

Public Abstract

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The incipient smart grid initiative and increasing use of distributed generation, along with classical problems of distribution system reconfiguration and restoration (DSR), have led to the need for efficient and reliable power distribution system simulation tools. One recently developed tool, the Fast Non-dominated Sorting Genetic Algorithm, or FNSGA, has been shown to be very effective at finding optimal distribution systems that are optimized with respect to voltages, currents, and power losses.

Despite its promise, the FNSGA has two shortcomings, which are addressed in this thesis. The first is that it uses a load flow sub-program (to determine voltages, currents, and losses throughout the power system in question) that is based on the classical Newton-Raphson numerical analytical approach, which often encounters convergence problems when applied to distribution (rather than transmission) systems, and it has burdensome memory and CPU time requirements when applied to large systems. In this thesis, the Newton-Raphson load flow program is replaced in the FNSGA with a revised version of the so-called direct method, the principal revision being a coded novel scheme for properly, rapidly, and repeatedly re-numbering the busses and branches in the power system for load flow analysis within the FNSGA. Validation results for the described scheme are presented by comparing results obtained with it and with the Newton-Raphson-based load flow scheme. The principal difference between the two methods is that the computation time is significantly reduced with the revised direct load flow method.

The second shortcoming of the FNSGA to be addressed here is that it is not optimized for certain important parameters, namely the initial population size N and the number of generations Gen , which could lead to excessive CPU time requirements. In this thesis, a parametric study was conducted to determine minimum values of N and Gen that lead to reasonably repeatable configurations of a distribution system that are optimized for the multiple objectives of voltages, currents, and power losses. Studies conducted on 16- and 32-bus test systems revealed that, to produce repeatable solution sets in the 16-bus system, optimum values of N and Gen are small enough that CPU times are very small. However, in the 32-bus system, N and Gen need to be so large that CPU times become prohibitive. Presumably, the problem would get worse with even larger systems. Fortunately, a solution to this problem was found, which involves removing certain branches from the pool of possibilities when producing the initial population N in the genetic algorithm. Disqualified branches are those determined in preliminary simulations to never appear in Pareto optimal solution sets. This method was shown to be very effective at leading to small enough optimum values of N and Gen that CPU times are reasonable.