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Application of AGPSO for Power loss minimization in Radial Distribution Network via DG units, Capacitors and NR

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Abstract: This paper presents an application of Autonomous Group Particle Swarm Optimization (AGPSO) to solve the power loss minimization problem in Radial Distribution Network (RDN) using optimal allocation and sizing of Distributed Generation (DG) units and capacitors with and without Network Reconfiguration (NR) to improve the efficiency of the RDN under seven cases (except Base Case). Further this work considers DG units and capacitors at three and four optimal locations in the RDN to examine the impact of power loss under two scenarios. The proposed technique has been tested on standard IEEE 69 bus DN and the results are compared with previous published methods. Simulation results reveal that the proposed method minimizes the real power loss in an effective and efficient manner under all the cases and scenarios.

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Keywords: Power loss,AGPSO, Bus Voltage profile, Distributed Generation allocation ,Capacitor allocation, Radial Distribution Network

1 Introduction

The need for electrical energy is increasing steadily. Hence power generation capacity has to be increased to meet the load demand which have significant economic impact on developing countries. As load increases, the power loss

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(I^2R) increases with poor voltage regulation. Alternatively, high reactive power flows in a network which results in increased power losses. It is understood that the power demand and power loss decide the power generation. The estimated real power loss in a DN is around 5% to 7% of the total power demand. Distribution utilities have to maintain node voltage between the limits which is essential for correct operation of the customer loads. Its deviation from the nominal value may be harmful and expensive, causing an ageing effect on them. The only alternative to improve the efficacy of the DNs is minimization of power loss. To promise low power loss, improvement in node voltage profile and improvement in power factor, several methods are being followed, out of which three important methods are optimal capacitor placement (OCP), Network Reconfiguration (NR) and optimal allocation of DG units (OADG).

Nomenclature

BC	-	Base Case
AC	-	After Compensation
MS	-	Main Source
N_{DG}	-	Total No. of DG units
N_C	-	Total No. of Capacitor units
P_{MS}	-	Total active power supplied by the Main Source
Q_{MS}	-	Total reactive power supplied by the Main Source
P_D, Q_D	-	Total active and reactive power demand in KW / KVAr respectively
$P_{DG}{}_{(t)}^{min}$	-	Minimum real power generated by DG unit in KW
$P_{DG}{}_{(t)}^{max}$	-	Maximum real power generated by DG unit in KW
TP_{Loss}	-	Total active power loss in KW
TQ_{Loss}	-	Total reactive power loss in KVAr
$TP_{Loss\,(net)}$	-	Net total active power loss in KW
$P_{DG(t)}$	-	Total active power supplied by DG at node 't'
V_t^{min}	-	Minimum Voltage at t^{th} node (0.95 p.u.)
V_t^{max}	-	Maximum Voltage at t^{th} node (1.05 p.u.)

DN comprises of groups of interconnected radial circuits. A proficient operation of DNs can however be done by using NR. NR is the process of changing the position of sectionalizing and tie-switches and thus changing the direction of power flow, which is subject to maintaining radiality structure during reconfiguration. Many researchers published their works on power loss reduction and voltage profile improvement in radial distribution network. A number of algorithms based on soft computing techniques have been developed to solve these problems [1- 7].

To provide reactive power compensation and to maintain security and reliability in RDN, Capacitors are placed along the RDN, thereby bus voltage and economy improved. However, if proper sized capacitors, are installed along the feeders, it will in turn maximize voltage regulation along with the improvement in power factor at the sub-station bus. From the review of available literature, optimal capacitor placement problem could be resolved using many artificial intelligence techniques [8-16]

During the past decade, due to liberalization of electricity markets, hike in fuel price, environmental aspects, and the cost involved in constructing a new large power plant, there is an urge for small DG units to be located in the DN to take care off the power demand. On the other hand by inserting DG units in the DN, the network becomes active and bi-directional. DG's role in modern DN is gradually increasing. It is predicted that about 20% of the new generations are being installed [17]. From the previous studies, it is well known that allocation of DG units optimally in the DN, results in power loss reduction, Voltage and reliability enhancement, power quality improvement, network upgrade deferral etc. [18-27].

Though, Individual usage of all the three methods is a viable solution for reduction of power loss and node voltage improvement, later studies demonstrated that, the combined usage of any two methods is very powerful to get better results. Optimal capacitor placements simultaneous with NR have been discussed by many researchers with the objective to minimize power loss with and without cost factor [28-30]. However the power loss reduction achieved using this combination yields less power loss reduction compared to power loss reduction via optimal DG