RECONFIGURATION AND DISTRIBUTED GENERATION (DG) PLACEMENT CONSIDERING CRITICAL SYSTEM CONDITION

Hossein MOARREFI
Hormozgan electrical distribution -Iran
hossein.moarefi@gmail.com

Maisam NEMATOLLAHI
Behrad consulting engineers-Iran
maisam.nematollahi@yahoo.com

Mahdi TADAYON
Behrad consulting engineers-Iran
mahdi.tadayon@gmail.com

ABSTRACT

This paper offers a method to reconfiguration and DG placement simultaneously considering critical system condition in distribution systems. The critical system conditions like tripping a 63/20kv distribution transformer and adding an external manoeuvre loud. Additional finding place and power of DG in this research, optimal power factor is obtained by the given algorithm. Reconfiguration of distribution system is implemented by adaptive genetic algorithm and graph theory to find an optimal structure system with place and power of distributed generators. The proposed algorithm is effectively tested on a 33-bus IEEE test system and a real life distribution system in Iran by Digsilent and. Matla.

INTRODUCTION

Distributed generation (DG) can be defined as small scale generation, which is installed near the consuming centre and is not directly connected to transmission systems. Distributed generation (DG) may make a contribution to improve power quality, minimize peak loads and eliminate the need for reserve margin. The connection of DG has led to changes, like increasing short circuit level system and buses voltage profiles that should be considered [1].
The installation of DG sources can significantly impact the distribution networks. This impact can be positive or negative depending on the operating conditions of the distribution system and DG [2]. The impact of DG interconnection on voltage profile was discussed in [3]. The authors of [4] have studied the impacts of DG upon transmission system transient and small-signal stability. There are a few searches about reconfiguration and DG placement simultaneously. Reference [5] investigated power flow algorithms to find the optimum size of DG at each load bus in distribution systems. In [6], an optimization model is proposed for distribution system expansion with DG in order to minimize the total cost. Celli et al. [7] proposed a multi-objective formulation for the siting and sizing of DG resources considering costs and network upgrading.
Extensive research work has been carried out about reconfiguration of radial distribution systems (RDS). These researches can be classified into conventional and artificial intelligence approaches. Merlin and Back [8] proposed a heuristic method for distribution system reconfiguration to minimize line losses. Several researches were developed in [9–14], which include heuristic and classical optimization techniques. In [15–18] various artificial intelligence techniques, like GA, ant colony optimization (ACO), Tabu search, particle swarm optimization (PSO) were investigated for multi-objective reconfiguration of RDS.
This paper proposed a method to multi-objective reconfiguration and DG placement simultaneously considering critical system condition in distribution systems. This method aims at achieving the minimum active and reactive power losses, control of short circuit level increasing, voltage profile improvement and optimal configuration of system. Additional to above goals, locating of DG with optimal size and power factor according to normal and critical system condition is considered. A 33-bus and a real life distribution system in Iran were selected for optimizing the configuration and to demonstrate the effectiveness of the proposed methodology for solving the optimal switching operation of distribution systems and DG placement

GENETIC ALGORITHM

Genetic Description

GA is a global search technique for solving optimization problems, which is essentially based on the theory of natural selection. Basic information and most important operation can be found in [19].
Produced chromosomes of GA are shown in Fig. 1, in which i is equal to number of tie switches of RDS, j and k is equal to number of buses which DG recourses are installed. The first section of chromosomes shows number of switches that should be opened to form radial distribution network. The second and third sections are equal to coefficients of power and power factor of DGs that are installed in each bus according to table1 This chromosome shows that branches 2, 9 of RDS should be opened and DGs with power of 0 (no DG), 0.12 MW and power factor of 0.9, 0.95 lead are installed in the first and last buses of RDS

coefficients	Power(MW/10)	Power Factor
1	0	0.9 lead
2	1	0.92 lead
3	1.2	0.95 lead
4	1.4	1
5	1.6	0.98 lag
6	2	0.95 lag
7	2.2	0.92 lag
8	2.4	0.9 lag
9	2.6	0.87 lag
10	3	0.85 lag

TABLE.I PROPOSED POWER AND POWER FACTOR OF DGs

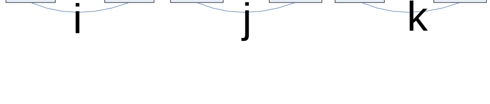

Fig.1 Produced chromosomes of genetic algorithm

Genetic actuators

The crossover and mutation of DG selection genes and branches selection genes are separately performed. The procedure of crossover and mutation genes is, respectively, illustrated in Figs. 2 and 3 in which i j and k are randomly selected. The information of chromosomes changed and new parents are produced

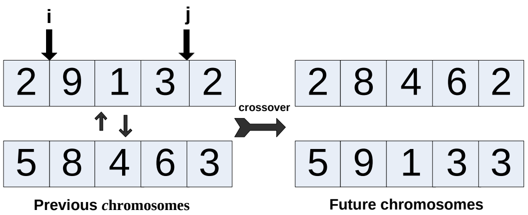

Fig. 2 Crossover actuator of genetic algorithm

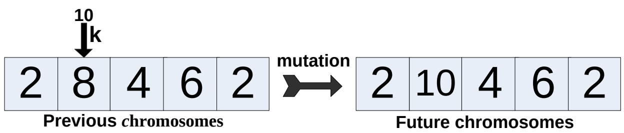

Fig. 3 Mutation actuator of genetic algorithm

Additional to these actuators two extra actuators are used in this paper, perturbation and preprocessing.

Perturbation made little change in the information of gene, for example a hi level of power or power factor of DGs are selected and for preprocessing the algorithm is run first time and the best population are recorded to running as initial population of basic algorithm. By preprocessing we can achieve to optimal configuration perfectly.

PROPOSED METHOD

Objective function

In this section the objective function of reconfiguration and DG placement is explained. The proposed objective function (C_{Total}) is constructed from several costs, active and reactive losses cost (C_{Loss}), buying and installing of DGs investment cost ($C_{Investment}$) and cost proportional to violating constraints ($C_{penalty}$). The total objective function can be expressed as (1).

$$\text{Min} \quad C_{Total} = C_{Loss} + C_{Investment} + C_{penalty} \tag{1}$$

Active and reactive losses costs function

In additional active losses, reactive loss is evaluated. The planning horizon (T) is considered to be two years because no extension will be undoubtedly performed until the next year in the network under study. The objective function of the losses can be expressed as (2).

$$C_{loss} = \sum_{t=1}^{T} 2 \times 365 \times (P_{loss} \times CT_1 + Q_{loss} \times CT_2) \tag{2}$$

Where

P_{loss}: Active losses (MWh)

Q_{loss}: Reactive losses (MVArh)

CT_1: Cost of active losses which is equal to100 ($/MWh)

CT_2: Cost of reactive losses which is equal to 45 ($/MVArh)

The Purchase and operational costs of DG

The objective function of the Purchase and operational costs of DG can be expressed as (3). The life time of DGs is assumed to be 14 years, so the total cost of installed DGs until the next year is assumed to be equal to the summation of 2/14 of the DGs purchase cost and the whole DG operational cost.

$$C_{Investment} = \sum_{j=1}^{N} (C_{DGj} \times .IC_{dg} \times 2/14) \tag{3}$$

Where

C_{DGj}: Installed power of DGs (MVA)

IC_{dg}: Purchase and operational DG Cost ($1.25*10^6$ $/ MVA)

N: number of proposed DGs

Violation of Constraint function

The constraints of nodal voltage, short circuit level of system and branch capacity can be included into the objective function by using penalty function method to relax inequality constraints. Constraints have been checked in the each iteration of GA and if they have not been satisfied, the is used

$$C_{penalty} = \omega_v . \sum_{j=1}^{N} \Delta v_j + \omega_i . \sum_{j=1}^{M} \Delta I_j + \omega_{isc} . \sum_{j=1}^{L} \Delta Isc_j \tag{4}$$

Where

C: Penalty function

N: Number of buses

M: Number of lines

L: Number of candidate buses for short circuit calculation

W_v: Voltage Deviation Cost which is equal to 1024($/v)

W_i: Current loading Deviation Cost which is equal to 890($/A)

$W_{ish:}$ System short circuit level Deviation Cost which is equal to 2650($/KA)

$\Delta v_{i:}$ Voltage Deviation

ΔI_j: Loading Deviation

ΔI_{SCj}: System short circuit level Deviation

RESULTS AND DISCUSSION

The proposed algorithm is tested on two feeders of 33-Bus IEEE and a real life distribution network of the city of Bandarabas in Iran (see Fig. 7) and satisfactory results are obtained. The basic data of proposed unbalance 33 bus system is expressed in table II. Table III shows the computational results of reconfiguration and DG placement on 33 bus system. The voltage profile of system before and after optimization can be seen in figures 4, 5. From profile voltage is observed that the minimum voltage of system is improved from 0.8913 to 0.9159. Fig.6 shows the considering critical system condition, tripping distribution transformer in DIgSILENT.

Quantity	Value
bus number	33
Voltage (kv)	12.66
System active load (MW)	1.715
System reactive load (Mvar)	2.3
Minimum voltage profile (pu)	0.89131
Total losses (MW)	0.1545

TABLE.II DATA OF 33 BUS TEST SYSTEM

Quantity	Value
Open branches	12-15-18-21-22
DGs power (MW)	0.1-0.2-0.14-0.25
Bus of DGs (MW)	28-17-2-32
Optimal power factor	0.95-0.95-0.98 0.85 lag
Minimum voltage profile (pu)	0.9124
Total losses (MW)	0.1241
Total losses reduction (%)	19

TABLE.III RESULT OF PROPOSED ALGORITHM ON 33 BUS TEST SYSTEM

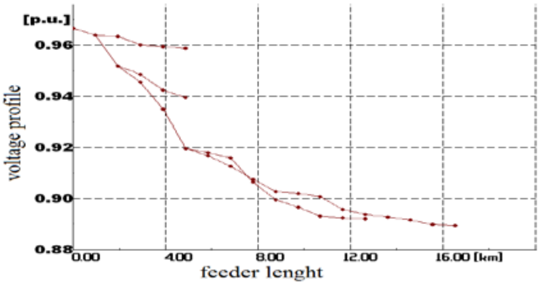

Fig. 4 voltage profile of system before optimization

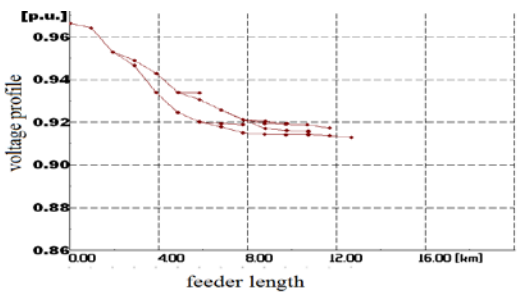

Fig. 5 voltage profile of system after optimization

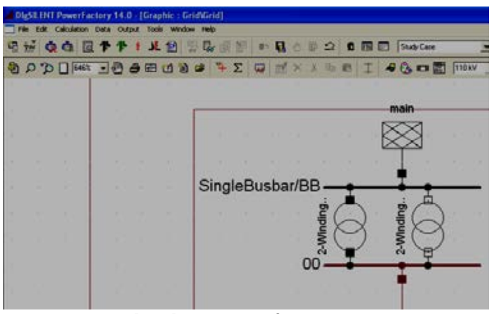

Fig. 6 tripping distribution transformer

The real system has 3 tie branches which have been named by Line0 to Line3. Total losses of the networks under study, when all tie switches are opened, is equal to 5319.61 kW (see Table IV). The main computational procedure of proposed optimization algorithm is also similar to Fig. 8. Figure 7 shows the computational results of reconfiguration and DG placement on real distribution system. The proposed algorithm offers DG1, DG2 with power of 2.2 and 1 MW and Line0, Line2 and Line3 as DG places and reconfiguration. By installing DGs and reconfiguration the total losses reduced to 1.0254 MW equal to 43.18%. The minimum voltage of new structure system is improved from 0.9124 to 0.9487.

Fig.7 real life distribution system of Tazian in Bandar Abbas in Iran

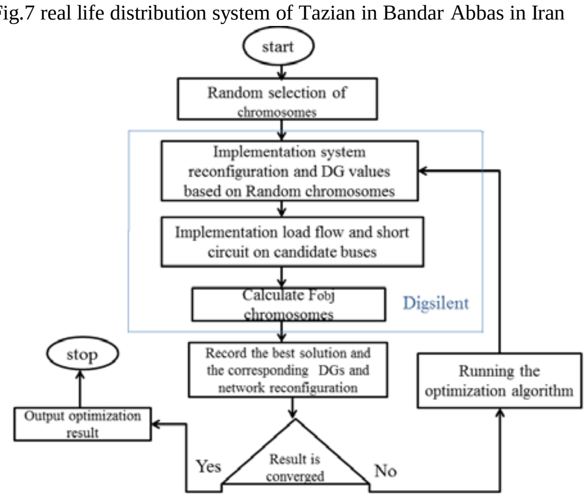

Fig. 8 flowchart of the proposed network reconfiguration and DG placement algorithm

By applying two extra actuators, perturbation and pre-processing, the optimal algorithm converged at minimum iteration and quickly.(Fig.9)

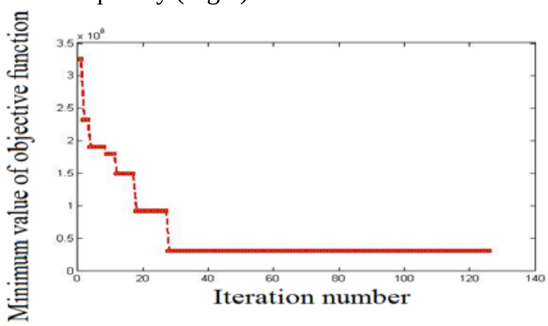

Fig. 9 convergence property of proposed GA

TABLE IV

Quantity	Value

Open branches	Line0, Line1, Line2
Number of sectionalizing switches	3
Number of buses	439
Minimum voltage profile (pu)	0.9124
Total active power (MW)	28.770
Total losses (MW)	1.80482

TABLE.IV DATA OF REAL LIFE DISTRIBUTION SYSTEM OF TAZIAN IN BANDAR ABBAS

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