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COMPUTER ORIENTED POWER FLOW CALCUTION FOR IEEE - 9 BUS SYSTEM USING NEWTON RAPHSON TECHNIQUE

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ABSTRACT

This paper work depicts the power flow calculation for IEEE 9 bus system. These power flow computations are the pillar of power system plotting and analysis. They are imperative for planning, functioning, economic scheme and inter-changing of power among the utilities. The paramount information of load or power flow calculation is to regulate the voltage magnitude and phase angle at each bus in the system in addition with true power and reactive power flow in every transmission lines. In this power flow analysis, iteration planning is used. The motive of this paper work is to compute the power flow calculation of IEEE-9 bus system using a Newton Raphson programming in MATLAB Software.

KEYWORDS- Power flow, Classification of buses, Power flow calculation (PFC), Gauss Siedel technique, Newton Raphson technique, Voltage profile, line losses .MATLAB

INTRODUCTION

Load flow analysis forms an essential requirement for system studies. These calculations also give 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 pivotal for the continuous valuation of the present performance of a power system and for the analyzing the effectiveness of alternative plans for system expansion to meet increased load demand.[1,2]

The load flow problem contains the computation of power flows and voltages of a power system. A single phase representation is sufficient since, bus systems are frequently linked with four quantities real and reactive power, voltage magnitude, and phase angles. In load flow calculation three types of buses are represented and at a bus; two of the quantities are specified. It is necessary to select one bus, called the swing or 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. The two primary considerations used in development of an effective computer program are the formulation of a mathematical description of the problem and the application of a numerical method for a solution.

EASE OF USE

The objective of this paper is to develop computer oriented program that allow user solve power flow calculation easily. However, other important objectives of power flow calculation are as follow.

1) It have a vital role in scheduling of recent network and accumulation of existing networks by addition of generators sites, meeting load demand and locating of new sites for transmission.
2) The estimation of power flow provides voltage magnitude and phase angle, injected power in the system and power flows in the interconnecting paths of the power system.
3) In order to determine the most favourable position in addition to optimal capacity of the generating system, lines and substation it is very beneficial.
4) The bus voltage is determined and also level of voltage at several buses kept within closed tolerances.
5) For analysing the functioning of lines in the system, transformer and generator at steady state conditions and reduction of losses in transmission system.

I. BUS CLASSIFICATION

A node to which one line or several lines, single or many loads and generators are linked is known as a bus. All buses in the system are related with several quantities that are Voltage, Phase angle, Active and Reactive power. Out of these four quantities, two quantities are known and other two quantities are calculated by using solution of equations. The quantities which are given based upon the buses connected in the power system are divided into 3 categories.

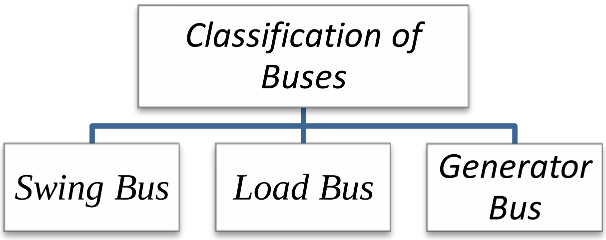

Figure1: Classification of Buses

II. POWER FLOW SOLUTION METHODS

The power flow study which is also recognized as load flow study is a significant tool concerning numerical analysis applied to a power system. By contrasting with traditional circuitt analysis, a load flow study often uses basic notation such as single line diagram and per unit system and focuses on reactive, real and apparent power rather than voltage and current. In the view point of mathematical modelling, load flow solution contains the couple of algebraic equation which are non linear that illustrate the system. Over the time intervals certain methodology has been recognized to solve the equation of power flow. There exist a number of software implementations of power flow studies. The best method used for load flow studies in power system is NR method.

III. NEWTON RAPHSON TECHNIQUE

The NR method is widely used for solving non linear equations. In large scale load flow analysis by the NR method has proved most successful owing to its strong convergence characteristics.

The Newton Raphson algorithm is expressed by

$$\begin{bmatrix}\Delta P\\ \Delta Q\end{bmatrix} = \begin{bmatrix}\frac{\partial P}{\partial \theta} & V\frac{\partial P}{\partial V}\\ \frac{\partial Q}{\partial \theta} & V\frac{\partial Q}{\partial V}\end{bmatrix}\begin{bmatrix}\Delta\theta\\ \frac{\Delta V}{V}\end{bmatrix} \qquad (1)$$

Where ΔP is the active power mismatches
ΔQ is the reactive power mismatches
V is the magnitude of bus voltage
δ is the phase angle of bus voltage

The power flow equation for a generic i^{th} bus of the power system network is given below.

$$P_i^{cal} = \sum_{j=1}^{N} V_i V_j \left(G_{ij}\cos(\theta_i - \theta_j) + B_{ij}\sin(\theta_i - \theta_j)\right) \qquad (2)$$

$$Q_i^{cal} = \sum_{j=1}^{N} V_i V_j \left(G_{ij} \sin(\theta_i - \theta_j) - B_{ij} \cos(\theta_i - \theta_j) \right) \quad (3)$$

It may be pointed out that in equation (1) the correction terms Δ V are divided by V to compensate for the multiple fact that jacobian terms (∂ P/∂ V*V) and (∂ Q/∂ V*V) are multiplied by V. It is shown in the derivatives terms that this artifice yields valuable simplification computations. Deliberated that the element connected between i^{th} bus and j^{th} bus as shown in Figure 2, for which self and mutual jacobian terms are given below.

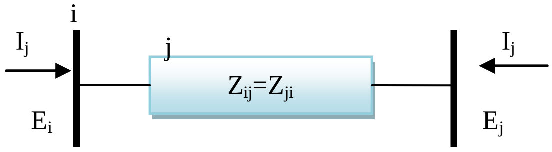

Figure 2: Equivalent Impedance

For i j

$$\frac{\partial P_i}{\partial \theta_j} = \sum_{j=1}^{N} V_i V_j \left(G_{ij} \sin(\theta_i - \theta_j) - B_{ij} \cos(\theta_i - \theta_j) \right) \quad (4)$$

$$\frac{\partial P_i}{\partial V_j / V_j} = \sum_{j=1}^{N} V_i V_j \left(G_{ij} \cos(\theta_i - \theta_j) + B_{ij} \sin(\theta_i - \theta_j) \right) \quad (5)$$

$$\frac{\partial Q_i}{\partial \theta_j} = -\sum_{j=1}^{N} V_i V_j \left(G_{ij} \cos(\theta_i - \theta_j) + B_{ij} \sin(\theta_i - \theta_j) \right) = -\frac{\partial P_i}{\partial V_j / V_j} \quad (6)$$

$$\frac{\partial Q_i}{\frac{\partial V_j}{V_j}} = \sum_{j=1}^{N} V_i V_j \left(G_{ij} \sin(\theta_i - \theta_j) - B_{ij} \cos(\theta_i - \theta_j) \right) = \frac{\partial P_i}{\partial \theta_j} \quad (7)$$

For i= j

$$\frac{\partial P_i}{\partial \theta_i} = -\sum_{j=1}^{N} V_i V_j \left(G_{ij} \sin(\theta_i - \theta_j) - B_{ij} \cos(\theta_i - \theta_j) \right) - V_i^2 B_{ii} = -Q_i^{cal} - V_i^2 B_{ii} \quad (8)$$

$$\frac{\partial P_i}{\frac{\partial V_i}{V_i}} = \sum_{j=1}^{N} V_i V_j \left(G_{ij} \cos(\theta_i - \theta_j) + B_{ij} \sin(\theta_i - \theta_j) \right) + V_i^2 G_{ii} = P_i^{cal} + V_i^2 G_{ii} \quad (9)$$

$$\frac{\partial Q_i}{\partial \theta_i} = \sum_{j=1}^{N} V_i V_j \left(G_{ij} \cos(\theta_i - \theta_j) + B_{ij} \sin(\theta_i - \theta_j) \right) - V_i^2 G_{ii} = P_i^{cal} - V_i^2 G_{ii} \quad (10)$$

$$\frac{\frac{\partial Q_i}{\partial V_i}}{V_i} = \sum_{j=1}^{N} V_i V_j \left(G_{ij} \sin(\theta_i - \theta_j) - B_{ij} \cos(\theta_i - \theta_j)\right) - V_i^2 B_{ii} = Q_i^{cal} - V_i^2 B_{ii} \qquad (11)$$

The mutual elements remain the same whether we have one transmission line or n transmission lines coming to an end at the bus.

IMPLEMENTATION

A MATLAB based program was developed for the Load flow analysis of electrical power systems. The procedure for load flow solution by the Newton-Raphson method is shown in flowchart of figure

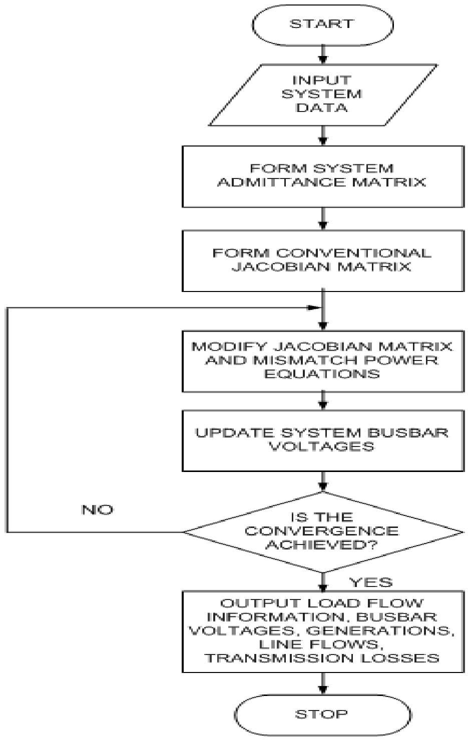

Figure 3 : Flowchart

The input data includes the basic system data needed for conventional load flow calculation, i.e., the number and types of buses, transmission line data, generation and load data. System admittance matrix and conventional Jacobian matrix is formed. At the next step, Jacobian matrix and the mismatched power flow equations are modified. The bus voltages are updated at each iteration. Convergence is checked and if no, Jacobian matrix is modified and power equations are mismatched until convergence is achieved. If yes, power flow results are displayed.

RESULT

The Load flow programming using NR technique is taken out for IEEE 9 bus systems to determine bus voltage profile, real and reactive power flows in the lines also technical losses. Load flow programming has been executed for the above cases and the result of the whole work obtained. Figure 4 show the single line diagram of the system and Table 1 represent busdata whereas Table 2 represents Line data of IEEE 9 bus system. The result using MATLAB programming is obtained and illustrate in Table 3 and Table 4. All data’s are in per unit (p.u) and the angle is given in degree.

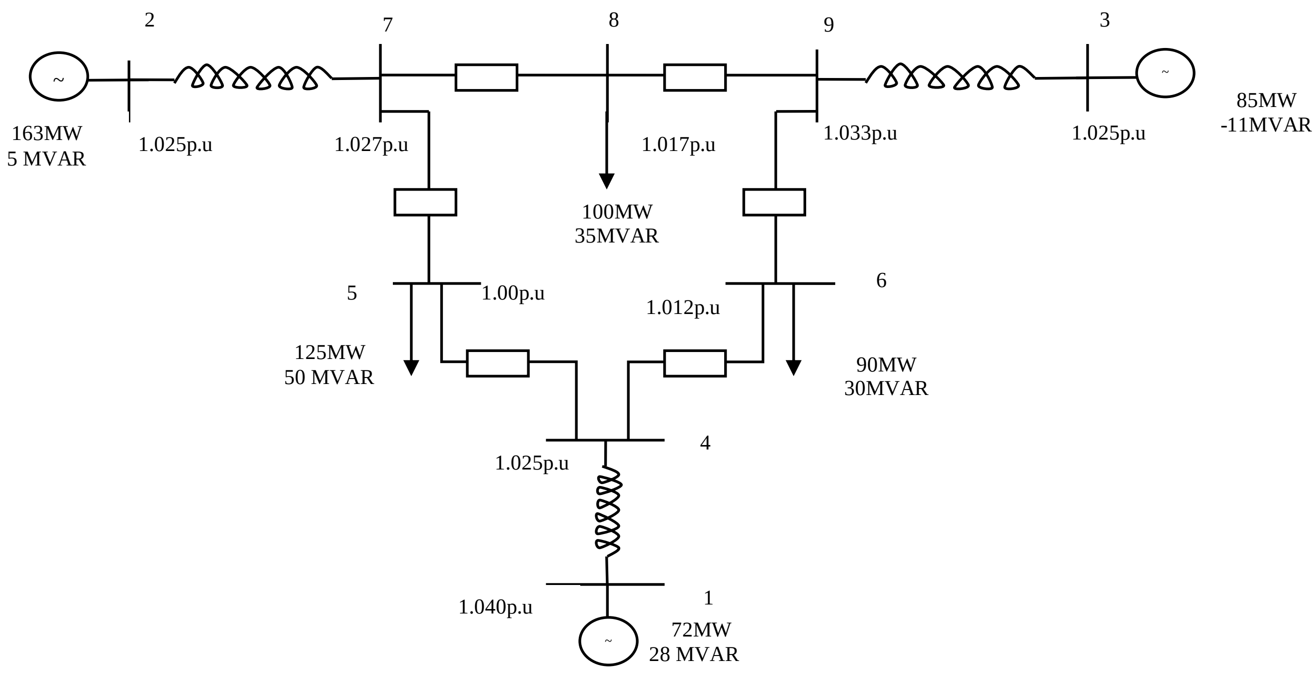

Figure 4: IEEE 9 Bus System

Table 1: Linedata of IEEE 9 bus system

S.No	From Bus	To Bus	R (p.u)	X (p.u)	Half Susceptance b/2 (p.u)	Transformer Tap
1.	4	1	0	0.0576	0	1.0
2.	2	7	0	0.0625	0	1.0
3.	9	3	0	0.0586	0	1.0
4.	5	4	0.01	0.068	0.088	1.0
5.	6	4	0.017	0.092	0.079	1.0
6.	7	5	0.032	0.161	0.153	1.0
7.	9	6	0.039	0.1738	0.179	1.0
8.	7	8	0.0085	0.0576	0.0745	1.0
9.	8	9	0.0119	0.1008	0.1045	1.0

Table 2: Busdata of IEEE 9 bus

Bus	Type	V	°	Generator		Load		Generator		Injected (MVAR)
				MW	MVAR	MW	MVAR	Q_{min}	Q_{max}	
1.	1	1.040	0	72	28	0	0	0	0	0
2.	2	1.025	0	163	5	0	0	-50	200	0
3.	2	1.025	0	85	-11	0	0	-50	200	0
4.	3	1.025	0	0	0	0	0	0	0	0
5.	3	1.000	0	0	0	125	50	0	0	0
6.	3	1.012	0	0	0	90	30	0	0	0
7.	3	1.027	0	0	0	0	0	0	0	0
8.	3	1.017	0	0	0	100	35	0	0	0
9.	3	1.033	0	0	0	0	0	0	0	0

Table 3 : Load Flow Analysis by Newton Raphson Technique

Bus no.	V(pu)	(˚)	Injection		Generation		Load	
			MW	MVAR	MW	MVAR	MW	MVAR
1.	1.0400	0.000	89.622	30.934	89.622	30.934	0.000	0.000
2.	1.0250	8.2139	180.00	20.666	180.00	20.66	0.000	0.000
3.	1.0250	3.7962	95.000	-0.459	95.00	0.459	0.000	0.000
4.	1.0241	-2.7782	0.000	0.000	0.000	0.000	0.000	0.000
5.	**0.9969**	-4.6257	-125.00	-50.000	0.000	0.000	125.0	50.00
6.	1.0098	-4.5338	-90.000	-30.00	0.000	0.000	90.00	30.00
7.	1.0183	2.0266	0.000	0.000	0.000	0.000	0.000	0.000
8.	0.9990	-1.3216	-145.00	-55.00	0.000	0.000	145.00	55.00
9.	1.0267	0.7538	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL			**4.622**	**-83.86**	**364.62**	**51.140**	**360.0**	**135.00**

Table 4: Losses and Line Flows in IEEE 9 Bus System

From bus	To bus	Active power (MW)	Reactive power (MVAR)	From bus	To bus	P (MW)	Q (MVAR)	Line losses	
								MW	MVAR
4	1	-89.622	-26.147	1	4	89.622	30.934	0.000	4.787
2	7	180.000	20.66	7	2	- 180.00	-1.138	0.000	19.528
9	3	-95.00	5.493	3	9	95.00	-4.459	0.000	5.034
5	4	-53.004	-31.313	4	5	53.368	33.906	0.381	2.593
6	4	-36.008	-8.519	4	6	36.236	9.754	0.228	1.235
7	5	73.674	3.181	5	7	- 71.996	5.262	1.678	8.443
9	6	55.116	0.183	6	9	- 53.992	4.825	1.124	5.009
7	8	106.326	21.548	8	7	- 105.36	-15.011	0.965	6.537
8	9	-39.638	-22.126	9	8	39.884	24.207	0.246	2.082
TOTAL LOSSES								**4.622**	**55.248**

CONCLUSION

Power flow computation plays a vital role for designing or planning future extension of power systems also it aids to determining the paramount operation of existing systems. The foremost information obtained from the PFC is the bus voltage magnitude and phase angle at different buses also active and reactive power flow in each line. Moreover, the line flow and line losses are also calculated in the each transmission line. The magnitude and phase angles of IEEE 9 bus system are computed by NR method, the calculations are compound, but by using MATLAB programming this result become simple and prompt as well as the number of iterations is very low.

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