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Power System Stability of Cordinated Voltage Controlling In Electric Power System

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Abstract
The coordinated voltage control has been done with DGs reactive power control and OLTC operation. The result indicates that involving DGs reactive powers in the voltage control will result in a reduction of number of OLTC operations and the reduction of the voltage level in the distribution system. Further, the results also indicate that from the coordinated voltage control, the losses can be decreased. In recent years, distributed generation, as clean natural energy generation and cogeneration system of high thermal efficiency, has increased due to the problems of global warming and exhaustion of fossil fuels. Many of the distributed generations are set up in the vicinity of the customer, with the advantage that this decreases transmission losses. However, output power generated from natural energy, such as wind power, photovoltaic's, etc., which is distributed generation, is influenced by meteorological conditions. Therefore, when the distributed generation increases by conventional control techniques, it is expected that the voltage change of each node becomes a problem. Proposed in this Seminar report is the optimal control of distribution voltage with coordination of distributed installations, such as the load ratio control transformer, step voltage regulator (SVR), shunt capacitor, shunt reactor, and static var compensator. In this research, SVR is assumed to be a model with tap changing where the signal is received from a central control unit. Moreover, the communication infrastructure in the supply of a distribution system is assumed to be widespread. The genetic algorithm is used to determine the operation of this control

Keywords: Distributed Generators, Distributed System, Genetic Algorithm, Reactive Power, Voltage Control, Voltage Regulator.

1.0 Introduction

Distributed Generator can be referred as small generating unit connected to the distribution network, which was not centrally planned and dispatched. Set of such generators can be called as Distributed generation (DG). The main reason for less generation by centrally located power plants is the time taken for installation of power plant. They include higher level of pollution as thermal power plants have large share in conventional power generating units. Benefits of distributed generation include power quality and reliability, transmission and distribution support, environmental performance, energy price risk management and some localized economic benefits. Voltage control is related to reactive power (Q) supply in the systems busbars using different equipment and technologies (Fabrice, 2015). This control is known as local control, since the reactive power can be supplied by the demand and thus reduces the voltage drop at busbars and improve the indices of power quality.

1.1 Statement of the Problem

1. Maintenance costs for transformer banks are higher than those for capacitor banks. In general, tap changes should be avoided whenever the voltages can be maintained by switching of capacitor banks alone.
2. Problems of global warming
3. Exhaustion of fossil fuels
4. Decreases transmission losses
5. Meteorological conditions

1.2 Aim and Objectives

The aim of the report is to implement coordinated voltage control in electric power system. The objective of optimization are

1. To find the minimum switching cost that keeps all the voltages within limits.
2. To increase voltage profile
3. To reduce power loss

1.3 Scope

This research is the optimal control of distribution voltage with coordination of distributed installations, such as the load ratio control transformer, step voltage regulator (SVR), shunt capacitor, shunt reactor, and static var compensator. In this research, SVR is assumed to be a model with tap changing where the signal is received from a central control unit. Moreover, the communication infrastructure in the supply of a distribution system is assumed to be widespread. The genetic algorithm is used to determine the operation of this control

2.0 Review of Related Works

Genetic Algorithms (GAs) are adaptive heuristic search algorithm based on the evolutionary ideas of natural selection and genetics. As such they represent an intelligent exploitation of a random search used to solve optimization problems. Although randomized, GAs are by no means random, instead they exploit historical information to direct the search into the region of better performance within the search space. The basic techniques of the GAs are designed to simulate processes in natural systems necessary for evolution. In nature, competition among individuals for scanty resources results in the fittest individuals dominating over the weaker ones. GAs does not require linearity, continuity, or differentiability of the objective function, nor do they need continuous variables. These two features make GAs particularly effective in dealing with discrete control devices such as tap changing transformers and with objectives such as minimal number of control actions (Masato, 2017)

A considerable disadvantage of GAs is the amount of calculation time involved that increases exponentially with the number of independent variables. Several GA applications on the voltage-reactive power problem are known. Applications exist for planning and optimal allocation of reactive power sources, as well as for voltage security enhancement by preventive control. A simple Genetic Algorithm is an iterative procedure, which maintains a constant size population P of candidate solutions. During each iteration step (generation) three genetic operators (reproduction, crossover, and mutation) are performing to generate new populations (offspring), and the chromosomes of the new populations are evaluated via the value of the fitness witch is related to cost function. Based on these genetic operators and the evaluations, the better new populations of candidate solution are formed.

The electric industry deregulation introduced decentralization and competition (Masters, 2017). The decentralization increases the complexity in the system operation because before, in a regulated system, the utilities were vertically integrated and cooperated voluntary to operate a reliable system by coordinating their resources with neighboring utilities (Chao and Huntington, 2014), knowing that regulated tariffs would cover bundledcosts Under deregulation, the system operator is responsible forsystem reliability (Gómez, 2012). It buys different ancillary services from generators and users to maintain a reliable system (Hirst, 2016). However, legal responsibilities of system operators must be clearly defined by new regulations (Rothwell and Gómez, 2013). On the other hand, a major objective of electricity deregulation is to achieve a workably competitive wholesale market (Rothwell and Gómez, 2013). Wholesale electricity markets have high price volatility due to daily and seasonal variations in supply and demand (Hunt and Shuttleworth, 2017). This raises two important issues under deregulation: demand responsiveness to price variations and new investment in generation resources (Hunt and Shuttleworth, 2017). Larsen and Dyner, 2001 showed that the uncertainty and the risks increase when you want long-term studies, making it difficult to create highly accurate predictive models in deregulated electrical systems. An alternative is to make models to understanding the dynamic path into the future and between the tools useful for strategy formulation in utilities which needs to be added after a deregulation is the business dynamics or the System Dynamics (SD) (Phulpin, 2015)

3.0 Methodology

3.1 Implementation with Genetic Algorithm

The procedure for implementation of genetic algorithm to coordinated voltage control include the following;

Step 1: Generate randomly a population of binary string.

Step 2: Calculate the fitness for each string in the population.

Step 3: Create offspring strings through reproduction, crossover and mutation operation..

Step 4: Evaluate the new strings and calculate the fitness for each string (chromosome).

Step 5: If the search goal is achieved, or an allowable generation is attained, return the best Chromosome as the solution otherwise go to step 3.

3 phase 25 bus radial unbalanced systems is given in Fig 3.1,the line and load data is taken from,the base MVA is 30 MVA, base kV is 4.16 kV and 5 DGs are connected with P=0.06 p.u & Q=0.027 p.u at 5th,12th,15th, 18th & 22nd bus each. Only OLTC tap setting and DGs reactive powers are considered in this system genetic algorithm for the voltage control. The upper and lower voltage limits are 1.05 p.u & 0.95 p.u respectively and tap setting limits are ±10% are considered in this simulation. The Genetic Algorithm parameter is given in Table 1.The 100% & 70% load is considered for the simulation. The objective function of GA used for the study is

$$\sum_{m=1}^{n} \mathbf{1} V_{mref} - V_m \mathbf{1}$$

V_{mref} is mth node voltage standard value V_m is mth node voltage Constraint conditions: Node voltage: $V_{min} < V_{I} < V_{max}$ Reactive power of DG: $Q_{min} < Q_i < Q_{max}$ Tap position: $T_{min} < T_i < T_{max}$

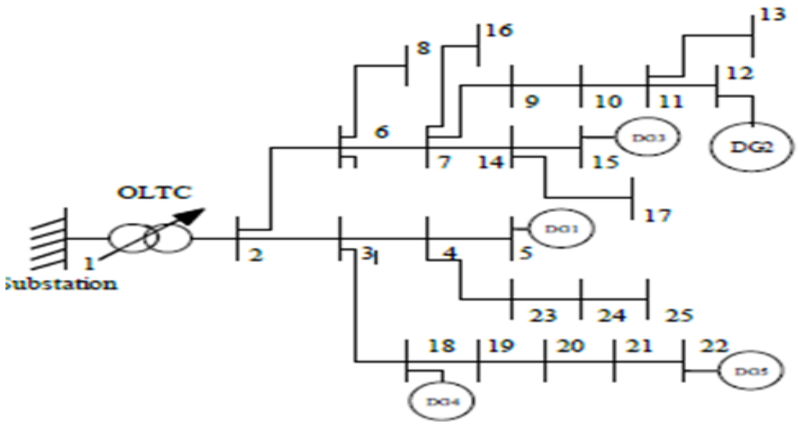

Fig 3.1: Proposed Model

Phase 25 bus unbalanced radial distribution system a genetic algorithm (GA) is a learning algorithm that imitates the evolution of organisms. In the natural evolution process of organisms, the reproduction of a set of individuals that forms a certain generation (i.e., the population) is such that those individuals with fitness to environmental adaptation survive with high probability. Reproduction that is based on the degree of conformity of an individual in a GA as an artificial model that imitates the evolution process of such a organism is performed, and the next-generation population is generated through crossover and mutation. The process is carried out by repeating such genetic operations, and if the individual of the last generation that fulfills end conditions can be found, the semioptimal solution in question may be determined. The flow of the basic operation of the GA shown in Fig 3.2 as explained below.

1) Initialization: individuals with random chromosomes are generated that set up the initial population.
2) Reproduction: the degree of conformity of each object is calculated and an individual is reproduced under a fixed rule depending on the degree of conformity. Here, some individuals with a low degree of conformity will be screened, while individuals with a high degree of conformity will increase.
3) Crossover: new individuals are generated by the method of intersection that has been set up.
4) Mutation: this is performed by an operation determined by the installed mutation probability or mutation, and a new individual is generated.
5) End judging: if end conditions are fulfilled, the best individual thus obtained is the semi optimal solution in question. Otherwise, return to 2) The GA parameters used are shown in Table I.

3.2 **Simulation of the Developed Model**

A. Method of Determination for Operations of Each Device

In this research, the amount of operation of each device is determined by solving the objective function and voltage opti

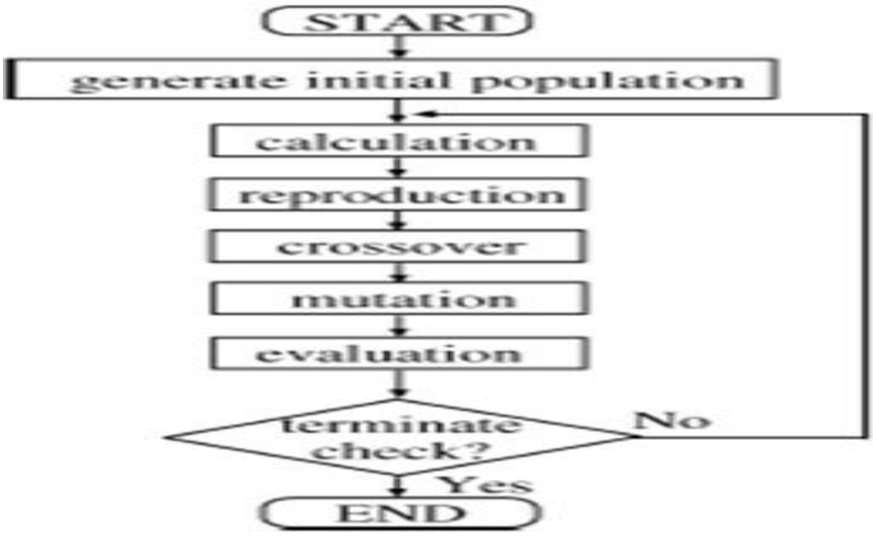

Fig. 3.2. GA algorithm flowchart.

Table 1: Ga Parameters

Generations	1,000
Population	50
Selection	Elitist preserving selection
Crossover	scattered
Mutation	Adaptive feasibility

mization of the whole power distribution system. The controller determines the amount of operation based on a GA, and a feasible area is discretely set in a large-scale optimization problem.

$$\min w_1 \sum 1 V_{nxcl} - V_u 1 + _{w2}\ Loss \quad (3.1)$$

Subject to the constraint

$$V_{o,\min \le} V_{o,\max}$$
$$t_{\min \le t \le} t_{max} \quad (3.2)$$

$V_{n,ref}$ Nth node voltage target value;

V_n Nth node voltage;

V_π Sending voltage;

$V_{n,\min,} V_{\pi,\max}$ Min, max value of sending voltage;

t Ratio of the tap of transformer;

$t_{\min,} t_{\max}$ Min, max the ratio of the tap of transformer;

$w_{1,} w_2$ Weighting values.

In order to take into consideration the maximization of the voltage margin and reduction of power loss with sufficient balance, the weighing coefficients are determined as w_1 =1.0 and w_2=10.0 by trial and error

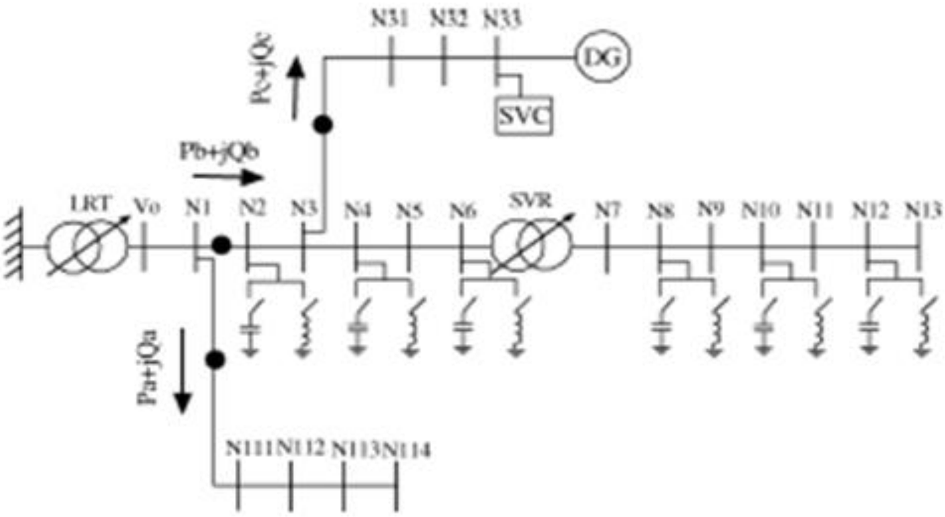

Fig. 3.3: Residential distribution network

4.0 Result and Discussion

Change of Power Flow in Each Case

		P_a+jQ_a	P_c+jQ_c	P_c+jQ_c
CASCi	Uncontrolled	0.0502+j0.0103	0.2137+j0.0570	0.0161+j0.0099
	LRT+SVR	+0.052 +j0.0103	0.2134+ J0.0565	0.0161+j0.0099
	LRT+SVR +SC+ShR	0.052+ J0.0103	0.2150-J0.1407	0.0161+J0.0099
	LRT+SVR+SC +ShR+SVR	0.0502+J0.0103	0.2150-J0.1051	0.0161-J0.0044
CASC2	Uncontrolled	0.1251 +j0.0338	0.405 +j0.1477	-0.0589 +j0.00189
	LRT+SVR	0.1250 +J0.0337	0.4050 +J0.1431	-0.0589 +J0.0189
	LRT+SVR +SC+ShR	0.1250 +J0.0338	0.4017 -J0.1431	-0.0590 +J0.0189
	LRT+SVR+SC+ShR+SVC	0.1250 +J0.0338	0.4020 -J0.0293	-0.0588 +J0.0473
CaSC3	Uncontrolled	0.2027 +j0.0446	0.8165 +j0.2619	0.1523 +j0.0316
	LRT+SVR	0.2024 +J0.0441	0.8058 +J0.2438	0.1520 +J0.0314
	LRT+SVR +SC+ShR	0.2025 +J0.0442	0.8028 -J0.0112	0.1520 +J0.0314
	LRT+SVR+SC+ShR+SVC	0.2025 +J0.0442	0.8029 -J0.1121	0.1521 -J0.0193

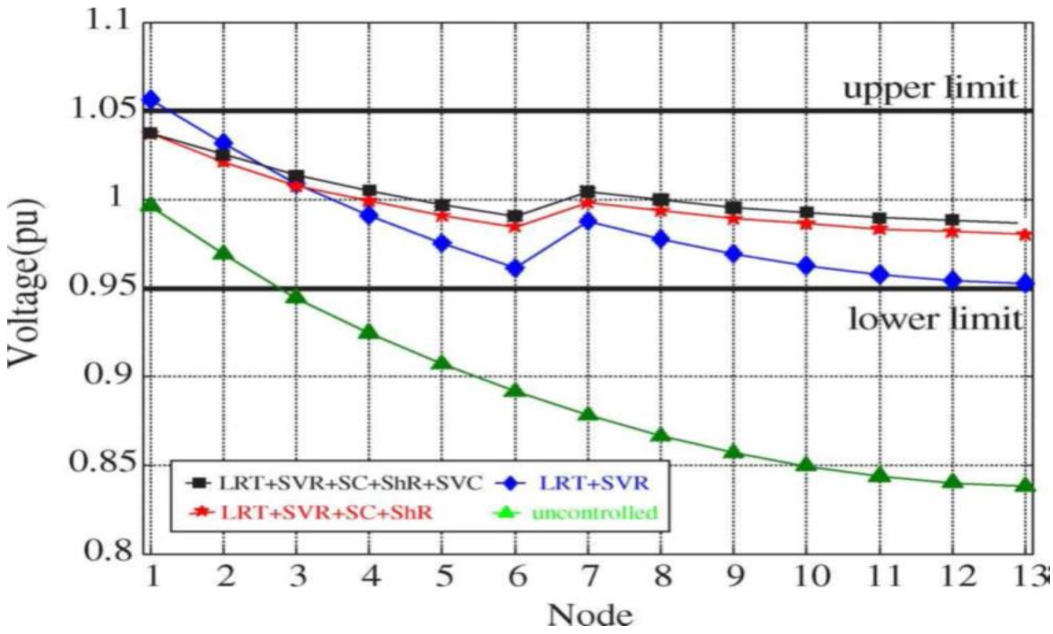

Fig. 4.1: Voltage profile (case 3)

Maximum limit from a viewpoint of the solution obtained for power transmission. Moreover, it can be confirmed that a large voltage margin can be taken by carrying out cooperation control of all the devices as in the other cases. If all devices are cooperatively controlled according to this simulation result, then a large voltage margin can be taken. Further, reduction of each control device's capacity, such as SC, ShR, and SVC, can be expected by performing cooperation control. Optical-fiber use is widespread in Nigeria. Actually, advanced distribution automation systems using an optical-fiber network are developed. Therefore, the central coordination of voltage regulating devices is possible in the near future.

Conclusion

The developed method for coordinated voltage control of distribution system interconnected with distributed generators. This method used genetic algorithm for optimization and backward forward sweep method for load flows. This methodology has been applied to 3 phase 25 bus unbalanced test systems with two various load conditions. The OLTC and DGs reactive powers are used for voltage control, it can be observed from the results obtained from simulation both voltage profile and losses were improved in each case considered and the no of operations of OLTC has been decreased with DGs reactive power participation in voltage control

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