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Optimized Power Flow Analysis of Modified IEEE 30 Bus System with Active Power Flow Factor and Reactive Power Flow Factor

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ABSTRACT*:* In the new era of electrical system the demand for electrical power is more than its generation. In order to matchup the demand, many methods are used such as new installation of the generation plant, generation rescheduling, using distributed generation and many more. All these steps could be implemented applied on the system, only if system performance with changing load is known.
In this paper firstly, line flow studies of the modified IEEE 30 bus system is made by using NR method. And then, for determining the system dependency on load, the load is varied from 80% to 130% with an increment of 2% of balanced load value. Thus the system is been studied for under load as well as for over load condition. This study gives the Flow Factor in terms of active power flow limit violation factor (APFLV) and reactive power flow limit violation factor (RPFLV). By flow factor, the priority list is obtained which shows that, which line violates the stability limit and on which the solution steps should be implemented.

Keywords: Power flow studies, Newton-Raphson algorithm, Flow factor, Node, System Active power losses, System Reactive power losses

I. INTRODUCTION

Power flow studies (PFS) in power system, is the steady state solution of the power system network in which the power system is designed as an interconnected network and then solved for the steady state power and voltages at each bus [1]. The steady state line flow in interconnected network is represented in nonlinear algebraic equations. And, for solving them iterative method is needed. Conventional methods for load flow analysis problem are based on iterative method such as the Newton-Raphson (NR) or the Gauss-Seidel (GS) methods. For stable system operation the system parameters should operates within stability limit. In this paper firstly, line flow studies of the modified IEEE 30 bus system is made by using NR method. And then, for determining the system dependency on load, the load is varied from 80% to 130% with an increment of 2% of balanced load value. Thus the system is been studied for under load as well as for over load condition. This study gives the Flow Factor in terms of active power flow limit violation factor (APFLV) and reactive power flow limit violation factor (RPFLV). By flow factor, the priority list is obtained which shows that, which line violates the stability limit and on which the solution steps should be implemented.

II. POWER FLOW ANALYSIS

For PFA using NR method, has two methods. The first method uses rectangular coordinates for the variable, while the second method uses the polar coordinate form [2]. In this paper, polar coordinate form is been used [2,3,4]

Step1: Form Y_{bus} .

Step 2: Assume initial values of bus voltage $|V_i|^0$ =1.0 and phase angle $\delta_i^0 = 0°$ for i=2,3,4……n .

Step 3: Convergence criterion is set to ∈ that means if the largest of absolute of the residues exceed ∈ the process repeated else terminated.
Step 3: Iteration count is set to K=0.
Step 4: Bus count is set to p=1Step.
Step 5: Say p is slack bus, if yes skip to step 10.
Step 6: real and reactive powers $Pp \text{ and } Qp$ are calculated respectively using equations,

$$P_p = \sum_{q=1}^{n} \{e_p(e_q G_{pq} + f_p B_{pq}) + f_p(f_q G_{pq} - e_q B_{pq})\}$$

$$Q_p = \sum_{q=1}^{n} \{f_p(e_q G_{pq} + f_q B_{pq}) - e_p(f_q G_{pq} - e_q B_{pq})\}$$

Step 7: Calculate $\Delta P_p^k = P_{sp} - P_p^k$ Step 8: Check for bus to be generator bus, if yes compare the reactive power Qpk with the upper and lower limits. If $Q_{gen} > Q_{\max}$ set $Q_{gen} = Q_{\max}$ else if $Q_{gen} < Q_{\min}$ set, $Q_{gen} = Q_{\min}$ and else if, the value is within the limit, the value is retained. If the limits are not violated, voltage residue is evaluated as, $\left|\Delta V_p\right|^2 = \left|V_p\right|^2_{spec} - \left|V_p^k\right|^2$ and then go to step 10.

Step 9: $\Delta Q_p^k = Q_{sp} - Q_p^k$ is evaluated.

Step 10: Bus count is incremented by 1, i.e. p=p+1 and check if all buses have been accounted else, go to step 5.

Step 11: Determine the largest of the absolute value of residue.

Step 12: If the largest of the absolute value of the residue is less than ∈ then go to step 17

Step 13: Jacobian matrix elements are evaluated.

Step 14: Voltage increments Δepk and Δfpk are calculated

Step 15: Calculate new bus voltages $epk+1 = epk + \Delta epk$ and $\Delta fpk = fpk + \Delta fpk$. Evaluate cosine δ and sin δ for all voltages.

Step 16: Advance iteration count is K =K+1, then go to step 4.

Step 17: Finally bus and line powers flow are evaluated and results printed.

Line flow analysis (LFA):-

[6,7]Anything which consumes the power either in the form of active power or reactive power is called as load. In past 20 years, the system load is keep on increasing but the supply of power is not increasing with the same rate which is resulting in the form of power deficiency condition. To avoid this condition, new installation of the generation plant, generation rescheduling, using distributed generation is major solution method. But, these are not economical. Thus for optimized solution of this problem, line factor should be known based upon which the power improvement method could be implemented to overcome undesired condition in system operation.

III. CASE STUDIES

A. IEEE 30 BUS SYSTEM: - *System data is taken from [8].*

IEEE 30 BUS SYSTEM CONNECTION DATA			
No. of lines	**No. of buses**	**No. of generator buses**	**Tolerance**
41	30	6	.0001

IV. RESULTS

Result obtained by load flow analysis of the IEEE 30 bus system using NR method –

)AD FLOW ANALYSIS RESULT OF IEEE 30 BUS SYSTEM			
ower	**ation**		**stem loss**
74	)83	2	-j0.059

<u>System study for under- loaded condition –</u>

Active Power Flow Factor

Sr.No.	Line No	From	To	Sensitivity value
1	36	28	27	0.0516
2	24	19	20	0.0203
3	20	14	15	0.00545

Reactive Power Flow Factor

Sr.No.	Line No	From	To	Sensitivity value
1	1	1	2	0.2790
2	10	6	8	0.1938
3	7	4	6	0.13914

System study for over- loaded condition –

Active Power Flow Factor

Sr.No.	Line No	From	To	Sensitivity value
1	1	1	2	3.0958
2	5	2	5	1.6365
3	2	1	3	1.4132

Reactive Power Flow Factor

Sr.No.	Line No	From	To	Sensitivity value
1	14	9	10	0.3585
2	27	10	21	0.2681
3	8	5	7	0.2161

V. CONCLUSION

Line flow analysis is done of IEEE 30 bus system along with the determination of the 'APF FACTOR' and 'RPF factor' both under loaded and overloaded conditions.

For the under loaded system condition,

- The most sensitive line for active power flow change is line number 36 which is between bus 28 and bus 27.
- The most sensitive line for Reactive power flow change is line number 1 which is between bus 1 and bus 2.

For the over loaded system condition,

- The most sensitive line for active power flow change is line number 1 which is between bus 1 and bus 2.
- The most sensitive line for active power flow change is line number 14 which is between bus 9 and bus 10.

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