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A Critical Analysis of Optimal Placement & Capacity for Distributed Networks (DGs) using Modified MO-GA

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Abstract: Several strategies are proposed to make a decision the premiere region and capacities of dispensed technology (DG) units to succeed in rock bottom value or price for machine system losses. During this take a glance at, the mixture of analytical and genetic set of rules methods is employed for many beneficial allocation of quite one DGs during a distribution community to decrease the machine losses. This aggregate ensures the convergence accuracy and pace in additional than one DG unit's allocation. During this study, the DGs active electricity, energy component, and region are simultaneously taken into consideration during distribution network losses minimization. The appliance will dictate handiest the foremost DG electricity era if the DG is about up through DG owner. However, both of the size and therefore the location of DG could also be determined by using the appliance if the DG is about up with the help of it. The proposed technique is implemented to 33-bus test distribution systems. Simulation consequences show that the proposed method outcomes in lower losses compared with the opposite methods.
Index Terms: Distributed Generation (DG), GA, Optimal Location, Loss Reduction, Optimal Power Flow.

I. INTRODUCTION

Distributed generation, also referred to as dispersed generation is a small scale generation being used to meet the ever increasing demand of electricity. Distributed energy is generated by small grid connected generators known as distributed energy resources (DER). Conventional power plants such as thermal, nuclear, hydro power plants are centralized whereas distributed generation resources are decentralized, located near to the load centers. Distributed generation prominently uses renewable resources such as solar power, wind energy, biomass, small hydro and photovoltaic systems. Various other technologies may also be adopted in distributed generation such as fuel cells, battery, micro turbines, small gas turbines and reciprocating engines [1-3].

This method is applied to 33-bus and 69-bus test distribution systems and results show the accuracy and effectiveness of the proposed method for optimal allocation of DG units in the distribution network.

The main contributions of this paper are listed as follows:

1) Combination of analytical and heuristic search methods for achieving high-speed and accurate convergence simultaneously.
2) Considering the dependency of the active power flow of the slack bus to the active power generated by DGs as a new constraint in minimizing distribution network losses.
3) Analytical solution of the problem for minimizing losses of the distribution network using a deterministic equation for DGs optimal output active power in terms of network loss coefficients and network demand.
4) Considering the DGs active power, power factor, and location during minimization of distribution network loss, simultaneously.

The rest of this paper is organized as follows: Section 2 describe the related work and section 3 explains the problem formulation and the proposed method. Simulations and results of multiple DG unit placements are investigated and discussed in Section 4. Finally, Section 5 concludes this paper.

II. RECENT DEVELOPMENT

1) *Mohammadreza Vatani et al:* A combination of analytical and GA methods has been proposed in this paper for multiple DG unit's allocation in the distribution system to minimize system losses. The proposed method has used the GA to find the optimal location for DGs installation and an analytical novel formulation has been used to determine the DG capacities. The proposed method has been compared with IA, LSF, and ELF methods in terms of loss reduction. The results illustrate that the proposed method reaches the lowest losses compared with other methods.
2) *Shreya Mahajan et al:* The optimal allocation of DG is a vital factor in the proper functioning of the power system network. Employing DG at an optimal location has several advantages such as, voltage profile improvement, reduction of system losses and enhancement of power system reliability and stability. This paper suggests a Newton Raphson based load flow method to choose proper position of DG. In this paper, a single DG source of capacity 2 MW is integrated in the system which is

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delivering real power only. This is an example of a solar photovoltaic cell which delivers real power only. This method is implemented on three different IEEE bus systems. The results of this method presented in this paper are demonstrating the applicability of this technique in different network systems. The results clearly show the voltage profile improvement and reduction of system real losses and reactive losses when the DG source is placed at an optimal location. A comparative study can be done by using other evolutionary algorithms like PSO, GA and meta-heuristic methods.

3) *Fabio Pereira et al:* This paper methodology allows solving the problem of the fixed costs allocation of a distribution network, with large penetration of DER, in particular of DG and DR resources. The Kirschen's tracing method and a variant of the MW-mile method are used to determine the impact of the energy resources and for the allocation of fixed costs. The developed scenarios focus on the study of the implementation of several DR approaches, as well as the impact that each DR approach can have on the allocation of fixed costs of a distribution network. For the developed scenarios, the DR approaches are implemented in two different ways, namely individually and simultaneously. For both scenarios, it can be seen that the DR approaches with a greater contribution and allocation of fixed costs are DR constant, linear and quadratic approaches. Thus, it can be seen that the different types of consumers have higher participation in DR events whose remuneration is one of these three approaches. Also, it is seen that when the DR approaches are implemented individually the consumers have higher participation than when the DR approaches are implemented simultaneously. In what concerns the impact that the DG resources have in the distribution network, it can be seen that the presence of several DG has high impact in the branches of network, ensuring a significant share of fixed costs, mainly in the branches far from the bus where the external suppliers inject energy.
4) *Fazel Abbasi et al:* Losses and ENS and costs associated with DGs are three important parameters in distribution systems that the planners are trying to reduce them. In this paper, at first, an approach for ENS calculation in the presence of DGs and storage systems is proposed. Then, the problem of minimizing of two of above parameters is established via simulating of DSR problem along with the optimal DG allocation and sizing problem, which is solved by the NSGA-II algorithm. This solution approach allows the losses, ENS and costs of each topology to be separately optimized under specific loads and constraints. The proposed algorithm is applied on two test systems and the effectiveness of this algorithm is then verified by the analysis of the results. The best topologies are shown in the frame of a set (front). As well, the proposed algorithm can be extended to optimize other objectives like either the system parameters or reliability indices. This feature can be useful for planners to improve the performance of distribution systems.
5) *Sriparna Roy Ghatak et al:* In this paper, weaker buses are detected by voltage stability indices (*FVSI and LQP*) for IEEE 33 and 69 bus systems. It is observed from the results that placing a DG on the weaker bus/area/zone gives maximum technical and financial benefit to the system as compared to healthier bus/area/zone. Therefore, to reduce the computational burden, the search space for the optimal allocation of DG can be restricted only to the weaker zone of the network. The new objective function is developed considering both technical (loss and voltage profile) and economical (benefit to cost ratio) aspects. An EPSO method is proposed for optimal allocation of DG while considering practical operating constraints. A significant improvement of voltage profile, considerable economic benefit and reduction of line loss is obtained from the optimal allocation of DG. The results are analyzed and compared with other popular PSO techniques and it can be concluded from the test results, that the proposed EPSO algorithm is reliable, and effective with respect to computational efficiency and solutions quality.

Table I Taxonomy and contribution of the reviewed optimal DG placement Models

No. Of Dg's	Design Variables	Load Profile	Load Model	Objective	Objective Function	Contribution
Single	Location + Size	One load level	Variable power	Multiple	Multi Objective	Multi objective ODGP, considering voltage rise issue and voltage dependent load, is solved by an interactive trade off methods.
Multiple	Type + location + size	Probabilistic	Probabilistic	Single	Min cost	A continuous stochastic ODGP model considering wind power volatility and load uncertainty utilizing the moment method.
Multiple	Location + size	One load level	Constant power	Single	Min power loss	An ABC method is proposed to compute the optimal DG unit's location, size, and power factor.
Multiple	Type + location + size	Probabilistic	Probabilistic	Multiple	Multi objective with weights	A monte-Carlo simulation embedded GA solve an ODGP with uncertainties represented by probability distribution functions.
Multiple	Location + size	Multi load level	Constant power	Single	Min cost	Simultaneous allocation of DGs and remove controllable switches considering a quantized multilevel load model.

Single	Location	One load level	Constant power	Single	Min cost	The optimal location of DGs is based on system reliability cost that is evaluated by a probabilistic approach.
Multiple	Location + size	One load level	Constant power	Single	Max voltage limit load ability	An ODGP model that maximize the voltage limit load ability is solved by a heuristic method based on continuation power flow.
Multiple	Location + size	One load level	Constant power	Multiple	Multi objective with weights	ODGP is solved by a hybrid GA-PSO, Where the GA searches the site of DG and the PSO optimizes the size of DGs.
Single	Location	Multi load level	Constant power	Single	Min power loss	An ODGP method based on the ranking of non- supplied energy and a method based on the ranking of power losses in lines.
Multiple	Number + location+ size	One load level	Constant power	Multiple	Goal objective index	ODGP, with a precise DG power flow model for wind turbines, is formulated as a single objective goal programming problem.
Multiple	Location	Multi load level	Constant power	Single	Max profit	ODGP is formulated as a bi-level programming problem solved by Chu-beasley GA codified to avoid non-feasible solutions.
Multiple	Location + size	One load level	Constant power	Single	Min cost	A hybrid model, which employs discrete particle swarm optimization and optimal power flow, is proposed for the ODGP problem.
Multiple	Size	One load level	Constant power	Single	Max DG capacity	Method to increase wind penetration level by placing new wind generation at voltage stability strong wind injection buses.
Multiple	Location + size	Time varying	Constant power	Multiple	Multi objective with weights	A two stage iterative method exploiting information on the time varying voltage magnitude and loss sensitivity factor at each node.
Multiple	Location + size	One load level	Constant power	Single	Min power loss	ODGP considering voltage stability is solved by differential evolution in conjunction with incremental bus voltage sensitivities.
Multiple	Location + size	One load level	Constant power	Single	Min power loss	An improved analytical method compute the optimal location and size of multiple distributed generation units.
Multiple	Location + size	Multi load level	Constant power	Single	Min power loss	Network reconfiguration and optimal DG placement are dealt simultaneously and solved by harmony search method.
Multiple	Size	Time varying	Probabilistic	Single	Min cost	ODGP considering the uncertainty and variability associated with the output power of renewable DG as well as load.
Multiple	Type + location + size	Time varying	Probabilistic	Single	Max voltage index	ODGP to improve voltage stability considering the probabilistic nature of both the renewable resources and the load demand.
Multiple	Type + location + size	Multi load level	Constant power	Single	Max DG capacity	ODGP of inverted based and synchronous based DGs considering standard harmonic limits and protection coordination constraints.

III. PROBLEM FORMULATION

There are two main Objectives for problem formulation. Minimize the system loss cost and improve the voltage profile.
The trouble is to determine allocation and size of DG, which minimizes the distribution energy losses for a fixed variety of DGs and a specific total potential of DGs. Therefore the following assumptions are hired in this method:

A. The maximum number of installable DGs is given (*D*).
B. The total installation capacity of DGs is given (*Q*).
C. The possible locations for DG installation are given.
D. The upper and lower limits of node voltages are given.
E. The current capacities of conductors are given.

For loss minimization, the objective function is given by

$$Min\ f = \sum_{i=1}^{n} P_i$$

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Where Pi = Nodal injected power at bus i.
n = Total no. of buses.

If the entire injected strength of distributed era is constant C MW, this equality constraint have to be expressed in shape of a penalty feature.

The Objective function can be formulated as

$$Min\ f = \sum_{i=1}^{n} P_i + \alpha \sum_{k=1}^{L} (P_k - C)$$

IV. PROPOSED METHODOLOGY

The basic idea is to search the optimal placement of DG at particular bus by Genetic algorithm. For is candidate solution load flow will be performed to determine the losses and voltage profile. The basic algorithm for Genetic algorithm is given in brief below: In order to determine the best placement and the best size of the DG units for distribution network, an algorithm has been created that would be appropriate given the particular constraints.

The major steps of the proposed algorithm are:
Step1: Initialize the variables of GA.
Step2: Creating an initial population by randomly generating a set of feasible solutions (chromosomes).
Step3: Evaluating each chromosome by running the load flow program.
Step4: Determining the fitness function of each chromosome in the population (1/Power Losses).
Step5: Applying GA operators to generate new population.
Step6: Apply the crossover operator to complete the members of the new population.
Step7: Apply the mutation operator to the new population.
Step8: Let the current population be the new population.

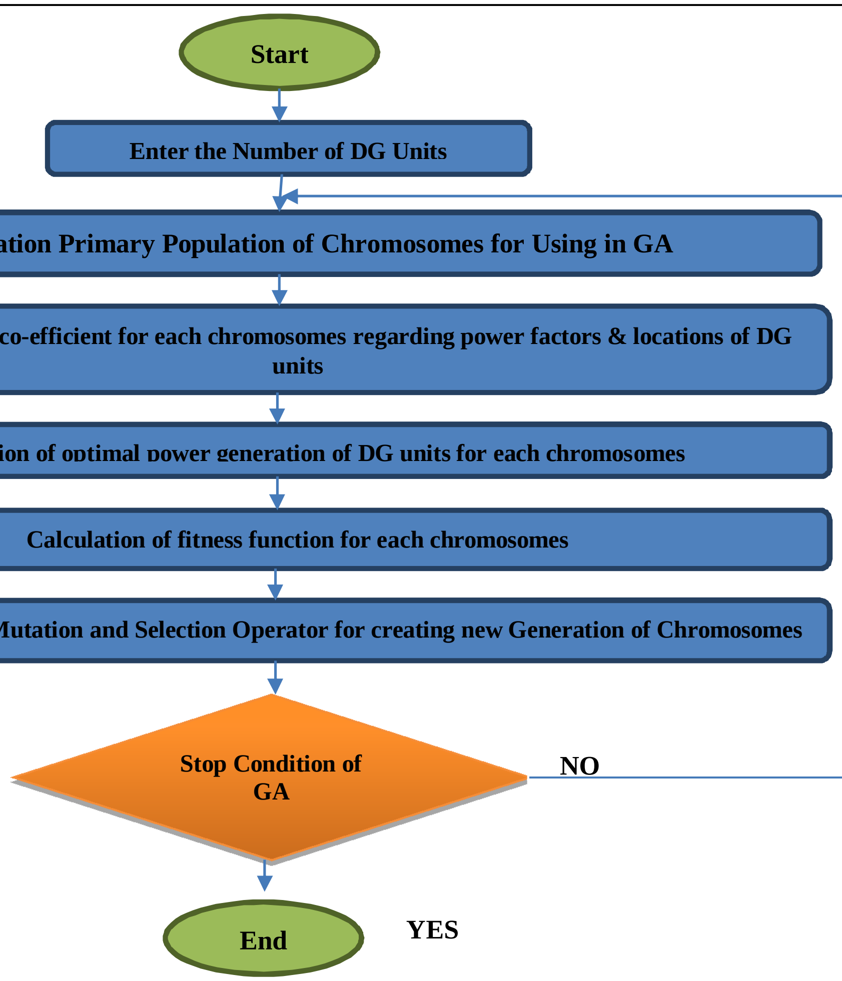

Figure 1: Proposed Methodology Genetic Algorithm (GA) Flow-Chart

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V. SIMULATION RESULTS

To evaluate the effectiveness of the proposed approach, the standard IEEE 33-bus test systems have been considered. Initially, several runs are done with different values of the algorithm's parameters and they are optimally specified.

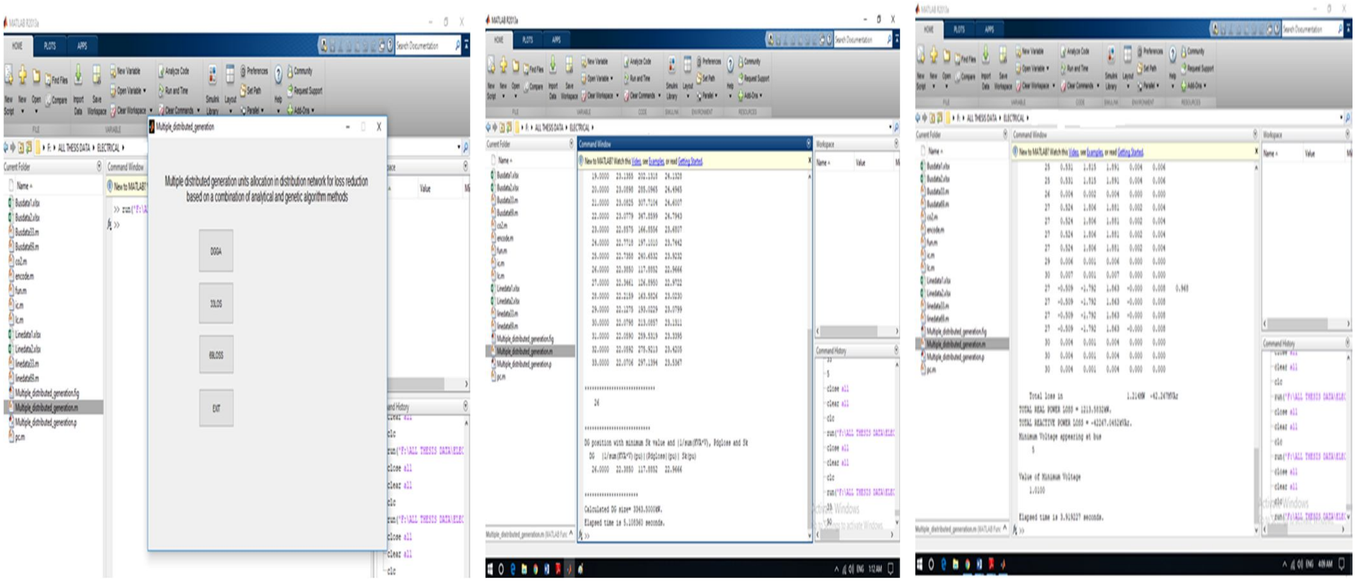

Figure 2: Main Graphical User Interface of Proposed Methodology, MATLAB Result Window for 33 Test Bus System (Shows DG Position, Pdg loss, and DG Size), MATLAB Result Window for 33 Test Bus System (Shows Losses and Minimum Voltage at Bus).

As above depicted these figures 2 shows the MATLAB result window for the proposed optimal methodology. Main graphical interface of proposed methodology shown in the figure 2 (a) and results in terms of DG best position, pdg-loss and DG size for the given percentage of total load at 90% shown in the figure 2 (b). Figure 2 (c) shows that the losses i.e. active and reactive losses and also minimum voltage at Bus 5.

Note: 33 bus test system and size of DG in percentage of summation of total load 90%.

Table 1: Multiple Distributed Generation Units Allocation in Distributed Network for 33 Test Bus System

DG	1/sum (KVA*V) (p.u.)	Pd_g loss (p.u.) kW	Sk (p.u.)
1.000	23.1425	193.1704	24.0956
2.000	23.1425	193.1704	24.0956
3.000	22.9073	153.0319	23.6623
4.000	22.7830	140.4957	23.4762
5.000	22.6621	130.1302	23.3041
6.000	22.4146	111.9424	22.9670
7.000	22.3939	116.9949	22.9712
8.000	22.3269	139.2754	23.0140
9.000	22.2615	179.3620	23.1465
10.000	22.2053	220.5510	23.2935
11.000	22.1957	228.3073	23.3222
12.000	22.1798	243.4588	23.3810
13.000	22.1364	305.5352	23.6439
14.000	22.1282	329.6918	23.7549
15.000	22.1260	356.7761	23.8863
16.000	22.1266	390.8236	24.0549
17.000	22.1465	453.8707	24.3859
18.000	22.1569	487.3771	24.5616
19.000	23.1355	202.1318	24.1328

20.000	23.0898	285.0965	24.4965
21.000	23.0825	307.7104	24.6007
22.000	23.0779	347.8599	24.7943
23.000	22.8575	166.8556	23.6807
24.000	22.7718	197.1010	23.7442
25.000	22.7358	240.6532	23.9232
26.000	22.3850	117.8852	22.9666
27.000	22.3461	126.8950	22.9722
28.000	22.2159	163.5826	23.0230
29.000	22.1275	193.0229	23.0799
30.000	22.0798	213.0857	23.1311
31.000	22.0590	259.5319	23.3395
32.000	22.0592	275.9213	23.4205
33.000	22.0706	297.1394	23.5367
DG Position with Minimum Sk value and [1/sum(KVA*V)], Pd_g loss			
DG	1/sum(KVA*V) (p.u.)	Pd_g loss (p.u.)	Sk (p.u.)
26	22.3850	117.8852 kW	22.9666
Calculated DG Size		3343.5000 kW	
Elapsed Time		10.802242 Second	

As the above depicted table 1 shows that the optimal position of DG and their losses i.e. Pdg-losses and also calculate the DG size for given total load in percentage i.e. 90%.

Table 2: Voltage Profile of IEEE-33 Test Bus System

Bus No.	Voltage with DG at 30 (p.u.)	Angle	Bus No.	Voltage with DG at 30 (p.u.)	Angle
1	1.0600	0	16	1.0743	0.0082
2	1.0430	0.0049	17	1.0701	0.0095
3	1.0354	0.0060	18	1.0732	0.0084
4	1.0298	0.0080	19	1.0716	0.0090
5	1.0100	0.0135	20	1.0708	0.0092
6	1.0244	0.0096	21	1.0683	0.0099
7	1.0190	0.0107	22	1.0684	0.0099
8	1.0100	0.0137	23	1.0729	0.0084
9	1.0664	0.0099	24	1.0689	0.0094
10	1.0682	0.0100	25	1.0648	0.0104
11	1.0820	0.0099	26	1.0648	0.0103
12	1.0788	0.0066	27	1.0622	0.0108
13	1.0710	0.0066	28	1.0242	0.0097
14	1.0773	0.0068	29	1.0622	0.0108
15	1.0759	0.0076	30	1.0622	0.0108

Table 3: Line Flow and Line Losses for 33 Test Bus System

Line	Power at bus & line flow			Line loss		Transformer\n
from to	MW	MVar	MVA	MW	MVar	tap\n
1	0.977	10.374	10.420	0.050	-3.799	-
2	1.634	46.754	46.782	0.264	-5.048	-
3	-0.177	20.308	20.309	0.128	-3.954	-
4	-0.307	24.261	24.263	0.047	-0.761	-
5	-0.669	25.736	25.745	0.213	-3.513	-
6	1.080	15.218	15.257	0.100	-3.695	-
7	-0.976	-13.271	13.307	0.042	-1.993	-
7	1.058	9.568	9.627	0.018	-1.721	-
8	-0.060	56.033	56.033	0.228	-0.134	-
9	-0.232	-15.294	15.296	-0.000	0.277	0.978
10	-0.133	-3.355	3.358	-0.000	0.035	0.969
10	-0.232	-2.780	2.789	0.000	0.005	-
11	-0.000	-12.791	12.791	-0.000	0.187	-
12	1.021	18.120	18.149	-0.000	0.431	0.932
12	1.021	18.120	18.149	-0.000	0.431	-
13	0.000	9.579	9.579	0.000	0.069	-
14	0.271	0.872	0.913	0.001	0.001	-
15	0.430	3.530	3.556	0.004	0.009	-
15	0.264	0.869	0.909	0.001	0.001	-
16	0.308	3.700	3.713	0.007	0.015	-
17	0.298	3.684	3.696	0.006	0.014	-
18	-0.281	-3.657	3.668	0.002	0.006	-
19	0.242	2.010	2.024	0.001	0.003	-
20	-0.226	-1.997	2.010	0.002	0.005	-
20	0.231	2.004	2.017	0.001	0.002	-
21	0.085	-0.314	0.325	0.000	0.000	-
22	0.050	-0.208	0.214	0.000	0.000	-
22	0.067	-0.325	0.332	0.000	0.000	-
23	0.434	2.372	2.411	0.003	0.006	-
24	0.117	-0.533	0.546	0.000	0.000	-
24	0.427	2.364	2.402	0.004	0.008	-
25	0.531	1.815	1.891	0.004	0.006	-
26	0.004	0.002	0.004	0.000	0.000	-
27	-0.509	-1.792	1.863	-0.000	0.008	0.968
27	0.524	1.806	1.881	0.002	0.004	-
28	-0.140	-6.130	6.131	0.000	-13.640	-
28	-0.318	-13.571	13.575	0.050	-4.269	-
29	0.006	0.001	0.006	0.000	0.000	-
30	0.007	0.001	0.007	0.000	0.000	-
30	0.004	0.001	0.004	0.000	0.000	-
Total Loss				1.214 MW	-42.267 MVar	-
Minimum Voltage appearing at bus 5 Value of Minimum Voltage					1.0100	

As above depicted Table 2 and 3 shows that the voltage profile and line flow and line losses for the 33 test Bus system. From the table value concluded the proposed system enhance the voltage profile and reduces the losses and also calculate the DG size. From the table 2 and 3 concluded that proposed system has provided best results at 90 percentage of load condition and also calculate the precise size and position of DG.

VI. CONCLUSION

The Genetic set of rules searches the situation and size of Distribution Generators to be installed simultaneously. For the duration of this thesis the effects of utility of Genetic Algorithm to the choicest vicinity and sizing of Distribution Generators inside the distribution community is offered. The effectiveness of the genetic algorithm to unravel the Distribution Generators allocation and sizing is proven thru examples. The effects supply the greatest locations and sizing of Distribution Generators to be mounted in distribution system which leads to discount of gadget losses alongside loss expenses. Since machine losses are decreased, hence the efficiency of the machine increases and improves the voltage profile and balance. The simulation and evaluation consequences show that the plant aggregate of Distributed Generation capabilities a giant impact on the losses and consequently the strength exported to the transmission. It is been additionally proved from the compression that the technique is effective for variable varieties of technology like wind generation, but that the inclusion of generation that simplest operates very on occasion at its maximum might also degrade the effectiveness of the most suitable allocation. Since Genetic Algorithm is based on random search of highest quality answers. Therefore in each run the end result can also deviate barely. Therefore exceptional practice is to run ten to twenty quantity of your time and choosing fine solution. By following this method the machine losses and voltage profile along aspect most efficient potential of DG are going to be determined for various systems.

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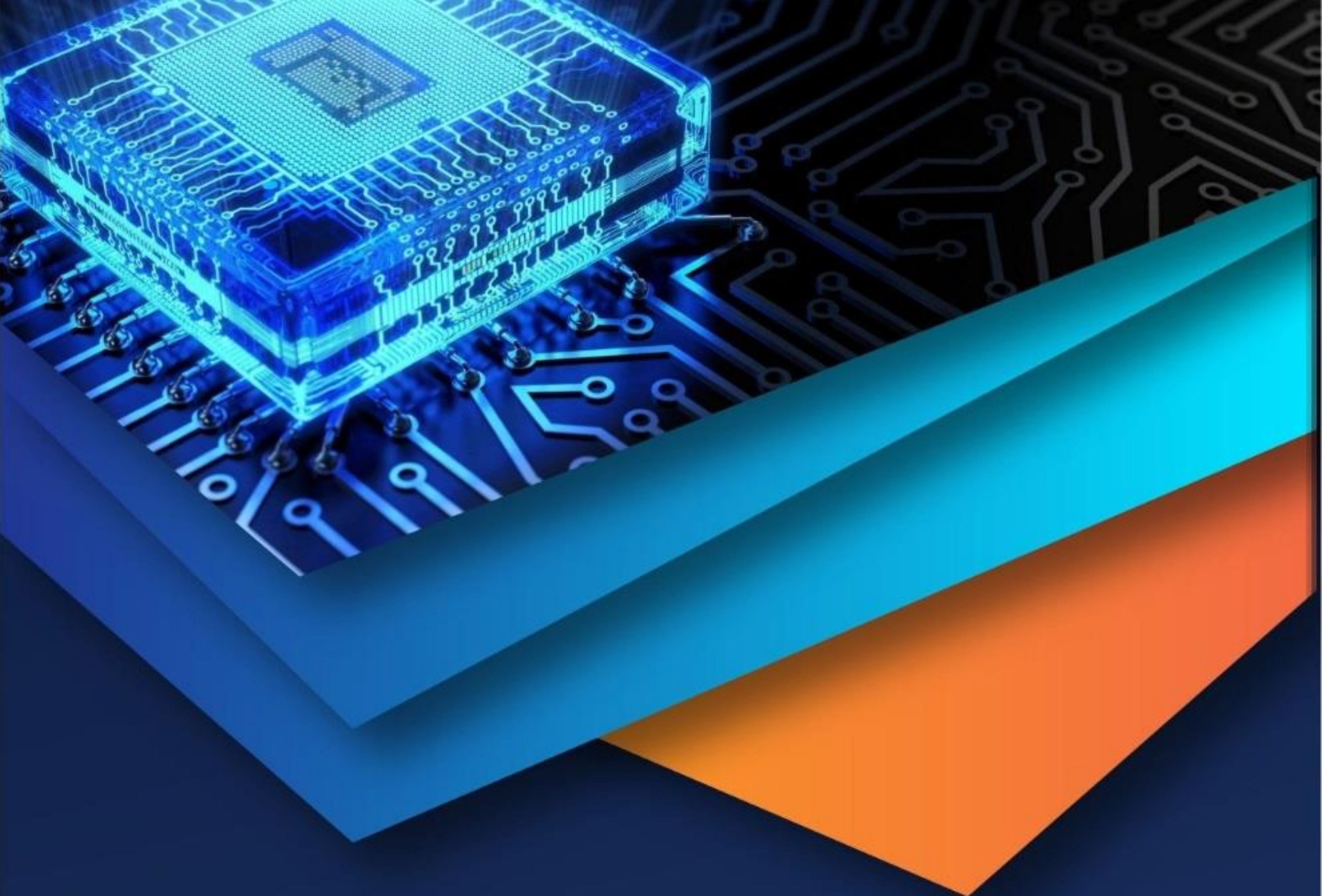

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