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COMPARISON OF BACTERIAL FORAGING OPTIMIZATION AND ARTIFICIAL BEE COLONY OPTIMIZATION TECHNIQUE FOR DISTRIBUTED GENERATION SIZING AND PLACEMENT IN AN ELECTRICAL DISTRIBUTION SYSTEM

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ABSTRACT

Integration of Distributed Generation (DG) in an electrical distribution system has increased recently due to voltage improvement, line loss reduction, environmental advantages, and postponement of system upgrading, and increasing reliability. Improper location and capacity of DG may affect the voltage stability on the Distribution System (DS). Optimization techniques are tools used to predict size and locate the DG units in the system, so as to utilize these units optimally within certain limits and constraints. The DG units' sizing and placement is formulated using mixed-integer nonlinear programming, with an objective function of improving the system stability margin; the constraints are the system voltage profile, feeders' capacity, power factor and the DG penetration level. In this paper the optimal sizing and DG placement in distribution systems is presented using Bacterial Foraging Optimization (BFO) and compared with Artificial Bee Colony Optimization (ABCO) algorithm. Two scenarios of DG are considered with some test cases indicate that BFO method can obtain better results than the BCO search method on the 69-bus radial distribution systems.

KEYWORDS: Distributed generation, electrical distribution system, artificial bee colony optimization (ABCO) algorithm and bacterial foraging optimization (BFO) technique.

INTRODUCTION

NOMENCLATURE

$S_{Load,k}$	Apparent load power at bus k
$S_{system\ j,k}$	System apparent power flows from bus j to bus k
$S_{system\ k,,j}$	System apparent power flows from bus k to bus j
$S_{rated\ j,k}$	Apparent rated power flows from bus j to bus k
$S_{rated\ k,,j}$	Apparent rated power flows from bus k to bus j
$S_{system,k}$	Apparent load power at bus k
P_j	Active power flows from bus j to bus k
Q_j	Reactive power flows from bus j to bus k
N	Number of buses
V_j	Bus voltage at bus j
V_k	Bus voltage at bus k
AP_k	Active power injected bus k
RP_k	reactive power injected bus k
L_j	Load demand at bus j
$S_{j,k}^{sys}$	System apparent power flows from bus j to bus k
V_{max}^{spec}	Maximum specified allowable voltage
P_{DGj}	Dispatchable DG rated active power at bus j
Q_{DGj}	Dispatchable DG rated reactive power at bus j
r_k	Line resistance connecting buses j and k
x_k	Line reactance connecting buses j and k

k	j+1
μ_p	Real power multiplier when there is no real power source set active power multiplier to 0 or when there is real power source set to 1
μ_q	Reactive power multiplier when there is no real power source set active power multiplier to 0 or when there is real power source set to 1
S_{max}^{DG}	Maximum DG unit size in KVA
S_{min}^{DG}	Minimum DG–unit size in KVA
$p.f_{max}^{DG}$	Maximum DG unit's working power factor
$p.f_{min}^{DG}$	Minimum DG unit's working power factor

INTRODUCTION

At present various types of Distributed Generation (DG) are becoming available and it is expected that is will rapidly grow in the future years. DG is defined as the application of small generators, scattered throughout a distribution system, to provide the electric energy needed by end customers. Such DG has several competences from the point of view location limitations and environmental restriction, as well as voltage stability in the distribution system [1]. The optimal placement and sizing of generation units on the distribution network has been continuously studied in order to achieve different aims [2]. The objective can be the minimization of the active losses of the feeder [3] or the minimization of the total network supply costs, which includes generators operation and losses compensation [4] or even the best utilization of the available generation capacity [5].

Integration of DG with Distribution System (DS) offers several technical and economical benefits to utilities as well as to customers [4]–[17]. However, mere inclusion of DGs may not guarantee the improvement in system performance. Depending on the size, location and penetration level, DG may have negative impacts on the performance of distribution network [4]–[8]. Hence, a proper allocation of DG units in the distribution system plays a crucial role.

For DG placement in the DS, various issues, such as reduction of system line loss [6]–[15], improvement in system voltage profile [4], [13], reduction of harmonic pollution [13], maximization of DG capacity [16], minimization of investment [17], [18] etc., have been aimed at by researchers in their single or multi-objective problem formulations. Different optimization techniques, such as Primal-Dual Interior-Point method [6], mixed integer nonlinear programming [7], [8], evolutionary programming (EP) technique [9], analytical approach [10]–[12], trade-off method [13], [14], Hereford Ranch algorithm [12], linear programming technique [16], genetic algorithm (GA) technique [17], heuristic approaches [15], Classical Second Order method [19], Tabu Search approach [10], and Decision Theory approach [21] have been exploited to solve the optimization problems for DG placement.

The presence of DGs in distribution networks can reduce line losses, increasing the durability of equipment, improving power quality, total harmony distortion networks and voltage stability by making changes in the path through which power passes. Among these the size and location of DGs are important factors. In this study the effect of location and capacity on increasing steady state voltage stability in radial distribution systems are examined through BFO and finally the results are compared to ABCO on the terms of line losses, voltage profile and power factor.

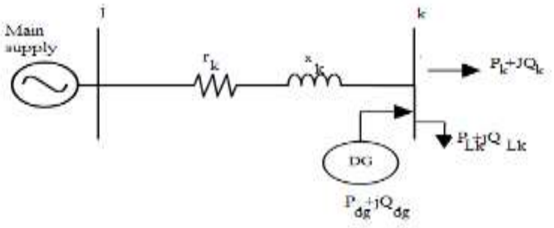

Fig: 1: Sample two-bus system with DG

The organization of this paper is as follows. Section II addresses the problem formulation. Section III addresses the BFO implementation on DS. Pseudo code for a BFO computation procedure for the problem is given in Section IV. Simulation result on the test systems are illustrated in Section V. Then, the conclusion is given in Section VI.

PROBLEM FORMULATION

The problem of DG application can be interpreted as determining the optimal placement and size of the DG to satisfy the desired objective function subject to equality and inequality constraints. Based on that the load flow algorithm used in [13] is applied in this paper. In Fig.1, a sample two bus system including DG-unit is considered. The mathematical formulations of the mixed integer nonlinear optimization problem for the DG-unit application are as follows: [12]

The objective function is to reduce the real power loss

$$Obj.Fun = \min \left(\sum_{j=0}^{n} \frac{P_j^2+Q_j^2}{V_j^2} \right) * r_k \quad \text{----------} \ (1)$$

The equality constraints are the three nonlinear recursive power-flow equations describing the system [10]

$$P_j - r_k \frac{(P_j^2+Q_j^2)}{V_j^2} - P_{L\,k} + \mu_P A\, P_k - P_k = 0 \quad \text{------------} \ (2)$$

$$Q_j - x_k \frac{(P_j^2+Q_j^2)}{V_j^2} - Q_{L\,k} + \mu_q R\, P_k - Q_k = 0 \quad \text{----------} \ (3)$$

$$V_k^2 = V_j^2 - 2(r_k P_j + x_k Q_i) + \frac{(r_k^2+x_k^2)(P_j^2+Q_j^2)}{V_j^2} \quad \text{-----------} \ (4)$$

Where i=0, 1, 2…... n

The inequality constraints are the system's voltage limits, that is, +5% or - 5% of the nominal voltage value

$$V_{min}^{spec} \leq V_j^{sys} \leq V_{max}^{spec} \quad \text{-------------------------------} \ (5)$$

In addition, the thermal capacity limits of the network's feeder lines are treated as inequality constraints

$$S_{j,k}^{sys} \leq S_{j,k}^{rated} \leq S_{k,j}^{sys} \quad \text{------------------------------} \ (6)$$

The discrete inequality constraints are the DG-unit's size (KVA) and power factor

$$S_{max}^{DG} \geq S_j^{DG} \geq S_{min}^{DG} \text{-------------------} \ (7)$$

$$p.f_{max}^{DG} \geq p.f_j^{DG} \geq p.f_{min}^{DG} \text{--------------} \ (8)$$

The power factors of DG are set to operate at practical values [14], that is, from unity to 0.85 towards the optimal result. The operating DG-unit's power factor whether lagging or leading must be dissimilar to the bus's load at which t he DG-unit is placed [15]. Consequently, the net total of both active and reactive powers of that bus where the DG-unit is placed will also decrease.

BACTERIAL FORAGING OPTIMIZATION IMPLEMENTATION

The BFO algorithm was first represented by Pasino in 2002. The idea in this method was adopted from biological and physical living behavior of *E. coli* bacteria existing in human intestine. This algorithm has three main processes namely Chemotaxis, Reproduction and Elimination fault Dispersal. These processes are introduced in this section [19].The *E. coli* bacterium has a plasma membrane, cell wall, and capsule that contains the cytoplasm and nucleoid.

When *E. coli* grows, it gets longer, and then divides in the middle into two "daughters." Given sufficient food and held at the temperature of the human gut of 37 ° C, *E. coli* can synthesize and replicate everything it needs to make a copy of itself in about 20 min; hence growth of a population of bacteria is exponential with a relatively short time to double. The *E. coli* bacterium has a guidance system that enables it to search for food and try to avoid noxious substances. The behavior of the *E. coli* bacterium, will be explained as its actuator (the flagellum), "decision making," sensors, and closed-loop behavior. This section is based on the work in [24, 25]. A simplified flowchart for proposed simplified BFO optimization is shown in figure 2.

(i) Chemotaxis: An *E. coli* bacterium can decide to move in two different ways depending on its environment. A bacterium is subject to change during its lifetime between the two ways of swimming (swim for a short time) and tumbling. In BFO, one moving unit length with random directions represents tumbling and one moving unit length with the same direction relative to the final stage represents swimming. The mathematical equation for

Chemotaxis is expressed as follows:

$$\theta^i(j+1,k,l) = \theta^i(j,k,l) + C(i)\frac{\Delta(i)}{\sqrt{\Delta^T(i)\Delta(i)}} \text{ ---} \qquad (9)$$

Where
θ^i : location of i^th bacterium
C(i) : movement length
Δ(i) : direction random vector
j : j^th chemotaxis
k : j^th reproduction
l : is representing j^th elimination and dispersal
N_C. : The number of chemotaxis

(ii) Reproduction: After the number of N_C Chemotaxis steps, reproduction step takes place. N_{re} represents the number of reproduction steps.

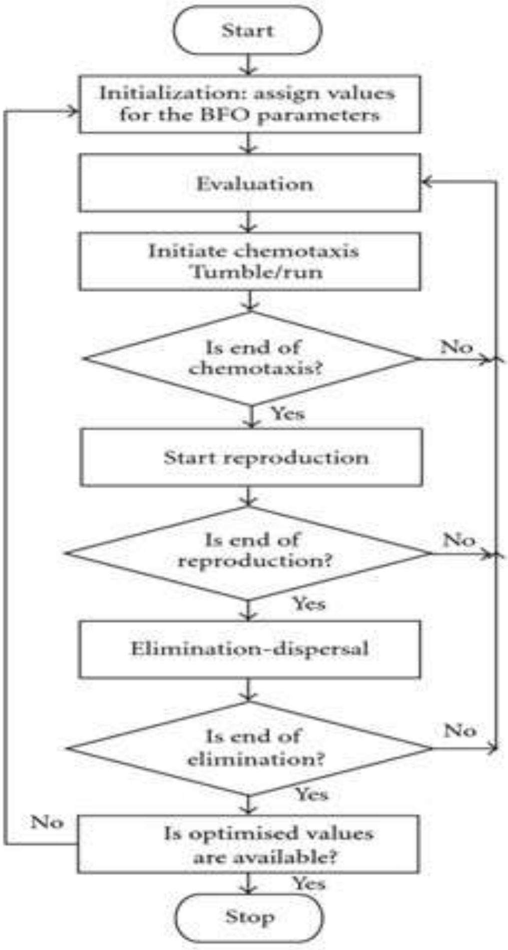

Fig 2.Proposed simplified BFO optimization flowchart

(iii) Elimination-Dispersal: The swimming process prepares the conditions for local search and reproduction process speeds up the convergence. In bacterial foraging, dispersion takes place after a definite number of reproduction processes. A bacterium is selected with regard to a prearranged probability of P_{ed} to be dispersed in the environment and moved to another position. These events can effectively prevent trapping in local optimal point. N_{ed} is the number of elimination and dispersal phenomenon and P_{ed} is defined for every bacterium with the probability of elimination and dispersal.

PSEUDO CODE FOR BFO ALGORITHM:

```
Step (1): Initialize the parameters,
        S: Total number of bacteria
             P: Number of parameters to be optimized
             $N_c$; Number of chemotactic steps
             $N_s$: Number of swarming,
             Nre: Number of reproduction steps
              Ned: elimination-dispersal steps
             $d_{attract}$, $w_{attract}$, $d_{repellant}$, $w_{repellant}$ :
             Attractant and repellant values
             $P_{ed}$ : Probability of elimination- dispersal
        C(i) : step size
step(2): Elimination-Dispersal loop $l = l + 1$
step(3): Reproduction loop $k = k + 1$
step(4): Chemotactics loop $j = j + 1$
step(5): Every bacterium $i = i + 1$
[a] Compute fitness function J(i,j,k,l)
 Let, $J(i, j, k, l) = J(i, j, k, l) + J_{cc}$
[b] Let, J (last) = J(i,j,k,l) to save this value.  we may find a better cost via a run.
[c] Tumble: Generate a random vector $\Delta(i)$ such
that $1 <= \Delta(i) <= -1$.
[d] Move: Let, $\theta^i(j+1,k,l) = \theta^i(j,k,l) + C(i)^* (\Delta(i) /$
$\surd(\Delta^T(i)^* \Delta(i)))$
[e] Compute J(i,j+1,k,l) and let, $J(i,j,k,l) = J(i,j,k,l)$
$+ J_{cc}$
[f] Swim: Let, m = 0.(counter for swim length)
(i) While m < Ns
(ii)Let, m = m+1
(iii) if $J(i,j+1,k,l) < J(i,j,k,l) = J(i,j,k,l) + J_{cc}$ then
Let, $J_{last} = J(i,j+1,k,l)$
$\theta^i(j+1,k,l) = \theta^i(j,k,l) + C(i)^* (\Delta(i) / \surd(\Delta^T(i)^* \Delta(i)))$
(iv) else, let m = Ns
[g] Go to next bacterium, if $i \neq S$
Step(6): if j < Nc, go to step(4)
Step(7): Reproduction:
[a] for the given k and l, and for each i = 1 to S,
(i) Let, $J_{health} = \sum^{i=1:Nc} J(i,j,k,l)$
(ii) Sort the fitness in ascending order
[b] The Sr bacteria with worse health value will
 die, the remaining Sr bacteria with best values
will split into two.
Step(8): if $k < N_{re}$, go to step(3)
Step(9): Elimination-Dispersal
 [a] for i = 1 to S, with probability $P_{ed}$,
eliminate and disperse each bacterium.
[b] if a bacterium eliminated, then add new one
to a random location on the search space.
Step (10): if $l < N_{ed}$, go to step (2), Else Terminate.
```

RESULTS

The proposed BFO algorithm is implemented in MATLAB programming, and was executed on an Intel dual core™ PC with 3.0-GHz speed and 4 GB RAM. To check the performance of the proposed BFO algorithm, the IEEE 69-bus radial distribution feeder system was considered in three test cases. In addition, the results of sample feeder systems were compared with ABCO. We studied two test cases. In both cases, the loads are identical to the values given in [11], ie. The total demands of the 69-bus system are 3802.19 kW and 2694.60 kVAR.

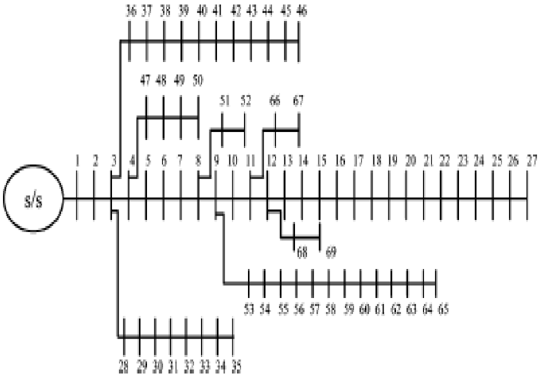

Fig. 3.Single-line diagram of the 69-bus feeder system

The single-line diagram of the IEEE 69-bus feeder system is shown in Fig. 3.The substation voltage and load power factors in both scenarios were considered as 1.0 p.u. and lagging p.f., respectively.

Power loss reduction analysis is based on the simple case of a IEEE 69 bus radial distribution feeder [4] is considered with following cases:
(I) System without DG
(II) System with one DG to share full load
(iii) System with two DGs to share full load

Case (I): System without DG

This is a reference scenario, in which no DG unit is connected to the system (base case).

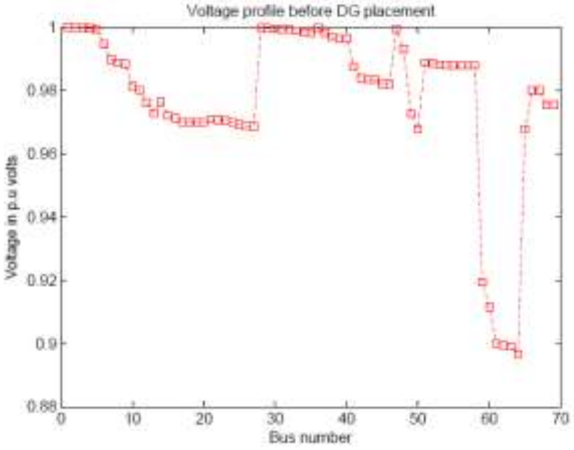

Fig .4: Voltage magnitude in p.u volts versus bus numbers before DG placement.

From figure 4, it is observed that from bus number 59 to 64 the voltages in p.u are 0.919, 0.912, 0.9, 0.9, 0.899 and 0.897 respectively. These voltages are the lowest among 69 buses.

Table1: Optimized results before DG placement

parameters	**values**
Real power (KW)	3892
Reactive power (KVAR)	2802
Active load (KW)	3802
Reactive load (KVAR)	2694
Total real power Loss (KW)	226
Total reactive power loss (KVAR)	202

Case 2: System with one DG to share full load using BFO

Fig .5 shows the fitness value versus chemotatic steps for one DG unit connected to share full load and Fig .6 shows the voltage magnitude in p.u volts versus bus numbers after one DG is placed using BFO. When comparing the voltage profile without DG from 59 to 64 buses, the improved voltages are presented using ABCO and BFO in Appendix 1.

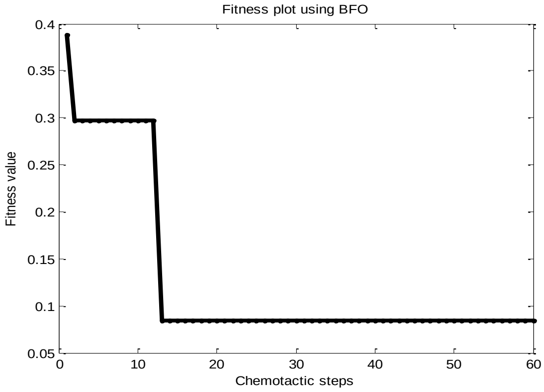

Fig .5: Fitness value versus chemotatic steps for one DG unit connected to share full load

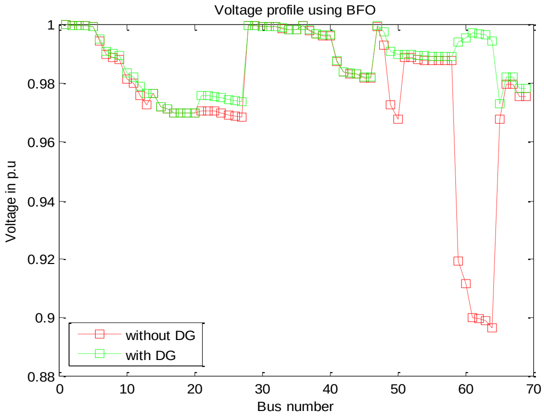

Fig .6: Voltage magnitude in p.u volts versus bus numbers after one DG is placed using BFO.

Table 2: Comparison between ABCO and BFO after one DG unit is connected to share full load

Particulars	**ABCO**	**BFO**
location of DG(bus no)	61	61
Value of DG (KVA)	1727.244	1734.8
Voltage (volts in p.u)	0.9977	0.9961
Angle (deg)	-0.3056	-0.1507

Power factor	0.9536	0.9886
Total power Loss (KW)	87.322	84.12
%Loss Reduction	61.36	62.78

Case 3: System with two DGs to share full load using ABCO and BFO
The parameters of power loss and other factors are presented in table 3.

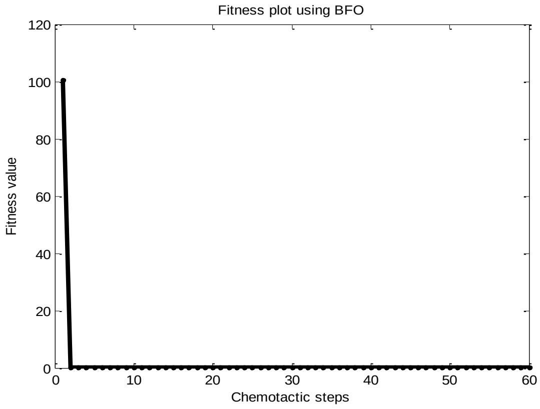

Fig .7: Fitness value versus chemotatic steps for one DG plus one capacitor unit connected with active power supply

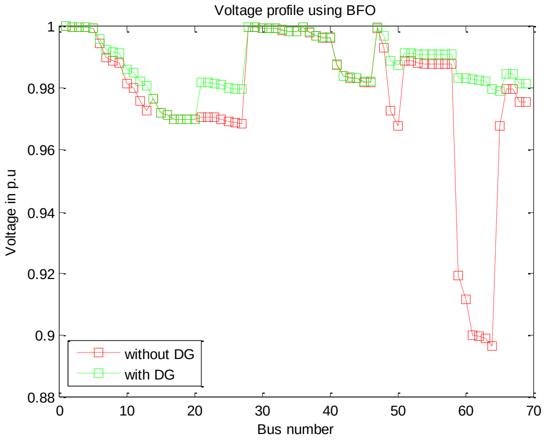

Figure.8: Voltage magnitude in p.u volts versus bus numbers after two DGs is placed using BFO.

Table 3: parameters after two DG units are connected to share full load

Particulars	**ABCO**	**BFO**
Placement of DG1 (Bus no)	21	61
Value of DG1 (KVA)	1858.6	1541.98
Placement of DG 2 (Bus no)	50	22
Value of DG 2 (KVA)	1256.7	764.5
Voltage at DG1 placed bus (p.u volts)	0.9847	0.9817
Angle at DG1 placed bus (degrees)	0.0416	0.1709
Power factor at DG1 placed bus	0.9991	0.9854
Voltage at DG2 placed bus (p.u volts)	0.9927	0.9800
Angle at DG2 placed bus (degrees)	-0.2195	0.3828

Power factor at DG2 placed bus	0.9759	0.9275
Total power Loss (kW)	91.279	90.90
%Loss Reduction	59.61	59.77

CONCLUSION

In this paper, a new population-based BFO has been implemented to solve the mixed integer nonlinear optimization problem. Simulations were conducted on the IEEE 69-bus radial distribution feeder systems. The proposed BFO algorithm successfully implemented the optimal solutions at two test cases. Among these two test cases BFO had the maximum power loss reductions as well as voltage improvements.

The BFO algorithm is simple, easy to implement, and capable of handling complex optimization problems. Further insight of the solution quality achieved by carrying out 30 independent runs for these test cases. Evidently, the BFO algorithm has excellent solution quality and convergence characteristics.

The efficiency of the proposed BFO algorithm is confirmed by the fact that the standard deviation of the results attained for 30 independent runs. Updating of the two parameters towards the most effective values has a higher probability of success than in other competing meta heuristic algorithms. The performance of the proposed BFO algorithm shows its superiority and the potential for solving complex power system problems in future.

Appendix: 1

Comparison between ABCO and BFO after one DG unit is connected to share full load

Bus No	**Voltage Magnitude**		**Power Factor**	
	BCO	**BFO**	**BCO**	**BFO**
1	1	1	0.9999995	0.9999995
2	0.99996392	0.99996306	0.99999828	0.99999833
3	0.99992784	0.99992612	0.99999633	0.99999647
4	0.99985997	0.99985567	0.99998708	0.99998775
5	0.99943659	0.99943229	0.99993731	0.99993879
6	0.99484730	0.99484298	0.99961581	0.99961212
7	0.99008334	0.99007900	0.99765982	0.99765071
8	0.98898246	0.98897811	0.99697482	0.99696446
9	0.98847496	0.98847061	0.99662859	0.99661765
10	0.98170275	0.98169837	0.97947944	0.97945236
11	0.98022067	0.98021629	0.973739	0.97370835
12	0.97621571	0.97621131	0.95472791	0.95468767
13	0.97304272	0.97303830	0.93608325	0.93603548
14	0.97655673	0.97655640	0.99538639	0.97617143
15	0.97214633	0.97214621	0.98136817	0.91361
16	0.97133217	0.97133209	0.98141116	0.99398859
17	0.97	0.97	0.96685730	0.90915488
18	0.96999645	0.96999657	0.98280685	0.99602673
19	0.96999241	0.96999241	0.99775805	0.99728856
20	0.96998981	0.96998981	0.98486785	0.95785267
21	0.97097813	0.97097370	0.94310654	0.94306145
22	0.97095673	0.97095230	0.94297610	0.94293097
23	0.97072331	0.97071888	0.94155143	0.94150574
24	0.97021525	0.97021082	0.93838937	0.93834247
25	0.96938393	0.96937950	0.93303946	0.93299057
26	0.96904102	0.96903658	0.93076707	0.93071738
27	0.96887970	0.96887526	0.92968483	0.92963475
28	0.99991676	0.99991504	0.99999516	0.99999532
29	0.99980182	0.99980010	0.99997349	0.99997388
30	0.99960759	0.99960587	0.9999925	0.99999270

31	0.99957331	0.99957159	0.99999465	0.99999482
32	0.99940194	0.99940022	0.99999996	0.99999997
33	0.99899110	0.99898938	0.99997663	0.99997627
34	0.99845307	0.99845135	0.99986836	0.99986750
35	0.99834496	0.99834324	0.99983918	0.99983823
36	0.99981828	0.99981657	0.99999571	0.99999586
37	0.99827461	0.99827299	0.99999071	0.99999093
38	0.99691443	0.99691289	0.99976109	0.99976005
39	0.99652186	0.99652034	0.99956697	0.99956561
40	0.99649933	0.99649791	0.99955339	0.99955194
41	0.98773821	0.98773722	0.97541137	0.97540627
42	0.98401896	0.98401819	0.95379503	0.95379114
43	0.98352813	0.98352739	0.95042065	0.95041704
44	0.98349364	0.98349290	0.94916703	0.94916348
45	0.98212138	0.98212073	0.94001392	0.94001130
46	0.98211021	0.98210956	0.93993390	0.93993129
47	0.99978950	0.99977918	0.99997164	0.99997396
48	0.99803687	0.99787707	0.99768133	0.99799928
49	0.99270697	0.99203731	0.96820661	0.97307788
50	0.99207149	0.99125757	0.96278945	0.96916718
51	0.98892625	0.98892190	0.99693871	0.99692828
52	0.98891113	0.98890678	0.99691598	0.99690552
53	0.98834296	0.98833861	0.99652889	0.99651779
54	0.98820154	0.98819719	0.99642373	0.99641246
55	0.98810733	0.98810297	0.99635321	0.99634183
56	0.98810733	0.98810297	0.99635321	0.99634183
57	0.98810733	0.98810297	0.99635321	0.99634183
58	0.98810733	0.98810297	0.99635321	0.99634183
59	**0.99122777**	**0.99382637**	**0.96055960**	**0.98616475**
60	**0.99225772**	**0.99480017**	**0.95591731**	**0.98629732**
61	**0.99575889**	**0.99614996**	**0.95358011**	**0.98865870**
62	**0.99741315**	**0.99580365**	**0.95447269**	**0.98910298**
63	**0.99496205**	**0.99535182**	**0.95562351**	**0.98966886**
64	**0.99475128**	**0.99513746**	**0.96105792**	**0.99222634**
65	0.96805329	0.96804885	0.92684500	0.92679393
66	0.98013056	0.98012182	0.97332579	0.97329490
67	0.98012952	0.98012513	0.97332088	0.97328999
68	0.97569112	0.97568672	0.95184096	0.95179946
69	0.97568945	0.97568504	0.95183188	0.951790378

Appendix: 2
Comparison between ABCO and BFO after two DG units is connected to share full load.

BUS No	**Voltage Magnitude**		**Power Factor**	
	BCO	**BFO**	**BCO**	**BFO**
1	1	1	0.9999995	0.9999995
2	0.999958	0.9999639	0.9999982	0.99999799
3	0.999917	0.9999279	0.9999963	0.99999547
4	0.999834	0.9998602	0.9999869	0.99998298

5	0.999456	0.9995767	0.9999108	0.99982646
6	0.995166	0.9588621	0.9999804	0.99693274
7	0.990713	0.9920588	0.9999994	0.99004936
8	0.989688	0.9911847	0.9999974	0.98770194
9	0.989220	0.9907981	0.9999975	0.98623070
10	0.982886	0.9853387	0.9987610	0.96345679
11	0.981504	0.9841565	0.9982216	0.95638465
12	0.977874	0.9812853	0.9977182	0.91211432
13	0.975237	0.9797482	0.9995144	0.99992406
14	0.976554	0.9765567	0.9999466	0.99148028
15	0.972145	0.9721463	0.8924218	0.91797006
16	0.971331	0.9713321	0.9959030	0.90871017
17		0.97	0.9871684	0.99467080
18	0.969996	0.9699964	0.9924517	0.97393673
19	0.969992	0.9699924	0.9932227	0.97778990
20	0.968981	0.9699898	0.9527308	0.94808115
21	0.973954	0.9800894	0.9993933	0.95889514
22	0.973940	0.9800902	0.9993620	0.92759742
23	0.973789	0.9798590	0.9989412	0.97078682
24	0.973460	0.9793557	0.9975837	0.95932318
25	0.973016	0.9785322	0.9925868	0.94279859
26	0.972675	0.9781925	0.9933234	0.99093467
27	0.972514	0.9780326	0.9936568	0.99942197
28	0.999906	0.9999168	0.9999951	0.99999418
29	0.999791	0.9998019	0.9999734	0.99997126
30	0.999597	0.9990769	0.9999247	0.99999129
31	0.999563	0.9995734	0.9999946	0.99999362

32	0.999391	0.9994020	0.9999999	0.99999984
33	0.998980	0.9989912	0.9999766	0.99997864
34	0.998442	0.9984531	0.9998684	0.99987320
35	0.998334	0.9983450	0.9998393	0.99984453
36	0.999808	0.9998183	0.9999956	0.99999479
37	0.998264	0.9982747	0.9999906	0.99998937
38	0.996905	0.9969145	0.9997619	0.99967618
39	0.996512	0.9965219	0.9995683	0.99957578
40	0.996490	0.9964995	0.9995547	0.99956227
41	0.987732	0.9877382	0.9754523	0.97547724
42	0.984014	0.9840190	0.9538690	0.95388467
43	0.983523	0.9835281	0.9504997	0.95051340
44	0.983489	0.9834936	0.9492477	0.94926092
45	0.982117	0.9821214	0.9401086	0.94011559
46	0.982106	0.9821102	0.9400287	0.94003564
47	0.999715	0.9997505	0.9999732	0.99996437
48	0.996754	0.9970245	0.9980790	0.99734891
49	0.987311	0.9883823	0.9742792	0.96338718
50	0.985513	0.9868116	0.9707564	0.95646911
51	0.989631	0.9911286	0.9999963	0.98777396
52	0.989616	0.9911135	0.9999955	0.98781893
53	0.989088	0.9906665	0.9999941	0.98642855
54	0.988947	0.9905254	0.9999890	0.98663268
55	0.988853	0.9904314	0.9999848	0.98676705
56	0.988853	0.9904314	0.9999848	0.98676059
57	0.988853	0.9904314	0.9999848	0.98676705
58	0.988853	0.9904314	0.9999848	0.98676759

59	**0.980454**	**0.9823534**	**0.9678392**	**0.99937542**
60	**0.980300**	**0.9822159**	**0.9419345**	**0.99568800**
61	**0.979718**	**0.9817821**	**0.8947905**	**0.98542472**
62	**0.979366**	**0.9814307**	**0.8934071**	**0.98489683**
63	**0.978906**	**0.9809722**	**0.8915910**	**0.98419468**
64	**0.976654**	**0.9787253**	**0.8824757**	**0.98052247**
65	0.971691	0.9772140	0.9944805	0.96419932
66	0.981414	0.9840667	0.9981125	0.95690702
67	0.981413	0.9840657	0.9981112	0.95691319
68	0.977350	0.9807634	0.9970298	0.91595130
69	0.977348	0.9807618	0.9970275	0.91596306

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