91

Effects of Distributed Generation penetration on system power losses and voltage profiles

Julius Kilonzi Charles*, Nicodemus Abungu Odero**

[*] Electrical & Electronics Eng. Dept, University of Nairobi
[**] Electrical & Electronics Eng. Dept, University of Nairobi

Abstract- In present times, the use of DG systems in large amounts in different power distribution systems has become very popular and is growing on with fast speed. Although it is considered that DG reduces losses and improves system voltage profile, this paper shows that this is not always true. The paper presents a GA-IPSO based approach which utilizes combined sensitivity factor analogy to optimally locate and size a multi-type DG in IEEE 57-bus test system with the aim of reducing power losses and improving the voltage profile. The multi-type DG can operate as; type 1 DG (DG generating real power only), type 2 DG (DG generating both real and active power) and type 3 DG (DG generating real power and absorbing reactive power). It further shows that though the system losses are reduced and the voltage profile improved with the location of the first DG, as the number of DGs increases this is not the case. It reaches a point where any further increase in number of DGs in the network results to an increase in power losses and a distortion in voltage profile.

Index Terms- Distributed Generation (DG), Particle Swarm Optimization (PSO), Genetic Algorithm (GA), system loss reduction, voltage profile improvement

I. INTRODUCTION

Distributed generation (DG) is small-scale power generation that is usually connected to distribution system. The Electric Power Research Institute (EPRI) defines DG as generation from a few kilowatts up to 50MW [1]. CIGRE define DG as the generation, which has the characteristics (CIGRE, 1999): it is not centrally planned; it is not centrally dispatched at present; it is usually connected to the distribution networks; it is smaller than 50-100MW. Ackermann *et al.* have given the most recent definition of DG as: "DG is an electric power generation source connected directly to the distribution network or on the customer side of the meter." [2].

In most power systems, a large portion of electricity demand is supplied by large-scale generators. This is because of economic advantages of these units over small ones. However, in the last decade, technological innovations and a changing economic and regulatory environment have resulted in a renewed interest for DG units. A study by the Electric Power Research Institute (EPRI) indicated that by 2010, 25% of the new generation was to be distributed. Natural Gas foundation concluded that this figure could be as high as 30% [3]. Different technologies are used for DG sources such as photo voltaic cells, wind generation, combustion engines, fuel cells and other types of generation from the resources that are available in the geographical area [4].

Systems Power Loss Minimization and Voltage Profile Improvement

Normally, the real power loss reduction draws more attention for the utilities, as it reduces the efficiency of transmitting energy to customers. Nevertheless, reactive power loss is obviously not less important. This is due to the fact that reactive power flow in the system needs to be maintained at a certain amount for sufficient voltage level. Consequently, reactive power makes it possible to transfer real power through transmission and distribution lines to customers. System loss reduction by strategically placed DG along the network feeder can be very useful if the decision maker is committed to reduce losses and to improve network performance (e.g. on the level of losses and/or reliability) maintaining investments to a reasonable low level [5]. This feature may be very useful in case of revenue recovered by distribution company (DISCO) which is not only based on the asset value but also on network performance. Studies indicate that poor selection of location and size of a DG in a distribution system would lead to higher losses than the losses without DG [6a, 6b]. In a power system, the system operator is obligated to maintain voltage level of each customer bus within the required limit. To ensure voltage profiles are satisfactory in distribution systems, different standards have been established to provide stipulations or recommendations. For example, the American National Standards Institute (ANSI) standard C84.1 has stipulated that voltage variations in a distribution system should be controlled within the range of -13% to 7% [7]. Actually in practice, many electricity companies try to control voltage variations within the range of ±6%. One of the upcoming widely adopted methods for improving voltage profiles of distribution systems is introducing distributed generation (DG) in distribution systems. The DG units improve voltage profiles by changing power flow patterns. The locations and size of DGs would have a significant impact on the effect of voltage profile enhancement.

Distributed Generation penetration, placement and sizing

Usually, DGs are integrated with the existing distribution system and lots of studies are done to find out the best location and size of DGs to produce utmost benefits. The main characteristics that are considered for the identification of an optimal DG location and size