Research Scholar: Pawan Kumar
Supervisor: Dr. Ikbal Ali
Co-supervisor: Prof. Mini S. Thomas
Department: Electrical Engineering, Faculty of Engineering & Technology, JMI
Title of the theses: Optimal operation of automated radial and meshed distribution system

ABSTRACT

The research work for this Ph.D. is to find optimal operation of the automated distribution systems by energy efficient reconfiguration for various load combinations that represent real world loads. In deregulated energy market, energy efficiency is a tool that could give the power utilities a competitive edge. Energy efficiency brings revolutionary changes in the day-to-day operation of automated distribution system and therefore, it is gaining momentum across the world. The distribution systems are the link between bulk power transmission and end-users of electricity. The automated operation in coordination with varying load demand and/or varying load behavior improves the system's **E**nergy **E**fficiency **P**erformance (**EEP**) in power delivery. Energy efficient operation help in benefiting the power utilities by reducing technical and commercial losses, improving cash flow, bettering schemes for load control and shedding, improving operational planning, and enhancing power quality and reliability. Further, these parameters in EEP analysis can be recognized as **E**nergy **E**fficiency **D**efining **P**arameters (**EEDP**s), and can be used to evaluate the distribution system's performance in different configurations.

The modern distribution system is continuously facing an ever-growing load demand. According to **I**nternational **E**nergy **A**gency world's energy need would be over 50% higher in 2030 than it is today, assuming that the demand grows at the rate of 1.8% annually. Therefore, primary need of power utilities is to optimize the system operation since even single unit of saved energy is often viewed as resource. Over the last few decades, considerable advances have been made in the optimization of power generation, transmission and distribution networks. Often, distribution systems are designed with a thumb rule approach which can result in expensive systems. In this scenario, energy efficient operation of automated distribution system assumes greater significance, and can help us derive maximum efficiency in power delivery by ensuring optimal use/control of available resources/switches.

The distribution systems are normally operated as radial or ring-main (meshed) networks; however, with the introduction of remote control capability to the switches, on-line configuration management has become an integral part of the distribution system operation. An important operation in configuration management is network reconfiguration. During operation the configuration can be automatically changed by modifying the status of the sectionalizing switches. By changing the operating condition, the network could be reconfigured with the following objectives:

- To reduce the system power loss
- To relieve the overload in the network
- To improve loadability margin at respective node

The first objective is referred to as *network reconfiguration and integration of distributed resources for the loss reduction*, and the second one as *load balancing*. However, in achieving the third objective, the expansion of the distribution system is the major challenge.

Another configuration management operation involves the restoration of service to maximum consumers during the restorative state following a fault. This problem is called *service restoration*, and it can be treated as a special case of load balancing. The network reconfiguration for loss reduction can also be used in planning studies with a different interpretation namely, to decide through which feeders new customers are to be supplied power. Therefore, in the third case, optimization of total energy consumption (kWh) may gain primacy over loss minimization.

The operational and commercial needs of the power utilities require operating the distribution system not only with the goal of minimizing losses but also of satisfying many other conditions, such as, to meet with the need of the competition in deregulated energy market. Also, in the recent year emphasis has been laid on ensuring reliability of power distribution and improving the power quality. Major changes in the power utilities, primarily initiated by restructuring and de-regulation, have increased interest in finding the energy efficient means of operating the distribution system. This could be achieved with implementation of ***S****upervisory* ***C****ontrol and* ***D****ata* ***A****cquisition* and ***E****nergy* ***M****anagement* ***S****ystem*, which enable power utility to develop remote control strategies for network reconfiguration and resizing the distributed resources.

The desired configuration can be chosen based upon the various EEDPs. The ultimate choice is made on the basis of priority of system requirement and reliability of the power supplying and power distribution model for the customer. In this thesis, the various EEDPs recognized for energy efficient operation are: purchasing and/or generating capacity at sub-station, load profile, power loss, loadability margin, node voltages, size and location of distributed resources, and the reliability of supplying power. In practice, however, variation in these EEDPs may not be uniform since the voltage dependent loads affect the system performance differently. Therefore, in order to meet the customer's requirement and satisfaction there is a need to develop a criterion which can be easily incorporated within the real time operating constraints while finding the energy efficient configuration. In this respect, important contributions of this Ph.D. thesis are the following:

- Modeling of practical load combinations representing real world loads in distribution systems.
- Identification of various parameters relating the electrical energy with system loading.
- Energy efficiency performance analysis of distribution system for:
    - Network Reconfiguration
    - Distributed Generation (DG) Placement and,
    - Shunt Capacitor Installation
- Energy efficient operation of distribution system for practical load combinations.
- Novel heuristics algorithm for efficient network reconfiguration.
- Coordinated operation and planning of distribution system using Harmony Search Algorithm (HSA).