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Load Flow Study of six bus System by Digital Computer

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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. This process is difficult and takes a lot of times to perform by manually. The objective of this project is to develop a tool for power flow analysis that will help for analysis become easier. The economic load dispatch plays an important role in the operation of power system, and different techniques have been used to solve these problems.

I. INTRODUCTION

In a power system, power flows from generating centers to the load centers. In this process, many things require investigation, such as the profiles of the bus voltages, flow of MW and MVAR in transmission lines, effect of re-arranging circuit configurations and installation of regulating devices, etc. for different loading conditions. Modern power systems have become so large and complex that these investigations should be done with some sort of simulation of the system. This simulation and subsequent assessment of power flow is commonly known as load flow analysis.

Load flow study thus aims at arriving at a steady state solution of complete power networks. Load flow study was previously to be done with the help of a network analyzers. Nowadays with the development of digital computers, this is mostly done with these computers. This report deals with the digital methods of solution detailed study is carried out in preceding paragraphs. Central to this method is the determination of complex voltages of the system buses. Active and reactive power flows are determined in terms of these complex voltages.

Load flow study is done during the planning of a new system or the extension of an existing one. This is also needed to evaluate the effect of different loading conditions of an existing system. Other studies, such as short circuit, stability, economic loadings, etc. require load flow study.

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Load flow analysis of a real life power system comprising a large number of buses, it is necessary to proceed systematically by first formulating the network model of the system. A power system comprises a several buses, which are interconnected by means of a transmission line.[1].

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

III. 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. Transformers are used to transfer power between different voltage levels or to regulate real and reactive through a particular transmission corridor. Most transformers are equipped with taps on the winding to adjust either the voltage transformation or the reactive flow through transformer, such transformers are called either load tap changer(LTC) transformers or on load tap changing (OLTC) transformer.

Another type of transformer is known as Phase shifting transformer (Phase shifter) Phase shifting transformers which are less common than LTC transformers. Vary the angle of phase shift across the transformer in order to control the MW power flow to the transformer this type of control can be very useful in controlling the flow of real power flow through a transmission system. Transformers provide a convenient means of controlling real and reactive power flow through a transmission line. Real power is controlled by means of shifting of the phase of voltage, and reactive power by changing its magnitude or phase angle through small values are called regulatory transformers.[2]

IV. ANALYTICAL ANALYSIS

Table 1: Impedances and Charging Admittances

BUS CODE i-m	Impedance Z_{im}	Half of line charging $Y_{im/2}$
1-4	0.080 + j0.370	0.0 + j0.015
1-6	0.123 + j0.518	0.0 + j0.021
2-3	0.723 + j1.05	0.0 + j0.0
2-5	0.282 + j0.640	0.0 + j0.0
3-4	0.000 + j0.133	0.0 + j0.0
4-6	0.097 + j0.407	0.0 + j0.015
5-6	0.000 + j0.300	0.0 + j0.0

Table 2: Specified Bus Loadings and Voltages

BUS code (i)	Specified voltages (V)	BUS loadings (P)	BUS loadings (Q)
1	1.05	-	-
2	1.1	0.5	-
3	-	-0.55	-0.13
4	-	0	0
5	-	-0.3	-0.18
6	-	-0.5	-0.05

Table 3: Admittance of Network Elements

BUS code (i-m)	Admittance (y_{im})
1-4	0.558 – j2.582
1-6	0.434 – j1.827
2-3	0.445 – j0.646
2-5	0.577 – j1.308
3-4	0.000 – j7.518
4-6	0.554 – j2.325
5-6	0.000 – j3.333

Table 4: BUS Admittance to Ground

BUS code (I)	Admittance to ground (y_{oi})
1	0.0 + j0.036
2	0.0 + j0.000
3	0.0 + j0.000
4	0.0 + j0.300
5	0.0 + j0.000
6	0.0 + j0.036

Table 5: Analytical Solution voltage and phase angles

BUS no.	Voltage Magnitude per unit	Phase angles in degree
1 (Load)	0.92	-12.2
2(Slack)	1.05	0
3 (Load)	0.92	-12.3
4	0.93	-9.8
5 (Generator)	1.1	-3.3
6 (Load)	1	-12.8

Table 6: Power System under Normal Operation Analytical Analysis

Element no	Buses connected	Power flow active in MW	Power flow reactive in MW
1	2-1	44.10	17.7
2	4-1	8.89	0.79
3	1-3	0.48	7.10
4	2-4	50.40	25
5	5-3	32.55	18
6	4-6	39.6	17.8
7	5-6	17.10	0.10

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V. SIMULATION ANALYSIS

Mathematical analysis power system is discussed previous paragraphs. For simulation analysis, programme is written in 'C' part of software developed will generate ladder diagram of the network (as shown in fig. The software is further developed that load flow values under normal condition will be displayed. Further the software is developed that load variations can be incorporated. Variations in generation of any generating station is possible. Shutdown of any line is also possible. The respective power flow will be displayed in the ladder network.

VI. 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.[3]

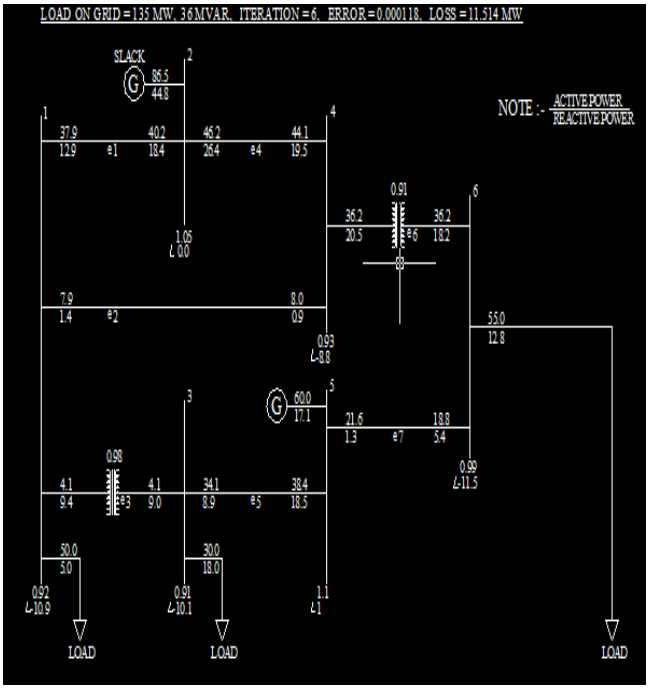

Figure 1: Single line diagram of 6 bus system.

TABLE 7: IMPEDENCES AND CHARGING ADMITTANCE

BUS CODE i-m	Impedance Zim	Line charging Y_{im}
1-4	0.080 + j0.370	0.0 + j0.015
1-6	0.123 + j0.518	0.0 + j0.021
2-3	0.723 + j1.05	0.0 + j0.0
2-5	0.282 + j0.640	0.0 + j0.0
3-4	0.000 + j0.133	0.0 + j0.0
4-6	0.097 + j0.407	0.0 + j0.015

TABLE 8: SPECIFIED BUS LOADINGS AND VOLTAGES

BUS CODE	SPECIFIEI VOLTAGE	BUS LOADINC (P)	BUS LOADING ((
1	1.05		-
2	1.1	0.5	-
3	-	-0.55	-0.13
4	-	0	0
5	-	-0.3	-0.18
6	-	-0.5	-0.5

Table 9: Power System under Normal Operation – Simulation Analysis

Ele men t no	Buses connected	Power flow active in MW	Power flow reactive in MW
1	2-1	44.3	17.8
2	4-1	8.9	0.8
3	1-3	0.5	7.2
4	2-4	50.9	25.2
5	5-3	32.8	18.3
6	4-6	39.6	17.9
7	5-6	17.2	0.1

Table 10: Normal Operation –Simulation Analysis

Load bus no.	Active power in MW	Reactive power in MW
1	50	5
3	30	18
6	55	13

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Remark : Under normal operation of power system all above load flow parameters are displayed on ladder diagram.

Table 11: Comparison of Output Load Flow by Analytical and Simulations Analysis

Element No.	Buses connected	Active Power			Reactive Power		
		Analytical	Comp. Simulation	%age error	Analytical	Comp. Simulation	%age error
1	2-1	44.10	44.30	0.45	17.70	17.80	0.56
2	4-1	08.89	08.90	0.11	00.79	00.80	1.25
3	1-3	00.48	00.50	0	07.10	07.20	1.39
4	2-4	50.40	50.90	0.99	25	25.20	0.79
5	5-3	32.55	32.80	0.77	18	18.30	1.64
6	4-6	39.60	39.60	0.25	17.80	17.90	0.56
7	5-6	17.10	17.20	0.58	00.10	00.10	0

Load flow analysis is carried out for the system under study both analytical and simulation results are compared, error up to 2 % is allowed. With the programme software developed in this dissertation is most useful for power system analysis, The Newton Raphson method is widely used for load flow analysis of symmetrical as well as unsymmetrical power system calculations. This method is robust and very efficient for power system analysis of real network under normal or unsymmetrical operating conditions. This proposed method can be estimated to be a useful tool for unsymmetrical network analysis and suitable for application such as to calculation of bus voltage and system voltage profile ,line flows display on ladder diagram., to understand the effect of change in circuit configurations and incorporating new circuit changes in the system will be displayed on ladder diagram for decision making.

The development of any country is related to the growth of electrified region of that country. As the industrial growth increases, the demand in additional power requirement increases. Power engineers are facing the challenges to supply reliable power under normal as well as emergency conditions without loosing stability.

VII. 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.

The computer program for load flow analysis by Newton Raphson method contains line data, bus data, active and reactive generation limits, magnitude of voltages in p.u. and its angle in degrees. Then for the load flow analysis computer programme is run and will get the power flow status on output ladder diagram. In this computer software there is a very good facility which is incorporated i.e. shutdown of any line element, changing transformer taps to get better voltage, changing of load of any buses, changing of generation of the generating station, for all corresponding changes, programme is run separately and respective output of load flow is displayed on the ladder diagram.

Analytically Load flow analysis for this type of large non linear load equations is tedious, complicated and time consuming. To get the required output no. of iteration are to be performed for converging the system within specified limits. Hense for solution of such type of solving the non linear equations is carried out by computer software developed in'C' where we get the results within fraction of second and all load variation, voltage variation, shutdown of line, transformer tap changing, all these facilities are available for power system study. This software can developed for the any electrical network for "n" no. of buses, a very useful tool for the power engineer to get the current status of system loading while incorporating certain changes, the net desired output will be displayed on ladder network, which helps for proper decision. This software is developed for load flow analysis .

This program is designed to provide, professional engineers, a very powerful tool to analyze and study three phase power systems.

1. Bus voltage (magnitude and angle)
2. Bus power (P,Q) and bus power factor.
3. Flow of P and Q through branches.
4. Line losses and total system loss.
5. Line and transformer loadings.
6. Automatic voltage control by transformer tap adjustments.

This software is having facility to take shutdown of any element, change in load of any load bus, change in generation of any bus, change in transformer taps for better voltage profile.

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VIII. FUTURE SCOPE

In case of the power system, where more than one generating units and number of power grids are interconnected, changeover or shutdown of particular grid line is a great task for the power engineers to maintain the stability of the system. During any abnormal tripping of any one grid liner, sudden increase in load is difficult to maintain 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. Designed software is an intelligent and integrated package of the state of the art electrical engineering programs designed to meet all needs power engineers at substation. This software is having ability to model up to 'n' no. of buses, 'n' no. of branches. Further this software can be unique in their ability to handle hybrid, three phase, single phase, balanced, unbalanced, AC and DC systems. 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 all critical conditions for proper decision making.

The system developed in this report is an 'OFF LINE' system by adding some hardware 'ON LINE' system can be developed. Such 'ON LINE' help may result in increasing reliability of the power system grid.

IX. APPLICATIONS

The Analytical solution of load flow by Newton Raphson method is widely used for load flow analysis of symmetrical as well as unsymmetrical power system calculations. This method is robust and very efficient for power system analysis of real network under normal or unsymmetrical operating conditions. But analytical solution is tedious and time consuming this is not at all useful in emergency situation to find alternatives for stable stability. Software developed can be a very useful tool for network analysis. This software is also useful for

- Voltage calculations and system voltage profile.
- Power flows display on ladder diagram.
- Effect of change in circuit configurations and incorporating new circuit changes in the system.
- Effect of temporary loss of transmission capacity and generation on supplied loads and accompanied effects.
- Economic system operation .
- System transmission loss minimization.
- Transformer taps settings for economic operation.
- Possible improvement in an existing system by change in conductor size and system voltage.

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