# CONTENTS

## Nomenclatures

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|---|---|
| $P_{G_i}$ and $Q_{G_i}$ | real and reactive powers of generator at bus $i$; |
| $P_{D_j}$ and $Q_{D_j}$ | real and reactive power loads at bus $j$ respectively; |
| $P_i$ and $Q_i$ | power injections at the node $i$; |
| $V_i$ | magnitude and angle of the voltage at bus $i$; |
| $\theta_i$ | angle of the voltage at bus $i$; |
| $n$ | total number of buses in system; |
| $G_{ij}$ | conductance of line connected between bus $i$ and $j$ bus; |
| $B_{ij}$ | susceptance of line connected between bus $i$ and $j$ bus; |
| $P_{ij}$ and $Q_{ij}$ | real and reactive powers flow in line connected between bus $i$ and $j$ bus; |
| $S^{max}{}_{ij}$ | maximum MVA limit of the transmission line connected between bus $i$ and $j$; |
| $b_{ij}$ | line charging susceptance of transmission line connected between bus $i$ and $j$; |
| $N_g$ | the number of generators bus; |
| $N_d$ | the number of demand bus; |
| $P_i(x)$ | bus active power mismatch equations; |
| $Q_i(x)$ | bus reactive power mismatch equations; |
| $h(x)$ | functional inequality constraints including line voltage magnitude constraints, simple inequality constraints of variables such as generator power, generator reactive power, transformer tap ratio; |
| $t$ | the vector of transformer tap ratios; |
| $B_j$ | the benefit function of $j^{th}$ consumers; |
| $C_i$ | the active power generation cost function of generator $i$; |
| $C_{Qi}$ | reactive power generation cost of generator $i$; |
| $D_j$ | consumer demand function at the consumer node $j$; |
| $a_i$, $b_i$ and $c_i$ | predetermined cost coefficients of generator $i$; |
| $P_j$ | consumer price at the consumer node $j$; |

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| $P_{j,base}$ and $P_{D_{j,base}}$ | base consumer price and base demand value at the consumer node *j*; |
| $P_{L,ij}$ and $Q_{L,ij}$ | the real and reactive power loss in the line connected between bus $i$ and $j$; |
| $P_{Loss}$ and $Q_{Loss}$ | the total active and reactive power loss in the system; |
| $N_g$ | number of generator bus; |
| $N_d$ | number of demand bus; |
| $T$ | total number of transaction; |
| $k$ | index for set of transaction in the system; $(k\epsilon T)$ |
| $P_{G_i}^k$ | active power output of $i^{th}$ generator in transaction $k$; |
| $Q_{G_i}^k$ | reactive power output of $i^{th}$ generator in transaction k; |
| $P_{D_j}^k$ | active power demand by consumer j in transaction k; |
| $P_{Loss}^k$ | active power loss in transaction k; |
| ${B_j}^k$ | benefit function of demand j of transaction k; |
| ${C_i}^k$ | cost function of generator $i$ of transaction $k$; |
| $C_{slack}$ | cost function of slack bus generator; |
| $V_i$ | voltage magnitude of $i^{th}$ bus; |
| $V_i^{min}$, and $V_i^{max}$ | minimum and maximum voltage limits at bus $i$ in the system; |
| $P_{l,}^k$ | power flow in $l^{th}$ transmission line due to transaction $k$; |
| $P_{l,}^{max}$ | maximum power flow limit of $l^{th}$ transmission line; |
| $D(k)$ | set of consumers in transaction $k$; $(k\epsilon T)$ |
| $G(k)$ | set of generators in transaction $k$; $(k\epsilon T)$ |
| $w^k$ | welfare of traction $k$; |
| ${\alpha_l}^k$ | resource allocation weighting matrix (RAWM) index for $l^{th}$ line in $k^{th}$ transaction; |
| $\lambda_l^k$ | Lagrange multiplier of $l^{th}$ line corresponding to $k^{th}$ transaction; |
| $K_i$ | Incremental transmission loss coefficients corresponding to bus $i$; |
| $z_1$ and $z_u$ | slack variables; |
| $\lambda$, $\pi_1$ and $\pi_u$ | the vectors of Lagrange multipliers; |
| $\mu$ | barrier parameter; |

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| $p_{inq}$ | number of inequality constraints; |
| $\sigma^{Iter}$ | centering parameter; |
| $\rho^{Iter}$ | complementary gap; |
| $\varepsilon$ | tolerance value; |
| $X_i = (x_{i1}, ......, x_{in})$ | the coordinates of particle $i$; |
| $V_i = (v_{i1}, ....., v_{in})$ | the flight speed of particle $i$; |
| $c_1$ and $c_2$ | two positive numbers; |
| $rand_1$ and $rand_2$ | two random numbers; |
| $P^{Iter}{}_{best}$ | particle's best position until iteration $Iter^{th}$; |
| $G^{Iter}{}_{best}$ | group's best position until iteration $Iter^{th}$; |
| $W_{min}$ and $W_{max}$ | are the initial and final weights; |
| $Iter_{max}$ and $Iter$ | are the maximum and current number of iteration. |

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# CHAPTER I

# INTRODUCTION

## 1.1. PREAMBLE

The introduction of competition in power market aims to make it more efficient. In fact, the power market is referred to as the ability of market participants to profitably maintain prices above a competitive level for a significant period of time. Out of various objectives for an efficient competitive market, the social welfare maximization is an important objective. In general, to achieve the objective of maximum social welfare, it is necessary that the market structure should be fair and equitable giving all market participants incentives to maximize the total profits in a power market. Now a days, multi-transaction structures have been established in the power market. In multi-transaction power market, each transaction has certain number of generators and demands of consumers which are coordinated by bilateral/multilateral contracts. The sellers and buyers can pair up to reach at an agreement on the detailed bilateral/multilateral contracts. In this type of power market both are participating in double sided auction market and moreover they trade the power through bidding process. Thus, they are making contracts for future periods of few weeks or longer, up to several years. This can also be setup for few hours to next day. Now, some of the power markets are establishing the contracts for minute-ahead contracts among the participants. Recently, researchers have included the benefits of consumers in market operations in order to achieve improved social welfare. However, involvement of consumers makes the system complex and thus the operation of transmission network becomes even more important. This may cause congestion problem in the network. Thus the congestion management is one the important issues and it becomes more complex due to multi-transaction in the power market.

One of the congestion management techniques is by rescheduling the generators output at their minimum cost. In the present scenario, subsequent to considering their benefits, the consumers play a vital role in the market. Managing the congestion by only controlling the generators alone may not fulfill the above objective. Therefore, it is utmost important to incorporate the