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Optimal Placement of Solar based DG in Distribution System for minimizing losses and THD using PSO Technique

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Abstract: Renewable energy based distributed generators (DGs) play an important role in the electricity generation due to increased demand of electrical power, limited availability of fossil fuels and environmental concerns. The solar energy is one of the most available and feasible from of renewable energy due to their advantages. Distributed generation (DGs) is generally located near to load centers. The optimal placement of DG in the distribution system which gives many benefits such as system power loss and harmonic minimization, voltage profile and stability improvement, environmental friendliness, and reliability enhancement. In this paper, the Newton Raphon's power flow method with particle swarm optimization (PSO) algorithm is used for optimal placement of DG in a distribution system. The proposed method is tested and validated in standard IEEE-14 bus and IEEE-33 bus test systems. The proposed optimal placement of DG units is found to be robust and provide higher efficiency for the minimization of the losses and THD and improvement of the voltage profile.

Keywords: Distributed Generation (DG), Power loss minimization, Harmonic distortion, Solar DG, Particle Swarm optimization (PSO).

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I. INTRODUCTION

The electrical energy is the important part of the human life and for economic development. The energy demand in across the world is ever increasing and expected to grow in future. The engineers are continuously trying to make it simple, like easy to generate, transmit and distribute with minimum electrical power loss at less expensive cost and easy to use for the consumers.

In a specific order of minimization, DG is one of the efforts in the distribution system. Distributed generation is the dispersed generation or decentralized generation or embedded generation which acquires by renewable and non-renewable energy sources. A non-renewable source primly contains gas turbine, reciprocating engine, mini turbine, and fuel cell while a renewable source contains PV solar, wind, mini hydro, geothermal and biomass.

Due to the limitation of fossil fuels sources, environmental concerns and the increasing demand for high quality electric power, the renewable energy resources are used in power distribution system. The renewable sources are highly efficient to reduce global warming and green house emission. Distributed generation resources in power distribution system is used to reduce the power losses and operating cost in the plant, transmission and distribution network and to improve power quality as well network reliability. The improper allocation of distributed generation units is increasing the losses as well as causing the problem in system performance [1]. Due to increasing non-linear loads in distribution network, the optimal allocation of distributed generation resources in the presence of capacitors and non-linear loads is crucial. Non-linear loads and renewable energy resources cause, harmonic distortions due to usage of converters [2, 3]. In this paper, Particle Swarm Optimization (PSO) technique is presented as the optimization technique for the placement of DG in distribution system in order to power loss and THD reduction in distribution network.

II. PROBLEM FORMULATION

The main goal of solar based DG placement is to reduce the real power losses and THD of the distribution network.

-Objective Function: The main objective functions for optimal placement of DG are:

- Minimization of power losses and TDH.
- Improve the voltage profile in a distribution system.

-Constraint:

i. Voltage limitation at load bus

$V_{min} \leq V_{BUS} \leq V_{max}$

ii. Branch capacity limits

$0 \leq B_{ij} \leq B_{ij\,max}$

iii. Total Harmonic Distortion

$THD_{BUS} \leq THD_{max}$

iv. Maximum penetration of DG units in the system

$\sum_{t=1}^{m} P_{DGt} \leq \sum_{i=1}^{n} P_{Di}$

III. SOLAR IRRADIATION MODELING AND OUTPUT CALCULATION OF SOLAR MODULE

The output power of PV module mainly depends upon meteorological conditions like solar temperature and irradiance of a specific location. So it is necessary to model the stochastic nature of solar irradiance using the beta distribution function. The uncertainty of solar irradiance is given by beta probability density function (beta PDF) [4].

$$f_b(s) = \begin{cases} \frac{\Gamma(\alpha + \beta)}{\Gamma(\alpha)\Gamma(\beta)} * S^{(\alpha-1)} * (1-S)^{(\beta-1)}, & for\ 0 \leq s \leq 1, \\ & \alpha \geq 0, \quad \beta \geq 0 \\ 0 & otherwise \end{cases} \qquad (1)$$

Here

$$\alpha = \frac{\mu \times \beta}{1-\mu}$$

$$\beta = (1-\mu) \times \left(\mu \times \left(\frac{1+\mu}{\sigma^2 - 1}\right)\right)$$

Where, S is the intensity of solar radiation in KW/m^2, f is the probability density function. S, α and β are parameters of beta PDF, μ and σ are mean and standard deviation of solar irradiance respectively.

Solar model output power W_{PV} is given as

$$W_{PV} = n \times FF \times V \times I \qquad (2)$$

$$FF = \frac{V_{mp} \times I_{mp}}{V_{oc} \times I_{sc}}$$

$$V = V_{oc} - K_V \times T_c$$

$$I = x[I_{sc} + K_i(T_c - 25)]$$

$$T_c = T_a + x\left(\frac{N_{OCT} - 20}{0.8}\right)$$

Where *FF* is the fill factor, *n* is the number of modules; *V* and *I* are the voltage and current of cell at specified state, *Ta* and *Tc* are ambient and cell temperature respectively and N_{OCT} is nominal operating cell temperature in ^{o}C.

The expected output power of solar photovoltaic module is 97.179 watts [5].

IV. PARTICLE SWARM OPTIMIZATION ALGORITHM FOR OPTIMAL PLACEMENT OF SOLAR BASED DG

Particle Swarm Optimization (PSO) is an optimization techniques are used for minimize or maximize of the objective function such as to solve the objective problem in power distribution system. For explanations of PSO are covered by natural and algorithm selections.

4.1 PSO In natural behavior

PSO is a population based optimization method first developed by James Kennedy and Russell Eberhart in 1995, based on the social behavior of bird flocking or fish schooling in nature [6].where that's have their own view point to find food and eventually move only one direction only for move to the best food in groups. The behavior of the bird flocking are shown in figure1.

Figure1: Bird Flocking [6**]**

The steps involved for solving the objective function are
Step 1: In initialization, are included the parameters of PSO and the constraint that are used for this project.
Step 2: The fitness functions are evaluated than the personal best (Pbest) and global best (Gbest) are finding for iteration equal to zero in this step.
Step 3: For this step, the value of velocity and position are calculated by using the formula from equation (3) and (4) below.
Step 4: These steps are repeated to step-3to calculate new fitness functions. Then, the new Pbest and Gbest are finding referred by new fitness function values when iteration equal to one.
Step 5: Step-3 is repeated to get new velocity and new position when iteration is equal to one.
Step 6: These steps are repeated until the value is conversing.
Step 7: Collect all the result.

PSO is one of the optimization techniques that are increasing rapidly to different area of electrical power systems. Moreover, PSO is an algorithm that will optimizes a problem with trying to get best solution with regard to the constraints. This optimization been done through the movement of the particles in process to find the global optimum solution. The figure 2 is shown the concept of searching by PSO and some mathematical formula for the particles position and velocity in PSO technique.

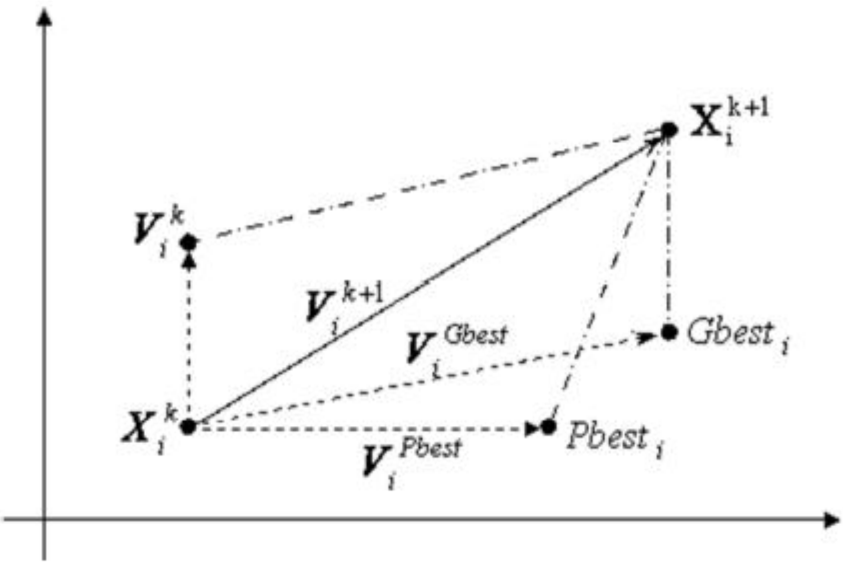

Figure 2: Concept of a searching by PSO [7]

Velocity of n particle,

$$v_{n+1} = \omega * (v_n + c_1 r_1 (Pbest_n - x_n) - c_2 r_2 (Gbest_n - x_n)) \quad (3)$$

Best location.

$$x_{n+1} = x_n + v_{n+1} \quad (4)$$

Where

V_n	Current velocity;
V_{n+1}	Updated velocity;
C_1 *and* C_2	Acceleration factors;
r_1 *and* r_2	Randomly generated numbers with a range of [0,1] to stop the swarm converging too quickly;
W	Inertia weight, which enhance the exploration ability of particles;
$Pbest_1^k$	Personal best position particle *i* achieved based on its own experience;
$Gbest_1^k$	Global best particle position based on overall swarm's experience;
k	Iteration index.

This formula reflects the fact that the movement of every particle is influenced by the position of the best known local and also appeared towards the most well-known position in the search space, an efficient position enhanced found by different particles. This is predictable to travel towards a group of the best solution.

V. RESULT AND DISCUSSION

5.1Introduction

This paper describes the result of the proposed approach on the basis of voltages and bus number. In this chapter the result performed without DG, voltage with PSO and voltages with GA is explained in brief. Test systems are IEEE-14 bus and IEEE-33 bus systems for investigation of study.

In order to the optimum bus location the following system parameters are investigated:

I. Voltage magnitude and angle at each bus.
II. Power losses and THD

Two cases are considered with regard to the impact of the DG unit installation in power distribution system as follows:

I. Performance of the system without DG installation.
II. Performance of the system with DG installation.

5.2 Results of proposed work

5.2.1 Test system – I: IEEE-14 bus

The algorithms are tested on IEEE- 14 bus test system. The total system load 259 MW and 81.9 MVAR .The total active power loss without placement of solar DG is 12.6210 KW are obtained using Newton-Rephson method. The diagram of this network is shown in figure 3.

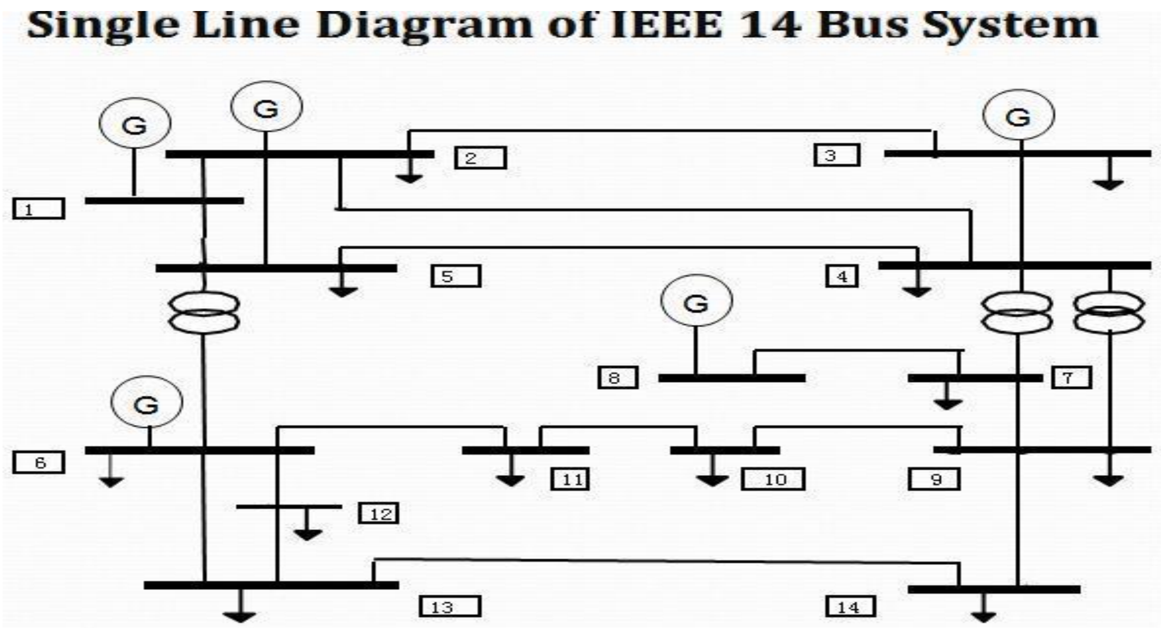

Figure 3: Line diagram of 14-bus distribution System

5.2.2 Comparison voltage profile

Table 1: Comparison of voltages with DG and without DG

Bus Number	Voltage without DG	Voltage with GA	Voltage with PSO
1	1.060	00	1.060
2	1.045	1.045	1.045
3	1.069	1.010	1.010
4	1.032	1.020	1.033
5	1.045	1.024	1.033
6	1.023	1.060	1.060
7	1.095	1.056	1.095
8	1.045	1.080	1.080
9	1.072	1.039	1.072
10	1.032	1.038	1.035
11	1.067	1.052	1.067
12	1.058	1.058	1.064
13	1.066	1.050	1.065
14	1.035	1.025	1.070

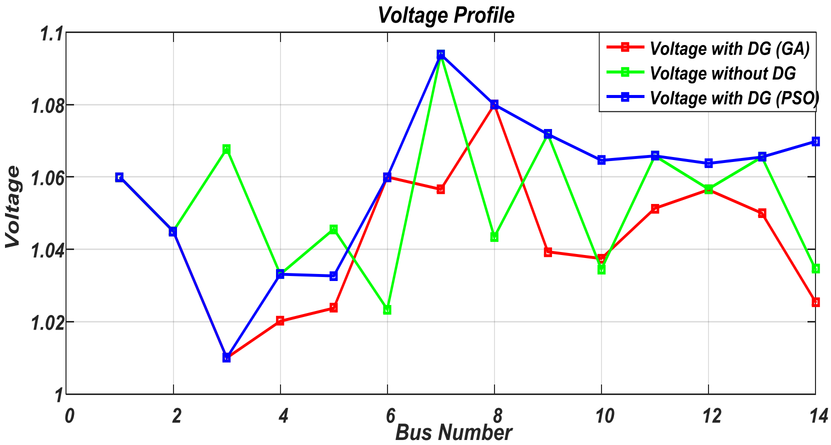

Figure 4: Voltage Profile Comparison without and with DG

In figure 4 shows the comparison voltages profile before and after placement of DGs. It is observed that voltage profile improved effectively with placement of DGs. From the above results indicates that the proposed method minimized power losses and THD effectively with satisfying all constraints.

5.2.3 Result comparison between PSO and GA

The optimal placement of solar DG in IEEE-14 bus system, reduce the power losses from 12.6210 KW to 3.8855 KW using PSO compared to 4.2340 KW for GA. The power loss reductions are 8.73 KW for PSO and 8.41 KW for GA. The percentage power loss reduction about 69.21 % for PSO and 66.64 % for GA, which indicates that PSO show higher percentage loss reduction compared to GA as shown in Table 2.

Table 2: Comparison of proposed method with GA method

Methodology	Bus Number	DG size KW	Power loss KW	Power loss reduction KW	% loss reduction KW	%THD reduction
Without DG	-	-	12.6210	-	-	2.34
With DG (GA)	8	507.7	4.2340	8.41	66.64	1.78
	6	748.1				
	3	854.7				
	4	005.8				
With DG (PSO)	10	101.3	3.8855	8.73	69.21	1.32
	5	068.8				
	4	003.5				
	3	283.3				

5.2.4 Test system – II: IEEE-33 bus

The algorithms are tested on IEEE- 33 bus test system. The total system load 3.72 MW and 2.30 MVAr. The total active power loss without placement of solar DG is 345.23 KW and reactive power loss is 110 KVAR, are obtained using Newton-Rephson method. The line diagram of this network is shown in figure 5.

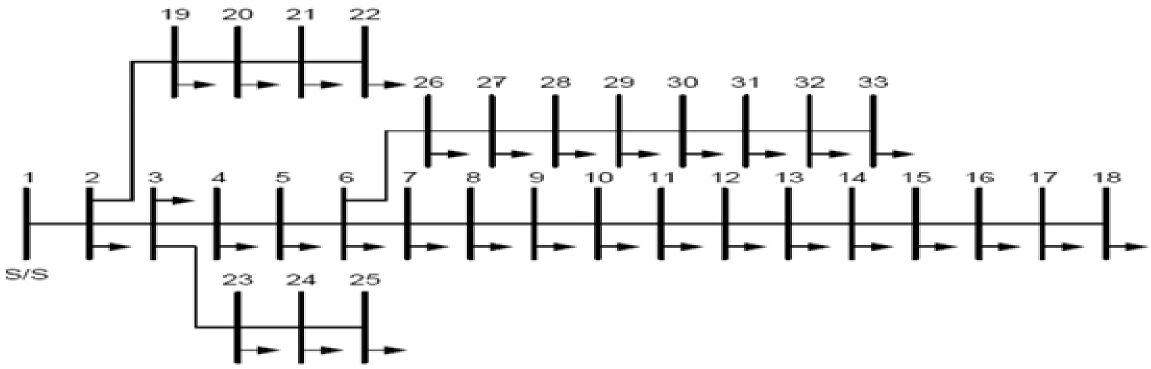

Figure 5: Line diagram of 33-bus distribution System

Table 3: Comparison of voltages profile with DG and without DG

Bus Number	Voltage without optimization	Voltage with GA	Voltage with PSO
1	1.00	1.00	1.00
2	0.981	0.988	0.998
3	0.970	0.983	0.987
4	0.963	0.976	0.982
5	0.954	0.969	0.979
6	0.945	0.958	0.972
7	0.937	0.953	0.971
8	0.930	0.940	0.955
9	0.929	0.933	0.949
10	0.924	0.928	0.947
11	0.923	0.927	0.946
12	0.920	0.925	0.946
13	0.915	0.919	0.945
14	0.914	0.916	0.939
15	0.913	0.915	0.940
16	0.935	0.914	0.938
17	0.952	0.912	0.935
18	0.970	0.911	0.934
19	0.996	0.997	0.997
20	0.987	0.993	0.979
21	0.985	0.992	0.973
22	0.972	0.991	0.972
23	0.968	0.980	0.984
24	0.960	0.972	0.977
25	0.954	0.970	0.974
26	0.940	0.954	0.970
27	0.938	0.952	0.969
28	0.930	0.940	0.958
29	0.925	0.932	0.950
30	0.920	0.929	0.947
31	0.924	0.925	0.944
32	0.923	0.924	0.943
33	0.923	0.923	0.933

5.2.5 Voltage profile with DG using PSO and GA

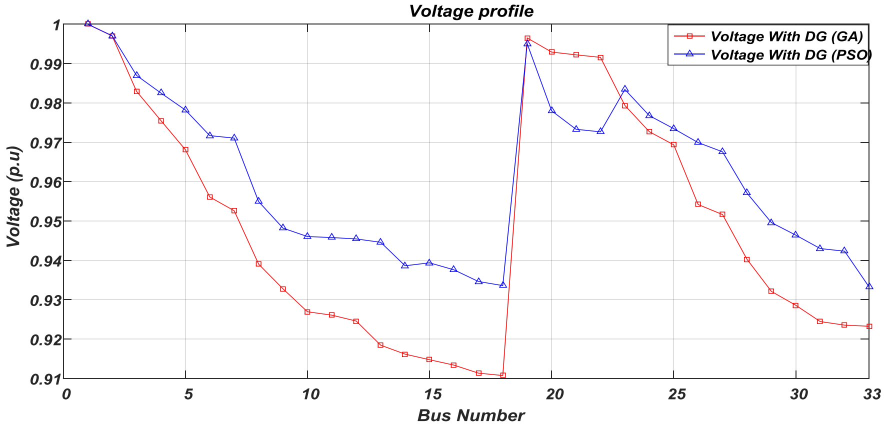

Figure 6: Voltage Profile with DG using PSO and GA

In figure 6 shows the voltages with DG on the different buses. For GA the maximum voltage is on bus number 1 where the voltage is 1.00. The minimum voltage is at bus number 18 which is 0.911. For PSO the maximum voltage is on bus number 1 where the voltage is 1.00. The minimum voltage is at bus number 18 which is 0.932. The minimum voltage levels improve 0.911 p.u to 0.932 p.u.

5.2.6 Comparison voltage profile

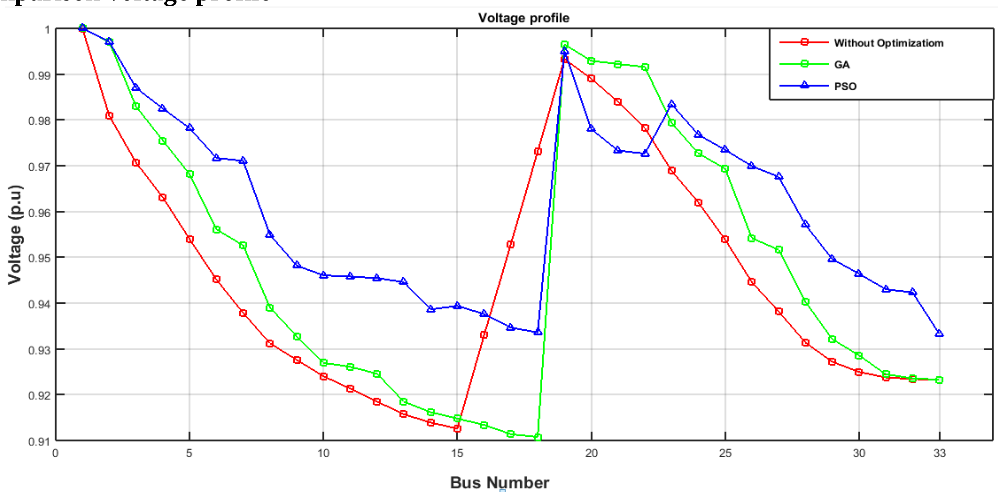

Figure 7: Voltage Profile Comparison with and without DG using PSO and GA

In figure 7 shows the comparison voltages profile before and after placement of DGs. It is observed that voltage profile improved effectively with placement of DGs.

5.2.7Ccomparison result between PSO and GA

The optimal placement of solar DG in IEEE-33 bus system, reduce the power losses from 345.23 KW to 151.3081 KW using PSO compared to 208.4592 KW using GA. The power loss reductions are 193.921KW for PSO and 136.771 KW for GA. The percentage power loss reduction about 56.172 % for PSO and 39.617 % for GA, which indicates that PSO show higher percentage loss reduction compared to GA as shown in Table.4.

Table 4: Comparison of proposed method with GA method

Methodology	Bus Number	DG size KW	Power loss KW	Power loss reduction KW	% loss reduction KW	%THD reduction
Without DG	-	-	345.23	-	-	2.34
With DG	33	170	208.4592	136.771	39.62	1.9
	30	350				
	32	620				

(GA)	28	342				
	20	123				
With DG (PSO)	7	100	151.3081	193.921	56.172	1.02
	13	250				
	32	350				
	33	341				
	31	111				

VI. CONCLUSION

This research work presented the optimal placement of solar based DG in distribution system using PSO technique for minimize the active power losses and THD, as well as improve voltage profile. The proposed technique is tested on IEEE14-bus and IEEE 33-bus test system. The result obtained by PSO technique is compared with GA technique. The result indicated that the proposed technique is more effective at finding optimal locations and sizes of DG units in distribution system. However, minimize the losses and THD, as well as improve the voltage profile after optimal DG placement and sizing in the distribution system.

The results obtained from test system-I for solar DG shows that, percentage reduction in the real power loss is 69.21% and THD is 1.32 % using PSO as well as reduction in real power loss is 66.64 % and THD is 1.78 % using GA. The results obtained from test system-II shows that, percentage reduction in real power loss is 56.172 % and THD is 1.02 % using PSO as well as reduction in real power loss is 39.617 % and THD is 1.9% using GA. It also improved the overall voltage profile using PSO in the distribution system.

The results clearly indicated that proposed method performed better compared to the other methods for minimizing losses and THD for DG unit placement and sizing.

REFERENCES

[1]. Mustafa F.shaaban, Yasser M. Atwa,"DG Allocation for benefit maximization in distribution networks", *IEEE Transaction on Power system, 28(2), 2013*, 639-649.

[2]. Abdelazeem, A.Abdelsalam, Ehab F. El-Saadany, "Probabilistic approach for optimal planning of distributed generators with controlling harmonic distortion", *IET Gener. Transm. Distrib.7 (10),* 2013, 1105–1115.

[3]. V.Ravikumar Pandi, H.H. Zeineldin, "Determining optimal location and size of distributed generation resources considering harmonic and protection coordination limits", *IEEE Transaction on Power system, 28(2),* 2013, 1245-1254.

[4]. Teng, Jen-Hao, et al. "Optimal charging/discharging scheduling of battery storage systems for distribution systems interconnected with sizeable PV generation systems." *Power Systems, IEEE Transactions on 28(2*), 2013, 1425-1433. 220 W PV Module, Solar Gate Technology Corporation, Feb. 20 15.

[5]. [Online]. Available: http://www.solargatetech.com.

[6]. Kennedy J and Eberhart R, "Particle Swarm Optimizer," IEEE International Conference on Neural Networks (Perth, Australia), *IEEE Service Center Piscataway,NJ, 4*, 1995, 1942- 1948.

[7]. D.P. Kothari and J.S. Dhillon, *Power system Optimization, New* Delhi; Prentice-Hall, India, 2006.

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