Optimal Reactive Power Dispatch Using Self-Balanced Differential Evolution Algorithm

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Abstract— Reactive Power Dispatch (RPD) is one of the major optimization problems in power system which has multi-variable and nonlinear characteristic with equality and inequality constraints. Differential Evolution (DE) algorithm is a simple but powerful algorithm widely used to solve power system optimization problems. In this paper a new and novel variant called Self-Balanced Differential Evolution (SBDE) is developed to improve the performance of DE algorithm and balance the exploration and exploitation processes. Two different objective functions have been considered viz., the minimization of total real power loss and total bus voltage deviation under normal and stressed conditions. Voltage magnitude of the generator, transformer tap ratio and reactive power of capacitor banks are considered as control variables. The proposed approach is applied in IEEE 57-bus and IEEE 118-bus test systems for performance assessment. The obtained results demonstrate the proficiency of the proposed approach and the results are compared with the results reported in the literature.

Keywords — Power System, Evolutionary Computing, Optimization, Self-Balanced Differential Evolution, Reactive Power Dispatch.

INTRODUCTION

Optimal operation and planning of power system networks have been an economic criterion. Optimal Power Flow (OPF) is a powerful concept for power system planning and operation first formulated by Carpentier in 1960s. Optimal Reactive Power Dispatch (ORPD) is a sub problem of OPF. It is a procedure that allocates the reactive power generation so as to minimize the transmission loss, results in lowest production cost satisfying the operation constraints [1].

ORPD has significant influence on the economic and secure operation of power systems. It is an important tool both in planning for the future and day to day operation of power system. ORPD is a mixed integer problem which has both continuous and discrete variables. Earlier it has been solved by conventional optimization approach such as linear programming, interior point method [2] and quadratic programming [3]. Due to the multi-modal characteristics and the non-linearity, non-differential, non-convex nature of the ORPD problem, the majority of the conventional optimization techniques may converge to a local optimum [4]. To overcome the drawbacks in conventional approach, recently heuristic algorithms like Genetic Algorithm (GA) [5], Particle Swarm Optimization (PSO) [6],Ant Colony Optimization(ACO) [7],Differential Evolution (DE) [8], Evolutionary programming (EP) [9], Seeker Optimization [17], Gravitational search algorithms (GSA) [15], and Opposition based Gravitational search algorithms (OSGA) [16] are used to solve ORPD problem.

Differential Evolution algorithm is simple but powerful and efficient evolutionary algorithm in solving global optimization problems proposed by Storn and Price [4] in 1995.The good performance of DE in terms of convergence speed, accuracy, and robustness makes it attractive for applications to various real world optimization problems. Simple DE has been used to solve the reactive power optimization problem in [8], where the value of mutation factor (F) and Crossover Ratio (CR) is assumed constant for all generation and makes unsuitable for all system. D.Devaraj et al. [18] have proposed GA based ORPD for voltage stability enhancement in which they consider a fixed value for crossover ratio.

DE with small modification is also applied to solve ORPD problem [13]. Though DE is a simple algorithm, but different control parameters settings show different characteristics. A larger value of F is effective for global search, whereas smaller can accelerate the convergence characteristics. On the other hand, a larger CR results in higher diversity of the population, since the trial vector will inherit more information from the mutant vector. However, a smaller CR focuses on local exploitation since the target vector will contribute more information to the trial vector. Indeed, it is still an issue to choose suitable settings of F and CR to balance the exploration and exploitation of DE during the evolution [11].

During the past years, many variants have been introduced in DE. Recently Harish Sharma et al. [11] have proposed a Self-Balanced Differential Evolutionary algorithm (SBDE). InDE mutation performs exploration (ability to expand the search space) and selection performs exploitation (ability to find the optima around a good solution). To maintain the balance between exploration and exploitation a new control parameter called cognitive learning factor is introduced in DE. In this paper cognitive learning factor is denoted as 'C'. Mutation factor is also dynamically varied according to the earlier information. So these modifications improve the performance.

This paper proposes a novel SBDE algorithm to solve the ORPD problem. The problem is formulated as a nonlinear optimization problem with equality and inequality constraints. Two different objectives are considered such as minimization of real power loss and total voltage deviation under normal and stressed condition. The proposed algorithm is successfully tested on IEEE 57 and IEEE 118 bus systems and the simulation results are compared to those reported in the literatures.

The remainder of the paper is organized as follows: Section 2 presents the formulation of ORPD problem. Section 3 briefly explains the overview of DE. In Section 4 the algorithm of SBDE in solving the ORPD problem is presented. To analyze the performance of the SBDE algorithm, it is tested on IEEE 57, and IEEE 118 bus systems and the results are discussed in Section 5. Finally conclusions are drawn in the last section.

II. Problem Formulation

RPD problem is formulated as mixed integer problem with both continuous and discrete variables. The objective function of the RPD problem is expressed as follows.

2.1 Objective functions

P_{loss}: Minimization of real power loss

Minimization of real power loss is considered asthe one of the objective functionsand is expressed in eqn. (1).

$$Min\ f = \sum_{k=1}^{nl} P_{loss} = \sum_{i=1}^{NB}\sum_{j=1}^{NB} g_k\left(V_i^2 + V_j^2 - 2V_iV_j\cos(\delta_i - \delta_j)\right) \quad (1)$$

g_k- Conductance of the kth line

v_i, v_j - Voltage magnitude at the end buses i and j of the kth line.

δ - Voltage phase angle at the end buses i and j.

nl –number of transmission of lines

NB- total number of buses

TVD: Minimization of total voltage deviation

Bus voltage is the most important thing when security and service quality indices are considered. To improve voltage profile, the load bus voltage can be minimized. The objective function *total voltage deviation* can be expressed as in eqn. (2).

$$\textbf{Total Voltage Deviation} = \sum_{i=1}^{NPQ} \left|V_{Li} - V_L^{ref}\right| \quad (2)$$

Voltage at ithload bus.

V_L^{ref} – 1 p.u.

NPQ - Number of load buses

2.2 Equality constraints

These constraints eqns. (3) and (4) represent power balance equation

$$P_{Gi} - P_{Di} = V_i \sum_{j=1}^{NB} V_i\left(g_{ij}\cos\theta_{ij} + B_{ij}\sin\theta_{ij}\right) \quad (3)$$

$$Q_{Gi} - Q_{Di} = V_i \sum_{j=1}^{NB} V_i\left(G_{ij}\sin\theta_{ij} - B_{ij}\,cos\theta_{ij}\right) \quad (4)$$

P_{Gi} – Real power generation of generator i.

Q_{Gi} – Reactive power generation of generator i.

P_{Di} – Real power demand at generator bus i

Q_{Di} – Reactive power demand at generator bus i

V_i,V_j- Voltage magnitude at bus i,j

NB- total number of buses

2.3 Inequality constraints

Limits of the state and control variables are the inequality constraints expressed from eqn. (5) to (8).

$$V_{G_i}^{min} \le V_{G_i} \le V_{G_i}^{max},\ i = 1, \dots, N_G \quad (5)$$

$$P_{G_i}^{min} \le P_{G_i} \le P_{G_i}^{max},\ i = 1, \dots, N_G \quad (6)$$

$$Q_{C_i}^{min} \le Q_{C_i} \le Q_{C_i}^{max},\ i = 1, \dots, N_C \quad (7)$$

$$T_i^{min} \le T_i \le T_i^{max},\ i = 1, \dots, N_T \quad (8)$$

$V_{G_i}^{min}$,$V_{G_i}^{max}$ - minimum and maximum limits of voltage at ith generator

$P_{G_i}^{min}$,$P_{G_i}^{max}$ - minimum and maximum limits of real power at ith generator

$Q_{C_i}^{min}$, $Q_{C_i}^{max}$ - minimum and maximum limits of capacitor banks

T_i^{min} ,T_i^{max} - minimum and maximum limits of transformer tap settings

The reactive power generation Q_G,loadbus voltage magnitude V_L and line flow S_L operating constraints are expressed in eqns. (9) to (11).

$$Q_{G_i}^{min} \le Q_{G_i} \le Q_{G_i}^{max},\ i = 1, \dots, N_G \quad (9)$$

$$V_{L_i}^{min} \le V_{L_i} \le V_{L_i}^{max},\ i = 1, \dots, N_{PQ} \quad (10)$$

$$S_{L_i} \le S_{L_i}^{max},\ i = 1, \dots, N_L (11)$$

Where N_G, N_{PQ} and N_L are the number of generator buses, the number of PQ buses, and the number of load buses respectively.

III. Differential Evolution - Overview

Differential evolution algorithm was proposed by Storn and Price [4] in 1995 to solve real parameter optimization problems. DE is also a population based searching algorithm and the optimization process involves following four steps.

Initialization

All independent variables are initialized randomly within their feasible numerical range between 0 and 1. NP is the population size. D is the control variables which are going to be optimized. It is initialized using the MATLAB function in eqn. (12)

Unifrnd (min, max, NP, D) (12)

Mutation

After initialization, the mutation operation is applied to generate the mutant vector Y_i for each target vector Xi in the current population. In order to explore the search space, difference vector is added to the base vector. The mutation equation is given eqn. (13).

$$Y_i(G) = X_{i1}(G) + F * \left(X_{i2}(G) - X_{i3}(G)\right) \quad (13)$$

Where F is the mutation scaling factor, F∈{0 ,1}.

Crossover

After mutation process, to increase the diversity of the current population, DE performs the crossover operation to produce the trail vector. Two types of crossover schemes can be used with DE. These are exponential crossover and binomial crossover. The binomial variant was widely used in different applications [6].

$$U_{i,j}(t) = \begin{cases} Y_{i,j}(t) & \text{if } rand_{k,i} \leq CR \text{ or } k = I_{rand} \\ X_{i,j}(t) & \text{if } rand_{k,i} \leq CR \text{ or } k = I_{rand} \end{cases} \quad (14)$$

$rand_k$, i ε [0, 1], I_{rand} is chosen randomly from the interval [1 . . . D] once for each vector to ensure that at least one vector component originates from the mutated vector Y_i. CR is the crossover control parameter between 0 and 1.

Selection

The selection operation selects, according to the fitness value of the population vector and its corresponding trail vector. For minimization problem the $vector_i$ which is having the lower fitness value is chosen. All solutions in the population have the same chance of being selected as parents.

$$X_{i,j}(t+1) = \begin{cases} U_i(t) & \text{if } f(U_i(t)) \leq f(X_i(t)) \\ X_i(t) & \text{if } f(X_i(t)) \leq f(U_i(t)) \end{cases} \quad (15)$$

3.1. Need For New variants of DE

The main control parameters of DE are (i) Mutation scaling factor (F) (ii) Crossover ratio (CR) (iii) Number of population (NP). They have a large impact on performance of the algorithm. Selecting suitable value of F and CR is a tedious process. To avoid that situation, many literatures suggest F and CR should be adaptive in each generation. This adaptive nature improves the performance of the DE algorithm. So far many variants are introduced in the literature concentrated on the F.

IV. SELF-BALANCED DIFFERENTIAL EVOLUTION

In this section, new variant of DE, named SBDE is presented. It is proposed by Harish Sharma [11] in 2014. Exploration and exploitation are the important terms in optimization. Exploration means expanding the search space, i.e. global search, on the other hand, exploitation means search around the good solution i.e. local search. To maintain the proper balance between the exploration and exploitation, a new mutation operation is introduced. It is given in equation (16).

$$Y_i(G) = C * X_{i1}(G) + F * (X_{i2}(G) - X_{i3}(G)) \quad (16)$$

G is the generation counter

C is the Cognition Learning Factor

It is dynamic based on the probability of fitness. Its value is calculated using eqn. (17).

$$Fi\,(G+1) = (rand(0,1) - 0.5) * (1.5 - prob\_i\,(G)) \quad (17)$$

In the above equation probability is calculated using eqn. (18).

$$prob_i(G) = \frac{0.9 * fitness(G)}{maxfit(G)} + 0.1 \quad (18)$$

C varies between [0.1-1] according to the fitness of an individual X and it is the most important parameter in SBDE. It controls the balance between exploration and exploitation capabilities of the algorithm.Furthermore, the range ofscale factor F is also dynamically varied. The dynamic scale factor controls the differentiation rate in mutation process in a better way. By varying C and F, exploration and exploitation capabilities of DE can be balanced. So it is named as Self Balanced Differential Evolution (SBDE).

4.1 Application of SBDE to solve reactive dispatch problem

The following sections explain the constraints handling mechanism and implementation of SBDE on the ORPD problem.

4.2 Constraint handling mechanism

It is worth mentioning that during the process of optimization, all the constraints are satisfied as follows.

(a) The load flow equality constraints are satisfied by Newton Raphson (NR) power flow algorithm.

(b) The generator bus voltage (V_{Gi}), transformer tap setting (T_i) and switchable reactive power compensations (Q_{Ci}) are control variables and these are self-restricted between their respective minimum and maximum values by the algorithm.

(c) State variables constraints: The most common approach in the DE to handle constraints is to use penalties because they are simple and easy to implement.

4.3 Penalty Function Method

In this method of constraint handling [8], the fitness function is defined as the sum of the objective function f(x) and a penalty term which depends on the constraint violation. Most commonly used representation is given in eqn. (19).

$$F = f + R_1(P_{G_1} - P_{G_1}^{lim})^2 + \sum_{i=1}^{N_{PQ}} R_2(V_{Li} - V_{Li}^{lim})^2 + \sum_{i=1}^{N_G} R_3(Q_{G_i} - Q_{G_i}^{lim})^2 + \sum_{i=1}^{N_L} R_4(|S_L - S_L^{max}|)^2 \quad (19)$$

R1, R2, R3, R4 are penalty coefficient associated with real power generation, bus voltage magnitude, reactive power generation and apparent line flow limit violation respectively. The value of penalty coefficients can be fixed only by trial and error method and also problem depended.

The step by step procedure of implementation of SBDE algorithm for solving RPD is as follows.

4.4 Algorithm

1. Simulation parameters of SBDE, Number of Population (NP), scaling factor (F), Crossover (CR), Number of control variables (D), lower and upper limit of control variables (L & U), and maximum number of iteration are defined.
2. An initial population Xi is generated randomly using eqn. (12).
3. Run NR power flow available in MATPOWER package and calculate the objective function value (PLoss1).
4. Start iteration counter G=1.
5. Find probability of each individual's according to eqn. (18).
6. Perform mutation operation to generate donor vector according to eqn. (16).
7. Perform crossover operation to generate trail vector according to eqn. (14).
8. Run NR power flow and calculate the objective function value (P_{Loss2}) for trail vector.
9. For each individual's compare the objective functions value of initial and trail vectors.
10. If trail vector dominates the initial vector according to eqn. (15), update the value of C for next generation and trail

vector replaces the target vector and go to step 14, otherwise continue.

11. When an individual is not updated re-initialize the individuals and set C value equal to 0.1 otherwise retains the previous value.
12. Same target vector is selected for next generation.
13. Calculate the value of F according to eqn. (17).
14. If the current iteration number reaches the predefined maximum iteration, stop the process. Otherwise go to step

The flowchart of the proposed SBDE based ORPD is illustrated in Fig. 1.

V. RESULTS AND DISCUSSIONS

In order to demonstrate the efficiency and robustness of the proposed SBDE algorithm, it is first tested on standard IEEE-57 bus test system and then in IEEE-118 bus system. The generator voltages (V_G), transformer tap settings (T_i) and reactive power injections (Q_C) are taken as control variables. MATLAB program is written for SBDE algorithm and the power flow is calculated using MATPOWER 5.0 package. The details of control variables and their limits are given in Table I. The Parameters used for the simulation are summarized in Table II.

5.1 IEEE 57-bus system

The topology and the system data of the IEEE 57-bus system can be found in [27]. The network consists of 80 branches, seven generator buses and 50 load buses. Fifteen branches 4-18,4-18, 21-20,24-26, 7-29, 34-32,11-41, 15-45,14-46,10-51, 13-49, 11-43,40-56, 39-57, 9-55have tap changing transformers. The buses with possible reactive power source installations are given in Table II. The available reactive powers of capacitor banks are within the interval 5 to 10MVAr. It also gives the details of the control variables and their maximum and minimum limits.

5.2 Case A: Base Load Condition(P_{Loss})

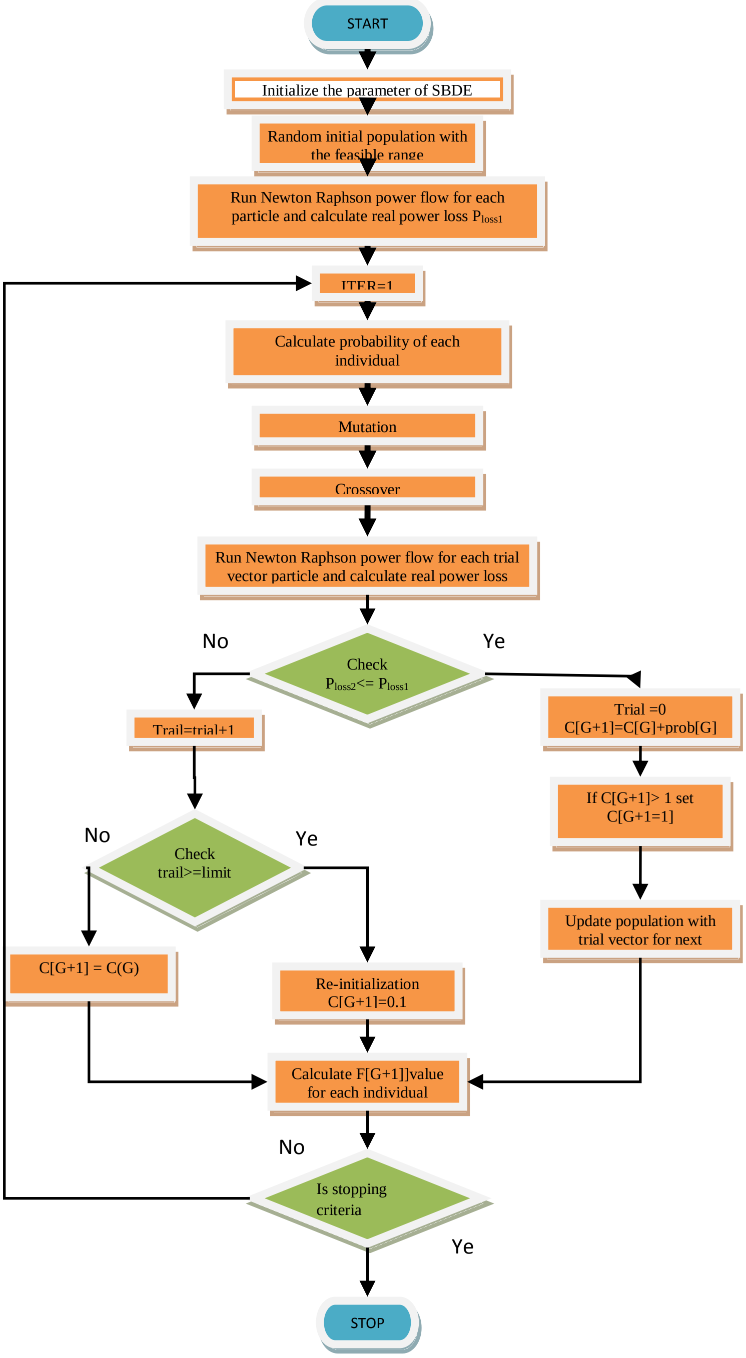
In this case, RPD problem is solved by the proposed method with base load condition load bus voltage limit is taken as (0.94-1.06) p.u.

5.2.1 Case A1:Minimization of Real Power Loss (P_{Loss})

In this case, the SBDE algorithm is run with minimization of real power losses as the objective function Fig.2 shows the convergence characteristic of the performance of the optimization technique in terms of P_{loss}.

Table III gives the details of the control variables and P_{loss}after optimization. The results obtained by SBDE approach is compared with the results those reported in literature like OGSA[16], GSA [15], nonlinear programming (NLP) [17], canonical GA (CGA) [17], Adaptive GA (AGA) [17], PSO with adaptive inertia weightweight (PSO-w) [17], PSO with a constriction factor (PSO-cf) [17], CLPSO [17], a real standard version of PSO, called as SPSO-07 [17], DEs with local search, instead of their corresponding originalversions and denoted as L-DE [17],L-SACP-DE [17], LSaDE [17],SOA [17], BBO [14],BBO (after relaxing Q-limit of bus 2 and 9) [14] for the

Fig. 1. Flowchart for SBDE based ORPD



same IEEE 57 test system. The results of the comparison are given in Table III.**From the comparison, the proposed SBDE algorithm gives the minimum loss that shows the better performance of the SBDE algorithm**.

Table I.Details of control variables for IEEE 57 bus system

Variable	Bus/branch no.	Minimum limit	Maximum limit
Generator bus voltage	1,2,3,6,8,9,12	0.94 p.u	1.06 p.u
Transformer tap position	Branch 4-18, 4-18, 21-20,24-26, 7-29, 34-32,11-41, 15-45, 14-46,10-51, 13-49, 11-43,40-56, 39-57, 9-55	0.9p.u	1.1p.u
Q power source installation	10,12, 15, 17, 20, 21, 23, 24, 29	5Mvar	10Mvar

Table II. Simulation parameters for IEEE 57 bus

Parameter	Value
No. of population (NP)	100
Scaling Factor(F)	0.8
Crossover Ratio(CR)	0.8
Maximum No. of iteration	500

5.2.2 Case A2: Minimization of Total Voltage Deviations (TVD):

In this case, the proposed SBDE approach is applied for the improvement of voltage profile in the objective function (TVD), the results obtained from the proposed SBDE method for optimal settings of the control variables are given in Table IV.The total voltage deviations are decreased from base case value **of 1.23358 to 0.6396** with a reduction of **48.15%.** Fig.3 shows the convergence characteristic of the performance of the optimization technique in terms of Voltage Deviations with SBDE for the best run out of 30 trials. **The proposed SBDE is found to be performing better than OSGA [16]. The comparison between SBDE and OSGA is listed in Table IV.It is also important that time taken for convergence by SBDE is lesser than OSGA.**

5.3 130% of base load

In order to analyze the system under stressed conditions, the active and reactive loads of each bus are increased to 130% of the base load condition. In this case all load bus voltage limit is taken as (0.94-1.06) p.u. Two Different objective functions are considered separately such as minimization of real power loss and total voltage deviations.

5.3.1 Case B1: Minimization of Real Power Loss (P_{Loss})

The system performance like optimum control variables before and after optimization using SBDE is given in third column of Table V. Fig. 4 shows the convergence characteristic of the performance of the optimization technique in terms of $P_{loss}$with SBDE. The resultshows real power loss value is decreased from **85.22 MW to 75.45 MW** with a reduction of **11.46%.** These optimistic results are good indication that the system relieving from the stressed condition to a better levelout of 30 trials. It is clear from Fig.4 the real power loss values are significantly reduced with proposed approach. Also this significant reduction shows the dominance of the proposed approach**. It can be observed that the performance and robustness of SBDE algorithm is better than the other algorithm for the system under stressed condition.**

5.3.2 Case B2: Minimization Of Total Voltage Deviations(TVD):

The results obtained from the proposed SBDE method for optimal settings of the control variables are given in the fourth column of Table V. The total voltage deviations are decreased from base case value of **1.5415 to 1.0239** with a reduction of **33.6 %** under stressed condition. Fig. 5 shows theconvergence characteristics of IEEE-57 bus for voltage deviation under stressed condition.

Fig.2 Convergence characteristics forP_{loss} minimization (caseA1)

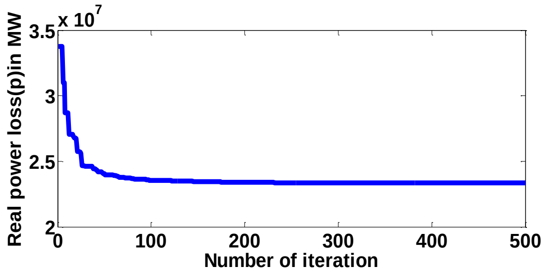


Fig.3 Convergence characteristics of VD minimization (Case A2)

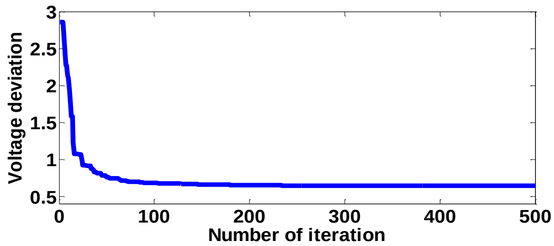


Fig.4 Convergence characteristics of loss minimization (case B1)

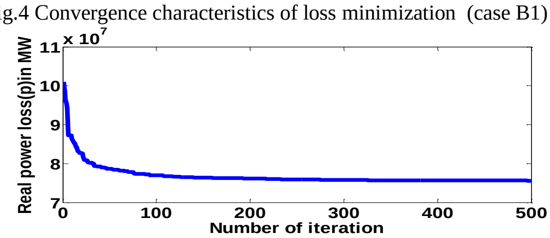


Fig.5 Convergence characteristics of VD minimization (Case B2)

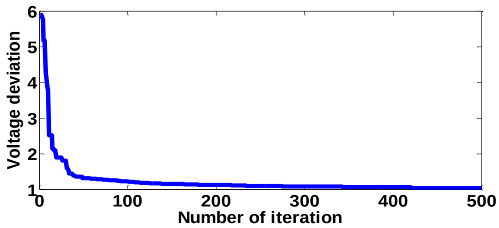


Table III.Comparison of simulation results for IEEE 57-bus test power system with P_{loss}minimization(Case A1)
NR* means Not reported

Variable	CLPSO[17]	PSO-07[17]	L-DE[17]	L-SACP-DE[17]	L-SaDE[17]	SOA[17]	BBO[14]	BBO*[14]
Generator voltage								
V_1,p.u	1.0541	1.0596	1.0397	0.9884	1.0600	1.0600	1.0600	1.0600
V_2,p.u	1.0529	1.0580	1.0463	1.0543	1.0574	1.0580	1.0504	1.0580
V_3,p.u	0.0337	1.0488	1.0511	1.0278	1.0438	1.0437	1.0440	10442
V_6,p.u	0.0313	1.0362	1.0236	0.9672	1.0364	1.0352	1.0376	1.0364
V_8,p.u	1.0496	1.06	1.0538	1.0552	1.0537	1.0458	1.0550	1.0567
V_9,p.u	1.0302	1.0433	0.94518	1.0245	1.0366	1.0369	1.0229	1.0377
V_{12},p.u	1.0342	1.0356	0.99078	1.0098	1.0323	1.0336	1.0323	1.0351
Transformer tap ratio								
T_{4-18}	0.99	0.95	1.02	1.05	0.94	1.00	0.96693	0.99165
T_{4-18}	0.98	0.99	0.91	1.05	1.00	0.96	0.99022	0.96447
T_{21-20}	0.99	0.99	0.97	0.95	1.01	1.01	1.0120	1.0122
T_{24-26}	1.01	1.02	0.91	0.98	1.01	1.01	1.0087	1.0110
T_{7-29}	0.99	0.97	0.96	0.97	0.97	0.97	0.97074	0.97127
T_{34-32}	0.93	0.96	0.99	1.09	0.97	0.97	0.96869	0.97227
T_{11-41}	0.91	0.92	0.98	0.92	0.9	0.90	0.90082	0.90095
T_{15-45}	0.97	0.96	0.96	0.91	0.97	0.97	0.96602	0.97063
T_{14-46}	0.95	0.95	1.05	1.08	0.96	0.95	0.95079	0.95153
T_{10-51}	0.98	0.97	1.07	0.99	0.96	0.96	0.96414	0.96252
T_{13-49}	0.95	0.92	0.99	0.91	0.92	0.92	0.92462	0.92227
T_{11-43}	0.95	1.00	1.06	0.94	0.96	0.96	0.95022	0.95988
T_{40-56}	1.00	1.00	0.99	0.99	1.00	1.00	0.99666	1.0018
T_{39-57}	0.96	0.95	0.96	0.96	0.96	0.96	0.96289	0.96567
T_{9-55}	0.97	0.98	1.1	1.1	0.97	0.97	0.96001	0.97199
Capacitor banks								
Q_{C-18},p.u	0.09888	0.03936	0	0	0.08112	0.09984	0.09782	0.09640
Q_{C-25},p.u	0.05424	0.05664	0	0	0.05808	0.05904	0.058991	0.05897
Q_{C-53},p.u	0.0.6288	0.03552	0	0	0.06192	0.06288	0.6289	0.062948
P_{loss},p.u	0.2451520	0.2774430	0.278126	0.2791553	0.2426739	0.2426548	0.24544	0.242616
TVD,p.u	NR*	NR*	NR*	NR*	NR*	NR*	NR*	NR*
CPU time ,s	423.30	421.98	426.97	427.23	408.97	382.23	NR*	NR*

Variable	SBDE	OGSA[16]	GSA[15]	NLP[17]	CGA[17]	AGA[17]	PSO-w[17]	PSO-d[17]
Generator voltage								
V_1,p.u	1.0600	1.0600	1.06000	1.06	0.9686	1.0276	1.06	1.06
V_2,p.u	1.0591	1.0594	1.06000	1.06	1.0493	1.0117	1.0578	1.0586
V_3,p.u	1.0494	1.0492	1.06000	1.0538	1.0567	1.0335	1.04378	1.0464
V_6,p.u	1.0436	1.0433	1.00810	1.06	0.9877	1.0010	1.0356	1.0415
V_8,p.u	1.0599	1.0600	1.05495	1.06	1.0223	1.0517	1.0546	1.06
V_9,p.u	1.0454	1.0450	1.00980	1.06	0.9918	1.0518	1.0369	1.0423
V_{12},p.u	1.0416	1.0407	1.018591	1.06	1.0044	1.0570	1.0334	1.0371
Transformer tap ratio								
T_{4-18}	0.9001	0.9000	1.10000	0.91	0.92	1.03	0.90	0.98
T_{4-18}	0.9006	0.9947	1.08263	1.06	0.92	1.02	1.02	0.98
T_{21-20}	0.9785	0.9000	0.92198	0.93	0.97	1.06	1.01	1.01
T_{24-26}	0.9833	0.9001	1.01673	1.08	0.90	0.99	1.01	1.01
T_{7-29}	0.9001	0.9111	0.99626	1.00	0.91	1.10	0.97	0.98
T_{34-32}	0.9539	0.9000	1.10000	1.09	1.1	0.98	0.97	0.97
T_{11-41}	0.9012	0.9000	1.07462	0.92	0.94	1.01	0.90	0.90
T_{15-45}	0.9014	0.9000	0.95434	0.91	0.95	1.08	0.97	0.97
T_{14-46}	0.9022	1.0464	0.93772	0.98	1.03	0.94	0.95	0.96
T_{10-51}	0.9166	0.9875	1.01679	0.98	1.09	0.95	0.96	0.97
T_{13-49}	0.9000	0.9638	1.05257	0.98	0.90	1.05	0.92	0.93
T_{11-43}	0.9000	0.9000	1.10000	0.98	0.90	0.95	0.96	0.97
T_{40-56}	1.0139	0.9000	0.97999	0.98	1.00	1.01	1.00	0.99
T_{39-57}	0.9824	1.0148	1.02465	1.08	0.96	0.94	0.96	0.96
T_{9-55}	0.9021	0.9830	1.03731	1.03	1.00	1.00	0.98	0.98
Capacitor banks								
Q_{C-18},p.u	9.8684	0.0682	0.07825	0.08352	0.084	0.0168	0.05136	0.9984
Q_{C-25},p.u	9.9999	0.0590	0.005869	0.00864	0.00816	0.01536	0.05904	0.05904
Q_{C-53},p.u	9.9759	0.0630	0.046872	0.1104	0.05376	0.03888	0.06288	0.06288
P_{loss},p.u	**0.2333**	0.2343	0.234611	0.25902	0.2524411	0.24564	0.242702	0.24280
TVD,p.u	2.0282	1.1907	NR*	NR*	NR*	NR*	NR*	NR*
CPU time,s	**302.67**	307.39	321.4872	NR*	321.4872	NR*	353.08	404.63

Table IV. Simulation results for IEEE-57 bus TVD minimization(Case A2)

Variable	SBDE	OGSA[16]
Generator voltage		
V_1 ,p.u	1.0269	1.0138
V_2,p.u	1.0163	0.9608
V_3,p.u	1.0124	1.0173
V_6,p.u	1.0012	0.9898
V_8,p.u	1.0303	1.0362
V_9,p.u	1.0255	1.0241
V_{12},p.u	1.0016	1.0136
Transformer tap ratio		
T_{4-18}	1.0141	0.9833
T_{4-18}	0.9872	0.9503
T_{21-20}	0.9784	0.9523
T_{24-26}	1.0161	1.0036
T_{7-29}	0.9798	0.9778
T_{34-32}	0.9174	0.9146
T_{11-41}	0.9001	0.9454
T_{15-45}	0.9240	0.9265
T_{14-46}	0.9705	0.9960
T_{10-51}	1.0014	1.0386
T_{13-49}	0.9001	0.9060
T_{11-43}	0.9569	0.9234
T_{40-56}	1.0315	0.9871
T_{39-57}	0.9017	1.0132
T_{9-55}	0.9929	0.9372
Capacitor banks		
$Q_{C-18,p.u}$	9.9479	0.0463
Q_{C-25},p.u	9.9970	0.0590
Q_{C-53},p.u	9.9781	0.0628
P_{loss}, MW	0.27521	0.3234
TVD,p.u	**0.6396**	0.6982
CPU time ,s	329.96	419.17

6.1 IEEE 118-bus system

The topology and the system data of the IEEE 118-bus system can be found in [28]. The network consists of 186 branches, fifty four generator buses and 64 load buses. Fifteen branches 8-5, 26-25, 30-17, 38-37, 63-59, 64-61, 65-66, 68-69,81-80 have tap changing transformers.

Table VI gives the details of the simulation parameters. The buses with possible reactive power source installations are given in Table VII. The available reactive powers of capacitor banks are within the interval 5 to 10MVAr.

Parameter	Value
No. of population (NP)	100
Scaling Factor(F)	0.8
Crossover Ratio(CR)	0.8
Maximum No. of iteration	500

Table VI. Simulation Parameters for IEEE-118 Bus

Table V. IEEE-57 bus Simulation results for case B1 and B2 (130 % increase in base load case)

Sl.No	Control Variables	**Case B1(SBDE)**	**Case B2(SBDE)**
1	V1	1.0600	1.0432
2	V2	1.0600	1.0240
3	V3	1.0599	1.0249
4	V6	1.0389	1.0022
5	V8	1.0600	1.0377
6	V9	1.0463	1.0322
7	V12	1.0502	1.0158
8	T 4-18	0.9007	0.9061
9	T 4-18	0.9011	1.0831
10	T 21-20	1.0012	0.9660
11	T 24-26	0.9804	1.0942
12	T 7-29	0.9002	0.9325
13	T 34-32	0.9519	0.9000
14	T 11-41	0.9001	0.9001
15	T 15-45	0.9000	0.9155
16	T 14-46	0.9000	0.9649
17	T 10-51	0.9178	0.9669
18	T 13-49	0.9001	0.9001
19	T 11-43	0.9000	0.9178
20	T 40-56	1.0298	1.0298
21	T 39-57	0.9788	0.9001
22	T 9-55	0.9012	1.0113
23	Qsh18	9.6384	8.0985
24	Qsh25	9.9997	9.9999
25	Qsh53	9.9976	9.9559
P_{loss}(MW)		**75.457**	83.255
T.V.D		3.9821	**1.0239**

Table VII.Control Variables of IEEE-118 Bus system

Variable	**Bus/branch no.**	**Minimum limit**	**Maximum limit**
Generator bus voltage	1,4,6,8,10,12,15, 18,19,24,25,26,27,31,32,34,36,40,42,46,49,54,55, 56,59, 61,62,65,66,70,72,73,74,76,77,80,85,87,89,90,91, 92,99,100,103,104,105, 107,110,111,112, 113,116.	0.94 p.u	1.06 p.u
Transformer tap position	Branch 8-5, 26-25, 30-17,38-37, 63-59, 64-61,65-66, 68-69,81-80.	0.9p.u	1.1p.u
Q power source installation	5,34,37,44,45,46, 48,74,79,82,83, 105,107,110.	5 Mvar	10 Mvar

6.2 Case C: Base Load Condition

In this case, RPD problem is solved by the proposed method with base load condition load bus voltage limit is taken as (0.94-1.06) p.u.

6.2.1 Case C1:Minimization of Real Power Loss(P_{Loss})

In this case, the SBDE algorithm is run with minimization of real power losses as the objective function. Fig.6 shows the convergence characteristic of the performance of the optimization technique in terms of Ploss after optimization. The results obtained by SBDE approach is compared with the results those reported in literature like GSA[15], OGSA[16], CLPSO[24], PSO[24]for the same IEEE 118 test system. The results of the comparison are given in Table VIII. From the comparison, the proposed SBDE algorithm gives the minimum loss that shows the better performance of the SBDE algorithm compared to other algorithms. It can be observed that P_{loss}reduces over the evolutions and converge to a minimum value from the base case value of **132.45 MW to 123.89MW** with a reduction of **6.46 %. The results in the table VIII indicate the superiority of SBDE for larger power systems.**

6.2.2 Case C2: Minimization of Total Voltage Deviations(TVD)

In this case, the proposed SBDE approach is applied for the improvement of voltage profile in the objective function (TVD), the results obtained from the proposed SBDE method for optimal settings of the control variables are given in Table IX. The total voltage deviations are decreased from base case value of 1.4393 to **0.3059** with a reduction of **78.74%.** Fig.7 showsthe convergence characteristic of the performance of the optimization technique in terms of Voltage Deviations with SBDE for the best run out of 30 trials. The proposed SBDE is found to be better than OSGA [16].**The comparison between SBDE and OSGA is listed in Table IX. The time taken for convergence is found to be lesser with SBDE than OSGA.**

6.3 130% of base load

In order to analyze the system under stressed conditions, the active and reactive loads of each bus are increased to 130% of the base load condition.

In this case all load bus voltage limit is taken as (0.94-1.06) p.u. Two Different objective functions are considered separately such as minimization of real power loss and total voltage deviations.

6.3.1 Case D1: Minimization Of Real Power Loss(P_{Loss})

The system performance like optimum control variables before and after optimization using SBDE is given in Table X. Fig. 8 shows the convergence characteristic of the performance of the optimization technique in terms of $P_{loss}$with SBDE for the best run out of 30 trials. It is clear from Fig.8 the real power loss values are significantly reduced with proposed approach. The results shows real power loss value isdecreased from **335.02 MW to 310.98 MW**. These optimistic results are good indication that the system relieving from the stressed condition to a better level reduction of 7.17%. The proposed algorithm performs well even under stressed condition.

Fig.6 Convergence characteristics of loss minimization(Case C1)

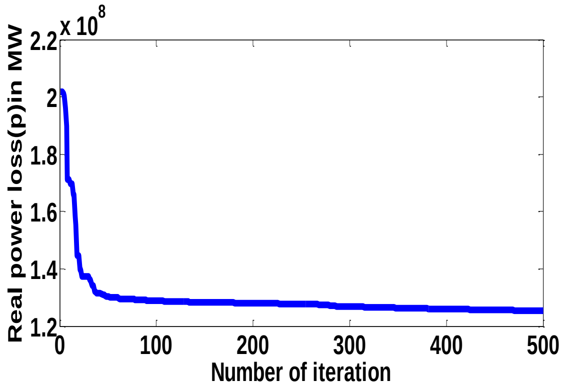


Fig.7 Convergence characteristics of VD minimization(Case C2)

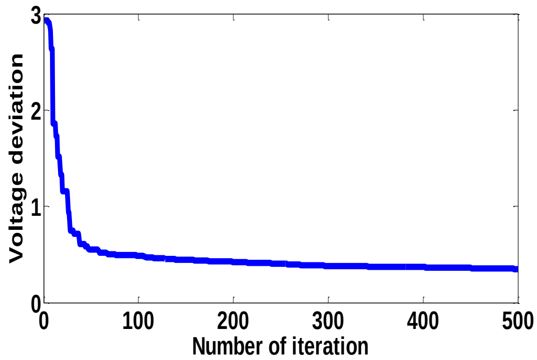


Fig.8 Convergence characteristicsof loss minimization(Case D1)

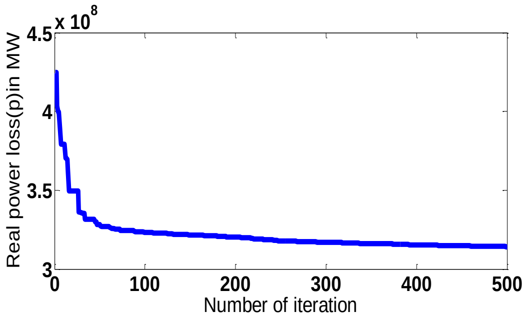


Fig.9 Convergence characteristics of VD minimization(Case D2)

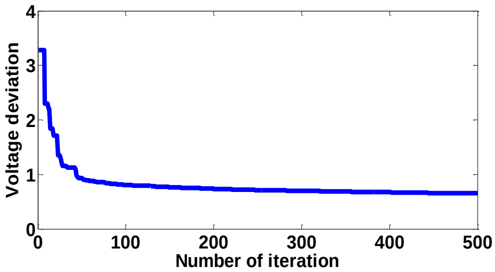


Table VIII Comparison of simulation resultsof IEEE 118 bus testpower system with P_{loss} minimization objective.(Case C1)

Variable	SBDE	OGSA[16]	GSA[15]	CLPSO[24]	PSO[24]	Variable	SBDE	OGSA[16]	GSA[15]	CLPSO[24]	PSO[24]
Generator voltage						Generator voltage					
V_{1},p.u	0.9994	1.0350	0.9600	1.0332	1.0853	V_{91},p.u	1.0029	1.0297	1.0032	1.0288	0.9615
V_{4},p.u	1.0154	1.0554	0.9620	1.0550	1.0420	V_{92},p.u	1.0161	1.0353	1.0927	0.9760	0.9568
V_{6},p.u	1.0132	1.0301	0.9729	0.9754	1.0805	V_{99},p.u	1.0100	1.0395	1.0433	1.0880	0.9540
V_{8},p.u	1.0214	1.0175	1.0570	0.9669	0.9683	V_{100},p.u	1.0178	1.0275	1.0786	0.9617	0.9584
V_{10},p.u	1.0506	1.0250	1.0885	0.9811	1.0756	V_{103},p.u	1.0101	1.0158	1.0266	0.9611	1.0162
V_{12},p.u	0.9991	1.0410	0.9630	1.0092	1.0225	V_{104},p.u	0.9862	1.0165	0.9808	1.0125	1.0992
V_{15},p.u	1.0038	0.9973	1.0127	0.9787	1.0786	V_{105},p.u	0.9919	1.0197	1.0163	1.0684	0.9694
V_{18},p.u	1.0037	1.0047	1.0069	1.0799	1.0498	V_{107},p.u	0.9963	1.0408	0.9987	0.9769	0.9656
V_{19},p.u	1.0054	0.9899	1.0003	1.0805	1.0776	V_{110},p.u	0.9886	1.0288	1.0218	1.0414	1.0873
V_{24},p.u	1.0089	1.0287	1.0105	1.0286	1.0827	V_{111},p.u	0.9918	1.0194	0.9852	0.9790	1.0375
V_{25},p.u	1.0208	1.0600	1.0102	1.0307	0.9564	V_{112},p.u	0.9732	1.0132	0.9500	0.9764	1.0920
V_{26},p.u	1.0600	1.0855	1.0401	0.9877	1.0809	V_{113},p.u	1.0230	1.0386	0.9764	0.9721	1.0753
V_{27},p.u	1.0107	1.0081	0.9809	1.0157	1.0874	V_{116},p.u	1.0286	0.9724	1.0372	1.0330	0.9594
V_{31},p.u	1.0136	0.9948	0.9500	0.9615	0.9608	Transformer tap ratio					
V_{32},p.u	1.0063	0.9993	0.9552	0.9851	1.1000	T_{8}	1.0037	0.9568	1.0659	1.0045	1.0112
V_{34},p.u	1.0080	0.9958	0.9910	0.0157	0.9611	T_{32}	1.0208	1.0409	0.9534	1.0609	1.0906
V_{36},p.u	1.0043	0.9835	1.0091	1.0849	1.0367	T_{36}	0.9961	0.9963	0.9328	1.0008	1.0033
V_{40},p.u	1.0045	0.9981	0.9505	0.9830	1.0914	T_{51}	1.0080	0.9775	1.0884	1.0093	1.0000
V_{42},p.u	1.0014	1.0068	0.9500	1.0516	0.9701	T_{93}	1.0125	0.9960	1.0579	0.9922	1.0080
V_{46},p.u	0.9884	1.0355	0.9814	0.9754	1.0390	T_{95}	0.9925	0.9956	0.9493	1.0074	1.0326
V_{49},p.u	1.0077	1.0333	1.0444	0.9838	1.0836	T_{102}	1.0015	0.9882	0.9975	1.0611	0.9443
V_{54},p.u	0.9808	0.9911	1.0379	0.9637	0.9764	T_{107}	1.0197	0.9251	0.9887	0.9307	0.9067
V_{55},p.u	0.9879	0.9914	0.9907	0.9716	1.0103	T_{117}	0.9823	1.0661	0.9801	0.9578	0.9673
V_{56},p.u	0.9838	0.9920	1.0333	1.0250	0.9536	Capacitor banks					
V_{59},p.u	1.0140	0.9909	1.0099	1.0003	0.9672	Q_{C-5},p.u	7.6611	-0.3319	0.00	0.0000	0.0000
V_{61},p.u	1.0110	1.0747	1.0925	1.0771	1.0938	Q_{C-34},p.u	8.7965	0.0480	7.46	11.7135	9.3639
V_{62},p.u	1.0091	1.0753	1.0393	1.0480	1.0978	Q_{C-37},p.u	7.5200	-0.2490	0.00	0.0000	0.0000
V_{65},p.u	1.0366	0.9814	0.9998	0.9684	1.0892	Q_{C-44},p.u	6.0547	0.0328	6.07	9.8932	9.3078
V_{66},p.u	1.0162	1.0487	1.0355	0.9648	1.0861	Q_{C-45},p.u	8.7156	0.0383	3.33	9.4169	8.6428
V_{69},p.u	1.0370	1.0490	1.1000	0.9574	0.9665	Q_{C-46},p.u	7.4596	0.0545	6.51	2.6719	8.9462
V_{70},p.u	1.0133	1.0395	1.0992	0.9765	1.0783	Q_{C-48},p.u	7.0826	0.0181	4.47	2.8546	11.809
V_{72},p.u	1.0030	0.9900	1.0014	1.0243	0.9506	Q_{C-74},p.u	8.2526	0.0509	9.72	0.5471	4.6132
V_{73},p.u	1.0090	1.0547	1.0111	0.9651	0.9722	Q_{C-79},p.u	10.000	0.1104	14.25	14.8532	10.592
V_{74},p.u	1.0071	1.0167	1.0476	1.0733	0.9713	Q_{C-82},p.u	7.4406	0.0965	17.49	19.4270	16.454
V_{76},p.u	0.9955	0.9972	1.0211	1.0302	0.9602	Q_{C-83},p.u	7.0206	0.0263	4.28	6.9824	9.6325
V_{77},p.u	1.0169	1.0071	1.0187	1.0275	1.0781	Q_{C-105},p.u	7.4342	0.0442	12.04	9.0291	8.9513
V_{80},p.u	1.0238	1.0066	1.0462	0.9857	1.0788	Q_{C-107},p.u	7.1210	0.0085	2.26	4.9926	5.0426
V_{85},p.u	1.0186	0.9893	1.0491	0.9836	0.9568	Q_{C-110},p.u	8.9172	0.0144	2.94	2.2086	5.5319
V_{87},p.u	0.9995	0.9693	1.0426	1.0882	0.9642	P_{loss},MW	**123.89**	126.99	127.76	130.96	131.99
V_{89},p.u	1.0314	1.0527	1.0955	0.9895	0.9748	TVD,p.u	0.8990	1.1829	NR*	NR*	NR*
V_{90},p.u	1.0020	1.0290	1.0417	0.9905	1.0248	CPU,s	885.02	1152.32	1198.65	1472	1215

NR* means Not reported

Table IX Comparison of simulation results for IEEE - 118 bus test power system with TVD minimization objective(Case C2)

Variable	SBDE	OGSA[16]	Variable	SBDE	OGSA[16]	Variable	SBDE	OGSA[16]
Generator voltage						Transformer Tap		
V_{1},p.u	1.0033	1.0388	V_{65},p.u	0.9828	0.9724	T_{8}	1.0079	0.9841
V_{4},p.u	1.0159	0.9872	V_{66},p.u	1.0100	1.0020	T_{32}	1.0025	1.0377
V_{6},p.u	0.9980	0.9925	V_{69},p.u	0.9968	0.9827	T_{36}	1.0053	0.9573
V_{8},p.u	0.9800	0.9905	V_{70},p.u	1.0053	0.9997	T_{51}	0.9889	0.9952
V_{10},p.u	0.9998	0.9919	V_{72},p.u	0.9859	1.0123	T_{93}	0.9788	0.9622
V_{12},p.u	1.0053	1.0077	V_{73},p.u	1.0135	0.9960	T_{95}	1.0419	1.0320
V_{15},p.u	1.0018	1.0034	V_{74},p.u	1.0114	1.0232	T_{102}	1.0160	1.0137
V_{18},p.u	1.0024	0.9773	V_{76},p.u	1.0113	1.0015	T_{107}	1.0308	0.9795
V_{19},p.u	1.0178	1.0324	V_{77},p.u	1.0056	1.0124	T_{117}	0.9592	0.9985
V_{24},p.u	1.0053	1.0285	V_{80},p.u	1.0226	1.0226	Capacitor banks		

V_{25},p.u	0.9991	0.9705	V_{85},p.u	1.0060	1.0117	Q_{C-5},p.u	7.9251	-0.2403
V_{26},p.u	0.9734	1.0175	V_{87},p.u	1.0142	1.0058	Q_{C-34},p.u	9.0933	0.0371
V_{27},p.u	1.0101	1.0117	V_{89},p.u	1.0103	1.0076	Q_{C-37},p.u	8.0202	-0.0437
V_{31},p.u	1.0016	1.0014	V_{90},p.u	0.9787	0.9753	Q_{C-44},p.u	8.4524	0.0375
V_{32},p.u	1.0011	0.9988	V_{91},p.u	0.9986	0.9836	Q_{C-45},p.u	7.1315	0.0400
V_{34},p.u	1.0068	1.0158	V_{92},p.u	1.0151	1.0272	Q_{C-46},p.u	6.9449	0.0749
V_{36},p.u	0.9999	0.9916	V_{99},p.u	0.9856	0.9612	Q_{C-48},p.u	7.4755	0.0796
V_{40},p.u	1.0092	1.0132	V_{100},p.u	1.0154	1.0032	Q_{C-74},p.u	7.8995	0.0883
V_{42},p.u	0.9974	0.9892	V_{103},p.u	1.0095	0.9843	Q_{C-79},p.u	8.6257	0.1218
V_{46},p.u	1.0311	1.0607	V_{104},p.u	0.9908	0.9880	Q_{C-82},p.u	8.9486	0.0380
V_{49},p.u	1.0077	1.0031	V_{105},p.u	0.9999	1.0003	Q_{C-83}.p.u	7.4944	0.0627
V_{54},p.u	1.0234	1.0236	V_{107},p.u	1.0104	1.0033	Q_{C-105},p.u	8.2667	0.0459
V_{55},p.u	1.0085	1.0176	V_{110},p.u	1.0034	1.0040	Q_{C-107},p.u	8.8299	0.0830
V_{56},p.u	1.0103	1.0149	V_{111},p.u	1.0165	1.0331	Q_{C-110},p.u	7.2219	0.0221
V_{59},p.u	0.9930	1.0584	V_{112},p.u	0.9930	0.9877	P_{loss},MW	160.77	157.72
V_{61},p.u	1.0029	0.9829	V_{113},p.u	1.0161	0.9705	TVD,p.u	**0.3059**	0.3666
V_{62},p.u	1.0005	1.0562	V_{116},p.u	0.9996	1.0270	CPU,s	**838.13**	1121.17

Table X Simulation results for case D1 and D 2

Variable	CaseD1 (SBDE)	CaseD2 (SBDE)
Generator Voltage		
V_1,p.u	1.0185	1.0011
V_4,p.u	1.0195	1.0062
V_6,p.u	1.0294	1.0078
V_8,p.u	1.0421	0.9865
V_{10},p.u	1.0338	0.9963
V_{12},p.u	1.0203	1.0102
V_{15},p.u	0.9933	1.0071
V_{18},p.u	0.9986	0.9851
V_{19},p.u	0.9861	1.0109
V_{24},p.u	1.0169	1.0141
V_{32},p.u	0.9971	0.9992
V_{34},p.u	0.9923	0.9985
V_{36},p.u	0.9875	1.0019
V_{40},p.u	0.9953	1.0144
V_{42},p.u	0.9942	1.0108
V_{46},p.u	0.9879	1.0451
V_{49},p.u	1.0206	1.0223
V_{54},p.u	0.9737	1.0296
V_{55},p.u	0.9756	1.0156
V_{56},p.u	0.9731	1.0203
V_{66},p.u	1.0318	1.0222
V_{69},p.u	1.0598	1.0505
V_{70},p.u	1.0140	0.9967
V_{72},p.u	1.0079	1.0058
V_{73},p.u	0.9968	1.0050
V_{74},p.u	1.0074	1.0201
V_{76},p.u	0.9848	1.0084
V_{77},p.u	1.0061	1.0055
V_{80},p.u	1.0249	1.0315
V_{85},p.u	1.0229	1.0092
V_{25},p.u	1.0126	1.0042
V_{26},p.u	1.0533	1.0035
V_{27},p.u	1.0052	1.0125
V_{31},p.u	1.0134	0.9917
V_{59},p.u	1.0049	1.0335
V_{61},p.u	1.0012	1.0086

V_{62},p.u	0.9867	0.9950
V_{65},p.u	1.0560	0.9910
V_{87},p.u	1.0323	1.0312
V_{89},p.u	1.0548	1.0228
V_{90},p.u	1.0297	0.9858
V_{91},p.u	1.0193	1.0042
V_{92},p.u	1.0202	1.0154
V_{99},p.u	1.0089	1.0154
V_{100},p.u	1.0168	1.0184
V_{103},p.u	1.0138	0.9990
V_{104},p.u	1.0238	1.0054
V_{105},p.u	1.0122	1.0007
V_{107},p.u	0.9956	1.0595
V_{110},p.u	1.0102	1.0049
V_{111},p.u	0.9900	1.0121
V_{112},p.u	0.9960	0.9798
V_{113},p.u	1.0076	1.0128
V_{116},p.u	1.0551	0.9973
Transformer Tap		
T_8	1.0137	0.9520
T_{32}	1.0229	1.0053
T_{36}	1.0002	1.0233
T_{51}	1.0777	1.0176
T_{93}	1.0453	0.9520
T_{95}	1.0327	1.0518
T_{102}	0.9687	0.9787
T_{107}	0.9008	1.0083
T_{117}	0.9949	0.9561
Capacitor banks		
Q_{C-5},p.u	6.8727	6.9909
Q_{C-34},p.u	8.3476	8.6539
Q_{C-37},p.u	7.2743	7.5771
Q_{C-44},p.u	7.8486	8.2375
Q_{C-45},p.u	6.9064	7.4200
Q_{C-46},p.u	6.3055	6.4317
Q_{C-48},p.u	6.1935	7.6498
Q_{C-74},p.u	8.8791	6.7949
Q_{C-79},p.u	8.9278	8.4426
Q_{C-82},p.u	6.7530	9.1108
Q_{C-83}.p.u	6.7879	7.7867
Q_{C-105},p.u	8.0907	7.2426
Q_{C-107},p.u	7.6151	7.5487
Q_{C-110},p.u	9.0950	7.3381
P_{loss},MW	**310.98**	160.77
TVD,p.u	1.1966	**1.0239**
CPU,s	877.02	853.56

6.3.2 Case D2: Minimization Of Total Voltage Deviations(TVD)

The results obtained from the proposed SBDE method for optimal settings of the control variables are given in the of Table X. The total voltage deviations are decreased from base case value of 1.7209 to **1.0239** with stressed condition. The convergence characteristic is shown in Fig.9.

Conclusion

In this paper, a novel Self-Balanced Differential Evolution algorithm for solving the reactive power dispatch problem is proposed. The new method makes the parameters F and C of DE become self-adaptive based on the previous fitness value. Two different objective functions such as minimization of real power loss (P_{Loss}) and minimization of total voltage deviation (TVD) were considered under normal and stressed conditions. The proposed approach has been evaluated on the standard IEEE 57 and IEEE 118 bus test systems under different cases. The results were compared with the results reported in the literature. **The comparison confirms the effectiveness and the solution quality of the proposed approach. SBDE is superior in performance for larger power systems like IEEE 57 and IEEE 118 is proven by the shown results. It is also suitable for solving multi objective problems.**

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