

CONTINGENCY ANALYSIS IN OPEN ACCESS TRANSMISSION SYSTEM

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ABSTRACT

Maintaining power system security is indispensable task for power system engineers. The security estimation is an essential job as it gives the information about the system state in the event of contingency. A power system is secure against some uncertainty conditions, if it operates within specified operating limits for pre and post contingencies. Contingency ranking attempts to calculate approximately the impact of various uncertainty conditions like transmission line outages, transformer outages and generator outages. This paper demonstrates an accurate method of ranking the contingency based on transmission losses. The method used in this paper is based on sensible approach taking real situations into account. Generally N-1 contingencies are considered for contingency ranking (CR) but in this paper N-2 contingencies are also performed with power transactions in WSCC- 9 bus RTS by using PSAT with MATLAB and results are presented.

Key words: Contingency, Contingency Ranking,

1.INTRODUCTION

The restructured power system is a competitive market in which the consumers are treated as customers. There are plenty of choices available for customers to get electrical energy. The Restructured system is also called as horizontally unbundled system. Unbundling means separation of Generation, transmission and distribution companies into independent competitive commercial entities. The generating companies consists of generating plants to produce electrical energy. The transmission companies consists of transmission system components such as transmission lines, cables and compensating devices. The distribution company controls the operation of power distribution system.(P.Deepika et al.-2017) The Generation and distribution companies submit their bids to the Independent System Operator (ISO). The main role of ISO is matching the power supply with the demand and also needs to

maintain the reliability of the system. It is the ability power system to undergo a set of disturbances without affecting the safety and supply quality following the contingency is called as power system security(kanimozhi et al.-2015).Contingency ranking is a procedure of contingency analysis process which uses Performance Index (PI) calculation(Radha Rani et al.,- 2011). In contingency ranking the contingencies are arranged in decending order based on the calculated PI of all contingencies and sorted out based on the severity of contingency.(javan et al.,-2011)

2. LOAD FLOW ANALYSIS

Load flow studies are one of the most imperative aspects of power system planning and operation. The load flow gives us the steady state parameters of the entire system voltages, real and reactive power generated and absorbed and line losses. Since the load is a static quantity and it is the power that flows through transmission lines, the purists prefer to call this Power Flow studies rather than load flow studies.

Magnitude of Voltage $|V|$, phase angle (δ) , actual true power (P) and Reactive power (Q) these parameters are associated in load flow studies.

The mathematical formulation of power flow problem results into nonlinear algebraic equations which can be solved only by various iterative techniques. The different types of iterative techniques are,

- Gauss seidel load flow solution
- Fast decoupled load Flow solution
- Newton Raphson load flow solution

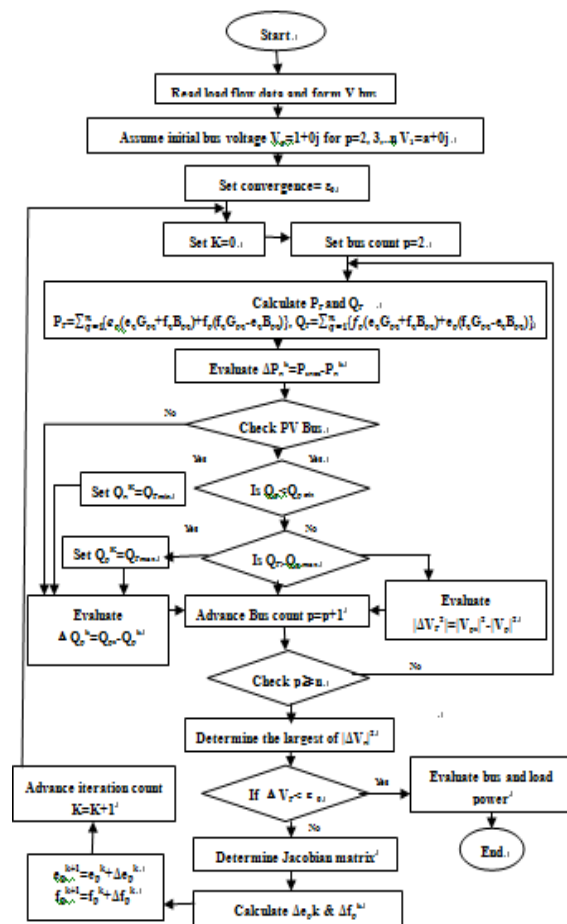


Fig1.Flowchart for Newton Raphson method

In the above methods NR method is preferred for load flow studies because less number of iterations are needed, Suitable for large size systems and it is more reliable.

3. CONTINGENCY RANKING.

The event of outages of Transmission line, Transformer and generator in the power system Network is called as Contingency. The Contingency is unpredictable in nature. It causes power system instability and it also affects the continuity and security of the power system(karthikeyan.R-2011) . The process of analyzing the power system after the contingency process to identify whether the system is secure or not is called as contingency analysis. The contingency analysis are performed suddenly which prevents the other related series accidents. The difficulty in contingency analysis is the contradiction between the accuracy of the system and the speed required to model the contingencies.(Sundararaju.K. et al.,-2011) In the selection of contingency process the many algorithms are developed. There are two selection methods first one is ranking methods next is screening methods. Screening methods are used to identify the critical contingencies. Ranking method use scalar Performance Index to quantify the contingency severity.

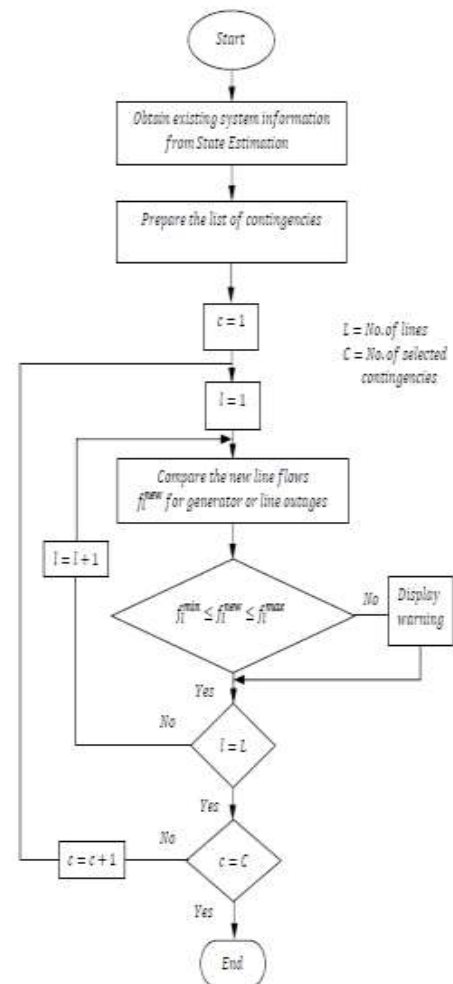


Fig.2 Flowchart for Contingency selection

4. TRANSMISSION LOSS

Real power loss in transmission line connected between buses p and q can be simplified as

$$L_{pq} = L_{pqv} + L_{pq\delta} \quad (1)$$

$$L_{pqv} = g_{pq}(V_p - V_q)^2 \quad (2)$$

$$L_{pq\delta} = g_{pq}(\delta_p - \delta_q)^2 \quad (3)$$

Where g_{pq} represents the real part of the line admittance δ_p represents the phase angle of voltage at the p^{th} bus and V_p represents the bus voltage magnitude of p^{th} bus. Eq (2) is the first part of loss equation which is quadratic function of voltage magnitude differences and it is calculated by reactive power flows. The next part of losses are given by equation (3) which is the quadratic function of phase angle differences and it is calculated by real power flows. Total losses in this system consists of NB buses is the sum of the losses of individual buses

$$P_L = P_{LV} + P_{L\delta} \quad (4)$$

Where,

$$P_{LV} = \sum_{p=1}^{NB-1} \sum_{q=p+1}^{NB} g_{pq} (V_p - V_q)^2 \quad (5)$$

$$P_{L\delta} = \sum_{p=1}^{NB-1} \sum_{q=p+1}^{NB} g_{pq} (\delta_p - \delta_q)^2 \quad (6)$$

P_{LV} is depends upon reactive power flows so this part cannot be used for MW line flow PI calculations. $P_{L\delta}$ is the functions of bus voltage phase angle difference. It is called as ' δ 'loss.

5. WHEELING TRANSACTION

The use of some parties transmission system for the benefit of other parties is called as wheeling transaction. The parties denotes both utility and non utility organizations.

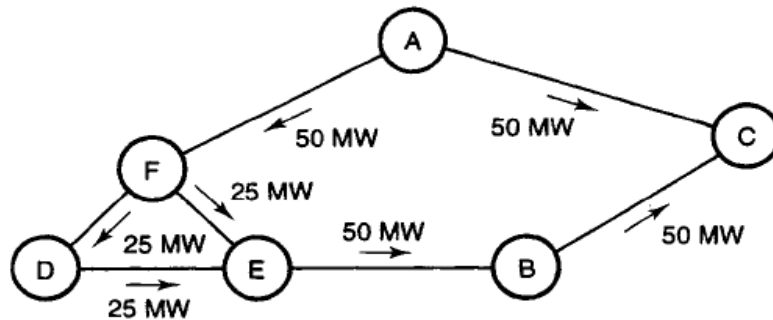


Fig.3. Wheeling Transaction

There are two types of wheeling transactions involved in wheeling transaction. They are,

- Bilateral Transaction
- Multilateral Transaction

The Wheeling transaction established between two parties in deregulated power system environment to sell and buy Electrical Energy is called as Bilateral Transaction.

Multiple parties involves in Wheeling Transaction for selling and buying of electrical energy is called as multilateral transaction. The multilateral transactions based on bilateral transactions among market participants(Wood.A.J-2009).

6.SYSTEM DESCRIPTION.

WSCC 9 bus system has three generators, three transformers, six transmission lines and three load buses.

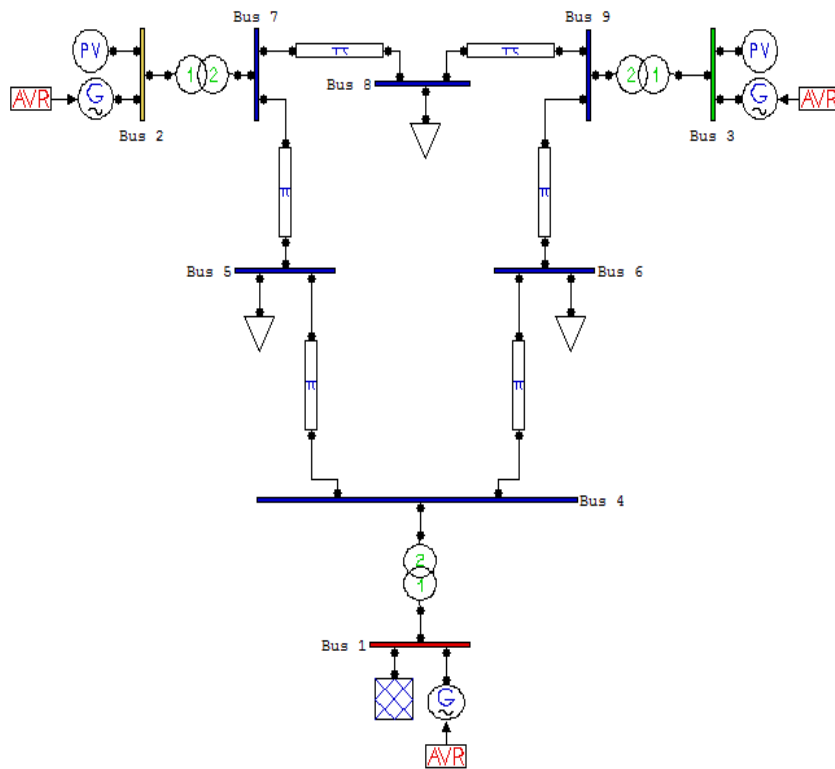


Fig 4.WSCC 9 bus system

Table1.Base case simulation results

Bus No	Voltage in (kV)	phase angle (deg)	Real power generation (MW)	Reactive power generation (MVar)	Real power load (MW)	Reactive power load (MVar)
Bus 1	17.16	0	71.641	27.0459	0	0
Bus 2	18.45	9.28	163	6.6537	0	0
Bus 3	14.145	4.6648	85	10.8597	0	0
Bus 4	235.9313	-2.2168	0	0	0	0
Bus 5	228.9951	-3.9888	0	0	125	50
Bus 6	232.9105	-3.6874	0	0	90	30

Bus 7	235.927	3.7197	0	0	0	0
Bus 8	233.653	0.72754	0	0	100	35
Bus 9	237.4412	1.9667	0	0	0	0

6.1. POWER TRANSACTIONS

(a).Bilateral transaction

S. No	Power removal at bus no	Power injected at bus no	Amount of power transaction
1	6	8	20MW

Table 2 Power flow results at bilateral transaction

Bus No	Voltage in (kV)	Phase angle (deg)	Real power generation (MW)	Reactive power generation (MVar)	Real power load (MW)	Reactive power load (MVar)
Bus 1	17.16	0	70.919	24.1078	0	0
Bus 2	18.45	8.2209	163	7.0341	0	0
Bus 3	14.145	3.9588	85	-11.2398	0	0
Bus 4	236.3018	-2.191	0	0	0	0
Bus 5	229.4192	-4.3248	0	0	125	50
Bus 6	233.9555	-3.2487	0	0	70	30
Bus 7	235.8739	2.6593	0	0	0	0
Bus 8	233.336	-0.64921	0	0	120	35
Bus 9	237.4911	1.2614	0	0	0	0

(b).Multilateral transaction simulation result

S. No	Power removal at bus no	Power injected at bus No's	Amount of power transaction
1	5	6 & 8	50MW

Table 3 Power flow results at multilateral transaction

Bus No	Voltage in (kV)	Phase angle (deg)	Real power generation (MW)	Reactive power generation (MVar)	Real power load (MW)	Reactive power load (MVar)
Bus 1	17.16	0	70.864	22.5116	0	0
Bus 2	18.45	8.2479	163	6.1131	0	0
Bus 3	14.145	2.9257	85	-9.1157	0	0
Bus 4	236.5047	-2.1874	0	0	0	0
Bus 5	230.9365	-2.7339	0	0	75	50
Bus 6	232.661	-4.9378	0	0	110	30

Bus 7	236.0024	2.6894	0	0	0	0
Bus 8	233.0914	-1.2991	0	0	130	35
Bus 9	237.2121	0.22503	0	0	0	0

6.2. CHANGE IN LOAD (125% OF BASE CASE).

Table 4 Power flow results at change in load

Bus No	Voltage in (kV)	phase angle (deg)	Real power generation (MW)	Reactive power generation (MVar)	Real power load (MW)	Reactive power load (MVar)
Bus 1	17.16	0	150.8241	45.5008	0	0
Bus 2	18.45	3.5966	163	20.0795	0	0
Bus 3	14.145	-0.8892	85	-0.01614	0	0
Bus 4	234.1933	-4.7057	0	0	0	0
Bus 5	224.9146	-8.6205	0	0	156.25	62.5
Bus 6	230.2784	-8.0395	0	0	112.5	32.5
Bus 7	234.053	-2.0083	0	0	0	0
Bus 8	230.6534	-5.5436	0	0	125	43.75
Bus 9	236.0169	-3.6036	0	0	0	0

6.3. TRANSMISSION LINE LOSSES AT N-1 CONTINGENCY

S. No	Outage element	Real power loss in MW	Reactive power loss in MVAR
1	Line 4-5	9.5669	-38.7822
2	Line 4-6	6.136	-63.2739
3	Line 8-9	5.3532	-62.6164
4	Line 8-7	12.0928	-28.4681
5	Line 6-9	9.4914	-21.5785
6	Line 5-7	13.2083	0.75931
7	Transformer.2-7	4.4347	-71.5408
8	Transformer 3-9	3.6285	-88.8811
9	Generator at bus 2	4.4347	-71.5408
10	Generator at bus 3	3.6285	-88.8811

6.4. TRANSMISSION LINE LOSSES AT N-2 CONTINGENCY

S. No	Outage element	Real power loss in MW	Reactive power loss in MVAR
1	Both Transformers	10.1781	10.9423
2	Both Generators	10.1781	10.9423

6.5. CONTINGENCY RANKING BASED ON REAL POWER LOSSES IN TRANSMISSION SYSTEM

S. No	Outage element	Real power loss in MW	Contingency ranking
1	Line 4-5	9.5669	3
2	Line 4-6	6.136	5
3	Line 8-9	5.3532	6
4	Line 8-7	12.0928	2
5	Line 6-9	9.4914	4
6	Line 5-7	13.2083	1
7	Transformer.2-7	4.4347	7
8	Transformer 3-9	3.6285	8
9	Generator at bus 2	4.4347	7
10	Generator at bus 3	3.6285	8

7. Conclusion

Overloading of the transmission line leads to cascading outages which may cause instability in power system. In our Indian power system network many of the transmission elements like transmission line transmit power at their maximum load ability limit. In this paper N-1 and N-2 contingencies are demonstrated on WSCC- 9 bus RTS system and detailed comparison is portrayed with the help of Newton Raphson power flow analysis. This approach can take into account of real and reactive power losses occurring in the system under various uncertainty conditions. It easily handles multiple contingencies. Contingency ranking (CR) is also done based on transmission losses. From this information, proper monitoring and by selecting the necessary preventive actions instability of the power system can be avoided.

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