-SEIDEL technology to detect vague parameters of the 5 transport structure. The power and voltage information situation in the power flow calculation refers to a power system and the total voltage information on all the framework transport is made. Need for calculation for both the continuous state investigation and dynamic execution evaluation of the intensities framework. The paper illustrates the experience of joining the hip stream program and the framework programming of the MATLAB presentation.

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## **ABBREVIATIONS AND ACRONYMS**

OPF - Optimal Power Flow

PSAT - Power System Analysis Toolbox

MATLAB - MATrixLABoratory

P.U. - Per Unit

N-R Technique - Newton-raphson Technique

G-S Technique - Gauss-Siedel Technique

IEEE - Institute of Electrical and Electronics Engineers

# Chapter 1

## INTRODUCTION

### 1.1 Motivation

The electricity flow investigation is a framework that is governed by the formation of a state under the framework of various types under which the structure works. The weight stream game-plan tells about the open and dynamic power and voltage line-line streams and the ability of the other car in bars [1,3]. It is important to arrange for the structure of the other framework or for larger weight requests for the current weight. Special structures in a structural electric store, include personal and normal loads.

Traditional weight is broken, it recognizes that the dynamic features of dynamic and free-end installation have been selected, the voltage range is free. In any case, extremely, the allocation of an allocated framework is dynamic and responsive intensity structure, subject to voltage size and ring grouping. These effects, at whatever point pondered, a significant change in the results of weight stream and OPF considers. Rehash deviation is not considered as immense due to static examination as weight stream. The impacts of voltage deviations are fundamentally considered to get lively and careful outcomes and expanded structure soundness and security. The refinements in fuel cost are consistently huge when voltage-subordinate weight models have taken an interest in Perfect Power Stream (OPF) considers. The dynamic and responsive power requests, the quality, the occurrences, and the voltage profile are in like way affected.

### 1.2 Brief Review of Power System

In a power framework, each vehicle is connected to four numbers - dynamic and responsive forces, transport voltage degrees, and its stage points. In a store stream method, two of these four openings are mentioned and the rest are settled [4].

Age is the formation of intensity at power stations or making units. Transmission is a framework that controls the country or district from one bit to another. It is usually an

interconnection resource that is connected to various components of different electrical cables, which changes voltage levels, offers improved resuscitation.

Dissemination finally passes on the power (we will state locally when diverged from the transmission system) to the last loads (a larger part of which are given at low voltage) center steps through which the voltage is down (changed) to lower levels. There are bits of the world where the control and personalization of the business has started, the business scene has completely changed, whereas their impact still remains to be seen.

### **1.3 Classification of Buses**

A bus is an inside time when one or various lines, one or various stores and generators are associated. In a power structure each center or bus is related with 4 wholes, for instance, the monstrosity of voltage, make explanation behind voltage, dynamic or certifiable power and responsive power in weight stream issue two out of these 4 totals are appeared and remaining 2 are required to be settled through the strategy of the condition. Subordinate upon the totals that have been outlined, the busses are designed into 3 classes [4,6].

#### **1.3.1 Variables and Bus Classification**

Busses are gathered by which two out of the four components are resolved.

##### **1.3.1.1 Load Bus**

No generator is related to buses. On this bus, proper and open energy is shown. It is believed the stream is required to find voltage overflow and stage edge through the game plan. Only Pd and QDs have to be fixed, such as the bus can be allowed to switch inside acceptable areas of a hip bus voltage [5].

### 1.3.1.2 Generator Bus or Voltage Controlled Bus

Here the voltage extent relating to the generator voltage and veritable power  $P_g$  thinks about to its rating are resolved [3]. It is required to find the responsive power age  $Q_g$  and stage purpose of the bus voltage.

### 1.3.1.3 Slack (Swing) Bus

For the Slack Bus, it is acknowledged that the voltage greatness  $|V|$  and voltage organize  $\Theta$  are known, while veritable and open forces  $P_g$  and  $Q_g$  are gained through the heap stream course of action [2].

## 1.4 Objectives of the Study

The essential focal point of this undertaking is the improvement of a voltage subordinate weight model in which dynamic and responsive forces sway exponentially with voltage and execution of this model in Ideal Power Stream and examination of the possible results of the above with those got from OPF considers without association of weight models to guarantee least debacles and age costs [4].

### The main Objectives of the Study are:

- ➔ Power stream is a large or orchestrating period of new frameworks, or new ones, including new ones.
- ➔ The burden stream of action gives the nodal voltages and stage edges and subsequently the power imbue at all the busses and power moves interconnecting force channels through
- ➔ It is valuable in choosing the best territory similarly as the perfect furthest reaches of the proposed making station, substation and new lines.
- ➔ It chooses the voltage of the busses. The voltage level at the particular busses must be kept inside the shunt protections.
- ➔ Framework transmission disaster limits.
- ➔ Monetary system task with respect to fuel cost to make all the power required.
- ➔ The line streams can be known. The line should not to be over-burden, it suggests, we should not to work the close to their quality or warm cutoff focuses.

## 1.5 Overview

The power flow algorithm written in this the section is based on Gauss-Sidle method. A software program has been developed. The program provides the power flow solution for the given problem and calculates the full voltage angle and measurement information of each bus in a power system for the actual power and voltage conditions of the specific load and generator.

Type of Bus	Known Quantities	Quantities to be specified
Generator bus	P, Q	V , d
Load bus	P,  V	Q, d
Slack bus	V , d	P, Q

Figure 1.3 Type of Bus Known Quantities to be specified

The electricity flow analysis is needed for the exchange of power, they are in planning, operation, economic schedules and utilities. Power flow analysis is required for other analyzes such as other fixed stability, optimum power flow and temporary research. The main information of the power flow analysis is to find out the actual and reactionary energy flowing in each bus voltage and phase angle and the transmission lines in each transmission line.

Power flow analysis is an important tool involved in numerical analysis of a power system applied. In this analysis, repetitive techniques are used because of a known analytical method to solve the problem. This is the result of nonlinear set of equations or called energy flow equations. There are mathematical calculation methods for completing this analysis. This process is difficult and it takes a lot of time to run. Developing a toolbox for analyzing the power flow will surely help make analyzes easier.

Power flow analysis software can help users to calculate the power flow problem. In the last decade, some versions of education software packages, such as C, C ++, Pascal, or Fortran, have been developed for power engineering courses using advanced programming languages. Select an integrated research platform with this database and GUI function support.

Development of the use of MATLAB software by Power Stream Analysis Software Writer. For technical accounting, MATLAB is a high-performance language that is easy to use to use, visualize and programming, thus becoming an ideal indicator tool for primary and advanced courses of mathematics, engineering and science in the university environment. Most students are familiar with this, MATLAB is seen as a convenient environment for many users, rather than a high-performance language for technical computing, rather than a graphical user interface (GUI). MATLAB can be manipulated by various high and low-level commands in objects organized in Graphics Object Hierarchy based on data quiz and GUI design graphics system. If using MATLAB7, the GUI design increases the flexibility of the more flexible and versatile graphics system.



## Chapter 2

### LOAD FLOW

#### 2.1 Introduction

All the flow framework test estimates of load flow studies are definitely the most extraordinary. When the express part is overloaded and when the focus is to plan the attention plan. Beginning with the Basic Support System based on Load-Flow Examination [7,8]. On the job test, the load-flow test is used to guarantee that every generator keeps working on the ideal work point; Sales work will be met without overloading the environment, and the maintenance of the maintenance plan may continue without undermining the protection.

#### 2.2 Objectives of Load Flow [3]:

The objectives of any load-flow program are to make the going:

- ➔ Each voltage on each bus and the edge of the stage.
- ➔ Veritable and responsive power flowing in each part.
- ➔ Responsive power loading on each generator.

**The above destinations are accomplished by providing the load-flow program with the accompanying data:**

- ➔ Branch summary of the system affiliations i.e., the impedance of each segment, sending-end, and getting end center point #. Lines and transformers are addressed by their  $\pi$ -corresponding models.
- ➔ Voltage greatness and stage edge at one bus, which is the reference point for the rest of the structure.
- ➔ Certified power made and voltage extent at each generator bus.
- ➔ Certified and open power mentioned at each load bus.

The basic information is usually available because it is immediately aware of instant information (impedances, etc.) or funds that intensify control of staff staff (dynamic energy yield and generator enthusiasm).

**Load flow problem as follows:**

- ➔ At any bus, there are four measures of interest:  $|V|$ ,  $\theta$ , P, and Q.
- ➔ If any two of these sums are resolved, the other two must not be demonstrated else we end up with a more prominent number of inquiries than conditions.
- ➔ Since records enable the certified and responsive capacity to be correctly surveyed at loads, P and Q are resolved sums at loads, which are called PQ busses.
- ➔ In like way, the authentic power yield of a generator is obliged by the prime mover and the greatness of the voltage is compelled by the exciter, so and P and  $|V|$  are resolved at generators, which are called PV busses.
- ➔ This suggests  $|V|$  and  $\theta$  are dark at each load bus and  $\theta$  and Q are dark at each generator bus.
- ➔ Since the structure disasters are dark until a response to the load-flow issue has been found, it is critical to decide one bus that will supply these setbacks. This is known as the slack (or swing, or reference) bus and since P and Q are dark,  $|V|$  and  $\theta$  must be shown. As a rule, an edge of  $\theta = 0$  is used at the slack bus and all extraordinary bus focuses are imparted with respect to slack.

The earlier is compressed in the going with the one-line layout in which the foreordained sums are pushed, while the sums that are permitted to contrast during the cycling technique are appeared here and their jolts.

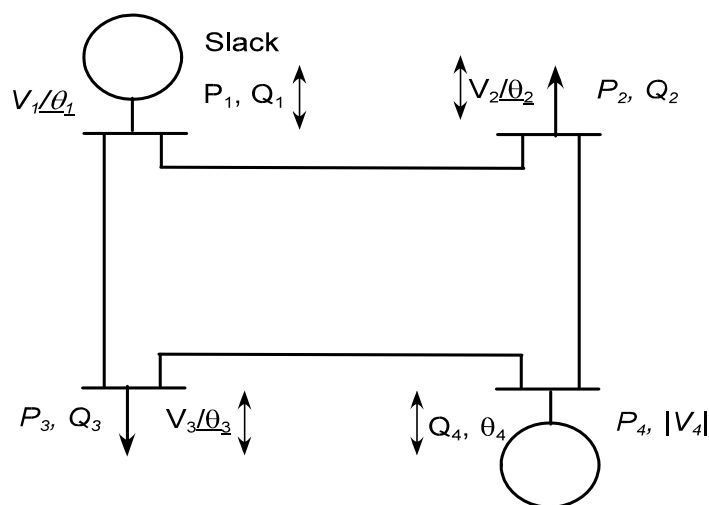


Fig. 2.1 Load Flow One-line Diagram

### 2.3 Information available from load-flow studies

The fundamental data contained in the load-flow yield is:

- All bus voltage degrees and phase angles w.r.t the slack bus.
- All bus dynamic and responsive power mixtures.
- All line sending-and receiving end complex power flows.
- Individual line adversities can be determined by subtracting receiving end complex impact from sending-end complex impact.
- Complete structure mishaps can be determined by summing thing iv) for all lines, or by summing complex impact at all loads and generators and subtracting the totals.

The largest information systems voltage profile obtained from the load flow. If  $|V|$  contrasts phenomenally over the system, colossal responsive flows will result; this, along these lines, will provoke extended certified influence setbacks and, in crazy cases, an improved likelihood of voltage breakdown [10, 11]. When a particular bus is an unacceptable low voltage, the general practice is known in the capacitor. Load-flow studies can be used on a pewiki bus, its voltage can reach a reasonable level, such as:

- Decided to reload the load with re-doled out as a PV type with the required voltage level.
- Estimates the estimated sequence of PQ from the bus).
- The result is expected to bring the voltage up to the predicted level of QC.

#### **Note that,**

If the predefined voltage isn't 1 pu, by then the estimation of  $Q_c$  must be adjusted by  $1/|V|^2$  to decide  $Q_c$  at evaluated voltage.

If a new line (or additional transformer) is presented, to strengthen the structure, a load-flow will show how the overloads will be in close-lines [9]. It will also show how low the response from the new line (significant for financial evaluation.)

## 2.4 Purpose of Load Flow Analysis

The purpose of Load Flow analysis is as follows:

- ❖ Select the degree of voltage and stage edge at all centers of feeder.
- ❖ Each line stream is resolved with KW and KVAR, MPR's and degrees or amperes and power factor.
- ❖ Select power events.
- ❖ Select the total commitment of Feeder Kilo Watt (KW) and KVAR.
- ❖ To choose the dynamic and responsive force of weight reliant on the described model for the store.

## 2.5 Load Flow Solution Methods

### 2.5.1 Classification of Buses

For load-flow analyzes, it is typical that the loads are suffering and they are depicted by their valid and responsive power utilization [12]. It is likewise expected that the generator terminal voltages are enduringly controlled and thusly are predictable. The indispensable target of the load flow is to discover the voltage degree of each transport and its edge when the powers made and loads are pre-chosen. To stimulate this, we arrange the various transports of the power structure appeared in the diagram underneath.

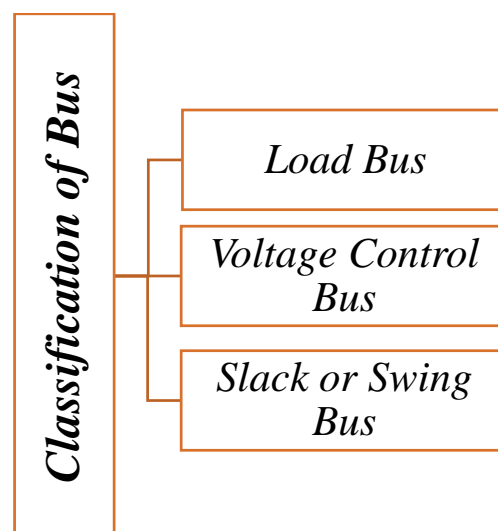


Fig. 2.1 Classification of Bus

### **2.5.1.1 Load Bus**

This is moreover called P-Q transport and at this transport, the dynamic and responsive power is infused into the structure [12]. Significance and stage reason for the voltage is to be enrolled. Here the dynamic power P and open power Q are illustrated, and the load transport voltage can be allowed inside a decent worth, i.e., 5 %. The stage edge of the voltage, i.e.  $\delta$  isn't basic for the load.

### **2.5.1.2 Generation Bus or Voltage Control Bus**

This transport is comparatively called the P-V transport, and on this transport, the voltage size identifying with conveying voltage and authentic or dynamic power P contrasting with its rating is illustrated [13]. Voltage degree is kept up suffering at a fated a rousing power by implantation of open power. The responsive power age Q and stage point  $\delta$  of the voltage is to be selected.

### **2.5.1.3 Slack, Swing or Reference Bus**

Slack transport in a power framework holds or produce the dynamic or responsive power from the power structure [13]. The slack transport does not pass on any load. At this transport, the degree and stage motivation behind the voltage is illustrated. The arranging reason for the voltage is conventionally set proportionate to zero. The dynamic and responsive power of this transport is consistently picked through the game-plan of conditions.

The slack transport is a long-winded idea in load flow considers and creates in light of the way that the I<sup>2</sup>R misfortunes of the framework are not known precisely ahead of schedule for the load flow estimation. In this manner, the complete blended power can't be exhibited at each transport. The sorting out reason for the voltage at the slack transport is regularly taken as reference or zero

## **2.5.2 Real and Reactive Power Injected in a Bus**

For the arrangement of the veritable and responsive power entering a transport, we need to portray the going with sums[16]. Give the voltage at  $i^{\text{th}}$  a chance to transport be indicated by

$$V_i = |V_i| \angle \delta_i = |V_i|(\cos \theta_i + j \sin \delta_i) \quad (2.1)$$

Also let us define the self-admittance at bus-  $i$  as

$$Y_{ii} = |Y_{ii}| \angle \theta_{ii} = |Y_{ii}|(\cos \theta_{ii} + j \sin \delta \theta_{ii}) = G_{ii} + jB_{ii} \quad (2.2)$$

Similarly, the mutual admittance between the buses  $i$  and  $j$  can be written as

$$Y_{ij} = |Y_{ij}| \angle \theta_{ij} = |Y_{ij}|(\cos \theta_{ij} + j \sin \delta \theta_{ij}) = G_{ij} + jB_{ij} \quad (2.3)$$

There are total buses in the electricity system. Injected on current bus -  $I$  was given as

$$\begin{aligned} I_i &= Y_{i1}V_1 + Y_{i2}V_2 + \dots + Y_{in}V_n \\ &= \sum_{k=1}^n Y_{ik}V_k \end{aligned} \quad (2.4)$$

Note that we no longer have any doubt in the transport and hope to take the transport negative. Therefore, no access to a transport and open energy will be taken in no doubt[16]. The mind-rebel power in the transport was then given to me

$$\begin{aligned} P_i - jQ_i &= V_i^+ I_i = V_i^+ \sum_{k=1}^n Y_{ik}V_k \\ &= |V_i|(\cos \delta_i - j \sin \delta_i) \sum_{k=1}^n |Y_{ik}V_k|(\cos \theta_{ik} + j \sin \theta_{ik})(\cos \delta_k + j \sin \delta_k) \quad (2.5) \\ &= \sum_{k=1}^n |Y_{ik}V_iV_k|(\cos \delta_i - j \sin \delta_i)(\cos \theta_{ik} + j \sin \theta_{ik})(\cos \delta_k + j \sin \delta_k) \end{aligned}$$

Note that,

$$\begin{aligned} &(\cos \delta_i - j \sin \delta_i)(\cos \theta_{ik} + j \sin \theta_{ik})(\cos \delta_k + j \sin \delta_k) \\ &= (\cos \delta_i - j \sin \delta_i)[\cos(\theta_{ik} + \theta_k) + j \sin(\theta_{ik} + \theta_k)] \\ &= \cos(\theta_{ik} + \delta_k - \delta_i) + j \sin(\theta_{ik} + \delta_k - \delta_i) \end{aligned}$$

Therefore, substituting in (2.5) we get the real and reactive power as

$$P_i = \sum_{k=1}^n |Y_{ik} V_i V_k| \cos(\theta_{ik} + \delta_k - \delta_i) \quad (2.6)$$

$$Q_i = \sum_{k=1}^n |Y_{ik} V_i V_k| \sin(\theta_{ik} + \delta_k - \delta_i) \quad (2.7)$$

### 2.5.3 Preparation of Data for Load Flow

Let genuine and responsive power created at the Bus-*I* be meant by  $P_{Gi}$  and  $Q_{Gi}$  individually[17]. Likewise given us a chance to indicate the genuine and receptive power devoured at  $I^{th}$  bus by  $P_{Li}$  and  $Q_{Li}$  individually. At that point the net genuine power infused in bus-*I* is

$$P_{i,ikj} = P_{Gi} - P_{Li} \quad (2.8)$$

Let's count by the injection power load flow program,  $P_{i,calc}$ . Then the difference between the actual injection and the calculated values is given

$$\Delta P_i = P_{i,ikj} - P_{i,calc} = P_{Gi} - P_{Li} - P_{i,calc} \quad (2.9)$$

Likewise, the befuddle between the receptive power infused and determined qualities is given by

$$\Delta Q_i = Q_{i,ikj} - Q_{i,calc} = Q_{Gi} - Q_{Li} - Q_{i,calc} \quad (2.10)$$

The reason for the flow of load is limited to two over confounds. It can be noted that (2.6) and (2.7) are used for the calculation of actual and acceptable energy (2.9) and (2.10). In any case, since a large number of voltages and their points were not previously known, it should be used to identify live voltages and their rectangles to identify sculptures and use a repetition method. It is expected that  $\Delta P_i$  and  $\Delta Q_i$  can decrease with each repetition and load flow when all the bus isolates are considered to be consolidated when the number is reduced to a very small number.

For load flow ponders, we will be thinking about the arrangement of Fig 2.1, which is 2 generators and 3 buss loads. While taking the PV bus on bus-5 bus, we identified the bus-bus as slash bus. Busses 2, 3 and 4P-Q are busses. The line impedances and the line charging inductions are given in Table 2.1. In light of this information, the Y bus network is given in Table 2.2. It is to be noted here that the sources and their interior

impedances are not considered while shaping the  $Y^{bus}$  framework for load flow thinks about which manage the bus voltages.

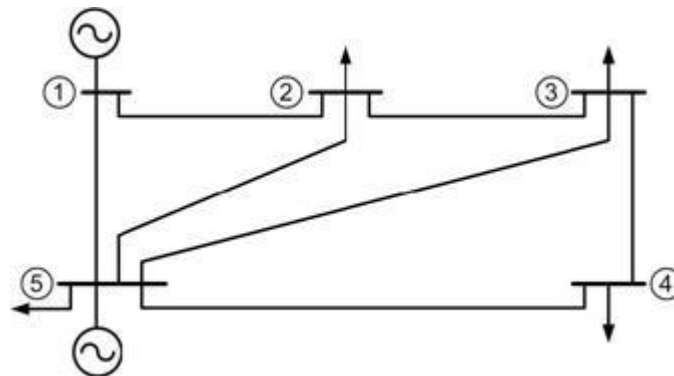


Fig. 2.2 The simple power system used for load flow studies.

**Table 2.1 Line impedance and line charging data of the system of Fig. 2.2.**

Line (bus to bus)	Impedance	Line charging ( $Y/2$ )
1-2	$0.02 + j 0.10$	$j 0.030$
1-5	$0.05 + j 0.25$	$j 0.020$
2-3	$0.04 + j 0.20$	$j 0.025$
2-5	$0.05 + j 0.25$	$j 0.020$
3-4	$0.05 + j 0.25$	$j 0.020$
3-5	$0.08 + j 0.40$	$j 0.010$
4-5	$0.10 + j 0.50$	$j 0.075$

Table 2.2  $Y_{bus}$  matrix of the system of Fig. 2.2.

	1	2	3	4	5
1	$2.6923 - j 13.4115$	$-1.9231 + j 9.6154$	0	0	$-0.7692 + j 3.8462$
2	$-1.9231 + j 9.6154$	$3.6538 - j 18.1942$	$-0.9615 + j 4.8077$	0	$-0.7692 + j 3.8462$
3	0	$-0.9615 + j 4.8077$	$2.2115 - j 11.0027$	$-0.7692 + j 3.8462$	$-0.4808 + j 2.4038$
4	0	0	$-0.7692 + j 3.8462$	$1.1538 - j 5.6742$	$-0.3846 + j 1.9231$
5	$-0.7692 + j 3.8462$	$-0.7692 + j 3.8462$	$-0.4808 + j 2.4038$	$-0.3846 + j 1.9231$	$2.4038 - j 11.8942$

The size of the bus voltage, their focus, the electricity made and consumed on each bus is given at Table 2.3. In this table, a segment of voltage and their edges are given in the boldface character. This demonstrates The power and responsive power delivered at the slack bus and the open power made at the P-V bus is dark. Thusly, all of them are shown in a dash (-). Since we need not waste time with these sums for our load flow, their basic assessments are not required. In like manner, a note from Fig. 2.1 that the slack bus does not contain any load while the P-V bus 5 has an area load and this has appeared in the load segment. Table 2.3 Bus voltages, power generated and load - initial data.



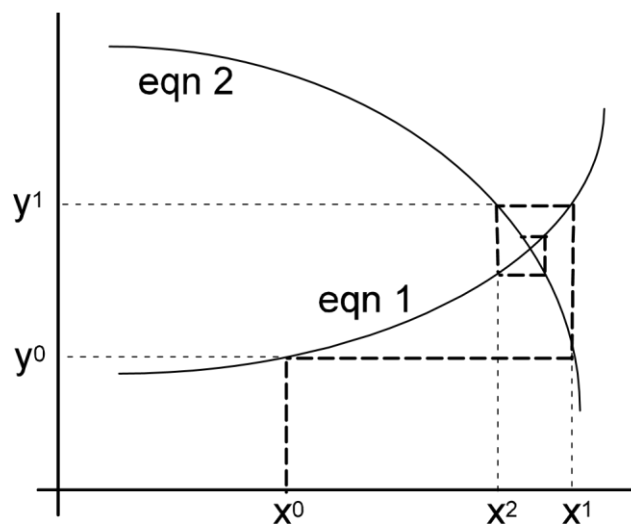
Bus no.	Bus voltage		Power generated		Load	
	Magnitude (pu)	Angle (deg)	P (MW)	Q (MVA <sub>r</sub> )	P (MW)	P (MVA <sub>r</sub> )
1	1.05	0	-	-	0	0
2	<b>1</b>	<b>0</b>	0	0	96	62
3	<b>1</b>	<b>0</b>	0	0	35	14
4	<b>1</b>	<b>0</b>	0	0	16	8
5	1.02	<b>0</b>	48	-	24	11

## 2.6 Solution of A Load Flow Problem

Following three methods are mostly used for the solution of a load flow problem:

- ✓ Gauss-Seidel Technique.
- ✓ Newton-Raphson Technique.
- ✓ Fast-Decoupled Technique.

### 2.6.1 Gauss-Seidel Technique



**Fig. 2.3 Curve of Gauss-Seidel Method**

Regardless of the way that not the best load-flow technique, Gauss-Seidel is the easiest to grasp and was the most extensively used strategy until the mid-1970s [17,19].

This structure was named after German mathematician Carl Friedrich Gauss and Philip Ludwig von Seidel was upgraded. This technique is shown for frameworks with non-zero stratified parts, but only the cross segment is filled in the equivalent and positive or corner round corners. The Gauss-Seidel(GS) system is an iterative procedure to illuminate a lot of non-direct arithmetical conditions. At initial, an answer vector is

recognized. The reconsidered estimation of this specific variable is picked up by reviewing a condition by substituting in it the present estimations of various parts. A practically identical system is looked for after every single other variable finishing one full emphasis. This strategy is then repeated until the course of action vector combines inside reasonable screw up points of confinement. The level of affiliation is flimsy to the essential characteristics that are recognized.

Basic power flow equation (2.6) and (2.7) aligners [22]. In an N-board power system, let the number of PQ buses be  $n_p$  and the number of PV (generator) buses such as  $n = n_p + n_g + 1$  PQ buses and voltage angle voltage scale and the angle PV bus is unknown is determined by the total number of  $2n_p + n_g$  amount. The known quantities include the  $2n_p$  number of actual and reactionary forces of P-cu buses, voltage measurements of 2D numbers of real power and PV buses, and voltage levels and slope bass angle. Therefore, there are enough known quantities to solve the problem of load flow. However, it is difficult to obtain a set of closed-form equations from (2.6) and (2.7). So we have to resort to obtaining the repetition solution of load flow problems. At the beginning of a repetitive strategy, many attributes are selected for a vague amount. This is then refreshed at every emphasis. The process, until all the so-called and actual quantities of lethargy, decreases under pre-determined honor.

In Gauss-Seidel load flow, we point to primary voltage of  $i^{th}$  bus by  $V_i^{(0)}$ ,  $i = 2, \dots, n$ . This should read as the voltage of  $i^{th}$  bus at the  $0^{th}$  iteration, or initial guess. Similarly, this voltage after the first iteration will be denoted by  $V_i^{(1)}$ . In this Gauss-Seidel load flow, the load buses and voltage controlled buses are treated differently [13]. Be that as it may, in both these types of transports we use the intricate power condition surrendered (2.5) for refreshing the voltages. Realizing the genuine and responsive power infused at any transport we can grow (2.5) as well

$$P_{i,ikj} - jQ_{i,ikj} = V_i^+ \sum_{k=1}^k Y_{ik} V_k = V_i^+ [Y_{i1}V_1 + Y_{i2}V_2 + \dots + Y_{ii}V_i + \dots + Y_{in}V_n] \quad (2.11)$$

We can rewrite (2.11) as

$$V_i = \frac{1}{Y_{ii}} \left[ \frac{P_{i,ikj} - jQ_{i,ikj}}{V_i^+} - Y_{i1}V_1 - Y_{i2}V_2 - \dots - Y_{in}V_n \right] \quad (2.12)$$

In this style, the voltage of a significant number of transports is strengthened. We will chart this view with the help of a program of 4.1 with framework information given in version 4.3 of 4.1. It is seen that certified and open forces are given separately in the MTA and MVAR. However, they are sorted in a single quantity where the base of 100 MVA is sorted.

### 2.6.2 Raphson Technique

The Newton-Raphson technique calculates the most efficient load-flow [12,19]. The essential (no approximations) Newton-Raphson calculation depends on the formal use of a remarkable calculation for the arrangement of a lot of concurrent non-straight conditions of the structure:

$$[\mathbf{F}(\mathbf{x})] = [\mathbf{0}]$$

Where,

$[\mathbf{F}(\mathbf{x})]$  is a vector of functions:  $f_1 \dots f_n$  in the variables  $x_1 \dots x_n$ .

The above articulation does not rise to zero until the Newton-Raphson process has joined (i.e., all the x's has been found) and the cycles must be performed, beginning at some underlying arrangement of qualities  $x_1, x_2, \dots x_n$ . In the load-flow issue the x's are voltage magnitude and stage edge at all PQ busses and voltage stage edges at all PV busses i.e., points at all busses aside from slack and  $|V|$  for all load busses. The emphases are performed by linearizing the non-straight conditions  $[\mathbf{F}(\mathbf{x})] = [\mathbf{0}]$  and altering the estimations of  $\mathbf{x}$ . This process can be used in single variable variables, which can be created by subtracting the two conditions used at the beginning of the Gauss-Seidel section,

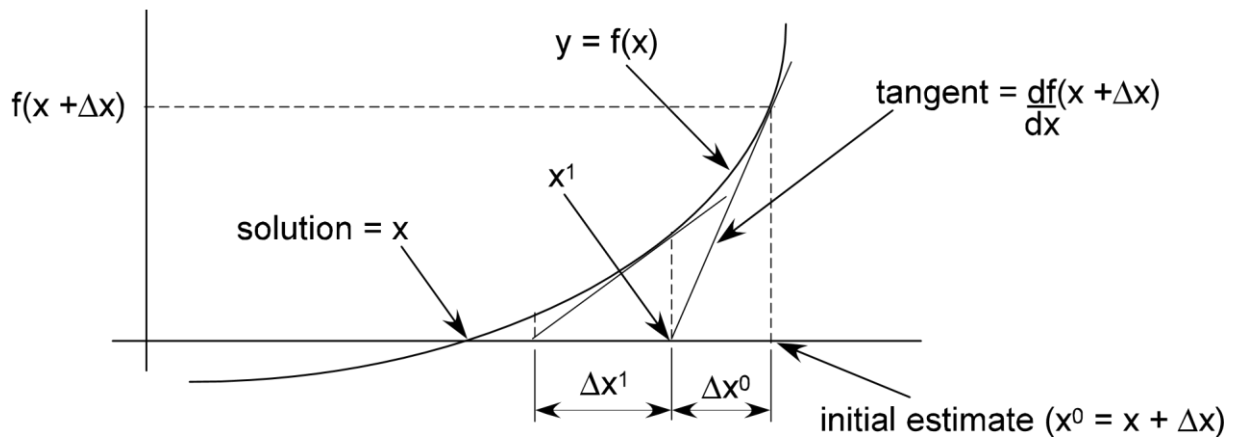
for example,

$$f(\mathbf{x}) = \text{eqn 1} - \text{eqn 2} \quad \{f(\mathbf{x}) = 0 \text{ at the solution}\}$$

$$\mathbf{f}(\mathbf{x}) = \mathbf{0} \text{ is the required}$$

#### **Solution:**

The initial estimate is  $\mathbf{x}^0 \approx \mathbf{x} + \Delta \mathbf{x}$ . This can be improved by applying trigonometry once the function has been differentiated.



An estimate for  $\Delta x$  is obtained from:

$$\Delta x^0 = f(x + \frac{df(x + \Delta x)}{dx} \Delta x)$$

Then the estimate of  $x$  is improved by:

$$x^1 = x^0 - \Delta x^0$$

Newton-Raphson philosophy is an iterative framework in which a lot of non-direct concurrent conditions is approximated into a huge amount of straight synchronous conditions utilizing Taylor's game-plan expansion [22]. In an N-transport bar control framework, there are n conditions for power stream  $P_i$  and n-conditions for responsive power stream  $Q_i$ . The measure of are  $2(n-1)$  in light of the manner in which that the voltage at the slack or swing transport is known and is kept both in immensity and stage

### 2.6.3 Fast Decoupled Technique:

The Energetic decoupled framework is a collaborator of Newton-Raphson strategy which is managed polar bearing with express approximations that outcomes in an adroit mean weight stream technique. Despite the way where that this structure requires a more noteworthy number of enhancements than the Newton8 Raphson framework, yet meanwhile eats up on an exceptionally essential level less time per highlight and

reaction for load stream issue is gotten quickly [17, 19, 22]. This structure finds various applications in credibility examination where obvious power blackouts are to be reenacted or a load stream game-plan is required for on-line control.

The smart decoupled power flow approach is an astoundingly rapid and productive strategy for getting the power flow issue outline. In this framework, both, the paces, additionally as the sparsity, are manhandled. This is incredibly an improvement of the Newton-Raphson method organized in polar ways with unequivocal approximations which result in a quick estimation for power flow approach.

This technique manhandles the property of the power structure wherein MW flow-voltage edge and MVAR flow-voltage degree is around coupled. Around the day's end, a little change in the size of the transport voltage does not influence the legitimate power flow at the transport and by and large, a little change in stage explanation behind the transport voltage has barely any effect on responsive power flow [22] .

Because of this free physical correspondence among MW and MVAR flows in a power structure, the MW- $\delta$  and MVAR-V checks can be decoupled. This decoupling results in an astoundingly head, lively and strong figuring. As we likely know, the sparsity feature of the endorsement cross section constrains the PC memory necessities and results in snappier figurings. The accuracy looks like that of the N-R structure. The condition of intensity flow studies utilizing N-R technique can be written in polar arranges as –

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} H & N \\ M & L \end{bmatrix} \begin{bmatrix} \Delta \delta \\ \frac{\Delta V}{V} \end{bmatrix} \quad (2.13)$$

where H, N, M and L are the elements (viz., J<sub>1</sub>, J<sub>2</sub>, J<sub>3</sub> and J<sub>4</sub>) of the Jacobian matrix.

Since changes in real power (i.e.,  $\Delta P$ ) are less sensitive to the changes in voltage magnitude (i.e.,  $\Delta V$ ) and changes in reactive power (i.e.,  $\Delta Q$ ) are less sensitive to the changes in phase angle of voltage (i.e.,  $\Delta \delta$ ), Eq. (2.13) can be reduced to –

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} H & 0 \\ 0 & L \end{bmatrix} \begin{bmatrix} \Delta \delta \\ \frac{\Delta V}{V} \end{bmatrix} \quad (2.14)$$

The Eq. (2.14) is decoupled equation and can be expanded as –

$$\Delta P = H\Delta\delta \quad (2.15)$$

$$\Delta Q = L\frac{\Delta V}{V} \quad (2.16)$$

The subsequent stage in determining the calculation is to make appropriate presumptions in inferring the articulations for H and L.

Off-diagonal element of H is –

$$\begin{aligned} H_{ik} &= \frac{\partial P_i}{\partial Q_k} = V_i V_k Y_{ik} \sin(\theta_{ik} + \delta_i - \delta_k) \\ &= V_i V_k Y_{ik} [\sin \theta_{ik} \cos(\delta_i - \delta_k) + \cos \theta_{ik} \sin(\delta_i - \delta_k)] \\ &= V_i V_k [Y_{ik} \sin \theta_{ik} \cos(\delta_i - \delta_k) + Y_{ik} \cos \theta_{ik} \sin(\delta_i - \delta_k)] \\ &= V_i V_k [-B_{ik} \cos(\delta_i - \delta_k) + G_{ik} \sin(\delta_i - \delta_k)] \end{aligned} \quad (2.17)$$

Similarly, off-diagonal element of L is –

$$\begin{aligned} L_{ik} &= \frac{\partial Q_i V_k}{\partial V_k} = V_i V_k V_{ik} \sin(\theta_{ik} + \theta_i - \theta_k) \\ &= V_i V_k [G_{ik} \sin(\delta_i - \delta_k) - B_{ik} \cos(\delta_i - \delta_k)] \end{aligned} \quad (2.18)$$

From Eqs. (2.17) and (2.18), we have –

$$\begin{aligned} H_{ii} &= \frac{\partial P_i}{\partial \delta_i} = -\sum_{k=1, k \neq i}^n V_i V_k V_{ik} \sin(\theta_{ik} + \delta_i - \delta_k) \\ &= -Q_i + V_i V_i Y_{ii} \sin \theta_{ii} = -Q_i - V_i^2 B_{ii} \end{aligned} \quad (2.19)$$

The diagonal elements of H are given as –

Similarly, diagonal elements for the matrix are given as –

$$\begin{aligned} L_{ii} &= \frac{\partial Q_i V_i}{\partial V_i} = 2V_i^2 Y_{ii} \sin \theta_{ii} + \sum_{k=1, k \neq i}^n V_i V_k V_{ik} \sin(\theta_{ik} + \delta_i - \delta_k) \\ &= 2V_i^2 Y_{ii} \sin \theta_{ii} + Q_i - V_i^2 Y_{ii} \sin \theta_{ii} = Q_i + V_i^2 Y_{ii} \sin \theta_{ii} = Q_i - V_i^2 B_{ii} \end{aligned} \quad (2.20)$$

On account of the quick decoupled power flow strategy for power flow contemplates, the accompanying approximations are made for assessing Jacobian components.

$$\begin{aligned}\cos(\delta_i - \delta_k) &\simeq 1 \\ G_{ik} \sin(\delta_i - \delta_k) &\leq B_{ik} \\ Q_i &\ll B_{ii}V_i^2\end{aligned}\quad (2.21)$$

With the above assumptions the Jacobian elements become –

$$\begin{aligned}H_{ik} = L_{ik} &= -V_iV_kB_{ik} \text{ for } k \neq i \\ \text{And, } H_{ii} = L_{ii} &= V_i^2B_{ii}\end{aligned}\quad (2.22)$$

With this Jacobian material Eqs (2.15) and (2.16) –

$$\Delta P_i = H \Delta \delta = V_iV_kB'_{ik}\Delta\delta_k \quad (2.23)$$

$$\text{And } \Delta P_i = L \frac{\Delta V}{V} = V_iV_kB''_{ik} \frac{\Delta V_k}{V_k} \quad (2.24)$$

Where  $B_{ik}$  and  $B_{ik}$  are elements of-  $B_{ik}$  matrix.

**Further decoupling and final algorithm for the fast-decoupled power-flow studies are obtained by:**

- (i) Representation of network elements that affect MVAR flow, such as shunt retention and phase transformer tap off-nominal
- (ii) Omitting from B'', the angle shifting effects of phase shifters.
- (iii) Dividing Eqs. (2.23) and (2.24) by  $V_i$  and assuming  $V_k = 1.0$  pu and also neglecting series resistance in calculating the elements of B'.

**With the above assumptions, Eqs. (2.23) and (2.24) for the power flow studies become:**

$$\frac{\Delta P_i}{V_i} = B' \Delta \delta \quad (2.25)$$

$$\text{And } \frac{\Delta Q_i}{V_i} = B'' \Delta V \quad (2.26)$$

In the above conditions B' and B'' are genuine and little and have for all intents and purposes indistinguishable structures as those of H and L freely [20]. Since they contain

just system acknowledgments, they are relentless and don't change during dynamic cycles for the approach of power flow issue, they should be studied just once and turned around once during the fundamental highlight and after that utilized in every single unique complement.

It is an aftereffect of the likelihood of Jacobian Lattices B' and B" and the sparsity of these structures that the strategy is quick. In this approach for power, flow considers, each cycle of highlight contains one reaction for  $\Delta\delta$  to restore  $\delta$  and one reaction for  $\Delta V$  to fortify V. The cycles have proceeded till  $\Delta P$  and  $\Delta Q$  at all load transports and  $\Delta P$  at all age transports are inside upheld (or foreseen) adaptability.

## 2.7 System Constraints

There are two sorts of imperatives.

- Equality limitations.
- Inequality limitations.

Inequality constraints are additionally characterized into two classes, for example:

1. **Hard Type** - The hard sort limitations have consistent and unequivocal qualities for the tapping scope of an on-load tap evolving transformer. These imperatives are inflexible in their qualities and don't engage changes in them.
2. **Soft Type** - The delicate sort limitations are not exceptionally unbending to changes and offer some adaptability in changing their qualities for ex - stage points and nodal voltages.

### 2.7.1 Equality Constraints

Basic Equality restrictions are:

$$P_p = \sum_{q=1}^n \{e_p(e_q G_{pq} + f_q B_{pq}) + f_p(f_q G_{pq} - e_p B_{pq})\} \quad (2.27)$$

$$Q_p = \sum_{q=1}^n \{f_p(e_q G_{pq} + f_q B_{pq}) - e_p(f_q G_{pq} - e_p B_{pq})\} \quad (2.28)$$

Where,  $V_p = e_p + jf_p$  ( real and imaginary components of voltage at the pth node)



And  $Y_{pq} = G_{pq} - jB_{pq}$  ( the nodal conductance and susceptance)

### 2.7.2 Inequality Constraints: [1]

The following are the primary categories of discrimination restrictions:

1. Generator constraints.
2. Voltage constraints
3. Running extra limit constraints.
4. Transformer tap settings.
5. Transmission line constraints.

#### 2.7.2.1 Generator Constraint

$$P_{pmin} \leq P_p \leq P_{pmax} \text{ and } Q_{pmin} \leq Q_p \leq Q_{pmax}$$

Warm Thought is one of the most outstanding constraints of a powerful era, but the absence of a vessel controls incredible energy age [22 ]. So, the most phenomenal plus, at least the reactionary energy is limited by the power of extreme age rotor and the strong reason to automatically stop the machine.

#### 2.7.2.2 Voltage Constraints

$$|V_{pmin}| \leq |V_p| \leq |V_{pmax}| \text{ And } \delta_{pmin} \leq \delta_p \leq \delta_{pmax}$$

The collection in voltage measure ought to be inside a recommended most inaccessible point for the exquisite development of the sorts of mechanical assembly related with the framework overall extra utilization of voltage controllers will make the structure cost unfit.

#### 2.3.2.3 Running Extra Limit Constraints

The variety of voltage measurements should be located at the maximum distance recommended for improved development of the type of compression with the framework. All things will make the structure disqualified considering excessive use of voltage controllers.

### 2.7.2.4 Transformer Tap Setting Constraints

The base tap setting in an autotransformer should be zero and the most outrageous should be one for instance  $0 \leq t \leq 1$ .

on the off chance that tapping is given on the discretionary side of a two-twisting transformer by then,  $0 \leq t \leq n$ , where  $n$  is the extent of progress [13, 21].

### 2.7.2.5 Transmission Line Constraints

The warm capacity of as far as possible the progression of dynamic and responsive power through the line and is communicated as  $C_p \leq C_p \text{ max}$ , where  $C_p \text{ max}$  characterizes the greatest stacking of the  $p^{\text{th}}$  line.

### 1.6 2.8 Optimal Power Flow

That's not really the important thing, the focus of construction station load is equidistant and their fuel costs are never the difference. So, many people will consider permanent interest, as well as temporary interest, as well as reduces the difficulties. Search for this age booking requirement [22]. In the structure of a connected connection, the basic goal is to demonstrate the true and responsive electricity booking of each power plant, which reduces the cost of work. With that power, the dynamic and responsive power of the generator has the flexibility to separate the fragile points illustrated to meet the request for hearing with the most casual imagery. This is depicted as a Perfect Power Flow (OPF) issue. The contemplations like the economy of activity, non-manageable power source outflows, the security of framework and passage of water at hydro age plants are identified with the ideal structure task. The key focal point of the budgetary weight dispatch issue is to compel the absolute conveying cost at different making stations while satisfying the heap needs and the loses in transmission joins. In light of the issue basic, an OPF model may give unmistakable control factors and framework essentials. Among the control factors, an OPF can fuse the going with [17,13]:

- ❖ Real and reactive power generation.
- ❖ Switched capacitor settings.
- ❖ Load MVA and MVA<sub>r</sub> (Load shedding).
- ❖ OLTC transformers tap changing.

## CHAPTER 3

### MODELLING OF LOAD

#### 3.1 Significance of Load Modelling

The decisions concerning structure strongholds and framework execution are commonly dependent on the deferred results of intensity stream and strength augmentation analyzes. For playing out an examination of the power structure, models must be formed to unite hugely noteworthy framework parts, for example, conveying stations, substations, transmission and stream peripherals, and weight contraptions. Much idea has been given to indicating age and transmission or dispersing gadgets. In any case, the appearing of loads has gotten basically less idea and stays to be unexplored woodlands and passes on various degrees for future movement. Advancing examinations have uncovered that portrayal and displaying of weight can massively impact examination results [9,11]. Endeavors in the strategies for improving weight models have been given prime significance.

#### 3.2 Favorable circumstances of Load Modelling in Power Flow Studies [14]

- ❖ The assortment of intensity demand with voltage enables better control limit.
- ❖ The genuine calculation of dynamic and responsive power demand at individual transports.
- ❖ Control of over and under voltage at burden transports.
- ❖ Minimization of incidents.
- ❖ Improvement in voltage profile.
- ❖ Reduction of Steady Fuel Cost.

#### 3.3 Characterization of Load Models

Weight models are extensively mentioned into two get-togethers:

This model passes on the open and dynamic power, at a specific preview of time, as a point of confinement of the tremendousness of vehicle bar voltage and rehash [10]. Both static and dynamic weight parts utilize static weight models. The static weight is model is given as an exponential cutoff of voltage,  $V$

$$P_d = P_0 (V/V_0)^\alpha$$

$$Q_d = Q_0 (V/V_0)^\beta$$

Where,

$P_d$  = Dynamic power requests of the load.

$Q_d$  = Reactive power requests of the load.

$P_0$  = Utilization of dynamic power at evaluated voltage,  $V_0$ .

$Q_0$  = Utilization of responsive power at evaluated voltage,  $V_0$

$\alpha$  = Active power exponent.

$\beta$  = Reactive power exponent.

$V$  = Supply voltage.

$V_0$  = Appraised voltage.

### 3.3.1 Dynamic Load Models

In Unique weight model, the dynamic and open power at a particular delineation of time is tended to as a piece of the centrality of voltage and repeat [13]. Dynamic weight models are as every now and again as possible used in concentrates concerning voltage soundness, between zone advancements and whole game plan security. Such models are routinely tended to using differential conditions.

#### Input-Output Form:

$$T_p \dot{P}_d + P_d = P_s(v) + K_p(v)V \quad (3.9)$$

$$T_p \dot{Q}_d + Q_d = Q_s(v) + K_q(v)V \quad (3.10)$$

$$K_p(v) = T_p P_t(v) \quad (3.11)$$

$$K_q(v) = T_q Q_t(v) \quad (3.12)$$

$$P_s = P_0 \left\{ \frac{v}{v_0} \right\}^\alpha \quad (3.13)$$

$$Q_s = Q_0 \left\{ \frac{v}{v_0} \right\}^\beta \quad (3.14)$$

$$P_t = P_0 \left\{ \frac{v}{v_0} \right\}^{\alpha} t \quad (3.15)$$

$$Q_t = Q_0 \left\{ \frac{v}{v_0} \right\}^{\beta} t \quad (3.16)$$

**State Form:**

$$T_p \dot{X}_p = P_s(v) - P_d \quad (3.17)$$

$$T_q \dot{X}_q = Q_s(v) - Q_d \quad (3.18)$$

Where,

$T_p$  = Recovery time constant of active load.

$T_q$  = Recovery time constant of reactive load.

$P_d$  = Model of active power consumption.

$Q_d$  = Model of reactive power consumption.

$P_s(v)$  = Steady-state part of active power consumption.

$Q_s(v)$  = Steady-state part of reactive power consumption.

$P_t(v)$  = Transient part of active power consumption.

$Q_t(v)$  = Transient part of reactive power consumption.

$\alpha_s$  = Steady-state active load-voltage dependence.

$\beta_s$  = Steady-state reactive load-voltage dependence.

$\alpha_t$  = Transient active load-voltage dependence.

$\beta_t$  = Transient reactive load-voltage dependence.

$P_0$  = Consumption of active power at rated voltage,  $V_0$ .

$Q_0$  = Consumption of reactive power at rated voltage,  $V_0$ .

$V$  = Supply voltage.

$V_0$  = Supply voltage during pre-fault conditions.

### 3.3.2 Composite Load Models

The composite burden models are proposed to join the effect of various zones. It is a blend of a static Burden (LS), a standard amazing recovery load (LG) and an absolute insistence motor weight (LIM). All the static weight parts are spoken to by the static

load(LS). The effects of thermo-statically controlled warming loads and all downstream on Burden Tap Changer (OLTC) moves are made the possibility of by the standard recovery load(LG) [16]. Each downstream blower and other turning burdens are tended to by an insistence motor.

$$T_p \frac{dpr}{dt} + P_r = N_p$$

$$N_p(V) = P_0(V/V_0)^{as} - P_0(V/V_0)^{at}$$

$$P_d = P_r + P_0(V/V_0)^{at}$$

$$T_p \frac{dQr}{dt} + Q_r = N_q(V)$$

$$N_q(V) = Q_0(V/V_0)^{\beta s} - Q(V/V_0)^{\beta t}$$

$$Q_d = Q_r + Q_0(V/V_0)^{\beta t}$$

Where,

Pr = Active power recovery.

Qr = Reactive power recovery.

### 3.4 Different models of static and dynamics of the load model

A part of the static and dynamic understanding models as follows [18]:

- ❖ **Constant Impedance Load Model-** It is a static weight model that sets the square with a power voltage level. It is known as such an expected compliance model.
- ❖ **Constant Current Load Model -** It is a static weight model which closely connected to the power voltage degree.
- ❖ **Constant Power Load Model -** It is a static weight model that is closely connected to electricity voltage degree.
- ❖ **Polynomial Load Model -** This is a static weight model where the control is seen as a biblical association with voltage measurements.

$$P = P_0[a_0(V/V_0)^2 + a_1(V/V_0) + a_2]$$

$$Q = Q_0[b_0(V/V_0)^2 + b_1(V/V_0) + b_2]$$

Where,

$$a_0 + a_1 + a_2 = 1 \text{ and } b_0 + b_1 + b_2 = 1$$

This model is in like manner called "ZIP" model as it cumulates all the above models into a solitary enunciation.

**Exponential load model** - This model is called "zip" model because it collects all the above models in neutral explanation.3.5 Incorporation of Static Load Model

The combination of the pillar model is best done by creating the Newton-Raffson process in its polar coordinates framework –

$$P_d = P_0 (V/V_0)^\alpha \quad \text{and} \quad Q_d = Q_0 (V/V_0)^\beta$$

By differentiating the above equation w.r.t V,

We get,

$$\frac{dP_d}{dV} = P_0 \cdot \alpha \cdot \left(\frac{V}{V_0}\right)^{(\alpha-1)} \cdot \frac{1}{V_0} + \frac{\partial P_0}{\partial V} \left(\frac{V}{V_0}\right)^\alpha$$

$$\frac{dQ_d}{dV} = Q_0 \cdot \beta \cdot \left(\frac{V}{V_0}\right)^{(\beta-1)} \cdot \frac{1}{V_0} + \frac{\partial Q_0}{\partial V} \left(\frac{V}{V_0}\right)^\beta$$

We know –

$$\frac{\partial P_0}{\partial V} = 2|V_i \parallel Y_{ij}| \cos(\delta_{ij}) + \sum_{k=1}^{\infty} |V_k \parallel Y_{ik}| \cos(\theta_{ik} + \theta_k + \delta_j)$$

$$\frac{\partial Q_0}{\partial V} = 2|V_i \parallel Y_{ij}| \cos(\delta_{ij}) + \sum_{k=1}^{\infty} |V_k \parallel Y_{ik}| \cos(\theta_{ik} + \theta_k + \delta_j)$$

Combining both the equations we get –

$$\frac{dP_d}{dV} = P_0 \cdot \alpha \cdot \left(\frac{V}{V_0}\right)^{(\alpha-1)} \cdot \frac{1}{V_0} + \left(\frac{V}{V_0}\right)^\alpha [2|V_i \parallel Y_{ij}| \cos(\delta_{ij}) + \sum_{k=1}^{\infty} |V_k \parallel Y_{ik}| \cos(\theta_{ik} + \theta_k + \delta_j)]$$

$$\frac{dQ_d}{dV} = Q_0 \cdot \beta \cdot \left(\frac{V}{V_0}\right)^{(\beta-1)} \cdot \frac{1}{V_0} + \left(\frac{V}{V_0}\right)^\beta [2|V_i \parallel Y_{ij}| \cos(\delta_{ij}) + \sum_{k=1}^{\infty} |V_k \parallel Y_{ik}| \sin(\theta_{ik} + \theta_k + \delta_j)]$$

More estimates are fully installed in two locations. The Jkbian grid is evaluated using the above conditions and results of OPF are achieved.

## CHAPTER 4

### SIMULATION RESULTS AND ANALYSIS

#### 4.1 Problem Statement

The conventional understanding is considered as an ideal IEEE 5 transport to join models to understand the level of stream techniques and understanding flow. The partition was created using MATLAB Power Structure Toolbox, which is known as PHP (Power Framework Analysis Tools Division). The result of qualitative results is plotted and separated.

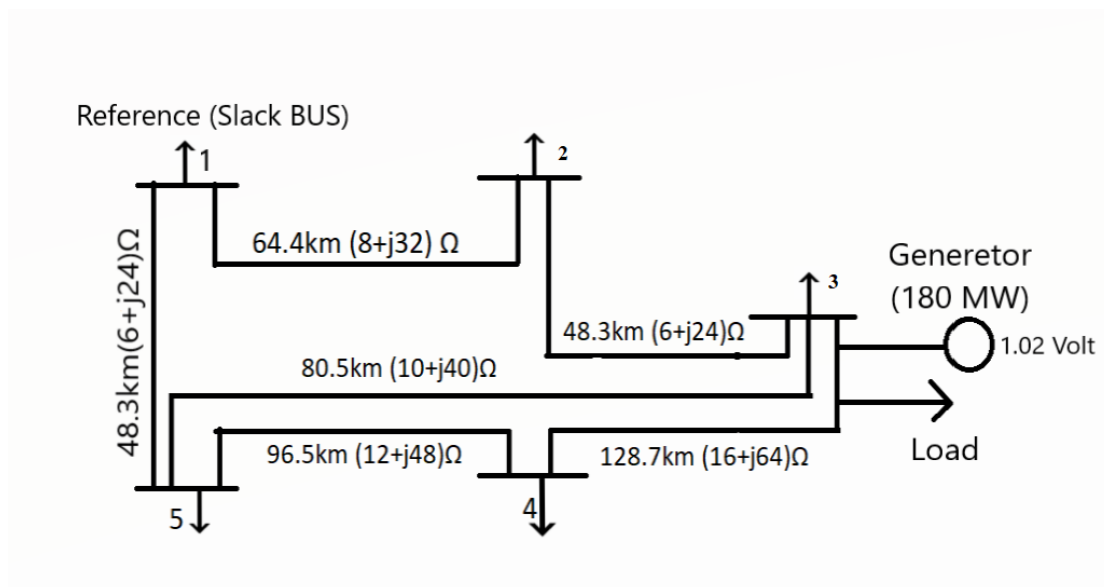


Fig 4.1 A Standard 5 Bus bar System [22]

#### 4.2 MATLAB Implementation

The implementation of the matlab takes place as follows: Suppose that  $a(x)$ ,  $b(x)$ ,  $c(x)$ ,  $f(x)$  sub-programs are  $(x)$ ,  $b(x)$ ,  $c(x)$ ,  $f(x)$  Respectively In addition, suppose that a sub-program  $(x)$  value of a subprime  $(x)$  is false (or 0)  $x \notin (0, \ell)$  or giving true (or 1)  $x \in (0, \ell)$ . Finally, assume that the boundary value is equipped with a subgroup  $(x)$  such as  $ub(0) = u_0$  and  $ub(\ell) = u_\ell$ . The following is an example of Matlab code.



### 4.3 Input values

The line data required for the above simulation is given in the table below.

INPUT Base,P MVA	INPUT Base,V KV	Base resistance	INPUT From	INPUT To	INPUT Length Km	Length mile	INPUT R $\Omega$	INPUT X $\Omega$	R Per unit	X Per unit	INPUT Charging Mvar	Charging Y/2
100	138	190.44	1	2	64.4	40.016228	8	32	0.04200798152	0.1680319261	4.1	0.0205
			1	5	48.3	30.012171	6	24	0.03150598614	0.1260239445	3.1	0.0155
			2	3	48.3	30.012171	6	24	0.03150598614	0.1260239445	3.1	0.0155
			3	4	128.7	79.970319	16	64	0.08401596303	0.3360638521	8.2	0.041
			3	5	80.5	50.020285	10	40	0.0525099769	0.2100399076	5.1	0.0255
			4	5	96.5	59.962205	12	48	0.06301197227	0.2520478891	6.1	0.0305

Table 4.1: Line Data of 5 bus bar system

INPUT Bus	INPUT Generation,P MW	Generation,Q Mvar	INPUT Load, P MW	INPUT Load,Q Mvar	INPUT V Per unit	INPUT Angle
1			65	30	1.04	0
2			115	60		
3	180		70	40	1.02	
4			70	30		
5			85	40		

Table 4.2: Generator Data for 5 Bus bar System

### 4.4 Matlab Code

```
clc
clear
format short G
file='gauss_seidal_power_flow.xlsx'
```

```

sh='Sheet1'
na=xlsread(file,sh,'d:d')
nb=xlsread(file,sh,'e:e')
r=xlsread(file,sh,'j:j')
x=xlsread(file,sh,'k:k')
ch=xlsread(file,sh,'m:m')
l=length(na)
bus=max(max(na),max(nb))

a=65;
b=50;
ab=[a b];
abc=char(ab);
basep=xlsread(file,sh,abc);

a=a+1;
b=50;
ab=[a b];
abc=char(ab);
baseq=xlsread(file,sh,abc);

a=79;
n=1;
for a=79:84
    b=2;
    for k=1:bus
        p=char(a);
        q=num2str(b);
        s=[p,q];
        w0=xlsread(file,sh,s);
        if w0~=0
            w(k,n)=w0;
        else
            w(k,n)=0;
        end
        b=b+1;
    end
    n=n+1;
end

a=a+1;
b=2;
for k=1:bus
    p=char(a);
    q=num2str(b);
    s=[p,q];
    w0=xlsread(file,sh,s);
    if w0~=0
        w(k,n)=w0;
        c=b;
    elseif w0==0
        w(k,n)=w0;
        c=b;
    else
        w0(k,n)=0;
    end
    b=b+1;
end
c=c-1;

```

```

        %y bus
z1=complex(r,x);
y=1./z1;
Y=zeros(bus,bus);
for k=1:1
    if na(k)>0 & nb(k)>0
        Y(na(k),nb(k))=Y(na(k),nb(k))-y(k);
        Y(nb(k),na(k))=Y(na(k),nb(k));
    end
end
for k=1:bus
    for n=1:1
        if na(n)==k | nb(n)==k
            Y(k,k)=Y(k,k)+y(n)+(ch(n)*i);
        end
    end
end
end
%Y
        %y bus completed

V=zeros(bus,1);
I=zeros(bus,1);
for k=1:bus
    if k==c
        h=(w(k,7)*pi)/180;
        x=w(k,6)*(cos(h));
        y=w(k,6)*(sin(h));
        V(k,1)=complex(x,y);
    elseif w(k,6)~=0
        x=w(k,6);
        y=0;
        V(k,1)=complex(x,y);
    else
        x=1;
        y=0;
        V(k,1)=complex(x,y);
        I(k,1)=1;
    end
end
end
%V
%I

S=zeros(bus,1);
s1=w(:,4);
s2=w(:,5);
for k=1:bus
    S(k,1)=(-1*(complex(s1(k,1),s2(k,1))))/basep;
end
end
%S
P=w(:,2);
J=zeros(bus,1);
for k=1:bus
    if k~=c & P(k,1)~=0
        P(k,1)=P(k,1)/basep;
        J(k,1)=1;
    end
end
end
Q=w(:,3);

```

```

%P
%J

% v detect
L=zeros(bus,bus);
for k=1:bus
    n=0;
    for m=1:l
        if na(m,1)==k | nb(m,1)==k
            n=n+1;
            if na(m,1)~=k & na(m,1)~=0
                L(k,n)=na(m,1);
            elseif nb(m,1)~=k & nb(m,1)~=0
                L(k,n)=nb(m,1);
            end
        end
    end
end
end
%L
% v detect complete

e1=1;
e2=1;
p=.000001;
t=0;

while(e1>p)
    t=t+1;
    e1=0;
    e2=0;
    vi=V;
    qi=Q;
    for k=1:bus
        if I(k,1)==1 & J(k,1)==0
            m=0;
            for n=1:bus
                if L(k,n)~=0
                    m=m+(Y(L(k,n),k)*V(L(k,n),1));
                end
            end
            V(k,1)=(((conj(S(k,1)))/(conj(V(k,1))))-m)/(Y(k,k));
        end
    end

    for k=1:bus
        if I(k,1)==0 & J(k,1)==1
            m=0;
            for n=1:bus
                if L(k,n)~=0
                    m=m+(Y(L(k,n),k)*V(L(k,n),1));
                end
            end
            g=V(k,1)*Y(k,k);
            h=g+m;
            Q(k,1)=-1*(imag((conj(V(k,1))*h));
            x=real(V(k,1));
            a=P(k,1);
            b=real(-1*S(k,1));
        end
    end
end

```

```

        d=a-b;
        V0= ((d/conj(V(k,1)))-m)/Y(k,k);
        y=imag(V0);
        V(k,1)=complex(x,y);
    end
end
vf=V;
qf=Q;

e1=max(abs(abs(vf)-abs(vi)));

end
H=abs(V)
O=angle(V)
N=O.*(180/pi);
B=w(:,1);

R=zeros(bus,1);
for k=1:bus
    R(k,1)=abs(V(k,1));
end
O=zeros(bus,1);
for k=1:bus
    O1=angle(V(k,1));
    O2=O1*(180/pi);
    O(k,1)=O2;
end

m=0;
for n=1:bus
    if L(c,n)~=0
        m=m+(Y(L(c,n),c)*V(L(c,n),1));
    end
end
g=V(c,1)*Y(c,c);
h=g+m;
ss=conj(V(c,1))*h;
P(c,1)=real(ss);
Q(c,1)=-1*(imag(ss));

W=zeros(bus,5);
W(:,1)=B;
W(:,2)=R;
W(:,3)=O;
W(:,4)=P;
W(:,5)=Q;

names = cell(bus,1);
for i=1:bus
    if I(i,1)==0 & J(i,1)==0
        names{i}=['Slack bus'];
    elseif I(i,1)==1 & J(i,1)==0
        names{i}=['PQ bus'];
    else
        names{i}=['PV bus'];
    end
end

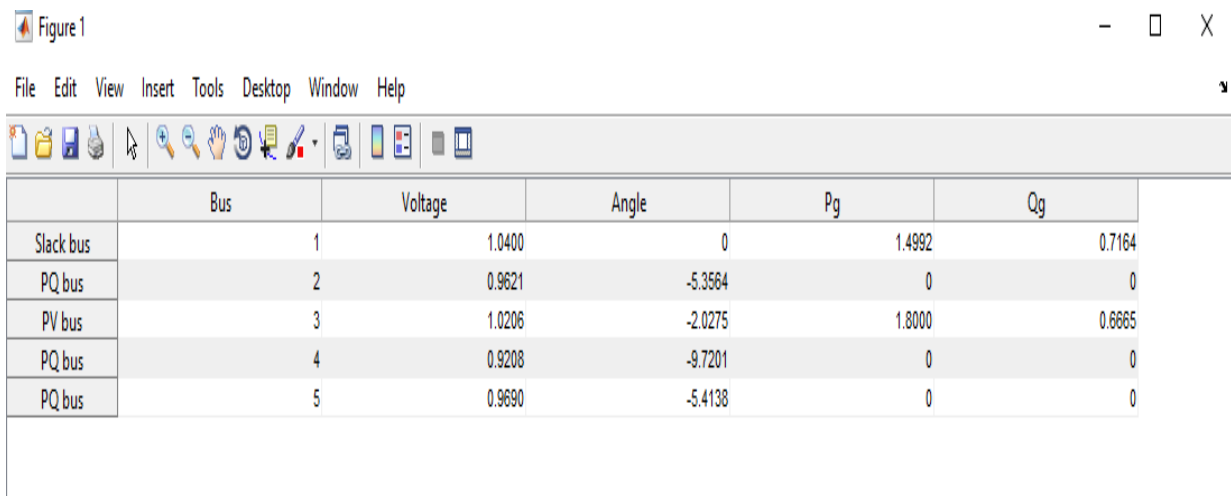
```

```

end
end
set(0,'units','pixels');
f=get(0,'screensize');
set(gcf(),'units','pixels');
set(gcf(),'position',[f(1,3)/10 f(1,4)/10 8*(f(1,3)/10)
8*(f(1,4)/10)]);
uitable('units','normalized','position',[0 0 1
1], 'ColumnWidth',{(8*(f(1,3)/10))/6}, 'data',W,...
'ColumnName',{'Bus','Voltage','Angle','Pg','Qg'}, 'RowName',names
)
t

```

## 4.5 Matlab Output



	Bus	Voltage	Angle	Pg	Qg
Slack bus	1	1.0400	0	1.4992	0.7164
PQ bus	2	0.9621	-5.3564	0	0
PV bus	3	1.0206	-2.0275	1.8000	0.6665
PQ bus	4	0.9208	-9.7201	0	0
PQ bus	5	0.9690	-5.4138	0	0

Fig. 4.1 Output Value

## 4.6 Result & Analysis

### 4.2.1 Voltage Magnitude

The information available from Table 4.1 shows the voltage size at different busses. It can be seen in general that if there is an event to load without voltage, voltage levels with low voltage levels are interestingly low [22]. In the past, voltage levels are noticeable more than 1 PU when dynamic energy time is dynamically enunciated. Inserting voltage ward loads emphasizes a level voltage profile, for example, the load flow increases voltage by 1 pu and reduces more than 1 pu.

### 4.2.2 Swing bus Active Power

Both types of load swing buses are 2.5% of dynamic energy. It is a very high standard and the record for power loss reduction. The dynamic power capacity of the swing bus

induces both voltage and phase-end variation, and the exercise uniquely predicts the standard load flow test without adding voltage-low loads [22].

#### **4.2.3 Generator Reactive Power**

The capacity of the response power is 4% to 16%. This range is noticeable for the dynamic energy difference of fully progressive swing transport. A generator transport that was used to fill the responses to the reactionary energy requirements in the current load-flow test, the load was shown when the voltage was changed [23]. The generator open-source complexity is in front of the audience edge difference and the voltage extender.

#### **4.2.4 Load Active Power**

Table 4.1 gives information about dynamic forces loading various busses. While there are no voltage-penile and freeload events, dynamic forces are not used in different buses. Due to voltage-low load, 28 different variations of voltage freeloads are used because certified power consumption is less [24]. Reducing the use of dynamic effects ensures less hazard and improved dauntlessness and system safety.

#### **4.2.5 Load Reactive Power**

Responsible strengths of different buses do not follow specific examples, for example, in some bushes, their voltage-load loads and in some cases are of high quality. In any case, fundamentally, difference ranges from 0.6% to 4.2%.

#### **4.3 Overall Comparison**

Table 4.1 gives information about the dynamic ability to load various transport. Dynamic power is used in various transport, if voltage-penile and freeloads are raised in a ceremony, then it is not increased. By the voltage-low load mood, the exact power consumption voltage is less than 28, as low as 28 frills [25]. Reducing the unique effect reduces the use of less problems and better reliable quality and framework safety.

## Chapter 5

### Conclusion & Future Scope

#### 5.1 Conclusion & Future Scope

For this example, 5 transport frameworks have been used, 5 transport information is taken from information reference [1]. Each emphasis is guessed using GUASS-SEIDEL conditions to illustrate voltage, dynamic and acceptable forces in each transport. Each MATLAB program depicts voltage, dynamic energy and acceptable power at each transport of each frame for each emphasis. Information about the program is given with the name of the document.

Such MATLAB refers to the understanding of written computer programs. This MATLAB program can be connected for any number of transport. We can have more impact with 5 transport power frameworks and a new transmission line or transportation. The future degree of this initiative can be reached with the Newton-Rapson strategy and rapid decoding technology [2].

These proposals mainly dismiss different models of dynamic and reactionary forces with voltage and repeat the effects on them. Basically, for easy calculation, the static understanding model is considered here, the burden is displayed on the request for dynamic and acceptable.



## REFERENCES

- [1]. C. L. Wadhwa (2009), "Electrical Power Systems", Chap 18, Chap 19.
- [2]. Dommel, H.W. and Tinney, W. F. "Optimal Power Flow Solutions", IEE Transactions on power apparatus and systems, Vol Pas-87, No. 10, October 1968
- [3]. Dias, L. G. And M.E.El-Hawary "Effects of active and reactive power modelling on optimal load flows", IEE PROCEEDINGS, Vol. 136, Pt. C, No. 5, September 1989
- [4]. Dias, L. G. And M.E.El-Hawary "Incorporation of load models in load flow studies", IEE PROCEEDINGS, Vol. 134, Pt. C, No. 1, January 1987
- [5]. Dias, L. G. And M.E.El-Hawary "OPF Incorporating load models maximizing net revenue", IEEE Transactions on Power Systems, Vol. 8, No. 1, February 1993
- [6]. Saadat H.(2010), "Power System Analysis", Chap 6, Chap 7.
- [7]. MATLAB, Version 2009, MathWorks.
- [8]. Milano, Federico, "Power System Analysis Toolbox", July 2005
- [9]. M.A Pai, "Operation of Reconstructed Power System", Chap 2
- [10].Sambit Kumar Dwivedi, "Load Modelling In Optimal Power Flow Studies",<http://ethesis@nitrrkl.ac.in>
- [11]. Mageshvaran, R., Raglend, I.J., Yuvaraj, V., Rizwankhan, P.G., Vijayakumar, T. and Sudheera (2008) Implementation of Non-Traditional Optimization Techniques (PSO, CPSO, HDE) for the Optimal Load Flow Solution. TENCON2008- 2008 IEEE Region 10 Conference, 19-21 November 2008.
- [12] Elgerd, O.L. (2012) Electric Energy Systems Theory: An Introduction. 2nd Edition, McGraw-Hill.
- [13] Kothari, I.J. and Nagrath, D.P. (2007) Modern Power System Analysis. 3rd Edition, New York.
- [14] Keyhani, A., Abur, A. and Hao, S. (1989) Evaluation of Power Flow Techniques for Personal Computers. IEEE Transactions on Power Systems, 4, 817-826.
- [15] Hale, H.W. and Goodrich, R.W. (1959) Digital Computation of Power Flow—Some New Aspects. Power Apparatus and Systems, Part III. Transactions of the American Institute of Electrical Engineers, 78, 919-923.
- [16] Sato, N. and Tinney, W.F. (1963) Techniques for Exploiting the Sparsity of the Network Admittance Matrix. IEEE Transactions on Power Apparatus and Systems, 82, 944-950.
- [17] Aroop, B., Satyajit, B. and Sanjib, H. (2014) Power Flow Analysis on IEEE 57 bus System Using Matlab. International Journal of Engineering Research & Technology (IJERT), 3.
- [18] Milano, F. (2009) Continuous Newton's Method for Power Flow Analysis. IEEE Transactions on Power Systems, 24, 50-57.
- [19] Grainger, J.J. and Stevenson, W.D. (1994) Power System Analysis. McGraw-Hill, New York.
- [20] Tinney, W.F. and Hart, C.E. (1967) Power Flow Solution by Newton's Method. IEEE Transactions on Power Apparatus and Systems, PAS-86, 1449-1460.

- [21] Bhakti, N. and Rajani, N. (2014) Steady State Analysis of IEEE-6 Bus System Using PSAT Power Tool Box. International Journal of Engineering Science and Innovation Technology (IJESIT), 3.
- [22] Hadi, S. (2010) Power System Analysis. 3rd Edition, PSA Publishing, North York.
- [23] Kabisama, H.W. Electrical Power Engineering. McGraw-Hill, New York.
- [24] Gilbert, G.M., Bouchard, D.E. and Chikhani, A.Y. (1998) A Comparison of Load Flow Analysis Using Dist Flow, Gauss-Seidel, and Optimal Load Flow Algorithms. Proceedings of the IEEE Canadian Conference on Electrical and Computer Engineering, Waterloo, Ontario, 24-28 May 1998, 850-853.