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Optimal Reactive Power Dispatch for Voltage Stability Improvement Considering Line Contingencies using PSO

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Abstract

This paper presents a swarm intelligence algorithm for monitoring and improving voltage stability in power system considering a contingency conditions; line outage. The Static Voltage Stability Index (*SVSI*) was used as the monitoring tools and as the objective function for the developed optimization technique. This index uses information on a normal load flow and is in the range of 0 (zero load) to 1 (system collapse). The proposed algorithm gives an optimal setting of control devices such as switchable VAR compensator and able to minimize total transmission losses, improved voltage stability and increase voltage profile of the system. The effectiveness of the proposed technique was validated on standard IEEE 30-bus Reliability Test System (RTS). The simulations results are compared with those obtained from the Evolutionary Programming (EP) technique in the attempt to highlight its merit.

1. Introduction

Issue on voltage stability is not new and it has been discussed since few decades ago. It is considered as a major concern in planning and operation of electric power system. The nature of voltage stability can be analyzed by examining the production, transmission and consumption of reactive power [Goel and Feng, 1999]. In power system, the average duration of interruption that customers suffer is a total of two to three hours per year, but increasing load makes the power grid more stressed leading to blackouts more often [Shaban and Go, 1993]. Voltage instability was found to be responsible for several major network collapses in many countries [Musirin, 2003]. Therefore, power control procedures are required in order to enhance the voltage stability in power system network. Insufficient reactive power support has been identified as one of the factors for power blackout [Visakha et. al, 2004].

2. Objective Function and Optimization Technique

In this study, line voltage stability index ermed as Static Voltage Stability Index (SVSI) was used as the objective function and indicator to voltage stability [Qi, 2004]. The mathematical equation for *SVSI* was formulated from a two-bus power system model and given as in equation (1):

$$SVSI_{ji} = \frac{2\sqrt{\left(X_{ji}^{2} + R_{ji}^{2}\right)\left(P_{ji}^{2} + Q_{ji}^{2}\right)}}{\left| |V_i|^2 - 2X_{ji}Q_{ji} - 2R_{ji}P_{ji} \right|} \qquad (1)$$

In addition, Particle Swarm Intelligence (PSO) is used as the main optimization technique in the attempt to search for an optimal solution for RPD.

3. Result and Discussion

The results for comparative studies with EP when load was subjected to bus 26 are tabulated in Table 1.From the table, it is observed that when PSO is used to optimize the RPD, it gives better results as compared to EP in terms of transmission losses and *SVSI* however EP manage to outperformed EP in terms of voltage profile.. At line outage number 1, 9 and 7, PSO method managed to reduce the *SVSI* value from 0.5442 to 0.2399, while EP only managed to reduce SVSI value to 0.4219. In addition, PSO also outperformed EP in reducing the total loss in the system from 74.22 MW to 4.94 MW with the reduction of 93.4 % instead of EP which is only able to decrease to 13.9 MW. For the voltage profile, EP method has improved the voltage profile from 0.801 p.u. to 1.172 p.u. but for the PSO voltage profile has only increased to 0.848 p.u. which is lower than EP.

Table 1: Comparison results for RPD between PSO and EP when bus 26 was reactively loaded

Line Outage No.	Pre			Post							
				PSO				EP			
	SVSI	Voltage	Loss	SVSI	Voltage	Loss	%ΔLoss	SVSI	Voltage	Loss	%ΔLoss
0	0.2418	0.845	20.18	0.2400	0.848	4.66	76.9	0.1707	1.026	8.38	58.5
1	0.5109	0.829	65.08	0.2400	0.848	4.54	93.0	0.4578	1.180	10.5	83.9
1,9	0.5275	0.812	69.18	0.2389	0.850	4.65	93.3	0.5649	1.221	11.9	82.8
1,9,7	0.5442	0.801	74.22	0.2399	0.848	4.93	93.4	0.4219	1.172	13.9	81.3

4. Conclusion

The two techniques have been successfully tested on the IEEE 30-bus RTS. The result indicated that these techniques had improved the result for all cases. The result shows that PSO technique outperformed EP in terms of transmission losses and voltage stability improvement. For future work, the larger test system can be incorporated together to achieve similar task.

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