International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-2 Issue-3, February 2013

Computer Oriented Load Flow Study of Electrical S/S

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Abstract---- ***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. It is also used to initialize other computer-aided power system software. This paper presents a novel production grade load flow program that can perform the power flow computations of modern electric power systems efficiently and accurately. The new program is capable of providing the power flow information of independent subsystems simultaneously. It possess a unique feature of changing the power levels of generators and loads locally or globally in power systems. The paper also describes the under going integration and initialization of the well-known system software MATLAB with the load flow program.***

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. 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.

Manuscript published on 28 February 2013.
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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 have 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 are based as on iterative technique because of their non-linearity. The solution must satisfy Kirchhoffs 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.

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II .NECESSITY

Load flow studies are undertaken to determine

i) The bus voltage and system voltage profile.
ii) The line flows.
iii) The effect of change in circuit configurations and incorporating new circuits on system loading.
iv) The effect of temporary loss of transmission capacity and generations on supplied load and accompanied effects.
v) The effect of in-phase and quadrature boost voltages on system loading data obtained from load flow can be further useful for

1) Economic system operations.
2) System transmission loss minimization.
3) Transformer taps setting for economic operations.

Possible improvement in an existing system by change of conductor size and system voltages.

Objectives:

For the purpose of load flow studies; a single-phase representation of the power network is used since the system is generally almost balanced. When systems have been of much smaller than the present size, networks have been simulated on network analyzer for power flow studies.This analyzer has been analogue type, scaled down miniature models of power system with resistances, reactance's, capacitance's, auto-transformers, loads and generators.The generations are just supply sources operating at a much higher frequency than 50 Hz to limit the size of the components. The generators are provided with voltage magnitude and phase angle controls. The loads are represented by constant impedance's. The load flow studies are obtained directly from measurements from any system simulated on the analyzer.With the advent of modern digital computers processing large data base storage capacity and high speed, the mode of load flow studies have changed from analogue to digital simulation. A large number of algorithms are developed for digital power flow solutions. The loads are generally represented by constant absorbers.

In the network at each bus or node there are four variables

- Voltage magnitude.
- Voltage phase angles.
- Real power
- Reactive power

Out of four quantities two of them are specified at each bus and the remaining two are determined from the load flow solutions.

III. 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.

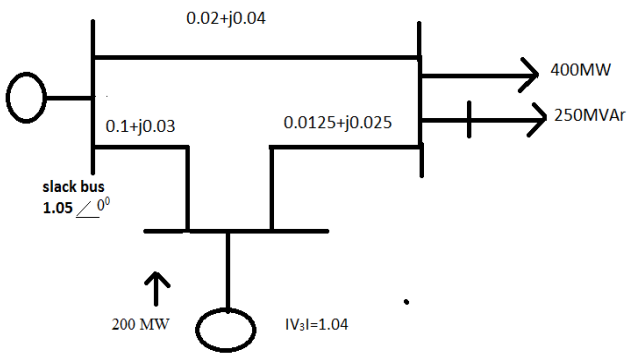

Fig 1: Single line diagram of 3 bus system.

Above figure shows 3 bus system.one Generator Bus,in which active power is 200MW and voltage magnitude is 1.04 pu .second is load Bus in which active and reactive powers are 400MW and 250MVAr resp.and third is Slack Bus in which active power is 1.05pu and phase angle is 0 degree.

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 3 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. 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 Mfile is there.then finally Load flow Mfile is there to calculate all the values of 4 quatntities of of all the buses.

TABLE 1: IMPEDANCES OF LINES

BUS CODE i-m	Impedances Z_{im}	Admittance Y_{im}
1-2	0.02+j0.04	-10+j20
1-3	0.1+j0.03	-10+j30
2-3	0.0125+j0.025	26-j62

TABLE 2: SPECIFIED BUS LOADINGS AND VOLTAGES

BUS CODE	SPECIFIED VOLTAGE(V (pu)	BUS LOADING(P) (pu)	BUS LOADING(Q (pu)
1	1.05	-	-
2	-	4	2.5
3	1.04	2	-

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IV. 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) Editpvpq .dat file.(ente the values of pv bus and pq bus)
5) if Q-limit is exist enter the values otherwist keep it blank.
6). Open the Load flow MATALB File programme.Thenrun this programme
7) In command window youwill see elapsed time of run and it will give output file as report .dat file 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.

V. FINAL RESULT

```
                    Detailed Report of Load flow (NR method)
                    ----------------------------
Iter. No = 1 Max. Real power mismatch at bus = 2, Max. mismatch = 0.09921789
--------------------------------------------------------------------------------
Converged loadflow iteration No = 2, Max. mismatch = 0.00021661
--------------------------------
 Loadflow results:
--------------------------------------------------------------------------------

Bus No     VbO          thetaO          PGO             QGO          PLO          QLO
--------------------------------------------------------------------------------
  1        1.050000      0.000000       2.184028        1.408481     0.000000     0.000000
  2        0.971684     -2.696233       0.000000        0.000000     4.000000     2.500000
  3        1.040000     -0.498666       2.000000        1.461615     0.000000     0.000000
--------------------------------------------------------------------------------
Line flows:
--------------------------------------------------------------------------------
                      Line flows                              Line flows
                  ----------------------                  ----------------------
 From   To        P-flow        Q-flow    From   To       P-flow        Q-flow
--------------------------------------------------------------------------------
  1      2         1.7935        1.1873     2      1      -1.7096       -1.0194
  1      3         0.3905        0.2212     3      1      -0.3887       -0.2157
  2      3        -2.2902       -1.4804     3      2       2.3887        1.6773
--------------------------------------------------------------------------------
Total real power losses in the system =  0.184206
Total reactive power losses in the system =  0.370239
```

TABLE 3: COMPARISON OF OUTPUT LOAD FLOW BY ANALYTICAL CALCULATIONS AND COMPUTER SIMULATIONS:

Element No.	Buses connected	Active Power		Reactive Power	
		Analytical	Comp. Simulation	Analytical	Comp. Simulation
1	1-2	2.1828	2.1840	1.4075	1.4084
2	2-3	4.0000	4.0000	2.50	2.50
3	1-3	2.0000	2.0000	1.4611	1.4616

VI. CONCLUSION

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. 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.This system considered consists of six total numbers of buses, number of the generated buses including slack bus are two, number of load buses are Three and number of elements are seven. The load flow analysis is performed for normal load and the corresponding voltage profiles are noted.The computer programme provides information of the parameters such as line data, bus data, active and reactive power, generation limit, number of iterations of load flow, magnitude of voltage in per unit and it's angle in degrees. Also, line flows in both the directions and real losses in the system are obtained in the same.In this program we can change the parameters of the system developed software provides and power output will be displayed accordingly on the ladder diagram.

In any organization, where more than one generating units and number of power control centers are installed, changeover or shutdown of particular PCC is a great task for the engineers to maintain the stability of the system. During any abnormal tripping of any one PCC incomer breaker, sudden increase in load is tomet by maintaining the stability. During power system operation a power engineer has to face two types of occurrences

1. Forced outages (Sudden interruption of supply)
2. Planned shutdowns.

In both the situations, load flow has to be maintained. The program developed, gives display of current state of the power system load flow, output on the ladder diagram. Such a software can assists the power engineer in critical conditions. The system developed is an 'off line' system by adding some hardware 'on-line' system can be developed. Such as 'on-line' help may result in increased reliability of the power system grid.

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