Steady state load shedding solution in power systems using genetic algorithm

M. Y. Abdelfattah

Electrical Engineering Department, Faculty Of Engineering, Alexandria University

Large power system disturbances sometimes cause the interconnected system to become isolated into separate subsystems. These subsystems will have either an excess of generation or of load. The problem of load shedding is concerned with the situation where isolated subsystems suffer from excess of load . The optimal load shedding policy is to obtain a post emergency steady state solution of the power system which realizes the minimum amount of load need to be shed to cope with the emergency. An exact nonlinear model is developed, and is characterized by small number of variables involved. These variables are the real load power at load busses only. The solution is obtained using a genetic algorithm technique. The model is applied successfully to 5-bus and 12-bus systems. The results obtained are presented and discussed.

تتعرض شبكات القوى الكهربية من حين لأخر لظروف تشغيل طارئة تتطلب أجراء حجب جزئ للأحمال. وتعتبر الأخطاء في الشبكات وكذلك زيادة الأحمال المطلوبة عن القدرة المتاحة من أهم الأسباب التى تدعو إلى أجراء هذه العملية. وتعتبر عملية الحجب الأمثل للأحمال هى العملية التى تؤدى إلى تقليل قيمه الأحمال التى يتم حجبها إلى الحد الأدنى لكى تتواءم الأحمال مع قدرات التوليد المتاحة أثناء الحالة المستقرة في هذه الظروف الطارئة. وقد تم بناء نموذج رياضي لاخطى دقيق لوصف المشكلة ويتميز هذا النموذج بانخفاض عدد المتغيرات. وهذه المتغيرات هى قدرات الأحمال الحقيقية فقط عند قضبان الأحمال فى الشبكة الكهربية. وقد تم حل النموذج الرياضي باستخدام خوارزم وراثى. وقد تم تطبيق النموذج بنجاح على شبكة مكونة من خمسة قضبان واثنا عشر قضيب.

Keywords: Load shedding, Genetic algorithm

1. Introduction

With present time interconnected power systems, conditions often arise which would result in the isolation of a part of the system. The isolated subsystem invariably has either an excess of generation or of load . The frequency deviation that accompanies system isolation is caused by the imbalance between load and generation. This effect is most serious in the subsystem that has excess of load, since speed governing is usually effective in reducing the generation in subsystems that suffer from an excess of generation. Therefore, most of the concern is for the subsystem suffering from an excess of load. A declining frequency situation will, therefore, develop in that part, sometimes to levels that may cause permanent damage to steam turbines. Load shedding provides the means of arresting such frequency decline after all available generation reserves are used up. Certain percentages of the loads are dropped in succession according to the declining frequency, until conditions become favorable and system frequency starts to return back to normal. If such process of load shedding is successful, a steady state, at normal frequency, will finally ensues with decreased loads.

The problem of optimal load shedding is essentially the problem of obtaining such steady state which guarantees a minimum of load dropped. At the same time, that steady state must be feasible in the sense that no operational constraints are violated. This ensures the practicability of the load schedule obtained. The problem is, therefore, a constrained power system optimization problem to which numerous mathematical optimization techniques may be applied. Several scholarly treatments of under frequency load shedding have been presented in the literature over the years [1 - 10].

In this paper an exact nonlinear formulation of the optimal load shedding problem is presented. Genetic algorithm technique is applied to the problem solution. The algorithm is applied to 5-bus and 12-bus systems. It proved to be not less efficient than another technique based on the use of

Lagrangian multipliers for equality constraints, penalty functions for inequality constraints and Newton's method of unconstrained optimization [5].

2. Problem description

As mentioned above, the objective of the optimal load shedding problem is to obtain a post emergency steady state solution of the power system which realizes the minimum amount of load need to be shed to cope with the emergency. Naturally, this steady state should satisfy system operational and equipment requirements prevailing after the emergency to be practically justified. In other words, two requirements should be met in the solution of the problem. These are:

1- An objective function representing the amount of load shed is minimized.
2- System post emergency constraints are satisfied.

Several forms of the objective function have been used for optimization. They have been formulated in terms of the actual load need to be dropped [3-4]. Load real powers [3], or real and reactive powers [4]. However, since, in general, reactive demand at any bus is not independent of the real demand at the same bus, it looks that an objective function formulated in terms of real powers only would suffice. Also, the objective function should give consideration to the priority polices set by individual utilities. An objective function possessing these features is suggested in [3], and is adopted in this paper. Mathematically, it is given by:

$$F = \sum_{i \varepsilon S} (C_i^{\cdot} - C_i)^2 / 2 k_i C_i^{\cdot} \qquad (1)$$

Now, consider a system of N busses with NL pure load busses, and NG=N-NL pure generator busses. Therefore, the post emergency constraints will be

1- Assuming all generators are operated at their maximum real power capacities, then all generators deliver fixed powers, therefore :

$$P_i = V_i \sum_{j=1}^{N} V_j Y_{ij} \cos(\delta_i - \delta_j - \theta_{ij}) \qquad i \varepsilon NG \qquad (2)$$

2- Without loss of generality, linear dependence between real and reactive demand can be assumed. These relations will, thus, take the form:

$$D_i(\underline{V}, \underline{\delta}) - \gamma_i C_i(\underline{V}, \underline{\delta}) = 0 \qquad i \varepsilon NL \qquad (3)$$

Where:

$$C_i(\underline{V}, \underline{\delta}) = -V_i \sum_{j=1}^{N} V_j Y_{ij} \cos(\delta_i - \delta_j - \theta_{ij}) \qquad i \varepsilon NL, \qquad (4)$$

$$D_i(\underline{V}, \underline{\delta}) = -V_i \sum_{j=1}^{N} V_j Y_{ij} \sin(\delta_i - \delta_j - \theta_{ij}) \qquad i \varepsilon NL. \qquad (5)$$

3- Inequality constraints reflecting system operational limits :

$$C_i^m \le C_i(\underline{V}, \underline{\delta}) \le C_i^{\cdot} \qquad i \varepsilon NL, \qquad (6)$$

$$D_i^m \le D_i(\underline{V}, \underline{\delta}) \le D_i^{\cdot} \qquad i \varepsilon NL. \qquad (7)$$

Other inequality constraints such as those imposed on reactive power generator busses and/or voltage magnitude for all busses can fairly be ignored here since we are searching for a solution during an emergency situation where some violations for voltage magnitude or generator reactive power can be tolerated.

The problem can now be stated in the standard form as:
Minimize the scalar function F of Eq. (1), subject to equality constraints (2, 3), and inequality constraints (6, 7).

3. Genetic algorithm (GA)

Genetic algorithms are attractive alternative to other optimization methods because of their robustness for many practical problems. The GA is a search procedure which mimics the way biological evolution work. The mathematical basis for GA is given in [11]. The main advantages of GA are:

1- The GA uses a set of population points which are randomly chosen. Therefore, the GA explore several areas of the search space, and, therefore, reduces the probability of striking false maxima or minima.

2- The GA does not require continuous derivatives calculations because transition rules are probabilistic and not deterministic. Each member of the population is evaluated to find its merit or fitness. Fitness is a single numerical value that indicates how well a member solves the original problem. The relative fitness of the best population push the GA towards the optimal solution. As the GA moves from one generation to the other, its objective is to produce better solutions to the original problem.

Three basic operators are utilized with Ga's solution technique. These operators are : the reproduction operator, the crossover operator, and the mutation operator.

3.1.The reproduction operator

This operator chooses individuals from the current generation for mating to produce a new generation . Selection is based on the fitness for each individual. This operator makes highly fit individuals most likely the ones to produce the new generation. The selection parameter determines the number of individuals which are chosen for mating. Several selection techniques are used for this purpose, among them tournament, proportional, ranking, etc. [11]. Elitism is an important operation used within the mating procedure. It forces the best individual of the current population to be member of the next generation. The reproduction process continues until the number of new individuals is equal to the original population size.

3.2. The crossover operator

This operator allows the exchange of information among individuals in the population and causes the characteristics of the best individuals to be recombined to reproduce the new generation.

3.3. The mutation operator

This operator ensures needed diversity. It is used to randomly change the value of one individual , or to change the value of an individual that does not satisfy the limits imposed by the problem. This operator is considered as a correction tool to remedy individuals produced by crossover if it produces an invisible individual. GA has been used for solving too many problems. This includes : power industry applications [12], control applications [13-14], distribution systems [15], machine design [16], and many others.

The Ga, here, is going to be used for the solution of the steady state optimal load shedding problem. This requires the problem stated in section (2) to be reformulated as given in the next section.

4. Genetic approach to load shedding solution

The variables involved in the solution of the load shedding problem are only the real load powers at all load busses. Therefore, a small number of variables is involved. The solution is obtained as follows :

1- Assume an initial value for the power system efficiency, e.g. 98%.
2- Knowing the system power generation, calculate the total expected system load power.
3- Randomly find value for an individual $[C_1 \ C_2 \ C_3 \ldots C_{NL}]$ satisfying equation (6).
4- Sum up the powers found in step (3). If the summation violates step (2), repeat step(3).
5- Evaluate the fitness function as given by equation (1) for this individual.
6- Repeat steps (3) to (5) until initial population is completely created, then go to step (7).
7- Calculate the average fitness function, which is the sum of all partial fitness function values divided by the population size.
8- Perform crossover operation for reproduction to form next generation.
9- Sum up load real powers. If this summation violates the power known from step (2), perform mutation operation on this individual.
10- Evaluate the fitness function as in step (5).

11- Repeat steps (8) to (10) until the new population is completely produced, then go to step (12).

12- Calculate the average fitness function as given in step (7).

13- Repeat steps (8) to (12) for next generation production until the average fitness function converges, then go to step (14).

14- Knowing load real powers at different load busses, calculate reactive load powers at the same busses from equation (3).

15- A normal load flow solution is carried out assuming one of the generator busses a slack bus. This solution is possible because number of available equations is 2NL+NG–1and the number of unknowns is 2N-NG-1= 2NL+NG–1 since one bus is chosen as a reference bus and generator busses acquiring fixed voltages.

16- Sum up generator busses real powers calculated from step (15). If summation does not match the known system power generation within a given tolerance, e.g. 10^{-4} p.u., reduce the assumed initial value for power system efficiency by 0.01% and repeat steps (2) to (16) until matching is reached.

5. Numerical results

Two systems have been used successfully to test the proposed method. The first is a 5-bus system , and the other is a 12-bus system. A computer program written in Pascal language was prepared for the digital simulation of the problem described in section 4. The values of GA parameters used are : maximum number of generations =100 ; population size = 300 ; crossover probability = 1.0 ; mutation is performed according to step (9) of section 4.

5.1. 5-Bus system

Figure 1. shows the 5-bus system. The transmission line impedance in per unit on a 100MVA base are given in Table1. Table2 shows the state prior the emergency. A normal load flow is used to obtain that state, with generator bus 5 taken as the slack generator. This is followed by a rotation of axes to make the voltage phase angle of load bus 3, the would be reference, equal to zero.

Emergency is simulated by a reduction in the available real generation at bus 5 from 1.0 p.u. to 0.3 p.u., while there is no reserve to be used at bus 4. Two sets of priority factors are used. The minimum vital loads at load busses 1, 2, and 3 are assumed to be zero. Tables 3 and 4 show the results using the proposed algorithm. Tables 5 and 6 show the results using method described in Ref. [5].

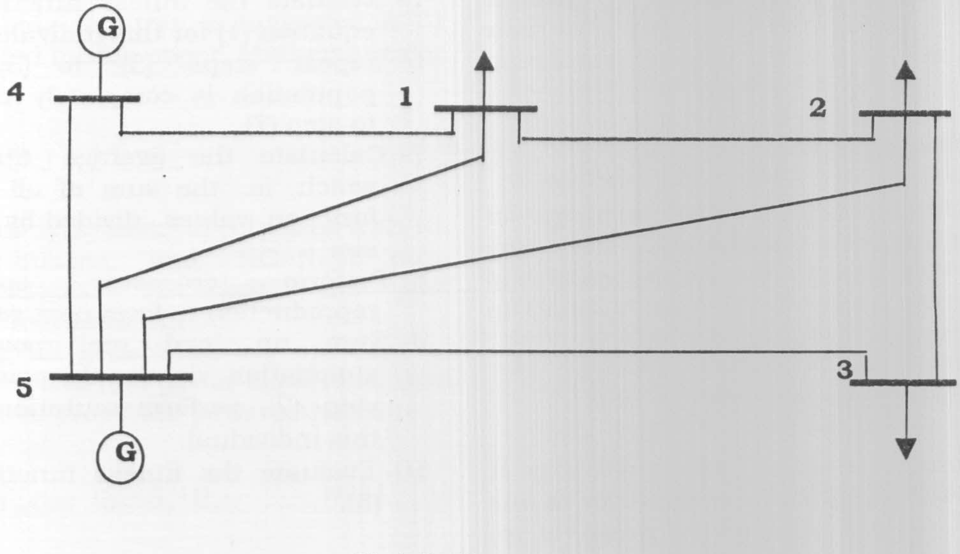

Fig. 1. 5 – Bus system.

Table 1. Transmission line impedance.

Bus code p – q	Impedance
1 – 2	0.01 +j0 .03
1 – 4	0.08 + j 0.24
1 – 5	0.06 + j 0.18
2 – 3	0.08 + j 0.24
2 – 5	0.06 + j 0.18
3 – 5	0.04 + j 0.12
4 – 5	0.02 + j 0.06

Table 2. System pre-emergency state.

Bus code P	V	δ	P	Q	C^*	D^*
1	1.01159	1.23206	0.00000	0.00000	0.500	0.100
2	1.00786	0.80543	0.00000	0.00000	0.600	0.100
3	0.99635	0.00000	0.00000	0.00000	0.800	0.200
4	1.06000	6.23678	1.00000	0.08330	0.000	0.000
5	1.05000	4.43741	0.96117	0.50021	0.000	0.000

Table 3. Optimal solution, $k_1 = k_2 = k_3 = 1$.

Bus code p	V	δ	C^m	C	C^*	D^m	D	D^*	P	Q
1	1.0262	0.995	0.00	0.33410	0.500	0.00	0.06682	0.100		
2	1.0237	0.674	0.00	0.39457	0.600	0.00	0.06576	0.100		
3	1.0156	0.000	0.00	0.53871	0.800	0.00	0.13468	0.200		
4	1.0600	4.961							1.0000	0.0159
5	1.0500	2.857							0.3002	0.3497

Objective function = 0.10536 Total load shed = 0.6326 p.u.

Table 4. Optimal solution , $k_1 = k_2 = 2$, $k_3 = 1$.

Bus code P	V	δ	C^m	C	C^*	D^m	D	D^*	P	Q
1	1.0278	1.460	0.00	0.29625	0.500	0.00	0.05925	0.100		
2	1.0251	1.129	0.00	0.34702	0.600	0.00	0.05784	0.100		
3	1.0119	0.000	0.00	0.62263	0.800	0.00	0.15566	0.200		
4	1.0600	5.288							1.0000	0.0087
5	1.0500	3.144							0.3000	0.3663

Objective function = 0.06708 Total load shed = 0.6341 p.u.

Table 5 .Optimal solution [5] , $k_1 = k_2 = k_3 = 1$.

Bus code p	V	δ	C^m	C	C^*	D^m	D	D^*	P	Q
1	1.0261	0.960	0.00	0.33488	0.500	0.00	0.06698	0.100		
2	1.0235	0.637	0.00	0.40046	0.600	0.00	0.06674	0.100		
3	1.0159	0.000	0.00	0.53195	0.800	0.00	0.13299	0.200		
4	1.0600	4.936							1.0000	0.0164
5	1.0500	2.834							0.3000	0.3484

Objective function = 0.10535 Total load shed = 0.6327 p.u.

Table 6. Optimal solution [5], $k_1 = k_2 = 2$, $k_3 = 1$.

Bus code p	V	Δ	C^m	C	C^*	D^m	D	D^*	P	Q
1	1.0279	1.496	0.00	0.29035	0.500	0.00	0.05807	0.100		
2	1.0252	1.161	0.00	0.34678	0.600	0.00	0.05780	0.100		
3	1.0116	0.000	0.00	0.62867	0.800	0.00	0.15717	0.200		
4	1.0600	5.313							1.0000	0.0081
5	1.0500	3.165							0.3000	0.3676

Objective function = 0.06704 Total load shed = 0.6342 p.u.

Comparison between Tables 3 and 5, and Tables 4 and 6 shows very good agreement between the results obtained using the GA and those obtained by the method described in Ref. [5]. Maximum deviation in voltage magnitudes is 0.03% and in voltage phase angles is 5.8%. The total amount of load shed differs by 0.01% in the case of equal priorities (Tables 3 and 5), while it is 0.06% in the case of unequal priorities (Tables 4 and 6).

5.2. 12-Bus System

Figure 2. shows the 12-bus system. The transmission line impedance in per unit on a 100MVA base are given in Table 7. Table 8 shows the state prior the emergency.

A normal load flow is used to obtain that state, with generator bus 12 taken as the slack generator. This is followed by a rotation of axes to make the voltage phase angle of load bus 9, the would be reference, equal to zero.

Emergency is simulated by a reduction in the available real generation at bus 12 from 2.4 p.u. to 1.5 p.u., while there is no reserve to be used at bus 11. Tables 9 and 10 show the results using the proposed algorithm. Tables 11 and 12 show the results using method described in Ref. [5].

Comparison between Tables 9 and 11, and Tables 10 and 12 shows very good agreement between the results obtained using the GA and those obtained by the method described in Ref. [5]. Maximum deviation in voltage magnitudes is 0.17% and in voltage phase angles is 9.3%. The total amount of load shed differs by 0.03% in the case of unequal priorities (Tables 10 and 12), while there is no difference in the case of equal priorities (Tables 9 and 11).

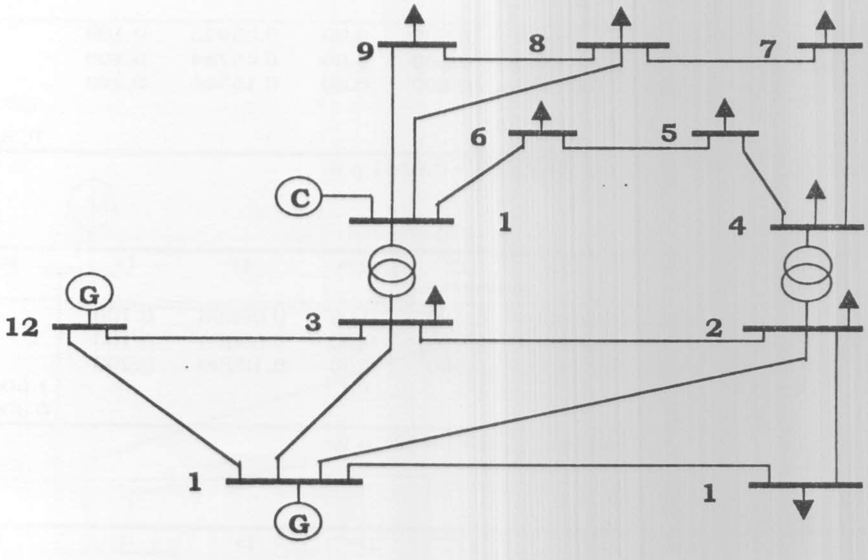

Fig. 2. 12 - Bus system.

Table 7. Transmission line impedance.

Bus code p – q	Impedance	Line charging
1 - 2	0.06701+j0.17103	0.0173
1 – 11	0.04699+j0.19797	0.0219
2 – 3	0.01335+j0.04211	0.0064
2 – 4 #	0.00000+j0.55618	0.0000
2 – 11	0.05811+j0.17632	0.0187
3 – 10#	0.00000+j0.25202	0.0000
3 – 11	0.05695+j0.17388	0.0170
3 – 12	0.05403+j0.22304	0.0246
4 – 5	0.03181+j0.08450	0.0000
4 – 7	0.12711+j0.27038	0.0000
5 – 6	0.08205+j0.19207	0.0000
6 – 10	0.09498+j0.19890	0.0000
7 – 8	0.17093+j0.34802	0.0000
8 – 9	0.22092+j0.19988	0.0000
8 – 10	0.06615+j0.13027	0.0000
9 – 10	0.12291+j0.25581	0.0000
11 – 12	0.01938+j0.05917	0.0264

Impedance of a transformer

Table 8. System pre-emergency state.

Bus code	V	δ	P	Q	C^*	D^*
1	0.98074	4.80245	0.00000	0.00000	0.942	0.190
2	1.00568	6.94313	0.00000	0.00000	0.478	0.039
3	1.01398	7.87854	0.00000	0.00000	0.293	0.143
4	1.00575	-1.53306	0.00000	0.00000	0.295	0.166
5	1.00458	-1.53480	0.00000	0.00000	0.090	0.058
6	1.02040	-0.83192	0.00000	0.00000	0.147	0.093
7	1.01137	-1.08993	0.00000	0.00000	0.050	0.050
8	1.04470	-0.06304	0.00000	0.00000	0.135	0.058
9	1.05244	0.00000	0.00000	0.00000	0.061	0.016
10	1.07000	0.89741	0.00000	0.56596	0.000	0.000
11	1.04500	12.38516	0.40000	0.48690	0.000	0.000
12	1.06000	16.97452	2.23353	-0.11398	0.000	0.000

Table 9. Optimal solution, $k_1 = k_2 = k_3 = k_4 = k_5 = k_6 = k_7 = k_8 = k_9 = 1$.

Bus code	V	δ	C^m	C	C^*	D^m	D	D^*	P	Q
1	1.0041	3.528	0.00	0.69415	0.942	0.00	0.14001	0.190		
2	1.0230	4.986	0.00	0.34655	0.478	0.00	0.02827	0.039		
3	1.0289	5.646	0.00	0.21124	0.293	0.00	0.10310	0.143		
4	1.0358	-1.238	0.00	0.21924	0.295	0.00	0.12337	0.166		
5	1.0331	-1.206	0.00	0.06258	0.09	0.00	0.04033	0.058		
6	1.0394	-0.653	0.00	0.10926	0.147	0.00	0.06912	0.093		
7	1.0344	-0.889	0.00	0.04040	0.050	0.00	0.04040	0.050		
8	1.0530	-0.066	0.00	0.10085	0.135	0.00	0.04333	0.058		
9	1.0578	0.000	0.00	0.04659	0.061	0.00	0.01222	0.016		
10	1.0700	0.676							0.0000	0.3632
11	1.0450	9.060							0.4000	0.0780
12	1.0600	11.985							1.5001	-0.0310

Objective function = 0.08778 Total load shed = 0.6601 p.u.

Table 10. Optimal solution, $k_1 = k_2 = k_3 = k_4 = 1$, $k_5 = k_6 = k_7 = k_8 = k_9 = 2$.

Bus code	V	δ	C^m	C	C^*	D^m	D	D^*	P	Q
1	1.0023	2.390	0.00	0.72893	0.942	0.00	0.14702	0.190		
2	1.0231	4.030	0.00	0.37227	0.478	0.00	0.03037	0.039		
3	1.0292	4.749	0.00	0.23115	0.293	0.00	0.11281	0.141		
4	1.0401	-1.461	0.00	0.23319	0.295	0.00	0.13122	0.166		
5	1.0388	-1.328	0.00	0.04615	0.090	0.00	0.02974	0.058		
6	1.0454	-0.676	0.00	0.07996	0.147	0.00	0.05059	0.093		
7	1.0410	-0.974	0.00	0.02820	0.050	0.00	0.02820	0.050		
8	1.0566	-0.092	0.00	0.07735	0.135	0.00	0.03323	0.058		
9	1.0608	0.000	0.00	0.03402	0.061	0.00	0.00892	0.016		
10	1.0700	0.545							0.0000	0.3115
11	1.0450	8.083							0.4000	0.0884
12	1.0600	11.025							1.5001	-0.0329

Objective function = 0.07329 Total load shed = 0.6598 p.u.

Table 11. Optimal solution [5] , $k_1 = k_2 = k_3 = k_4 = k_5 = k_6 = k_7 = k_8 = k_9 = 1$.

Bus code	V	δ	C^m	C	C^*	D^m	D	D^*	P	Q
1	1.0045	3.555	0.00	0.68676	0.942	0.00	0.13852	0.190		
2	1.0230	4.972	0.00	0.35092	0.478	0.00	0.02863	0.039		
3	1.0288	5.630	0.00	0.21555	0.293	0.00	0.10520	0.143		
4	1.0360	-1.242	0.00	0.21820	0.295	0.00	0.12278	0.166		
5	1.0330	-1.221	0.00	0.06639	0.090	0.00	0.04278	0.058		
6	1.0394	-0.661	0.00	0.10909	0.147	0.00	0.06901	0.093		
7	1.0355	-0.875	0.00	0.03642	0.050	0.00	0.03642	0.050		
8	1.0533	-0.066	0.00	0.10109	0.135	0.00	0.04343	0.058		
9	1.0579	0.000	0.00	0.04648	0.061	0.00	0.01219	0.016		
10	1.0700	0.673							0.0000	0.3618
11	1.0450	9.055							0.4000	0.0766
12	1.0600	11.977							1.5000	-0.0303

Objective function = 0.08752 Total load shed = 0.6601 p.u.

Table 12. Optimal solution [5], $k_1 = k_2 = k_3 = k_4 = 1$, $k_5 = k_6 = k_7 = k_8 = k_9 = 2$.

Bus code	V	δ	C^m	C	C^*	D^m	D	D^*	P	Q
1	1.0027	2.635	0.00	0.72089	0.942	0.00	0.14540	0.190		
2	1.0230	4.232	0.00	0.36878	0.478	0.00	0.03009	0.039		
3	1.0291	4.943	0.00	0.22460	0.293	0.00	0.10961	0.143		
4	1.0387	-1.438	0.00	0.23188	0.295	0.00	0.13048	0.166		
5	1.0371	-1.326	0.00	0.05197	0.090	0.00	0.03349	0.058		
6	1.0440	-0.678	0.00	0.08480	0.147	0.00	0.05365	0.093		
7	1.0394	-0.967	0.00	0.03053	0.050	0.00	0.03053	0.050		
8	1.0559	-0.084	0.00	0.08061	0.135	0.00	0.03463	0.058		
9	1.0602	0.000	0.00	0.03698	0.061	0.00	0.00970	0.016		
10	1.0700	0.573							0.0000	0.3224
11	1.0450	8.292							0.4000	0.0861
12	1.0600	11.231							1.5000	-0.0326

Objective function = 0.07350 Total load shed = 0.6600 p.u.

6. Conclusions

The steady state optimal load shedding problem is formulated using an exact nonlinear model. The variables involved in the solution of the load shedding problem using GA are only the real load powers at all load busses. Therefore, a smaller number of variables is involved in the solution. The algorithm has been tested for 5 - and 12 - bus systems. Comparison with other optimization technique [5] ,shows that the suggested algorithm is not less efficient than this other method. Yet the values of the objective function are different indicating the flatness of the objective function at the optimal solution. This is usually the case in this type of problem.

The features of GA are different from other search techniques in several aspects. First, GA searches from a population of strings. Thus it searches many peaks in parallel, which reduces the possibility of local optimal. Secondly, GA only needs to evaluate an objective function to guide its search. Therefore, there is no need for derivatives or other auxiliary knowledge. It requires neither deep mathematical knowledge nor great computer programming skill. However, the disadvantage of the proposed method is long computation time when compared with the other method [5].

List of symbols

$C_i^{\cdot}$ & $D_i^{\cdot}$	Are the active & reactive demands at load bus i prior to emergency respectively
C_i & D_i	Are the active & reactive demands at load bus i after emergency respectively
C_i^m & D_i^m	Are the minimum real & reactive vital demands at load bus i respectively
$V_i\,\varepsilon^{j\delta_i}$	Is the voltage at bus i
$[Y_{ij}\,\varepsilon^{j\theta_{ij}}]$	Is the bus admittance matrix of the post emergency system
γ_i	Is the constant parameter dependent on the power factor at load bus i , which will be assumed to be fixed [$\gamma_i = \tan(-\Phi_i)$, where Φ_i is the power factor angle at bus i]
k_i	Is the priority factor assigned to load at bus i
S	Is the set of load busses

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