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Computer Oriented Load Flow Study of Five Bus System using Matlab

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Abstract- Power flow analysis is the backbone of power system analysis and design. They are necessary for planning, operation, economic scheduling and exchange of power between utilities. The principal information of power flow analysis is to find the magnitude and phase angle of voltage at each bus and the real and reactive power flowing in each transmission lines. Power flow analysis is an importance tool involving numerical analysis applied to a power system. In this analysis, iterative techniques are used due to there no known analytical method to solve the problem. To finish this analysis there are methods of Mathematical calculations which consist plenty of step depend on the size of system. This process is difficult and takes a lot of times to perform by hand. The objective of this project is to develop a toolbox for power flow analysis that will help the analysis become easier. Power flow analysis software package Develops MATLAB programming and MATLAB GUI. I have used NEWTON-RAPHSON method to find the unknown parameters of 5 BUS systems. The power flow computation consists of imposing specified power and voltage input conditions to a power network and producing the complete voltage information at all the system buses. The calculation is required for both the steady state analysis and the dynamic performance evaluation of power systems.3The paper also describes the undergoing integration and initialization of the well-known system software MATLAB with the load flow program.

Key Words- Power flow, Bus Classification, Five Bus System, Newton Raphson method, Voltage profile. Real and Reactive Power.

I. INTRODUCTION

Load flow calculations provide power flows and voltages for a specified power system subject to the regulating capabilities of generation, and tap changing under load transformers as well as specified net interchange between individual operating systems. This information is essential for the continuous evaluation of the current performance of a power system and for the analyzing the effectiveness of alternative plans for system expansion to meet increased load demand. This analysis requires the calculation of numerous load flows for both normal and emergency operating conditions.

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The load flow problem consists of the calculation of power flows and voltages of a network for specified terminal or bus conditions. A single phase representation is adequate since power systems are usually balanced Associated with each bus are four qualities. The real and reactive power, the voltage magnitude, and the phase angles. Three types of buses are represented in the load flow calculation and at a bus; two of the quantities are specified. It is necessary to select one bus, called the slack bus, to provide the additional real and reactive power to supply the transmission losses, since these are unknown until the final solution is obtained. At this bus the voltage magnitude and phase angles are specified. The remaining buses of the power system are designated either as voltage controlled buses or load buses. The real and reactive powers are specified at a load bus. Network connections are described by using code numbers assigned to each bus. These numbers specify the terminals of transmission lines and transformers code numbers are used also to identify the types of buses. The two primary considerations in the development of an effective engineering computer program are 1) The formulation of a mathematical description of the problem; and 2) The application of a numerical method for a solution. The analysis of the problem must also consider the inter-relation between these two factors. The mathematical formulation of the load flow problem result in a system of algebraic non-linear equation. The equations can be established by using either the bus or loop frame of references. The coefficients of the equations depend on the selection of the independent variables i.e. voltages or currents. Thus either the admittance or impedance network matrices can be used. Early approaches to the digital solution of load flows employed the loop frame of reference in admittance form. The loop admittance matrix was obtained by a matrix inversion. These methods did not have wide spread application because of the tedious data preparation required to specify the network loop. Further more, the required matrix inversion was time consuming and had to be repeated for each subsequent case involving network changes. Later approaches used the bus frame of reference in the admittance form to describe the system. This method gained wide spread application because of the simplicity of data preparation and the ease with the bus admittance matrix could be formed and modified for network changes in subsequent cases. Also combination of voltages and currents has been used as the independent variables. This formulation uses a hybrid matrix consisting of impedance, admittance, current ratio, and voltage ratio elements. The ability to formulate efficiently the network matrices has led to the use of the bus frame of reference in the impedance form. However, the majority of load flow programs for large power system studies still employ methods using the bus admittance matrix.

This approach remains the most economical from the point of view of computer time and memory requirements. The solution of the algebraic equations describing the power system is based as on iterative technique because of their non-linearity. The solution must satisfy Kirchhoff's laws i.e. the algebraic sum of all flows at bus must be equal to zero, and the algebraic sum of voltages in a loop must equal to zero. One or other of these laws is used as a test for convergence of the solution in the iterative computational method. Other constraints are placed on the solution are the capability limits of reactive power sources, the tap setting range of tap changing under load transformers and the specified power and the specified power interchange between interconnected systems.

II. OBJECTIVE OF LOAD FLOW STUDY

- Power flow analysis is very important in planning stages of new networks or addition to existing ones like adding new generator sites, meeting increase load demand and locating new transmission sites.
- The load flow solution gives the nodal voltages and phase angles and hence the power injection at all the buses and power flows through interconnecting power channels.
- It is helpful in determining the best location as well as optimal capacity of proposed generating station, substation and new lines.
- It determines the voltage of the buses. The voltage level at the certain buses must be kept within the closed tolerances.
- System transmission loss minimizes.
- Economic system operation with respect to fuel cost to generate all the power needed
- The line flows can be known. The line should not be overloaded, it means, we should not operate the close to their stability or thermal limits.

III. BUS CLASSIFICATION

A bus is a node at which one or many lines, one or many loads and generators are connected. In a power system each node or bus is associated with 4 quantities, such as magnitude of voltage, phage angle of voltage, active or true power and reactive power in load flow problem two out of these 4 quantities are specified and remaining 2 are required to be determined through the solution of equation. Depending on the quantities that have been specified, the buses are classified into 3 categories.

Variables and Bus Classification

Buses are classified according to which two out of the four variables are specified.

Load bus: No generator is connected to the bus. At this bus the real and reactive power are specified. it is desired to find out the voltage magnitude and phase angle through load flow solutions. It is required to specify only Pd and Qd at such bus as at a load bus voltage can be allowed to vary within the permissible values.

Generator bus or voltage controlled bus: Here the voltage magnitude corresponding to the generator voltage and real power Pg corresponds to its rating are specified. It is required to find out the reactive power generation Qg and phase angle of the bus voltage.

Slack (swing) bus: For the Slack Bus, it is assumed that the voltage magnitude $|V|$ and voltage phase Θ are known, whereas real and reactive powers Pg and Qg are obtained through the load flow solution.

IV. THEME

The Newton-Raphson method for performing the load flow calculation was used. Taylor series expansion for a function of two or more variables is the basis of the Newton-Raphson method. Partial derivatives of order greater than 1 are neglected in the series terms of the Taylor series expansion. The Newton-Raphson method was use because it calculates corrections while taking into account all other interactions. The number of iterations required by the Newton-Raphson method using bus admittances is practically independent of the number of buses. For these reasons shorter computer time for a solution of the load flow problem could occur when analyzing large electrical power systems. The solution of the load flow problem is initiated by assuming voltage values for all buses except the slack bus. The slack bus is the point at which the voltage is specified and remains fixed. The voltage at the slack bus is fixed because the net power flow of the system cannot be fixed in advance until the load flow study is complete. The power calculation at the slack bus supplies the difference between the specified real power into the system at the other buses and the total system output plus losses. The Newton-Raphson method for load flow analysis will be used to solve the load flow problem at the local and coordinator problem levels.

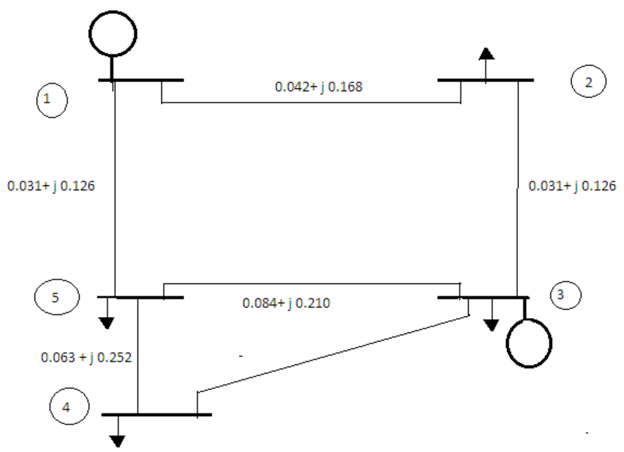

Fig 1: Single line diagram of 5 bus system.

Above figure shows 5 bus systems. One Slack Bus, in which voltage magnitude is 1.04 and phase angle, is 0 degree. Second is Load Bus in which active and reactive powers are 115MW and 60 MVAr respectively. And third is Generator Bus in which active power is 180 MW and voltage magnitude is 1.02. Fourth is Load Bus in which active and reactive powers are 70MW and 30 MVAr respectively. And fifth is also is load Bus in which active and reactive powers are 85MW and 40 MVAr respectively. This programme is like a SCADA system. It means with the help of SCADA we can monitor the system. In similar manner from this programme we can observe all the load flows of electrical power system on computer screen. Above single line diagram is the simple 5 bus system we are considering here, theactive, reactive, voltage magnitude and phase angle of all the buses are calculated within a few seconds from this programme. wejus have to enter all the values of quantity of all the buses in note pad. I prepare this programme in 4 Mfile.

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According to newton raphson method or any load flow study we have to build Ybus or admittance matrix first. Then I make jacobian matrix then for power flow another M file is there.then finally Load flow M file is there to calculate all the values of 4 quantities of all the buses.

Table 1: Specified Bus Loadings and Voltages

BUS	GENERATION		LOAD		V.per unit	Remark
	P,MW	Q,Mvar	P, MW	Q,Mvar		
1	……..	……..	65	30	1.04<0	Swing Bus
2	0	0	115	60	1.00<0	Load Bus
3	180	……..	70	40	1.02<0	Generator Bus
4	0	0	70	40	1.00<0	Load Bus
5	0	0	85	40	1.00<0	Load Bus

V. STEPS TO RUN THE PROGRAMME

1) Open the programme folder.
2) Edit bus .dat file (write information of buses).
3) Edit nt.dat (Write the values of R and X for Y bus construction)
4) Edit pv pq .dat file.
   (Enter the values of pv bus and pq bus)
5) if Q-limit is exist enter the values otherwise keep it blank.
6) Open the Load flow MATALB File programme.
   Then run this programme
7) In command window you will see elapsed time of run and it will give output file as report .dat files in programme folder.
8) open that report file for clear values open that file in MATLAB.
9) From this we observe all the power system Active and Reactive powers values. 10. If any one branch is shutdown you can observe power will transfer to other branch.

VI. FINAL RESULT

TABLE 2: Comparison of Output Load Flow by Analytical Calculations and Computer Simulations

Element No.	Active Power		Reactive Power	
	Analytical	Comp. Simulation	Analytical	Comp. Simulation
BUS-1	2.347380	2.347380	1.000060	1.00000
BUS-2	1.150020	1.150000	0.599960	0.600000
BUS-3	1.800000	1.800000		1.104710
BUS-4	0.699970	0.700000	1.104710	0.300000
BUS-5	0.849970	0.850000	0.300080	0.400000
			0.400040	

Detailed Report of Load flow (NR method)

Iter. No = 1 Max. Real power mismatch at bus = 4, Max. mismatch = 0.06813623

Converged loadflow iteration No = 2, Max. mismatch = 0.00181057

Load flow results:

Bus No	VbO	thetaO	PGO	QGO	PLO	QLO
1	1.040000	0.000000	2.347380	1.000000	0.000000	0.000000
2	0.959250	-2.842293	0.000000	0.000000	1.150000	0.600000
3	1.020000	2.376247	1.800000	1.104710	0.000000	0.000000
4	0.904866	-6.633185	0.000000	0.000000	0.700000	0.300000
5	0.961280	-3.422244	0.000000	0.000000	0.850000	0.400000

Line flows:

Line flows				Line flows			
From	To	P-flow	Q-flow	From	To	P-flow	Q-flow
1	2	0.3965	0.4081	2	1	-0.3839	-0.3578
1	5	0.6006	0.5161	5	1	-0.5826	-0.4431
2	3	-0.7658	-0.2419	3	2	0.7875	0.3302
3	4	0.4951	0.2596	4	3	-0.4698	-0.1587
3	5	0.5168	0.1787	5	3	-0.5016	-0.1183
4	5	-0.2284	-0.1401	5	4	0.2339	0.1621

Total real power losses in the system = 0.098259

Total reactive power losses in the system = 0.395014

VII. CONCLUSION

In this paper Load Flow study using MATLAB software is carried out with an approach to overcome the problem of an under voltage. Load Flow Studies using MATLAB software is an excellent tool for system planning. A number of operating procedures can be analyzed such as the loss of generator, a transmission line, a transformer or a load. They are useful in determining the system voltages under conditions of suddenly applied or disconnected loads. Load flow studies determine if system voltages remain within specified limits under various contingency conditions and whether equipment such as transformers and conductors are overloaded. This dissertation work concerns with the load flow study of a power system. Before the advent of digital computers, the AC calculating board was the only means of carrying out load flow studies.

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These studies were therefore, tedious and time consuming. With the availability of fast and large size digital computers, all kinds of power system studies, including load flow, can now be carried out conveniently. In fact, some of the advance level sophisticated studies, which were almost impossible to carry out with the AC calculation board, have now become possible. For solving non-linear power flow equations; Newton-Raphson iterative method by polar coordinates is used. The results of the test system are studied.

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