REACTIVE POWER SUPPLIERS CONTROL USING A GENETIC ALGORITHM

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Abstract

One method to overcome the accommodate additional loads problems is adequate utilization of the reactive power supplier (RPS) equipment which is installed in the system. This paper used the successive iterative method between the genetic algorithm (GA) and Newton-Raphson method to solve the nonlinear combinatorial integer problem. The proposed method was applied to the IEEE 30 bus 6 generator system to prove its validity and effectiveness.

1. Introduction

Redistribution of reactive power in a power system is performed to improve the system voltage profiles. In order to maintain desired levels of voltage and reactive flow under various operating conditions and system configurations, power system operators may utilize a number of control tools such as switching var sources, changing generator voltages, and/or adjusting transformer tap settings.

Extensive studies have been performed. Nonlinear programming (NLP), successive linear programming (LP) and linearizing the constraints while maintaining a non-linear objective function have been proposed. Most of these approaches can be categorized as integer problems with constrained optimization techniques. This paper presents the operation of RPS equipment which has already been installed in a system for correcting unacceptable voltage profiles.

2. Genetic Algorithm

In this paper the genetic operation is based on the Simple Genetic Algorithm(SGA) Operation[6]. In the SGA, consider allele (string value), chromosome (string), and population as the construction elements of the group, and natural selection, cross-over and mutation as handling methods. Encoding and decoding are used to connect between the system and the GA.

The string is composed of alleles. Each allele takes a real value among 0 and 1. In this paper, the string is composed of amounts of reactive power which are injected and/or extracted from the RPS.

The Pyramid population which is illustrated in Fig. 1 and 2 is used in this paper[5]. The reason for introducing the pyramid population is that it facilitates quick convergence to the global minimum and low oscillation around it. Fig.1 and 2 show the pyramid population structure and the transition from old generation to new generation, respectively.

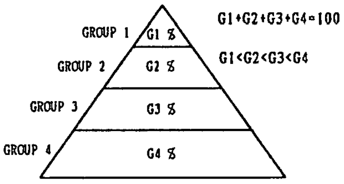

Fig. 1 Structure of population

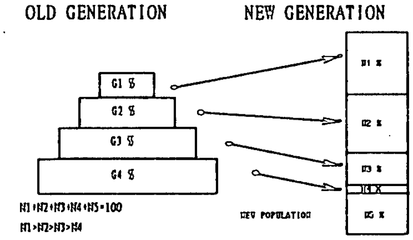

Fig. 2 Formation of next generation

3. Setting-up of the Reactive Power Supplier

An RPS operation has two problems. First, the RPS equipment operates in discrete form. Second, the system is a nonlinear system. The process of RPS installation is divided in three steps. : system calculation, RPS calculation and verification.

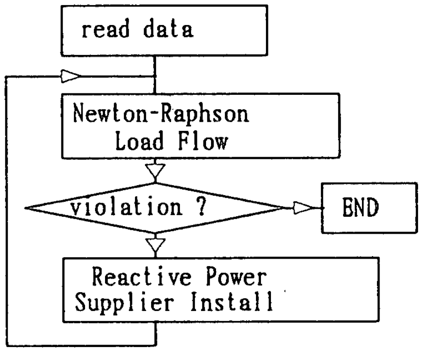

Fig. 3 Flow Chart of The Installation Process

3.1 System Calculation

The system calculation, in this paper, means the calculation of the node voltage of the system.

We calculate the performance of the system based on the Newton-Raphson load flow technique. After the iteration of Power Flow converged, we check if all the node voltages are inside the voltage limit. If the node voltages are out of the limit, we run the RPS calculation. Otherwise, the process is reporting the result and stopped.

3.2 RPS Calculation

For the calculation of RPS, we use the idea of decoupled load flow method. Therefore, the voltage magnitude depends on the reactive power and it quasi no relations with active power.

$$[\Delta Q]=[J_{22}][\Delta|V|] \qquad [1]$$

$[J_{22}]$ are known values that are determined by the system calculation step (Newton-Raphson load flow). $[\Delta Q]$ is calculated by GA. Inverse transformation of $[J_{22}]$ is needed in order to calculate the variation of the voltage magnitude. Every modification of RPS requires calculation of the Jacobian matrix of the system[1][2] as the system configuration is modified. In order to eliminate this calculation, we consider the introduction of a reactive power source instead of modifying the impedance of RPS (refer to Appendix).

The problem then become as linear integer combinatorial problem. Many studies have shown that the genetic algorithm method is one of the best methods to find the solution of combinatorial problems. Thus, we apply GA in the simplified system.

3.3 Verification of the System

We updated the system configuration, but this updated configuration does not guarantee the best load condition for the system. Therefore, we need to verify whether the updated system configuration satisfies the load conditions of the system. The process continues until all the voltages of the load node reach the limit or the RPS equipment have fully utilized.

4. Simulation & Results

To prove the validity of the method proposed, we applied the method to the IEEE 30 bus and 6 generator system. We tried to find the best setting of RPS in the IEEE 30 bus system. For the simulation, we only used four transformer settings as the RPS control equipment.

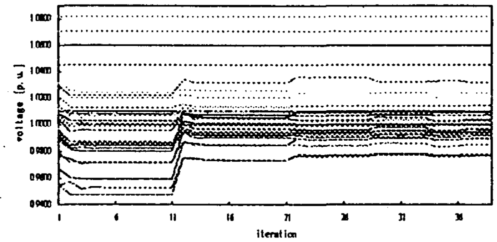

Fig. 4 Node voltage of the system

Table 1. Comparison between the two methods

	IEEE setting	Proposed
real power loss (MW)	21.400	21.130
reactive power loss(MVA)	83.550	83.830
power mismatch(MVAr)	0.3983	0.2940
worst node voltage(p.u.)	0.9736	0.9779

Fig. 4 has sudden changes in 11, 21, 28, 33, 36 and 39 iterations. Every sudden change in Fig. 4 means the beginning of the RPS calculation which changes the configuration of the system.

According the result of the Table 1, we obtained 0.44% of increasing the worst bus voltage magnitude than the IEEE standard stting system.

5. Conclusions

The proposed method using the successive iteration method between the nonlinear iteration method and integer combinatorial method produced good results for the reactive power supplier of the system. This means that we fully utilized the installed reactive power supplier equipment.

The results of the simulation proved the effectiveness and validity of the proposed method.

Appendix

A.1 Formulation of Transformer

$$Q=\frac{d-n}{dn}\cdot\frac{E'V_{ref}}{X} \qquad [A.1]$$

where,

d	the original transformer setting
n	the new transformer setting
X	the transformer impedance
E'	the primary side voltage
Vref	the reference voltage

A.2 Formulation of Shunt Capacitor

$$Q=V_n^{\,2}\cdot\Delta C+C_d\cdot(V_n^{\,2}-V_d^{\,2}) \qquad [A.2]$$

where,

C_d	the amount of capacitance installed
C_n	the amount of capacitance changed

$$\Delta C=C_n-C_d$$

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