World Academy of Science, Engineering and Technology
International Journal of Energy and Power Engineering
Vol:10, No:01, 2016

Multi-Agent System Based Distributed Voltage Control in Distribution Systems

Authors : A. Arshad, M. Lehtonen. M. Humayun

Abstract : With the increasing Distributed Generation (DG) penetration, distribution systems are advancing towards the smart grid technology for least latency in tackling voltage control problem in a distributed manner. This paper proposes a Multi-agent based distributed voltage level control. In this method a flat architecture of agents is used and agents involved in the whole controlling procedure are On Load Tap Changer Agent (OLTCA), Static VAR Compensator Agent (SVCA), and the agents associated with DGs and loads at their locations. The objectives of the proposed voltage control model are to minimize network losses and DG curtailments while maintaining voltage value within statutory limits as close as possible to the nominal. The total loss cost is the sum of network losses cost, DG curtailment costs, and voltage damage cost (which is based on penalty function implementation). The total cost is iteratively calculated for various stricter limits by plotting voltage damage cost and losses cost against varying voltage limit band. The method provides the optimal limits closer to nominal value with minimum total loss cost. In order to achieve the objective of voltage control, the whole network is divided into multiple control regions; downstream from the controlling device. The OLTCA behaves as a supervisory agent and performs all the optimizations. At first, a token is generated by OLTCA on each time step and it transfers from node to node until the node with voltage violation is detected. Upon detection of such a node, the token grants permission to Load Agent (LA) for initiation of possible remedial actions. LA will contact the respective controlling devices dependent on the vicinity of the violated node. If the violated node does not lie in the vicinity of the controller or the controlling capabilities of all the downstream control devices are at their limits then OLTC is considered as a last resort. For a realistic study, simulations are performed for a typical Finnish residential medium-voltage distribution system using Matlab ®. These simulations are executed for two cases; simple Distributed Voltage Control (DVC) and DVC with optimized loss cost (DVC + Penalty Function). A sensitivity analysis is performed based on DG penetration. The results indicate that costs of losses and DG curtailments are directly proportional to the DG penetration, while in case 2 there is a significant reduction in total loss. For lower DG penetration, losses are reduced more or less 50%, while for higher DG penetration, loss reduction is not very significant. Another observation is that the newer stricter limits calculated by cost optimization moves towards the statutory limits of ±10% of the nominal with the increasing DG penetration as for 25, 45 and 65% limits calculated are ±5, ±6.25 and 8.75% respectively. Observed results conclude that the novel voltage control algorithm proposed in case 1 is able to deal with the voltage control problem instantly but with higher losses. In contrast, case 2 make sure to reduce the network losses through proposed iterative method of loss cost optimization by OLTCA, slowly with time.

Keywords : distributed voltage control, distribution system, multi-agent systems, smart grids
Conference Title : ICEPEE 2016 : International Conference on Energy, Power and Electrical Engineering
Conference Location : London, United Kingdom
Conference Dates : January 18-19, 2016