LOAD FLOW ANALYSIS
FOR N.E. P. A. IIKV DISTRIBUTION NETWORK WITHIN LOKOJA TOWN.

BY

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A PROJECT REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG)

DEGREE IN THE

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CERTIFICATION

This is to certify that this project titled "Load flow analysis of Lokoja town" was carried out by Shaibu Enebe Dada under the supervision of MALLAM M.S. Ahmed and submitted to Electrical and computer Engineering Department, Federal University of Technology, Minna in partial fulfilment of the requirements for the award of Bachelor of Engineering (B.Eng.) degree in Electrical and computer Engineering.

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DECLARATION

I hereby declare that the project work is an original concept wholly carried out by me, under the supervision of Mal. M.S. Ahmed of the department of Electrical/computer engineering, Federal University of Technology Minna.

Shaibu Enebe Dada.
Student

27/5/200

Sign & Date

DEDICATION

This project work is dedicated to God Almighty for his unflinching love, protection and provision. Also to my late father to my late father Mr. Aguva J.E Shaibu.

ABSTRACT

In this project work, the electrical network distribution in Lokoja town is explained followed by the load flow problem and equation formulation using different methods. The load flow analysis is applied to 11kv distribution network. The data for load flow simulation program is prepared.

The simulation program is written in C-language which is more reliable than other computer languages.

1. Determination of real & reactive power flow in the distribution lines of a system base on certain prior assumptions regarding loads, & generations.
2. Computation of the voltage at all system buses.
3. Checking that no distribution line is overloaded, over loading means the operation too close to its distribution limit or (in the case of under ground cable over heating).

LITERATURE REVIEW

In the past, before the invention of computer, load flow analysis were made on alternate current (a.c) calculating boards which provide small-scaled single voltage sources. It was very tedious and time consuming to set-up the connection, making adjustment and reading data. Now digital computer provide the solution of load flow studies on complex systems. For example, the computer program may handle more than 1500 buses, 2500 lines, 500 transformers with tap-changing under load and 25 phase-shifting transformers. Complete results are printed quickly and economically.

The simulation program associated with the load flow program are a system of linked programs that have the following capabilities.

1. Basic programs involving calculation of voltage, power flow, angles, and interchanges between areas of a power system.
2. A network reduction program to represent large network as equivalents conjuction with the specified area to be studied.
3. A distribution - factors program that indicates the sensitivity of response of the various circuits to

iv. Effect of temporary loss of generation and transmission circuits on system loading.

v. Effect of inejecting in in-phase and quadrature boost voltage on system loading.

vi. Optimum system running conditions and distribution

vii. Optimum system losses.

viii. Optimum rating and tap change of transformers

ix. Improvement from change of conductor size and system voltage.

2.20 BUS CLASSIFICATION

Three types of buses are represented in load flow calculations. Associated with each bus are four quantities which are the real and reactive power, the voltage magnitude and the phase angle. At a bus two of there four quantities are specified. These buses are,

2.2.1 *(i) Voltage - Control Bus*

Here the voltage magnitude V. corresponding to the generation and real power P. Corresponding to its ratings are specified. It is required to find out the reactive power geeration Q and the phase angle of the voltage. This types of bus generally corresponds to either a generator where P is is fixed by turbine governor and V is fixed by automatic voltage regulations acting on the machine excitation, or a bus where the voltage is fixed by supplying reactive power from static shurt capacitors or retating synchronous compensators, example at substations.

2.2.2 (II) LOAD BUS

In this bus the real and reactive components of power are specified. It is desired to find out the voltage and

$$Y_{11} = Y_{11} + Y_{12} + Y_{13}$$
$$Y_{12} = - Y_{12}$$
$$Y_{13} = - Y_{13}$$

Where Y12 and Y13 is the self admittance of bus 1

Similarly nodal current equations for the other nodes can be written as follows:-

$$1_2 = V_1Y_{21} + V_2Y_{23} \text{ ------}(2)$$
$$1_2 = V_1Y_{31} + V_2Y_{32} + V_3Y_{33} \text{ ------}(3)$$

These can be written on matrix form as follows:

$$\begin{bmatrix} 1_1 \\ 1_2 \\ 1_3 \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} & Y_{13} \\ Y_{21} & Y_{22} & Y_{23} \\ Y_{31} & Y_{23} & Y_{33} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} \text{ ------ (4)}$$

or in complex form, these equations can be written as

$$1P = \sum_{q=1}^{n=3} Y_{pq}V_q. \quad P = 1 \text{ to } 3. \text{ --- (5)}$$

From this the nodal current equations for n-bus system where each node is connected to all other nodes is written in the form

$$1_p = \sum_{q=1}^{n} Y_{pq} V_q, \; P = 1, 2, \text{ --- } n \quad (6)$$

or in matrix form.

$$\begin{bmatrix} 1_1 \\ 1_2 \\ , \\ , \\ , \\ 1_n \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} & \text{---}Y_{1n} \\ Y_{21} & Y_{22} & Y_{2n} \\ , & , & , \\ , & , & , \\ , & , & , \\ Y_{n1} & Y_{n2} \text{ --} & Y_{nn} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ , \\ , \\ , \\ V_n \end{bmatrix} \text{ ---- (6a)}$$

2.3.2 PROPERTIES OF NODAL ADMITTANCE MATRIX

The nodal admittance matrix has the following properties

(i) It is a square matrix of order nxn

(ii) It is symmetrical, since Yki = Yik where K and i are nodal numbers.

(iii) It is complex

(iv) Each of diagonal element Yki is the negative of the branches admittance between notes K and i, and is frequency at value zero.

(v) Each diagonal element Ykk is the sum of admittance of the branches which terminate on nodee K, including branches to ground.

(vi) Because in all but the smallest practical networks vary few non zero mutual admittances exist, the matrix Y is highly spares.

2.3.3 *Advantages of Nodal admittance Matrix Method.*

The nodal analysis has been found to be particularly suitable for digital computer work, and is almost exclusively used for routine network calculations. It has the following advantages.

(i) The numbering of nodes, performed directly from a system diagram, is very simple.

(ii) Data preparation is easy.

(iii) The number of variables and equations is usually less than with much method for power networks.

(iv) Network crossover branches present not difficulty

(v) Parallel branches do not increase the number of variables or equations.

(vi) Node voltage are available directly from the solution, and branch currents are easily calculated.

(vii) Off normal transformer tape can easily be represented

2.3.4. Developement of Load Flow Equation

The nodal current equations for n bus system can be remittencas as:

$$I_p = Y_{pq}V_q + \sum_{q=1}^{n} Y_{pq}Vq, \quad P-1,2, --- n \quad (6)$$

$$I_p = Y_{pq}V_q + \sum_{\substack{q=1 \\ q \neq p}}^{n} Y_{pq}Vq \quad ------ (7)$$

$$\therefore V_p = \frac{I_p}{V_{pq}} - \frac{I}{V_{pq}} \sum_{\substack{q=1 \\ q \neq P}}^{n} \quad ---- (7)$$

$$V_p{*}I_p = P_p - JQ_p \quad ------ (9)$$

$$1_p = \frac{P_p - JQP}{V^*_p} \quad ---- (10)$$

Where V^*_p is at bus P the complex conjugate of V_p. (Voltage at bus P).

Substituting for 1_p in equation (8) we get for

$$V_p: V_p = \frac{1}{Y_{pq}} \left[\frac{P_p - JQP}{V^*_p} - \sum_{\substack{q=1 \\ q \neq p}}^{n} Y_{pq}V_q \right], \; P = 1,2, \; -- \; n, \; -- (11)$$

Where P and q are node numbers.

lp has been substituted by the real and reactive power because normally in a power system there quantities are specified.

2.4 solution Techniques to load flow equations

The solution of algebric equations describing the power system are based on an iterative technique because of their non linearity. The solution must satisfy Kirchoff's laws, that is the algebric sum of all flows at a bus must equal zero, and the algebriac sum of all voltages in a loop must

$$Y_{pq} = \begin{bmatrix} Y_{11} & Y_{12} & 0 & Y_{14} & Y_{15} \\ Y_{21} & Y_{22} & Y_{23} & 0 & 0 \\ 0 & Y_{32} & Y_{33} & Y_{34} & 0 \\ Y_{41} & 0 & Y_{43} & Y_{44} & Y_{45} \\ Y_{51} & 0 & 0 & Y_{54} & Y_{55} \end{bmatrix}$$

By using this nodal admittance matrix along with equation (ii) the load flow equations for 5-bus system are written as follows;

Assuming bus 1 as the slack bus.

$V_1 = V_1$ specified fixed bus

$$V_2 = \frac{1}{Y_{22}} \frac{(P_2\ JQ_2)}{V^*_2} (Y_{21}V_1 + Y_{23}V_3)$$

$$V_3 = \frac{1}{Y_{33}} [\frac{P_3 - JQ_3}{V^*_3}) - (Y_{32}V_2\ Y_{34}V_4)]$$

$$V_4 = \frac{1}{Y_{44}} [\frac{P_4 - JQ_4}{V^*_4} - (Y_{41}V_1V_1 + Y_{43}V_3 + Y_{45}V_5)]$$

$$V_5 = \frac{1}{Y_{55}} [\frac{P_5 - JQ_5}{V^*_5} - (Y_{52}V_1 + Y_{54}V_4$$

TO understand the procedure for solution of these equations, simplifying assumption is made at the state that all the other buses except bus 1 are load, buses, that is buses where P Q are specified. The admittances and voltages are used in these quation are complex quanntities and the number of non linear equations is (n-1) where n is the number of buses in the system.

2.8 GAUSS METHOD

In this method, the same set of voltage is used throughout a complete iteration instead of immediately substituting each new value obtained to calculate the voltage at the next bus the flow chart for load flow solution using Gauss method is given on page 25.

former impedances which compose Zbus may be used in solving the load flow problem. The starting point in obtaining the data which must be furnished to the computer is the one-blue diagram of the system. values of series impedances and shunt admittance of transmission blues are necessary so that the computer can determine all the Y_{bus} or Z_{bus} elements. Other essential informations include transformer ratings, and impedances, shunt capacitors ratings and transformer tap settings.

Operation conditions must always be selected for each study.

2.7.8 INTERATIVE METHODS OF SOLUTION

As the load flow equations (II) are non linear, they can be solved by an iterative method. These iterative methods include:

(i) Gauss's method

(ii) Gauss-sidel method

(iii) Newton-Raphon method.

But before the these methods are explained, a specific example is taken and these methods are applied for the solution of load flow equations. Let us contener the figure below.

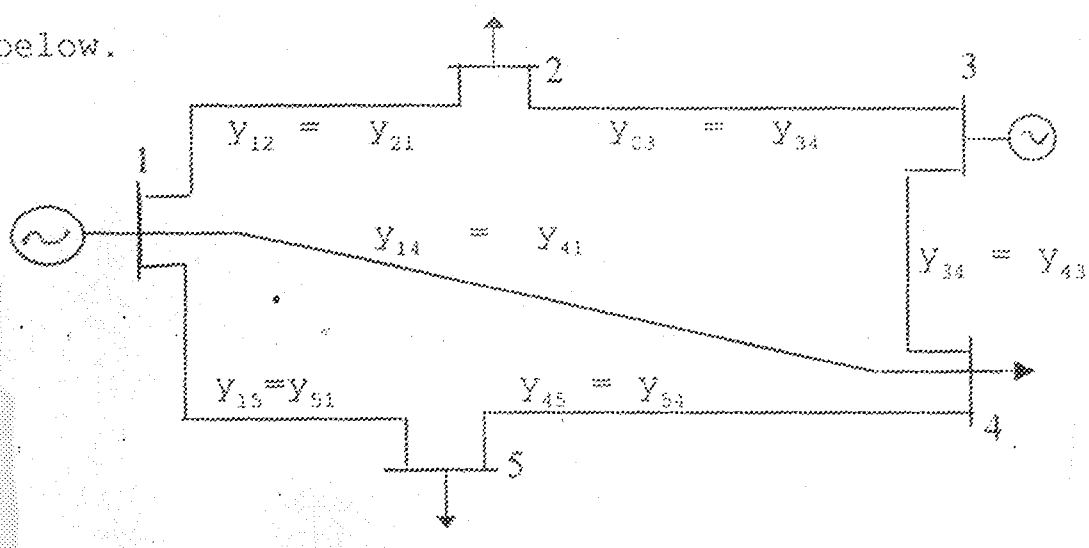


FIG 2 FIVE BUS SYSTEM

This bus system has two generators at buses 1 and 3 and three load buses 2,4 and 5. The nadal admittance matrix is also given as follows:

The procedure for the solution is as follows:

(1) Assume a flat voltage profile for all nodal voltage except the slack bus 1. set slack bus voltage to be a + jo.o. Assume a suitable value of convergence criterion E that is if the absolute value of the maximum change in voltage between any consecutive iterations is less than a pre-specified tolerance E, the convergence is achieved and the iteration procedure is terminated.

2. Set iteration count K = 0
3. Set bus count P = 1
4. Check for the slack bus, if it is not a slack bus go to the next step. Since voltage at the slack bus is fixed both in magnitued and phases it does not vary during iteration procedure and hence go to step 6 if it is a slack bus.
5. Calculate the bus voltage V^{k+1} using (ii) and the difference in the bus voltage.

$$V_p^k = V_p^{k+1} - V_p^k$$

6. Advance the bus count by 1 to evalueate other value of V_p^{k+1} and V_p^k

7. Check if all buses have been taken into account. If yes, go to the next step; otherwise go back to step 4.

8 Determine the largest absolute value of change in voltage $Vmax^1$
9. If 1 $Vmax^1$ is less than a specified tolerance E. evaluate line flows and point the voltage and line flows. If not advance the iiteration count K = K+1 and go back to step 3.

The table below show the different types of transformers and ther rating.

TABLE 3.1

33/11KVA	33/0.415KVA	11/0.415
7.5MVA	50KVA	2 X 50KVA
2X2.5MVA	300KVA	12 X 100KVA
	200KVA	13 X 200KVA
	2 X 500KVA	17 X 300KVA
		3 X 315KVA
		8 X 300KVA

TYPES OF TRANSFORMER AND THEIR RATING

The four busbars that comprise the N.E.P.A 11kv distribution network in Lokoja town are as follows:-

(i) G.R.A BUS

(ii) Town-ship bus

(iii) Army barack bus

iv) Lokongoma bus

or the purpose of the present project work the connection etween these buses is shown below.

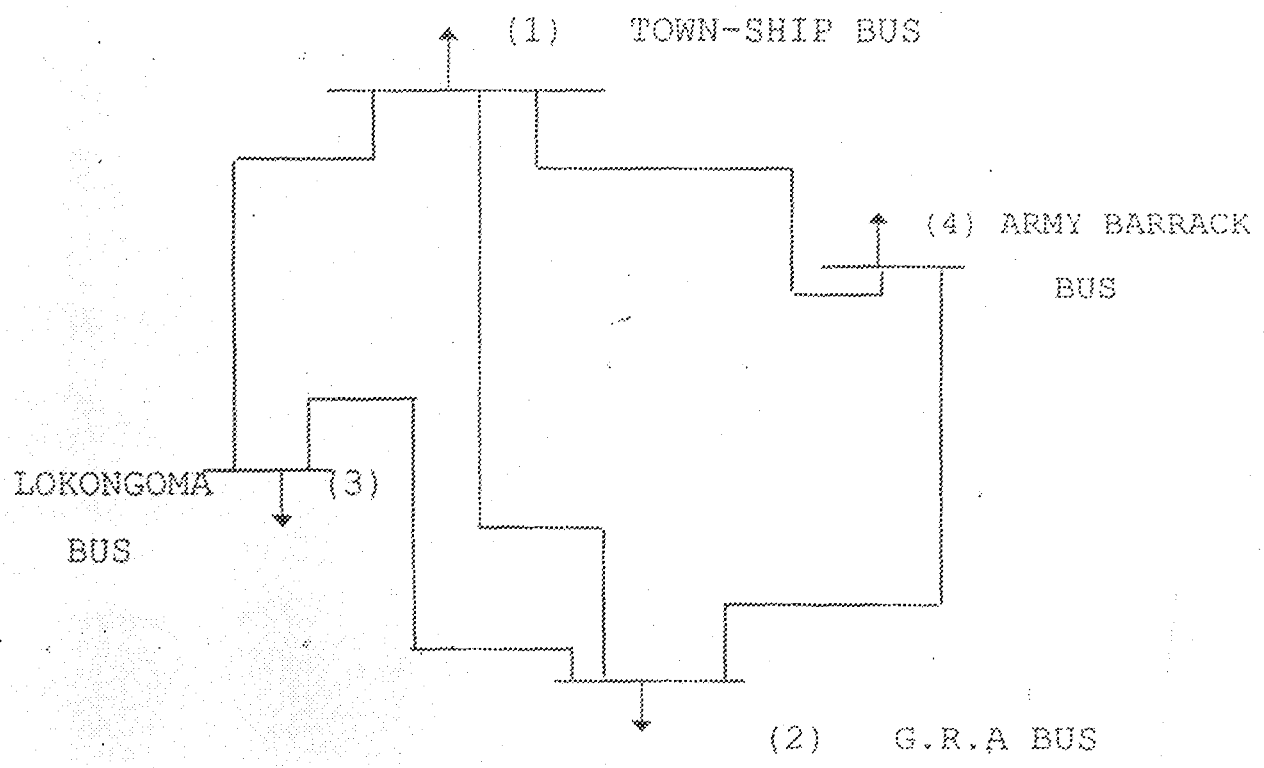


Fig 3.2 BUS INTERCONNECTION

3.2 BUS ... ...

.1.0 DATA PREPARATION

Since computer program is to be used for simulation, data s to be prepared. The datas include the resistance, the mittances and susceptances of the different lines connect- g the different buses together. The values are obtained by easuring the lengths of the various lines. The formular sed are as follows;

i) To calculate the resistance of a conductor.

The active resistance per kilometer R is given by:

Ω/km = p/A where P is the resitristy of the conductor used. is the cross - sectional area. Hence the total resistance f the particular line is obtained by multiplying R by the otal length of the line in km.

i) The reactance x_0

$$/km = 0.144g \log_{10} \frac{D_{GMD}}{R} + 0.0152 \text{ where}$$

s the radius of conductor, D_{GMD} - 1.26D for horizontally anged conductors. Also the total reactance of the line is ained by multiplying x_0 by the total length of the line in

$$(\Omega)/km = \frac{7.58 \times 10^{-6}}{\log_{10} \frac{D_{GMD}}{R}}$$

actical values of R = 0.155 /0/km.

x_0 = 0.41 /0/km

B = 7 .59 μΩ /0/KM

ese are used to obtain the data below

TABLE 3.2

Bus no	Bus no	lenght(km) (Ω)	Resistance (Ω)	Reactance (Ω)	Susceptance μΩ
1	2	4.172	0.6467	1.7105	31.6655
1	3	24.428	3.7863	10.0155	185.4090
1	4	27.718	4.2963	11.3644	210.3962
2	3	4.786	0.7418	1.9623	36.35574
2	4	23.857	3.6978	9.7614	181.0746

USE OF PER UNIT VALUE

In this project work a base of 100 MVA is used. The base kv is 11kv. A base impedance is therefore calculated from the two.

$$\text{base impedance} = \left(\frac{\text{base, kv}^2}{\text{base MVA}}\right) = \frac{11^2}{100} = 1.21$$

The value obtained is used to express the impedance of different lines per unit values.

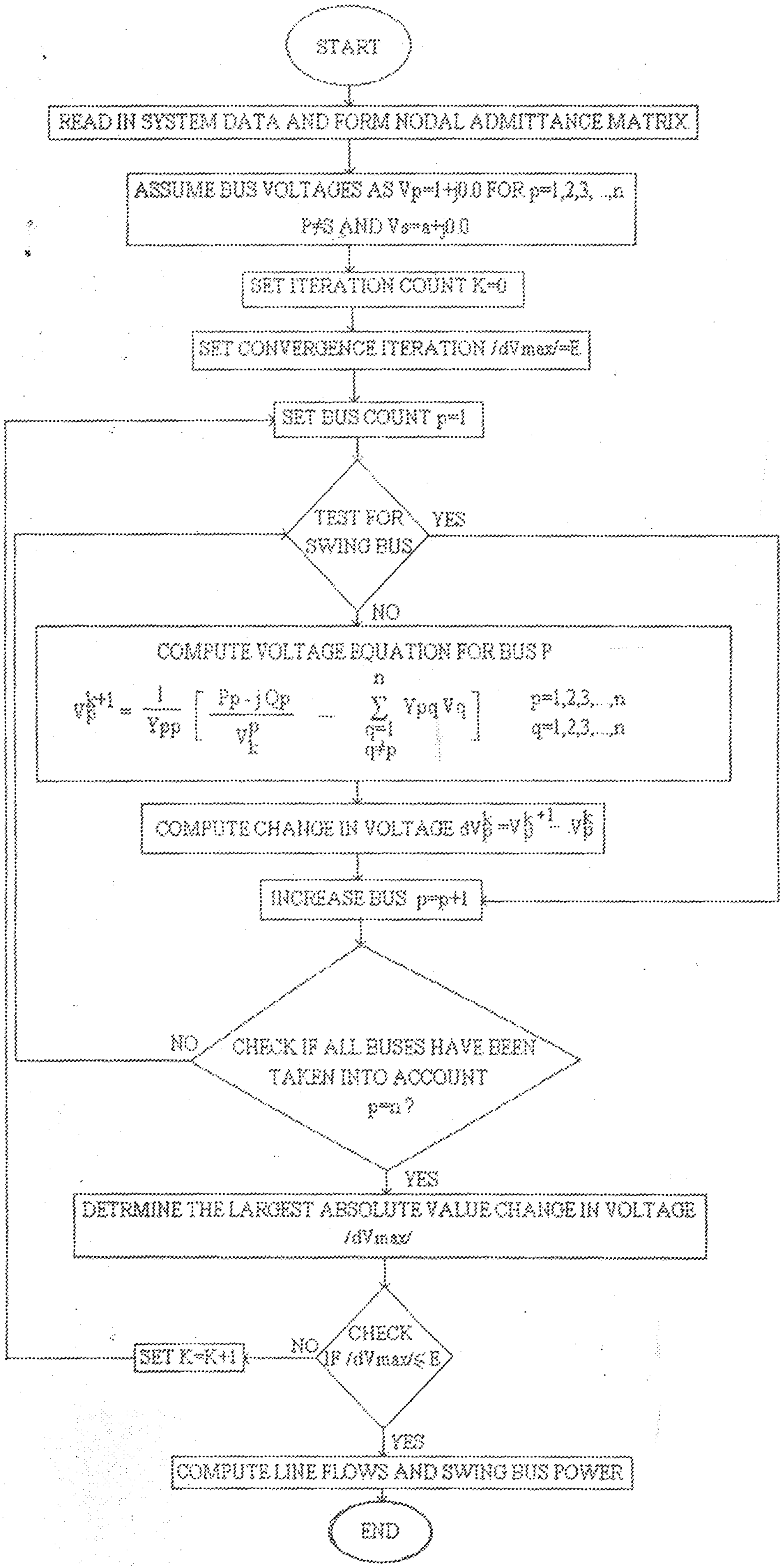
The bus data, that is, the voltage, the active and reactive power associated with each bus are given in per unit value in the table 3.3 below.

TABLE 3.3

BUS	NAME	VOLTAGE	LOAD MW	LOAD MVAR
1	G.R.A	1.0 + j0.0	0.0128	0.0078
2	Town-ship	1.0 + j0.0	0.0085	0.0052
3.	Army Barrack	1.0 + j0.0	0.0085	0.0052
4.	Lokongoma	1.0 + j0.0	0.0034	0.0020

3.2.0 THE SIMULATION PROGRAM

A C- language program is used for the simulation of this project work. The program is given.


START
READ IN SYSTEM DATA AND FORM NODAL ADMITTANCE MATRIX
ASSUME BUS VOLTAGES AS Vp=1+j0.0 FOR p=1,2,3, ..,n
P≠S AND Vs=a+j0.0
SET ITERATION COUNT K=0
SET CONVERGENCE ITERATION /dVmax/=E
SET BUS COUNT p=1
TEST FOR SWING BUS
YES
NO
COMPUTE VOLTAGE EQUATION FOR BUS P
p=1,2,3,...,n
q=1,2,3,...,n
COMPUTE CHANGE IN VOLTAGE
INCREASE BUS p=p+1
NO
CHECK IF ALL BUSES HAVE BEEN TAKEN INTO ACCOUNT
p=n ?
YES
DETRMINE THE LARGEST ABSOLUTE VALUE CHANGE IN VOLTAGE
/dVmax/
SET K=K+1
NO
CHECK IF /dVmax/≤ E
YES
COMPUTE LINE FLOWS AND SWING BUS POWER
END

```
#include<stdio.h>
#include<conio.h>
#include<math.h>
#define itermax 150
#define n 4
float Y [7][7],YS[7][7],YP[7][7],Pac[7][7],Pre[7][7];
float V[7],Vinstar[7],A[7],Vold[7];
float tol,sum1,sum2,sum;
int p,q,iter,row,col;
int converged;

void read_data(void)
{
   Y[1][1]=3.60;Y[1][2]=2.13;Y[1][3]=0.51;Y[1][4]=0.24;
   Y[2][1]=2.13;Y[2][2]=3.18;Y[2][3]=0.47;Y[2][4]=0.25;
   Y[3][1]=0.51;Y[3][2]=0.47;Y[3][3]=1.79;Y[3][4]=0.24;
   Y[4][1]=0.24;Y[4][2]=0.25;Y[4][3]=0.24;Y[4][4]=0.73;

   YS[1][2]=2.13;YS[1][3]=0.51;YS[1][4]=0.24;
   YS[2][1]=2.13;YS[2][3]=0.47;YS[2][4]=0.25;
   YS[3][1]=0.51;YS[3][2]=0.47;YS[3][4]=0.24;
   YS[4][1]=0.24;YS[4][2]=0.25;YS[4][3]=0.24;


   YP[1][2]=0.024;YP[1][3]=0.015;YP[1][4]=0.035;
   YP[2][1]=0.024;YP[2][3]=0.016;YP[2][4]=0.032;
   YP[3][1]=0.015;YP[3][2]=0.016;YP[3][4]=0.02;
   YP[4][1]=0.035;YP[4][2]=0.032;YP[4][3]=0.020;

   A[1]=0.00;A[2]=0.015;A[3]=0.004;A[4]=0.0;

   Vinstar[1]=1.05;Vinstar[2]=1.0; Vinstar[3]=1.0;
   Vinstar[4]=1.0;

   tol=0.001;
}

void computeV(void)
{
   iter=0;
   do
   {
         iter++;
         for (p=1;p<=n;p++)
               Vold[p]=V[p];

         for (p=1;p<=n;p++)
         {
               sum=0;
               q=1;
               do{
                     if (p!=q) sum+=Y[p][q] * V[q];
                     q++;
                     } while(q!=n);
```

```
            V[p]=((A[p]/Vinstar[p])-sum)/Y[p][p];
            converged=abs(V[p]-Vold[p])<tol;
        }
        p=0;

        do{
            p++;
            converged=abs(V[p]-Vold[p])<tol;
            } while (p!=n && converged);

    } while (!converged && iter!=itermax) ;
    printf("\n");
    if (!converged) printf("no convergence to specified
tolerance after %d iterations",iter);
 }

 void computepower(void)
 {
    for (p=1;p<=n;p++)
    {
        for (q=1;q<=n;q++)
        {
            if (p!=q)
            {
Pac[p][q]=V[p]*((V[p]-V[q])*YS[p][q]-V[p]*YP[p][q]/2)*0.85;
Pre[p][q]=V[p]*((V[p]-V[q])*YS[p][q]-V[p]*YP[p][q]/2)*0.62;
            }
        }
    }
 }

      main()
 {
    clrscr();
    row=3;
    gotoxy(20,10);
    puts("\nplease wait computation in progress");
    read_data();
    computeV();
    computepower();
    puts("\nBus voltages V");
    puts("-----------------------------");
    for (p=1;p<=n;p++)
    {
        printf("\nV %d=%e",p,V[p]);
        puts("\npresss ENTER to continue");
        getchar();
    }
    clrscr();
    row=3;
    gotoxy(19,1);
    puts("Active Power\tReactive Power");
```

```
	gotoxy(19,2);
	puts("------------\t-------------");

	for (p=1;p<=n;p++)
	{
		for (q=1;q<=n;q++)
		{
			if(p!=q){
				gotoxy(10,row);
				printf("\nP%d%d =  %e \t \t
%e",p,q,Pac[p][q],Pre[p][q]);
				row++;
				if (row==20){
					gotoxy(10,row+2);puts("\npress ENTER to
continue...");
					row=3;
					getchar();
					clrscr();
					gotoxy(19,1);
					puts("Active Power\tReactive Power");
					gotoxy(19,2);
					puts("------------\t--------------");
				}
			}
		}
	}
	printf("\nMaximum number of iteration allowed is
%d",itermax);
	printf("\nNo of iterations after which convergence occured
is %d",iter);
	puts("\npress ENTER to exit...");
	getchar();
	return(0);
}
```

```
Bus voltages V
-------------------------

V 1=0.000000
presss ENTER to continue

V 2=0.004717
presss ENTER to continue

V 3=0.000996
presss ENTER to continue

V 4=0.011756
presss ENTER to continue
Active Power    Reactive Power
------------    --------------

P12 =  -0.000000e+00          -0.000000e+00
P13 =  -0.000000e+00          -0.000000e+00
P14 =  -0.000000e+00          -0.000000e+00
P21 =  4.005651e-05           2.921769e-05
P23 =  6.860454e-06           5.004096e-06
P24 =  -7.357959e-06          -5.366981e-06
P31 =  4.238000e-07           3.091247e-07
P32 =  -1.487442e-06          -1.084957e-06
P34 =  -2.194840e-06          -1.600942e-06
P41 =  2.613659e-05           1.906433e-05
P42 =  1.570400e-05           1.145468e-05
P43 =  2.462878e-05           1.796452e-05
Maximum number of iteration allowed is 150
No of iterations after which convergence occured is 1
press ENTER to exit...
```

CHAPTER FOUR

4.0 RESULT AND CONCLUSION

The simulation progrme result are printed out and the voltages associated with each bus are printed out first, followed by the print out of the real and reactive powers flowing between the various buses. There are four buses and therefore four different values are printed out.

For the line flows, the real and reactive power flowing in each line connecting one bus to another is printed out.

Bus 1 is connected to all other buses, to the computer prints the real and reactive power flowing bus 1 to each of the other three buses. The total bus power is obtained by summing the flows on the lines terminating at the bus.

The results printed out by computer are in per unit values.

A base of 100 MVA is used, Therefore the actual value is obtained by multiplying the p.u. value by the base value (10^6), to get the real value in watts.

From the printout we can also see that there is no any generation, this is due to the fact that the system under study does not include any power generating.

4.1 CONCLUSION

A review of the objectives of this project is briefly discussed in this section. The project has taken a general look on load flow analysis.

The development of the simulation program written in C-language is the main area of contribution of this project work. Gauss method of solution is used. With this programme the user will be able to calculate the bus voltages, the real and reactive power associated with each bus in a power distribution network.

4.2 RECOMMENDATION

A lot of finance is needed to carryout such a practical work like this type. The state government and the local Government in particular should render financial assistance to the student to carryout such a project work. This proposition is to be taken into account for the next person to carry out this types of project.

Finally, it is my suggestion that National Electric Power Authority (N.E.P.A) especially Lokoja branch should assist financially.

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