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CONGESTION MANAGEMENT USING GENETIC ALGORITHM

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Abstract - In deregulated period of power system, load characteristics become more erratic. Unplanned transactions of electrical power through transmission lines of particular path may occur due to low cost offered by generating companies. As a consequence those lines driven close to their operating limits and becomes congested as the lines are originally designed for traditional vertically integrated structure of power system. This congestion in transmission lines is unpredictable with deterministic load flow strategy. Rescheduling active and reactive power output of generators is the promising way to manage congestion. In this paper Genetic Algorithm is applied for optimal solution of active and reactive power rescheduling for managing congestion. The generators sensitivity technique is opted for identifying participating generators for managing congestion. Proposed algorithm is tested on IEEE 30 bus system. Comparison is made between results obtained from proposed techniques to that of results reported in previous literature.

Keywords: Electricity Market, Generator sensitivities, Genetic Algorithm, Rescheduling, Transmission Congestion.

1. INTRODUCTION

Deregulation electricity markets induced competition in the existing power sector to promote the participation of private body to meet the increasing energy demand across the world. The problem of transmission congestion is predominating in deregulated electricity market structure as the existing lines are originally designed for vertically integrated unbundled operation. A transmission line is said to be congested when it operates closure to its operating limits. Under competitive environment large units of Generating Companies may offer lower electricity price to customers for profit maximization, this may change the power flow pattern and the transmission lines are often driven close to their thermal limits in order to satisfy the increased electric power consumption and trades due to increase of the unplanned power exchanges. If the exchanges were not controlled, some lines located on particular paths may become congested. To relieve the line from congestion and to ensure the secure operation of power system in a complex electricity market, appropriate congestion management strategy necessitates to be implemented. Congestion can be reduced by generation re-dispatch, load re-dispatch, reactive power support, and transmission system expansion.

2. PROBLEM FORMULATION

To manage congestion within the constrictions, problem formulation must be carefully done by considering all probable factors that affects the system. In the proposed strategy of congestion management, rescheduling of generator outputs is considered. The problem of optimum rescheduling of generator outputs is formulated including objective function and constraints.

2.1 Objective function:

Objective of the work is to relieve the line from congestion and minimize the rescheduling cost of generators participating in managing congestion. The active and reactive power rescheduling costs of generators for congestion management based on the bids received is given by-

$$\text{Minimize} \sum_{g}^{Ng} C_{Pg}\,(\Delta P_g)\Delta P_g + \sum_{g}^{Ng} C_{Qg}\,(\Delta Q_g)\Delta Q_g$$
(1)

Where:

C_{Pg}: Cost of the active power rescheduling corresponding to the incremental/ decremental price bids submitted by generator-g participating in congestion management.

ΔP_g : Active power adjustment of the generator-g.

ΔQ_g : Reactive power adjustment of the generator-g.

$C_{Qg}(\Delta Q_g)$: Cost of the reactive power rescheduling of generator-g participating in congestion management. It is expressed as:

$$C_{Qg}(\Delta Q_g) = \left\{C_g^P(S_{Gmax}) - C_g^g\left(\sqrt{S_{Gmax}^2 - \Delta Q_g^2}\right)\right\} \times \phi$$
(2)

Where, C_g^P is the cost of active power generation of generator *g* and is expressed as a quadratic function as

$$C_g^P(\Delta PG_{gn}) = a_n(\Delta PG_{gn}^2) + b_n(\Delta PG_{gn}) + c_n$$
(3)

2.2 Constraints:

To ensure the operation of system within operating range with feasible solutions inequality and equality constraints are incorporated. In the present work constraints are power flow constraint (4), operating limit constraints (5) (6)

Subject to

$$\sum_{g}^{Ng}\left((GS_g)\Delta P_g\right) + F_k^o \leq F_k^{max} \quad (4)$$

$$P_g^{min} \leq P_g \leq P_g^{max} \quad (5)$$

$$P_g - P_g^{min} = \Delta P_g^{min} \leq \Delta P_g \leq \Delta P_g^{max} = P_g^{max} - P_g \quad (6)$$

Where:

GS_g: Generator sensitivity

F_k^o : MVA flow

F_k^{max} : MVA flow limit

3. Case Study

Simulation studies were carried out on Intel Core 2 Duo processor, 2GB of RAM, 2.20 GHZ system in MATLAB 7.6 platform. The algorithm has been tested on IEEE 30 bus system [8] and modified IEEE 57 bus system [9]. IEEE 30 bus system consists of 6 generators, 24 load buses and 41 branches. Generator at slack bus is numbered as 1, while remaining are taken as 2,3,4,5 and 6. Numbering of load buses is taken from 7 to 30. Generating unit characteristics are given in table 1. Details of congested line and generator sensitivity values corresponding to the congested line are given in table 2 and 3.

Table I: Generating unit characteristic of IEEE 30 bus system.

Unit	Cost Coefficients			Generator Limits	
	a ($/MW^{2}h)	b ($/MWh)	c ($/h)	Pgmin (MW)	Pgmax (MW)
1	0.00375	2	0	50	250
2	0.0175	1.75	0	20	80
3	0.0625	1	0	15	50
4	0.00834	3.25	0	10	35
5	0.025	3	0	10	30
6	0.025	3	0	12	40

Table II. Congested Line Data

Congested Line	Rated MVA	MVA flow
1-7	130	140
7-8	130	136

Table III. Generator sensitivities

Unit	1	2	3	4	5	6
GS	0.00	-0.85	-0.78	-0.68	-0.66	-0.64

In modified IEEE 57 bus system consists of 7 generator buses and 80 branches. Slack bus is numbered as1, rest generator buses are numbered 2, 3, 4, 5, 6 and 7 respectively. Numbering of load buses is done from 8 to 57.

Table IV. Generating unit characteristic of IEEE 57 bus systems

Unit	Cost Coefficients			Generator Limits	
	ai ($/MW^{2}h)	bi ($/MWh)	ci ($/h)	Pgmin (MW)	Pgmax (MW)
1	0.0017	1.7365	0	50	575.88
2	0.01	10	0	10	100
3	0.0071	7.1429	0	20	140
4	0.01	10	0	10	100
5	0.0018	1.81	0	40	550
6	0.01	10	0	10	100
7	0.0024	2.439	0	30	410

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Table V: Congested line data

Congested Line	Rated MVA	MVA flow
5-6	200	210
6-12	50	58

Table VI: Generator sensitivities

Unit	1	2	3	4	5	6	7
GS	0.00	0.02	0.08	0.39	0.63	-0.229	-0.093

4. Result

Table VII Results for Active Power Rescheduling

		ΔPg1 (MW)	ΔPg2 (MW)	ΔPg3 (MW)	ΔPg4 (MW)	ΔPg5 (MW)	ΔPg6 (MW)	Cost of Active Power Rescheduling ($/Day)
Result Reported in [26]		-56.10	---	16.30	28.20	---	5.63	28901
GA	Roulette Wheel Iteration=500	10.3941	15.4789	0.2714	-0.4789	17.3719	-4.6596	26850
	Roulette Wheel Iteration=1000	72.7089	-5.5396	19.6520	-0.1052	12.3394	0.2414	28442
	Roulette Wheel Iteration=1500	-0.3973	50.2984	-4.5467	16.0937	70.9036	-2.0403	28964
	Tournament Iteration=500	-6.3323	56.2414	-5.1322	13.5091	35.6793	-4.0498	27893
	Tournament Iteration=1000	-5.4856	20.0389	13.3334	7.7378	-11.9236	7.7472	23466
	Tournament Iteration=1500	0.88768	10.8376	-0.9867	-3.5789	65.4987	-4.3278	27849
	Tournament Iteration=2000	-2.4683	25.8937	-0.2846	-8.5894	-4.6873	-3.2680	26389
	Roulette Wheel Iteration=1000	79.1413	5.8469	21.5147	-0.8955	12.8808	-5.5125	20035
	Roulette Wheel Iteration=1500	-0.9386	2.4376	67.8276	-3.5687	10.3678	-4.2768	25643
	Tournament Iteration=500	5.7848	-0.4895	-3.2878	17.5938	2.6894	8.6947	24895
	Tournament Iteration=1000	56.0924	35.4737	20.0697	-6.6833	11.5456	4.9970	21014
	Tournament Iteration=1500	7.4707	3.9644	-5.2978	-1.9035	6.8348	12.5208	26987
	Tournament Iteration=2000	34.2977	-4.3872	-5.3863	-0.3876	5.3862	10.3897	25684

		ΔQg1 (MW)	ΔQg2 (MW)	ΔQg3 (MW)	ΔQg4 (MW)	ΔQg5 (MW)	ΔQg6 (MW)	Cost of Active Power Rescheduling ($/Day)
Result Reported in [26]		-56.10	---	16.30	28.20	---	5.63	28901
GA	Roulette Wheel Iteration=500	-4.2096	10.9041	3.8387	-10.294	19.7616	-9.7784	7439.2861
	Roulette Wheel Iteration=1000	-0.4921	-1.8471	0.8067	23.292	8.4539	0.27571	7260.2395
	Roulette Wheel Iteration=1500	-6.2109	10.3561	-0.3869	-12.294	11.9306	20.7782	7238.3756
	Tournament Iteration=500	10.2356	-2.3561	0.8067	-0.8240	10.1246	12.4892	6892.2976
	Tournament Iteration=1000	5.2365	11.5269	6.3256	12.5483	-6.8235	9.4113	6538.2157
	Tournament Iteration=1500	-8.2235	2.5452	-0.3566	15.4923	-10.823	7.9723	7329.8362
	Tournament Iteration=2000	-6.9836	2.7659	-0.8735	12.7654	7.8763	-2.7654	7246.9878
	Roulette Wheel Iteration=1000	-4.2527	17.3175	0.8664	2.8011	-4.8370	-5.2875	6203.4681
	Roulette Wheel Iteration=1500	-0.2945	10.4739	-0.4836	14.0673	-3.8891	-1.9033	6483.3476
	Tournament Iteration=500	4.2568	0.1249	-9.3493	15.9033	-5.8455	9.8913	6533.8278
	Tournament Iteration=1000	-6.2109	-2.3561	0.8067	-12.294	10.1246	17.7562	6012.3658
	Tournament Iteration=1500	-5.2905	10.5402	-3.9636	2.49532	-9.8233	-0.9463	6341.3458
	Tournament Iteration=2000	-4.3972	9.3987	-2.4763	3.2876	-8.3866	-0.3962	6438.5865

Table VIII Results for Reactive Power Rescheduling

5. Conclusion & Future Scope:

In this paper optimal active and reactive power rescheduling output of generators are calculated for transmission congestion management to ensure the reliability of the deregulated power system under consideration. The results obtained by implementing Genetic Algorithm and are compared to previous literature. Results show that GA in successive iterations exhibits better results. Techniques are implemented on IEEE30. All generators are selected for congestion management due to few numbers.

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