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Implement the Harmonic Search Algorithm with Optimum Location of Capacitors Sizing and Dispatchable DGs to Control the Reactive Power on Interconnected Bus System

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ABSTRACT

Power system is combination of generation, transmission and Distribution Network. In modern trends power system operation is very-difficulty due to energy storage elements, and variable inductive load. In power system, control the reactive power is essential to maintain the safe and more reliability of power system operation. In this paper, to organize the real power and reactive power by optimizing and sizing of capacitors and Dispatchable-Distribution generators in a distribution network with help of Harmonic Search Algorithm. The constraints of power system like voltage, real power and reactive and branch current carrying capacity are included in the evaluation of the objective function. To validate planned development network an IEEE 30 bus investigation system is considered.

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1. INTRODUCTION

In power system, the electrical power transfer from generation station to Distribution side through transmission line. But practically 100% power not transfer from generating station to distribution side due to inductive reactance. Some power stored in energy storage elements like inductance and capacitance effect of system. This power is known as storage power or reactive power. The inductive storage power controlled by using shunt capacitors, FACT devices like SVC, STATCOM and power electronic devices and Dispatchable Distribution Generators etc., The placing of capacitors are depends on the requirement of inductive reactive power which is a benefit to the system. But practically load is not constant on power system then always changes the reactive power on system.

Anwar.S.Siddique, MD.Farrukhrahman[1] planned finest position of capacitors assignment on 10 bus radial distribution System by Using Fuzzy logic based technique to improve the voltage regulation and diminishing of energy loss. But drawback of Fuzzy system is very complex curse of dimensionality makes virtually impracticable in put into practice to set up a rule base with more than three inputs. M.Suneetha, R.SrinivasaRao[2] projected a scheme of inductive reactive power organized by best sizing of capacitors with the help of Particle swarm optimization on IEEE 30 bus system. G.V.K.Murthy, S.Sivanagaraju3 intended to reduce the active power loss, voltage sag index improvement and total harmonic distortion by insertion the finest achievable sizing of DG unit with facilitate of Artificial Bee Colony (ABC) algorithm.

K.Ravindra, R.Srinivasa Rao4 initiate a novel scheme for progress the profile of voltage on radial system, reconfiguration of the system by optimal locations for installation and 33-bus optimal locations for installation of DG units with help of Harmony Search algorithm on 69 bus and 33-bus Radial Distribution system. Duong Quoc Hung, N.Mithulananthan, Kwang Y.Lee5 presents a approach for minimize the energy losses per year by grouping of Dispatchable and non Dispatchable renewable distributed generation units. They conclude that maximum energy losses reduced by grouping of Dispatchable and non-Dispatchable DG units are better than non Dispatchable DG units on the distribution system.

T.D.Sudhakar, A.Vinoliyan6 focuses on power losses of overall system power by using optimum sizing of DG generators with facilitate of Big Bang Big Crunch algorithm on 33-bus distribution network and forward sweeper load flow method was used. Big Bang Big Crunch algorithm has elevated convergence speed and less computational time. Lucian loan Dulac, Mihali Abrudean and Dorn Bica7 describes to reduce the power losses distribution side of power system by using most favorable place of 2.3 MW distributed generator in IEEE 14 Bus system with help of Neplan Software and used Newton Raphson extensivemethod.

S.Chandrasakhar, P.V.N.Prasad, and J.Laxmi8 presents to pick up the power quality on distribution side and recover the profile of voltage, at same time reduce the power losses by using best possible sizing of DGs with help of PSO on IEEE 30 bus system. Rashmi Priya, Surya Prakash9 projected decrease the losses of power by using most select distributed generation position in 16 bus distribution system with help of Genetic Algorithm and MATLAB software. The Position of DGs are also depends upon the time changeable loading circumstances and current situation of losses. GA advantage is they need no information concerning the response surface; they are opposed to flattering attentive in restricted optima and solve optimization troubles in power system.

In power system, load is not constant load in 24 hours. Depends upon load every time changes reactive power and real power losses. In order to reduce power losses, capacitors and dispatchable DG have to be installed. From reference papers observed that to reduce power losses at change of load, different DGs have to be installed in increases unit price cost. But in order to reduce unit price cost by installing capacitors with DG based upon the present situation of load. In this paper proposed to reduce the power losses and improve the profile of voltage by optimum sizing of DG units with help of HSA algorithm on 69 bus with help of Harmonic Search Algorithm and MATLAB.

2. PROBLEM FORMULATION

The Distribution system in general contains many number of buses, with each bus having number of parameters like bus voltage, current, impedance, real power and reactive power and power factor individually. The propose work to validate as taken IEEE 30 bus system as shown in Figure 1.

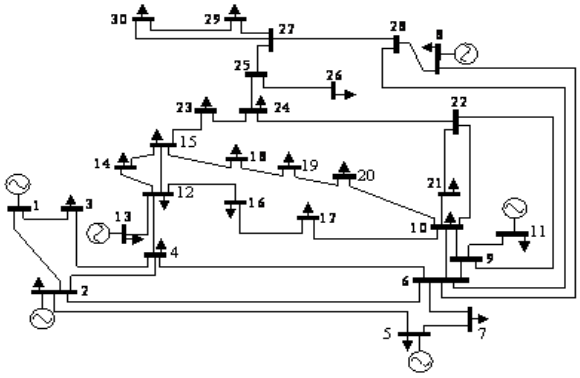

Figure 1. IEEE 30 bus system

Generally reactive power in the system have to be controlled according to the load demand and satisfying the following Equality and un equality constraints. The Equality constraints like balance equations of real and reactive power of all buses without slack bus as shown in (1-2). In Figure 2 is feeder line.

$$Pg_j - Pd_j - v_i(g_{ij} \cos\theta_{ij} + Bij \sin\theta_{ij}) = 0 \quad (1)$$

$$Q_g i - Q_{di} - v_i \Sigma_{j \in N} v_j(g_{ij} \sin\theta_{ij} + B_{ij} \cos\theta_{ij} = 0 \quad (2)$$

Constraints of in equality are given below. On generator side, limits of reactive power is $Q_{gi}^{min} \leq Q_{gi} \leq Q_{gi}^{max}$, i€N. Magnitude of voltage limits for each bus $V_i^{min} \leq V_i \leq V_i^{max}$, i€N. The problem of proposed network can be formulated to solve the function of fitness as shown in (3-5).

$$P_{i+1} = P_i - P - L_{i+1} - PLossi$$
$$= P_i - \left(\frac{R_i}{|V_i^2|}\right)\{P_i^2 + (Q_i + Y_i|V_i|2)2\} - P_{Lk+1} \quad (3)$$

$$Q_{i+1} = Q_i - Q_{Li+1} - QLossi$$
$$= Q_i - \frac{X_i}{|V_i^2|}\{P_i^2 + (Q_i + Y_{i1}|Vi|^2)^2\} - Y_{i1}|V_i|^2 \quad (4)$$

$$|V_{i+1}|^2 = V_i|^2 - 2(R_iP_i + X_iQ_i) + \frac{R_i^2 + Q_i^2}{|V_i^2|}(P_i^2 + Q_i^2 \text{ of shunt capacitors and DG on distribution side}$$
$$= \left|V_k^2 + \frac{R_i^2 + X_i^2}{|V_i^2|}(P_i^2 + Q_i + Y_i|V_i|^2)^2 - 2(R_iP_i + X_i(Q_i + Y_i \left|V_i^2\right|)\right) \quad (5)$$

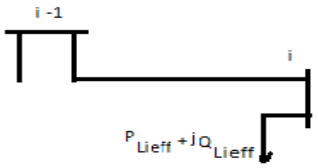

Figure 2. Feeder line

Compute power losses of line between i and i+1 as shown in (6), total power loss of feeder as shown in (7) and DG and capacitor installation on bus of distribution system as shown in Figure 3.

$$P_{Loss}(i, i+1) = \frac{R_i(P_i^2 + Q_i^2)}{|V_i^2|} \quad (6)$$

$$P_{Tloss} = \sum_{i=1}^{n} P_{loss\,(i,i+1)} \quad (7)$$

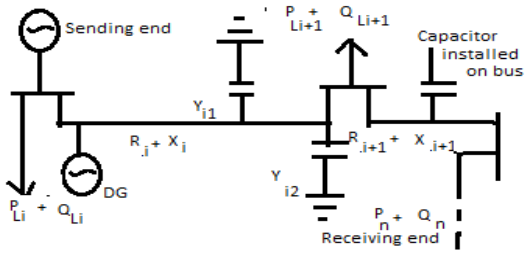

Figure 3. DG and capacitor installation on bus of distribution system

After installation of capacitors and DG on buses, more benefits such as power factor improvement, improving current carrying capacity and getting system more reliability and more efficiency and minimizing power losses as shown in (8-9).

$$P_{capacitorloss} = \frac{R_i}{V_i^2}(P_i^2 + Q_i^2) + \frac{R_i}{V_i^2}(P_G^2 + Q_G^2 - 2P_iP_G - 2Q_iQ_G)\left(\frac{G}{L}\right) \quad (8)$$

$$P_{loss}^{DG} = \frac{Rj}{V_j^2}(P_G^2 + Q_G^2) + \frac{R_j}{V_j^2}\left(P_G^2 + Q_G^2 - 2P_jP_G - 2Q_jQ_G\right)\left(\frac{G}{L}\right) \quad (9)$$

Net reduction power loss as shown in (10)

$$\Delta P_{loss}=\frac{R_i}{V_i^2}(P_G^2+Q_G^2-2P_iP_G+2Q_iQ_G)(\frac{G}{L}) \quad (10)$$

If $\Delta Power\ loss$ has positive sign than reduce the system losses with installation of DG other wise negative sign appears than high system losses maintain. The intention of the objective function of the problem is maximize the reduction of power losses in the system and satisfy the constraints as shown in (11).

$$\text{Maximize g} = \max(\Delta P_{\text{losses}}^{\text{capacitor}} + \Delta P_{\text{loss}}^{\text{DG}}) \quad (11)$$

The installation of capacitors and DG is depend upon the sensitivity analysis as shown in (12).

$$P_{\text{Lieff}} = \frac{(P_{\text{Lieff}}^2+Q_{\text{Lieff}}^2)R_i}{V_i^2} \quad (12)$$

Obtain the loss sensitivity factor as shown in (13)

$$\frac{\partial P_{\text{line loss}}}{\partial P_{\text{Lieff}}} = \frac{2P_{\text{Lieff}}R_i}{V_i^2} \quad (13)$$

The installation of DG is based on LSFs.

3. HARMONIC SEARCH ALGORITHM

Harmonic search algorithm is primary intended by Geemet al in 2001. It has been functional to solve method of Harmony Search is provoked by the innovative main elites of the harmony in musical group of organization. The Best Harmony in nature particular correction between more than a few sound that have different frequencies. For example melody band improve rehearsal after preparation, when ever get pleasarable music then it is final harmony. The term harmony in music refers to the sound result caused from two or more instruments (popular decision variables) that plays a same time. Harmony evaluate the communication between two or more sound waves and their communication.

The new algorithm was enthused by the managing process that a accomplished musician follows when he is performance in a music band the following choice: First to play renowned apparently, every member of the band known the subject and can play it by heart i.e a pleasant music (solution of optimal problem). The function of fitness is determined by following steps in Harmonic search algorithm:

Step1: To set the problem, give parameters of algorithm and Specify the objective function. Initiate the algorithm parameters of HAS are Harmonic Memory(HM), Maximum iterations, maximum, Pitch adjustable rate(PAR), Harmony memory size(HMS) and stopping criterion NI and set of decision variables x_1, x_2, x_3,……x_n, where x have to be maintain within proper range ximin≤xi≤ximax. Number of set of decision variables represented as N, it is decided the HM matrix range harmony memory is store the all set of decision variable. Pitch adjustable rate and Harmony memory considering rate are used to develop the solution vector.

Step2: To set the Harmony memory size this filled with decision variables.

$$\text{HM matrix} = \begin{bmatrix} x_1^1 & x_2^1 \ldots\ldots & x_N^1 \\ \vdots & \vdots & \vdots \\ x_1^{HMS-1} & x_2^{HMS-1} \ldots\ldots & x_N^{HMS-1} \\ x_1^{HMS} & x_2^{HMS} \ldots\ldots & x_N^{HMS} \end{bmatrix}$$

Step 3: New harmony have to be improvised. Determine the new harmony with help of

a. Pitch adjustable rate
b. Harmony memory
c. selection of variables randomly

Case(i): if random possible range values less than HMCR, the New harmony as taken from HM matrix other wise it worst harmony will be replaced by New harmony.

Case(ii): If HMCR is 0.75 indicates New harmony choose from old values which contain harmony memory with 75% probability otherwise 25% probability of new harmony generated by adjust the pitch adjustable rate and random selection variables. If random selection variables is maintain less than pitch adjustable rate then new harmony is given below:

xi1=old value xi ±random selection variables.

Otherwise xi1=xi

Case(iii): Suppose HMCR 0 and 1, then new harmony chosen from old values of Harmony memory range between 0 and 1 is taken as decision variables band width.

Step 4: Modernize the Harmony Memory If fitness of New Harmony x1 is better than old values in Harmony Memory than new harmony as taken in Harmony memory along with that worst old harmony which is presented in HM will be taken out.

Step 5: if reached optimum value New Harmony then Harmony Search algorithm is terminated otherwise repeat step 5 and 6.

4. PRACTICAL IMPLEMENTATION OF HAS ALGORITHM FOR MINIMIZING POWER LOSSES IN IEEE BUS BY OPTIMAL LOCATING DG AND CAPACITORS INSTALLATION

To validate proposed considered IEEE 30 bus system which has number of branches, number of feeders, line sectionalizing switches is shown in Figure 1. Here first select the candidate buses with open switches position. Calculate the sensitivity factor for candidate buses for present situation of real and reactive power losses which depend upon load. Then candidate buses have to be arranged in an order based on their sensitivity factors. The candidate bus which has more sensitivity then candidate buses are picked to Maintain capacitors and DG.

$$HM=\begin{bmatrix} os_1^1 & os_2^2 & os_3^3 & os_4^4 & s_1^1 & s_1^2 & s_1^3 & s_1^4 \\ os_1^H & os_2^H & os_3^H & os_4^H & s_1^H & s_2^H & s_3^H & s_4^H \end{bmatrix} \quad (14)$$

5. CASE STUDY

The proposed approach used NEWTON Raphson method to run optimum power flow along with Mat power version 12 and Mat power 5. MATLAB is a multi pattern numerical computing surroundings and a politeness any programming language improved by math works. The objective fuction is to minimize real power losses and reactive power losses in IEEE 30 bus system. in IEEE 30 bus, 4 generator buses, 22 load buses and number of feeders and line sectionlising switches are used.IEEE 30 bus system has superior reliability, it has number of generators units, back up power residue available in the event of one unit's breakdown. It has better power accessibility and redundancy. The generation capacity taken as 358.774 MW and reactive power is taken as 165.655 MVAR and gradually change the load, load real power is 333.4MW and load reactive power is 138.2MVAR. THE total power losses before optimization is 25.374 MW and 27.455 MVAR. The base case of voltage values of IEEE 30 bus system as shown in Table 1 and the base case of real and reactive power as shown in Table 2.

Table 1. Base data for Voltage:

Minimum Voltage Magnitude (volts)	Maximum Voltage magnitude (volts)	Minimum voltage Angle degree	Maximum voltage Angle degree
0.95 p.u @PV &PQ bus	1.1 pu for PV bus 1.05 pu @ PQ bus	-17.81 deg@ bus 30	0.00 deg @ bus1

Now optimize the objective function using Harmonic search algorithm, first given as initial parameter are set of decision variables N=9, Harmonic memory considering rate=0.85, Harmony memory size=20, Nmax=20, Pitch adjustable rate=0.3, the limits of Capacitors choosen for 0 to KW and DG is chosen from 0 to 2MW.

Newton Raphson Method: The Aim of Newton Raphson power flow is to resolve the voltage magnitude in addition to angle at every one bus in the power system not including slack bus and Jacobean matrix by using Equations 1, 2 and 5 for IEEE bus system

Table 2. Base Data for Real Power and Reactive Power:

Maximum power Losses(MW)	Maximum Reactive power4 losses(MVAR)
18.3 MW @line 1-2	37.3 MVAR @ line 1-2

6. RESULTS AND MAIN BLOCK DIAGRAMS

Figure 4 Harmonic Search Algorithm performance of Flow Chart are presented center, as shown below and cited in the manuscript.

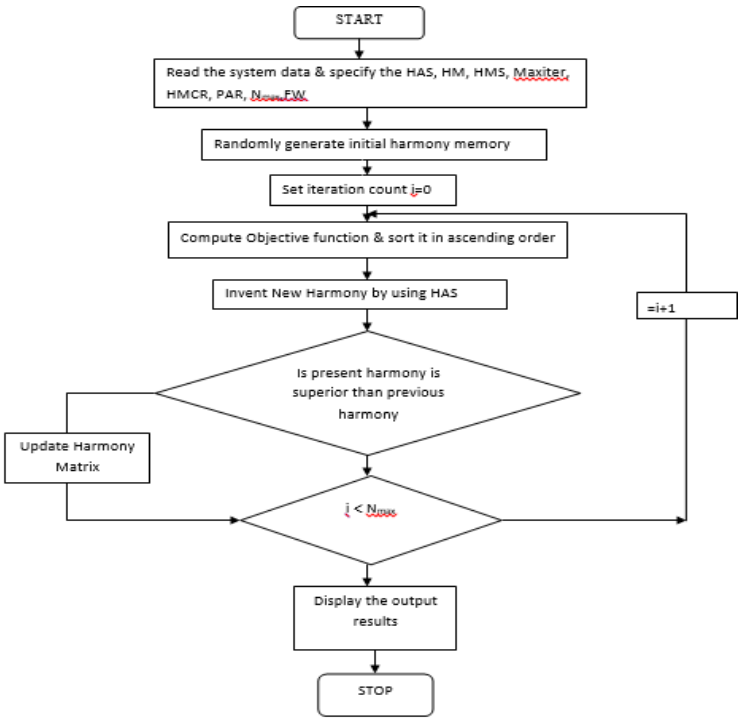

Figure 4. Harmonic search algorithm performance of flow chart

6.1. Case for Before optimization of HAS:

The details of Bus data, Load power , Generation power and each bus voltage magnitude and angle for before optimization as shown in Table 3. Tables Data For Load Bus, Generator Bus And Voltage In IEEE 30 System For Before Optimization Is Given Below are presented center, as shown below and cited in the manuscript.

Table 3. Data For Load Bus, Generator Bus And Voltage In IEEE 30 System For Before Optimization (continue)

Branch	Voltage volts		Load		GENERATION	
#	Mag(pu)	Ang(deg)	Active power P(MW)	Reactive power Q_L(MVAR)	Real power P_L(MW)	Reactive power Q_L (MVAR)
1	1.060	0.000	0.000	0.000	318.774	0.618
2	1.032	-6.652	21.700	12.700	40.000	50.000
3	1.005	-9.773	12.400	10.200	0.000	0.000
4	0.999	-11.682	17.600	1.600	0.000	0.000
5	0.989	-10.010	124.200	19.000	0.000	40.000
6	1.000	-13.583	0.000	0.000	0.000	0.000
7	0.987	-15.939	22.800	10.900	0.000	0.000
8	1.001	-14.366	30.000	30.000	0.000	40.00
9	1.011	-16.661	0.000	0.000	0.000	0.000
10	1.036	-18.266	5.500	2.000	0.000	0.000
11	1.082	-16.661	0.000	0.000	0.000	19.827
12	1.051	-17.510	11.200	7.500	0.000	0.000
13	1.071	-17.510	0.000	0.000	0.000	15.179
14	1.036	-18.415	6.200	1.600	0.000	0.000
15	1.031	-18.503	8.200	2.500	0.000	0.000
16	1.038	-18.105	3.500	1.800	0.000	0.000
17	1.031	-18.428	9.000	5.800	0.000	0.000
18	1.021	-19.124	3.200	0.900	0.000	0.000
19	1.018	-19.300	9.500	3.400	0.000	0.000
20	1.022	-19.099	2.200	0.700	0.000	0.000
21	1.024	-18.717	17.500	11.200	0.000	0.000
22	1.024	-18.702	0.000	0.000	0.000	0.000
23	1.020	-18.899	3.200	1.600	0.000	0.000
24	1.013	-19.078	8.700	6.700	0.000	0.000

Table 3. Data For Load Bus, Generator Bus And Voltage In IEEE 30 System For Before Optimization (continue)

Branch	Voltage volts		Load		GENERATION	
#	Mag(pu)	Ang(deg)	Active power P(MW)	Reactive power Q_L(MVAR)	Real power P_L(MW)	Reactive power Q_L (MVAR)
25	1.008	-18.661	0.000	0.000	0.000	0.000
26	0.990	-19.089	3.500	2.300	0.000	0.000
27	1.014	-18.139	0.000	0.000	0.000	0.000
28	0.998	-14.241	0.000	3.000	0.000	0.000
29	0.994	-19.393	2.400	0.900	0.000	0.000
30	0.982	-20.293	10.600	1.900	0.000	0.000
	Total		333.400	138.200	358.774	165.655

6.2. Case Ii

Data for after optimization of proposed system by using harmonic search algorithm. Tables IEEE 30 bus system data after optimization are presented center, as shown below and cited in the manuscript as shown in Table 4.

Table 4. IEEE 30 Bus System Data After Optimization (continue)

S.No.	Bus connection		Data for line power			Data for losses	
	From	To	Real power MW	Reactive power MVAR	Apparent Power MVA	Real power MW	Reactive power MVAR
1	1	1	318.774	0.648	318.775		
2	1	2	217.458	-11.961	217.787	1.619	3.707
3	1	3	101.316	12.610	102.098	0.844	2.610
4	2	2	18.30	37.300	41.547	-	-
5	2	1	-209.364	30.497	211.573	1.619	3.707
6	2	4	53.621	2.900	53,699	0.310	0.226
7	2	5	103.340	5.913	103.509	0.952	3.233
8	2	6	70.703	-1.769	70.725	0.545	0.933
9	3	3	-12.400	-10.200	16.056	-	-
10	3	1	-97.097	0.441	97.098	0.844	2.610
11	3	4	84.697	-10.497	85.345	0.190	0.389
12	4	4	-17.600	-1.600	17.673	-	-
13	4	2	-52.071	-1.770	52.101	0.310	0.226
14	4	3	-83.747	12.441	84.666	0.190	0.389
15	4	6	73.545	-22.816	77.002	0.141	0.328
16	4	12	44.673	-47.720	63.368	0.000	0.700
17	5	5	-124.200	21.000	125.963	-	-
18	5	2	-98.582	10.254	99.114	0.952	3.233
19	5	7	-25.618	11.328	28.010	0.076	-0.140
20	6	6	0.000	0.000	0.000	-	-
21	6	2	-67.978	6.435	68.282	0.545	0.933
22	6	4	-72.839	24.458	76.836	0.141	0.328
23	6	7	49.449	-0.854	49.456	0.131	0.109
24	6	8	29.544	-10.964	31.513	0.024	-0.076
25	6	9	27.547	-30.821	41.338	0.000	0.491
26	6	10	15.710	-11.454	19.435	0.000	0.244
27	6	28	18.576	-7.779	20.139	0.012	-2.252
28	7	7	-22.800	-10.900	25.272	-	-
29	7	5	25.995	-12.026	28.643	0.076	-0.140
30	7	6	-48.795	1.401	48.816	0.131	0.109
31	8	8	-30.000	10.000	31.623	-	-
32	8	6	-29.426	10.583	31.271	0.024	-0.076
33	8	28	-0.574	-0.264	0.631	0.000	-0.749
34	9	9	0.000	0.000	0.000	-	-
35	9	6	-27.547	33.278	43.201	0.000	0.491
36	9	10	27.547	7.483	28.546	-0.000	0.165
37	9	11	0.000	-19.129	19.129	0.000	0.140
38	10	10	-5.800	17.000	17.962	-	-
39	10	6	-15.701	12.676	20.676	0.000	0.244
40	10	9	-27.547	-6.661	28.341	-0.000	0.165
41	10	17	5.156	4.15	6.618	0.003	0.007
42	10	20	6.905	3.437	9.545	0.016	0.035
43	10	21	15.776	9.971	18.663	0.023	0.049
44	10	22	7.612	4.574	8.680	0.011	0.022
45	11	11	0.000	19.827	19.827	-	-

Table 4. IEEE 30 Bus System Data After Optimization (continue)

S.No.	Bus connection		Data for line power			Data for losses	
	From	To	Real power MW	Reactive power MVAR	Apparent Power MVA	Real power MW	Reactive power MVAR
46	11	9	-0.000	19.827	19.827	0.000	0.140
47	12	12	-11.200	-7.500	13.479	-	-
48	12	4	-44.673	51.223	67.967	0.000	0.700
49	12	13	0.000	-14.898	14.898	0.000	0.056
50	12	14	7,936	2.520	8.326	0.015	0.032
51	12	15	18.108	7.296	19.522	0.046	0.090
52	12	16	7.430	3.640	8.274	0.012	0.025
53	13	13	0.000	15.179	15.179	-	0.032
54	13	12	-0.000	15.179	15.179	0.000	0.001
55	14	14	-6.200	-1.600	6.403	-	-
56	14	12	-7.859	-2.359	8.205	0.015	0.032
57	14	15	1.659	0.759	1.824	0.001	0.001
58	15	15	-8.200	-2.500	8.573	-	-
59	15	12	-17.879	-6.847	19.145	0.046	0.090
60	15	14	-1.652	-0.753	1.816	0.001	0.001
61	15	18	6.138	1.869	6.417	0.008	0.017
62	15	23	5.193	3.230	6.116	0.007	0.014
63	16	16	-3.500	-1.800	3.936	-	-
64	16	12	-7.371	-3.517	8.167	0.012	0.025
65	16	17	3.871	1.717	4.235	0.003	0.006
66	17	17	-9.000	-5.800	10.707	-	-
67	17	10	-5.142	-4.115	6.586	0.003	0.007
68	17	16	-3.858	-1.685	4.209	0.003	0.006
69	18	18	-3.200	-0.900	3.324	-	--
70	18	15	-6.097	-1.785	6.352	0.008	0.017
71	18	19	2.897	0.885	3.029	0.001	0.002
72	19	19	-9.500	-3.400	10.090	-	-
73	19	18	-2.891	-0.873	3.020	0.001	0.002
74	19	20	-6.609	-2.527	7.076	0.003	0.007
75	20	20	-2.200	-0.700	2.309	-	-
76	20	10	-8.825	-3.260	9.408	0.016	0.035
77	20	19	6.625	2.560	7.103	0.003	0.007
78	21	21	-17.500	-11.200	20.777	-	-
79	21	10	-15.665	-9.729	18.439	0.023	0.049
80	21	22	-1.837	-1.471	2.353	0.000	0.000
81	22	22	0.000	0.000	0.000	-	-
82	22	10	-7.558	8.778	8.778	0.011	0.022
83	22	21	1.837	2.355	2.355	0.000	0.000
84	22	24	5.721	6.456	6.456	0.009	0.014
85	23	23	-3.200	-1.600	3.578	-	-
86	23	15	-5.158	-3.159	6.049	0.007	0.014
87	23	24	1.958	1.559	2.503	0.002	0.003
88	24	24	-8.700	-2.400	9.025		
89	24	22	-5.676	-2.920	6.383	0.009	0.014
90	24	23	-1.950	-1.543	2.487	0.002	0.003
91	25	25	-1.075	2.063	2.326	0.002	0.003
92	25	25	0.000	0.000	0.000	-	-
93	25	24	1.085	-2.046	2.315	0.002	0.003
94	25	26	3.545	2.368	4.264	0.009	0.014
95	25	27	-4.630	-0.322	4.641	0.005	0.009
96	26	26	-3.500	-2.300	4.188	-	-
97	25	25	-3.500	-2.300	4.188	0.009	0.014
98	27	27	0.000	0.000	0.000	-	-
99	27	25	4.655	0.367	4.668	0.005	0.009
100	27	25	4.655	0.367	4.668	0.005	0.009
101	27	28	-17.941	11.791	21.469	0.000	0.132
102	27	29	6.192	1.674	6.415	0.018	0.033
103	27	30	7.095	1.669	7.289	0.033	0.062
104	28	28	0.000	-3.000	3.000	-	-
105	28	6	-18.517	-3.479	18.840	0.012	-2.252
106	28	8	0.576	-3.482	3.529	0.000	-0.749
107	28	27	17.941	-11.131	21.113	0.000	0.132
108	29	29	-2.400	-0.900	2.563	-	-
109	29	27	-6.104	-1.507	6.288	0.018	0.033
110	29	30	3.704	0.607	3.754	0.007	0.013
111	30	30	-10.600	-1.900	10.769	-	-
112	30	27	-6.930	-1.357	7.061	0.033	0.062
113	30	29	-3.670	-0.543	3.710	0.007	0.013

Table 4. IEEE 30 Bus System Data After Optimization (continue)

S.No.	Bus connection		Data for line power			Data for losses	
	From	To	Real power MW	Reactive power MVAR	Apparent Power MVA	Real power MW	Reactive power MVAR
Total losses:						5.075	10.708

In Figure 5 is real power losses in KW versus number of iterations. The optimization algorithm has placed four shunts such as three capacitors and one DG in buses 11, 18, 26 and 30 with values as shown in Table 5.

Table 5. Results of Optimization Algorithm has Placed Three Shunt Capacitors in Buses 11, 18, 26 and 30 with Values

BUS	Capacitor Value in KVA	DG in MW
11	600	-
18	550	-
26	750	-
30	-	1.2MW

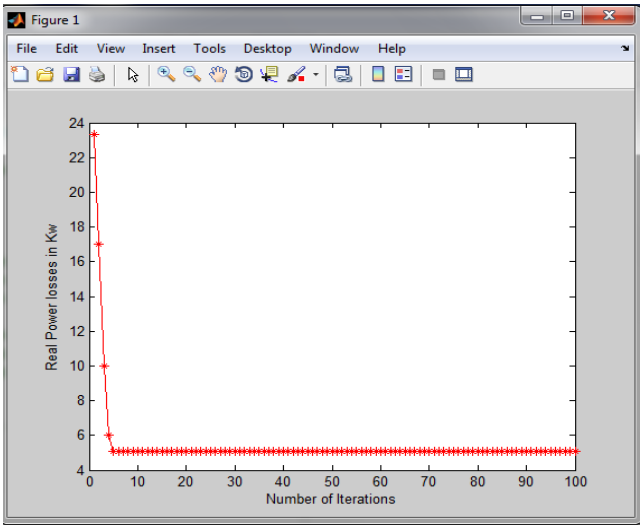

Figure 5. Curve for Number of iterations versus Real power losses in KW

7. CONCLUSION

In this paper, a new advance has been planned to reduce the real and reactive power losses by put in DG unit and capacitors on IEEE-30 bus system under varia-ble load condition by using Harmonic Search Algorithm Power losses vary with variation of load on the system. Capacitors and Dg installation is imitation to found the proposed method. The results show more effective in reducing power loss and improving voltage profile. Observation of references under load condition using more number of DGs which leads to high cost. In order to reduce cost instead of DGs, implemented optimum location sizing of capacitors and DG in which leads to low cost. The simulation results point to the fact that the losses can be reduced by the suitable location and sizing of the shunt devices and reduce the cost of unit.

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