ON SOME ASPECTS OF OPTIMAL REAL AND REACTIVE POWER DISPATCH FOR INTEGRATED POWER SYSTEMS

By

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Dedicated

to my **Father** Sri Narayana Rao

and

to the loving memory of
my **Mother** Smt. Achyutamba

CERTIFICATE

It is certified that the thesis work entitled 'On Some Aspects of Optimal Real and Reactive Power Dispatch for Integrated Power Systems' by Shri K.S. Linga Murthy, has been carried out under our guidance at the Indian Institute of Technology, Delhi and that this research work has not been submitted elsewhere for the award of any other degree or diploma.

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ABSTRACT

A large number of papers have appeared in literature for optimal real and reactive power dispatch over the past three decades using various optimization techniques such as classical, nonlinear programming, linear programming, quadratic programming etc.

The classical technique based on coordination equations for real power optimization even after more than three decades of its inception, is still very popular with the utilities for on-line applications, because of its inherent simplicity and speed of solution. Literature survey shows that such coordination equations, however, do not exist for reactive power optimization. The present work explores the feasibility of such coordination equations for reactive power optimization. A set of coordination equations for optimizing reactive power has been established for the first time and then the optimal power flow problem (optimization of both P's and Q's) is solved through a unified classical technique using coordination equations.

Out of several nonlinear optimization methods, Dommel and Tinney [7] approach is considered as a benchmark and is one of the most important contributions

for the solution of optimal power flow problem. However, there are short-comings associated with Dommel and Tinney approach as it needs a large computational time and memory mainly because of a large number of usual Newton-Raphson load flows and lack of effective evaluations of Lagrangian multipliers and incrementing of the step size. In order to make the Dommel and Tinney approach more efficient for real-time application the present work develops an improved version of the algorithm by using a constant symmetric load flow model [86] and efficient computation of Lagrangian multipliers. The algorithm is first tried for the optimal reactive power subproblem with the objective to bring the voltages at all the load type buses near desired values. Subsequently the same algorithm is used to solve the complete problem of optimal real and reactive power dispatch using a performance index based on minimization of the generation cost.

Recently Contaxis et al. [97] have solved both the subproblems of optimal real and optimal reactive power dispatch using linear programming. But, they have not considered the transformer taps so vital for reactive power control in their LP formulation for optimal reactive power dispatch. In view of this, a linear programming algorithm based on revised simplex method is developed for solving optimal power flow problem with real power generations as the control variables in case of optimal real power subproblem and voltage magnitudes of generator and synchronous condensor buses and transformer tap settings as the control variables in case of optimal reactive power subproblem. Different convergence criteria and approach to the iterative process from that used by Contaxis et al. have also been tried to investigate their effect on the convergence pattern of the solution.

The optimal power flow problem requires an appropriate objective function such as minimum generation cost/minimum pollution level/minimum transmission loss/ minimum voltage deviations etc. In essence the optimal power flow problem can be visualized as a multi-objective one. Literature survey shows that no attempt has been made so far to solve the optimal power flow problem as a multi-objective problem. Goal programming (GP) techniques are capable of handling decision problems with single or multiple objectives. A maiden attempt is made in the present work to solve the optimal power flow problem as a multi-objective one. The problem is solved using both the versions of goal programming (linear as well as nonlinear) techniques considering minimum generation cost and minimum transmission loss as the objectives.

Operating at absolute minimum cost cannot be the only criterion of dispatching electric power due to increasing world-wide concern over the environmental considerations. In reality while considering both pollution and generation cost aspects in the ELD problem, it can be seen that the objectives of achieving their minimum values simultaneously are of conflicting nature since minimum generation cost will provide higher pollution level and whereas minimum pollution level provides higher cost. Problems having such objectives of conflicting nature are best solved by goal programming techniques. Till date, these techniques have not been used for solving such power system problems. In view of this, the author is motivated to first solve the subproblem of ELD considering environmental considerations and finally extend the goal programming technique to the complete problem of active and reactive power dispatch in the presence of pollution constraints.

LIST OF PRINCIPAL SYMBOLS

P_i	net real power at i^{th} bus
Q_i	net reactive power at i^{th} bus
P_{G_i}	real generation at i^{th} bus
Q_{G_i}	reactive generation at i^{th} bus
P_D	total real power load of the system
Q_D	total reactive power load of the system
P_L	total real power loss of the system
Q_L	total reactive power loss of the system
V_i	voltage magnitude of i^{th} bus
V_{G_i}	voltage magnitude of i^{th} reactive source bus
V_{L_i}	voltage magnitude of i^{th} load bus
δ_{ij}	difference of the phase angles between i^{th} and j^{th} buses
[Y]	bus admittance matrix
[Z]	bus impedance matrix
R_{ij}	real part of Z_{ij} element of the bus impedance matrix
X_{ij}	imaginary part of Z_{ij} element of the bus impedance matrix
NP	number of generator buses
NQ	number of reactive source buses (the reactive sources are due to generators or synchronous condensors or static VAR sources)
NLB	number of load buses
NB	total number of buses
NTR	number of transformer taps
NSH	number of shunts

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