

Active and Reactive Power Pricing Considering Voltage Security

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-----ABSTRACT-----

The voltage security has become the major problem in the restructuring power industry. The voltage stability causes the system security due to insufficient reactive power supply. The system security is obtained by considering the reactive power. For the pricing of active and reactive power considering the voltage security the new SALIN approach is used. The problem is modeled as the multi objective optimal power flow. By assigning suitable value for the weighting factor the security of the system can be obtained. The weighting factor is assigned by the HHI (Herfindahl-Hirschman Index). The proposed method is verified using the IEEE 6 bus system in the PSAT-GAMS software.

KEYWORDS : Deregulation, Herfindahl-Hirschman Index, Reactive power, Voltage security, Weighting factor

Date of Submission: 4 January 2014



Date of Acceptance: 05 March 2014

I. INTRODUCTION

The electric power industry turns towards the restructuring area for the past years. The restructure eliminates the monopoly in the power system. The main concern in the restructuring is the system security. When load get increased in the power system the voltage stability is less. The system may get collapsed when the reactive power is not supported. This paper mainly gets focus on the security of the electrical power system. For the security of the power system the reactive power management is very essential. The supply and demand of the system should be balanced by taking account all the constraints. In this paper the voltage security constraint is mainly taken into account. An optimization process is used to solve the security constraint problem. The weighting factor in the multi objective function is the main role in the optimization process. In this paper a new method called SALIN is used by considering the HHI to assign the value of weighting factor. The active power market is mainly focused by most of the researches in electricity markets. In this paper the electricity pricing is considered for both active and reactive power markets. In most cases in which the reactive power cost is required the active power bids is used as the reactive power bids [1]. This makes approximate pricing. Here this approach is used for the active and reactive power separately. The optimal power flow is used for the operation of active and reactive power in order to minimize the losses, cost and improvement of voltage stability [2]. The security constrained optimal power flow is introduced due to the various limitation of the optimal power flow like,

- Contingency that affects the robustness, stability of the system.
- Cost for the requirement of contingencies

To incorporate voltage stability constraints into OPF formulation various methods are used. Ramesh et.al.[3] shows a non linear optimization approach to maximize the social welfare and the maximum distance to collapse point in an power market using the reactive support like SVC. The optimization takes place by considering the equality and inequality constraint. The Security Constrained Optimal Power Flow problem is solved using the interior point method [4] due to its speed of convergence and handling inequality constraints in an easy manner. In the deregulated electricity market the pricing for system security and reliability are considered separately. The social welfare and the power consumption get increased. The restructuring of the power system is done for the effective and efficient power supply[7].

II. MULTI OBJECTIVE OPTIMAL POWER FLOW

The Multi Objective Optimal Power Flow technique improves the voltage security and minimizes the generation cost. The pricing system for power system security in deregulated electricity market that includes voltage stability constraint in a multi-objective OPF problem [5].

In this the social welfare and distance to voltage collapse point are maximized as,

$$\min - w_1 \times \text{social welfare} - w_2 \times \lambda_c \quad (1)$$

W_1 - Weighting factor of social welfare

W_2 - Weighting factor of maximum loading margin

Including the reactive power cost the above system is modified as,

$$\min - w_1 (C_{D_P}^T P_D + C_{D_Q}^T Q_D - C_{S_P}^T P_S - C_{S_Q}^T Q_G) - W_2 \lambda_c \quad (2)$$

P_S, P_D - Bounded supply and demand active power bids

C_{S_P}, C_{D_P} - Bid prices for active power supply and demand

C_{S_Q}, C_{D_Q} - Supply and demand bids for reactive power

Q_G - Generated reactive power

The equality and inequality constraints are given as,

$$\begin{aligned} f(\delta, |v|, Q_G, P_S, P_D) &= 0 \\ f_c(\delta_c, |v|_c, Q_{G_c}, P_S, P_D) &= 0 \\ \lambda_{c_{\min}} &\leq \lambda_c \leq \lambda_{c_{\max}} \\ P_{S_{\min}} &\leq P_S \leq P_{S_{\max}} \\ P_{D_{\min}} &\leq P_D \leq P_{D_{\max}} \\ Q_{G_{\min}} &\leq Q_G \leq Q_{G_{\max}} \\ Q_{G_{\min}} &\leq Q_{G_c} \leq Q_{G_{\max}} \\ I_{ij}(\delta, |V|) &\leq I_{ij_{\max}} \\ I_{ji}(\delta, |V|) &\leq I_{ji_{\max}} \\ V_{\min} &\leq V \leq V_{\max} \\ V_{\min} &\leq V_c \leq V_{\max} \end{aligned} \quad (3)$$

The equality constraints are the active and reactive power flow equations. The inequality constraints are the loading margin limit, supply and demand bid block, reactive power limit, thermal limit and security limit. The objective is the pricing of active and reactive power and is given as,

$$\min C_{\text{total}} = - \sum_{i=1}^{N_g} [Cost(P_{G_i}) + Cost(Q_{G_i})] \quad (4)$$

III. PROPOSED METHOD

For the accurate pricing of the active and the reactive power considering the voltage security the SALIN algorithm is introduced. First the bid prices for each market participant are provided using the cost based pricing then considering these values as the market bids the pricing of active and reactive for power is find out for the different values of weighting factor in the multi objective optimization problem. Weighting factor plays an important role in the optimization problem. Here a new reactive market power index is used for determining the weighting factor. When the voltage security level increases the maximum reactive power capacity is increased in the generators. When the level of voltage security is increased, some producers reduce the production so the buyers will reduce their demand while some others increase the production.

3.1. REACTIVE MARKET POWER INDEX

The reactive market indices (HHI) determine the system where an additional source of reactive power injection is required or not. The reactive market power index namely the Herfindahl-Hirschman Index is the sum of squared market share of firms in the industry and the indicator of the amount of competition among them. It ranges between 0 and 1.

$$HHI = \sum_{i=1}^N S_i^2 \quad (5)$$

N - Number of market participants.

S_i - Percentage market share of each participant.

The HHI is used to measure the reactive market power. According to merger guide lines of U.S. Department of justice the value of HHI is less than 3800 correspond to the weak market [6]. The voltage change is calculated by

$$\begin{bmatrix} \Delta\theta \\ \Delta V \end{bmatrix} = (J^{-1} e_i^Q) Q_i^{\text{margin}} \quad (6)$$

J – Jacobian Matrix

e_i^Q – Vector of all zeros where reactive power is injected

$$Q_i^{\text{margin}} = Q_i^{\text{max}} - Q_i^{\text{actual}}$$

S_i can be calculated as,

$$S_i = 100 \frac{\Delta V_i}{\sum_{k=1}^n \Delta V_k} \quad (7)$$

The value of HHI is increased as Q_i^{margin} decreases. The value of HHI decreases when the number of generators increases.

3.2. Weighting Factor

The weighting factor plays the major role in the optimization process. The proposed method allows the market operators to preserve the level of security within acceptable range by controlling the weighting factor. For determining the appropriate values of weighting factors the new approach is used. The HHI index is used for assigning suitable values to the weighting factor. The paper focus on the pricing on reactive market power using a multi objective OPF in which both active and reactive power markets are considered simultaneously. The pricing is performed using an OPF formulation to minimize the active and reactive power production cost. Selecting unsuitable value of weighting factor lead to reactive market power. To measure the reactive market power HHI is used. The range of the weighting factor lies between 0.4-0.8. For lower value of weighting factor, the voltage security is less and for higher value the voltage security is high.

IV. CASE STUDY

The proposed method is tested using the IEEE 6 bus using the PSAT-GAMS software. The required data is obtained from[8]

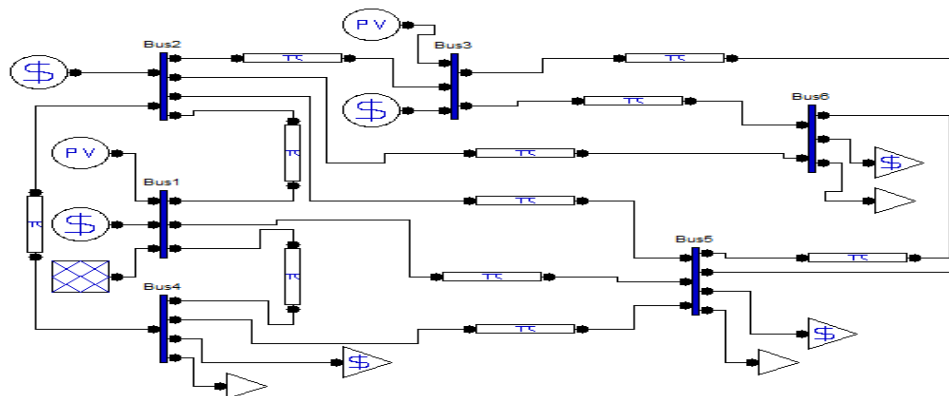


Fig.1: PSAT model of IEEE 6 bus system

The six bus system consist of supply bid blocks and the demand bid blocks where the cost is set and it is needed to run the OPF.

PROCEDURE:

- Open The Psat Tool Box Using The Matlab Software.
- Click The Open Data File So That The Load Data File Page Opens. Select The File Which We Need And Load It. So That The Data File Is Set.
- Run The Power Flow And The Result Is Viewed In Static Report.
- Run Opf And The Result Is Viewed In The Static Report.
- Click Edit And Move On To Opf Settings So That The Psat-Opf Block Opens. Set The Weighting Factor And Click Run Opf. The Result Is Viewed In The Static Report.
- Click Interface And Move To Gams. The Psat-Gams Block Opens. Set The Parameters Like Weighting Factor, Optimization Model, Flow Limits, Line Selection And Click Run Gams. For The Output Click View Gams Output.

OUTPUT:

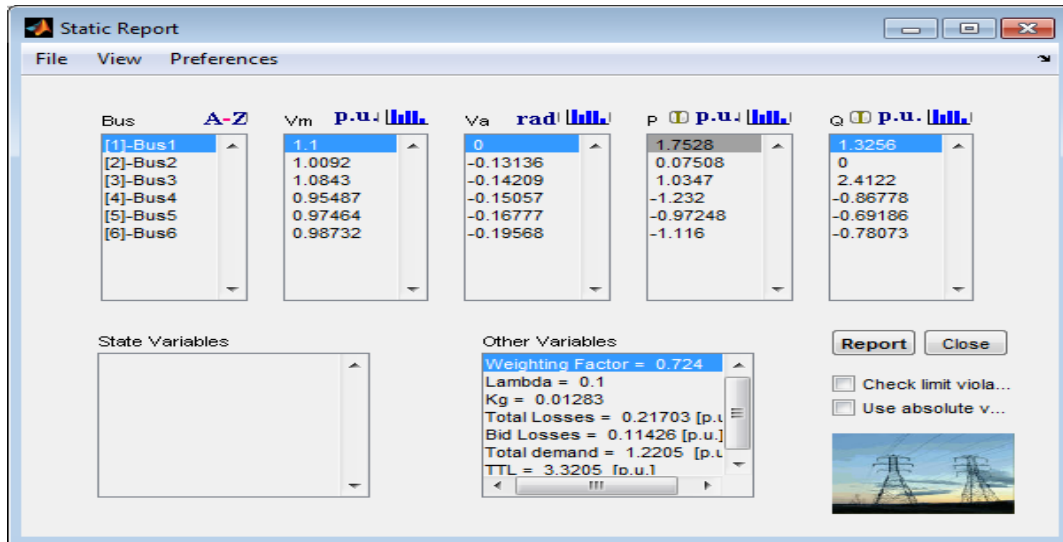


Fig.2: Output of OPF including the WEIGHTING FACTOR

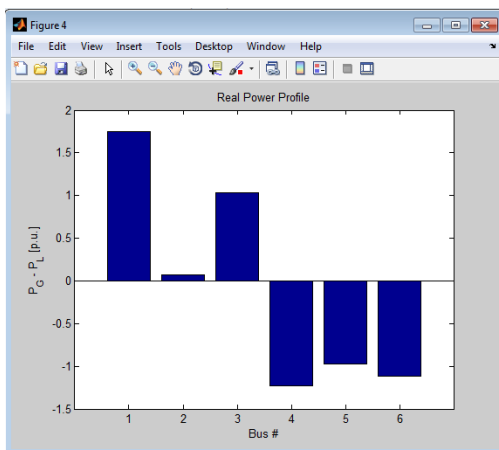


Fig.3: Real power flow of bus 5

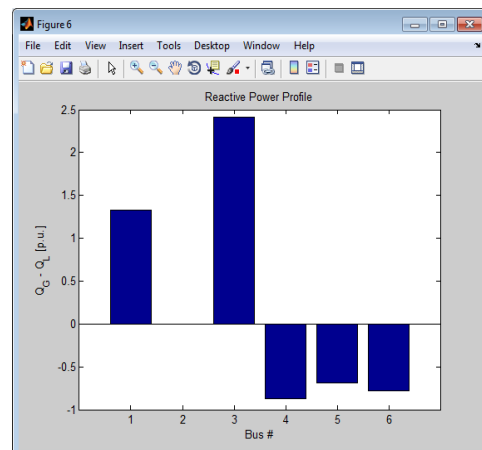


Fig.4: Reactive power flow of bus 5

V. CONCLUSION

For the active and reactive power pricing considering the voltage security, new method SALIN is used. In this multi objective optimization problem the weighting factor is set at the range in which the security of the voltage is obtained. The proposed method shows the choice of the range of the weighting factor where the pricing is accurate. The social welfare and the distance to voltage collapse is maximized using this method. For the future implementation various parameters can be included using other softwares.

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BIOGRAPHIES AND PHOTOGRAPHS



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