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IMPACT OF DISTRIBUTED GENERATOR IN POWER SYSTEM NETWORK

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Abstract—With the increased demand for power, the complexity, cost and power loss in the electrical transmission lines will be increased. In addition, the voltage in areas away from generation there will be less for the allowable value. Distributed generation reduces the transmission losses by power generation close to loads. The presence of distributed generators (DG) in the electrical network is an important effect on power losses and voltage profile. This effect cannot be described as beneficial or harmful but it is dependent on the allocation and size of DG on each distribution network section. There are many methods to determine the best location of the distributed generators in distribution network. Artificial intelligence One of these methods. This paper presents a simple method for investigating the problem of Schering to find best location and size of (DG) for reducing power losses subjected to constraint of voltage regulation in distribution network to improve the voltage profile of the system and minimize power losses. Also, this paper compare between two methods to determine the optimal location of (DG). The suggested technique is programmed under MATLAB and MATPOWER software. The results Obtained show that DG can reduce Electrical Power losses and improving voltage profile of the system which is depends on the optimal Location and appropriate size.

Index Terms— Distributed generation, Artificial intelligence, Simulated annealing, Voltage profile, Power losses, and MATLAB.

1 Introduction

Electricity is produced and delivered to customers through generation, transmission and distribution system. Some considerable loads that necessitate a high level of voltage and losses reduction in the network are located in remote or isolated areas. Setting these loads afar from the power station leads to a more increasing in the voltage drop to be out of limit, and an increase in the power losses. Many methods are suggested to improve voltage profile and to reduce power losses in distribution system Distributed generation (DG) One of these methods. Distributed generators are small scale generators is usually connected to distribution system and located close to consumers. Normally Distributed Generators are in range of 1 kW ratings to 100 MW [1]. There are many definitions of the DG but have the same meaning, for example, the working group of CIGRE devoted to distributed generation defines distributed generation as all generation units with a maximum capacity of 50MW to 100MW [2], that are usually connected to the distribution network and that are neither centrally planned nor dispatched. The definition of the location of the distributed generation plants varies among different authors. Most authors define the location of DG at the distribution side of the network, some authors also include the customer's side, and some even include the transmission side of the network [1]. There are a number of technologies are used for distributed generation.

The Distributed Generation technologies are following [3]:
• Wind Turbines.
• Fuel Cells.
• Photovoltaic.
• Reciprocating Engines (diesel).
• Combustion Gas Turbines.
• Micro turbines.

Using of DGs has many Advantages to the customers and the distribution systems and they also have negative effects sometimes.

The positive impacts of the performing of DG are as follows [4]:
• Line loss reduction
• Voltage profile improvements
• Power quality improvements
• Short lead time and located close to load
• Low cost.
• Reduction of peak power requirements.
• Increased electric system reliability.
• Increased efficiency levels.
• Reduced environmental impacts.

The negative impacts of the performing of DG might be as follows [4]:
• Unsteadiness of the voltage profile owing to the bidirectional power flows.
• Unsteadiness of the voltage profile owing to the bidirectional quality of the supply.

System frequency deviations; the installations of DG increases the burden on the system operator to maintain the system frequency.

• Less choice between morecostly primary fuels; most DG technologies are based on gas.

• Higher harmonics; some DG technologies produce direct current. Thus, these units have to be connected to the grid via a DC–AC interface, which may contribute to higher harmonics. Depending on the network configuration, the penetration level and the nature of the DG technology, the power injection of DG may increase the power losses in the distribution system. The optimal location and appropriate size of DGs in power systems is very important for obtaining their maximum potential benefits. The non-optimal placement of DG can result in an increase in the system power losses and the consequence is that the voltage profile can fall below the allowable limit [5].

Position of DG units on the electrical network has been constantly studied in order to achieve different targets and objectives with different types of DG in different test systems are studied in literature survey. Analytical approach for real power loss minimization in power distribution system has been presented to size and site DG in [6]. Optimum location & optimum size of DG unit for voltage profile improvement & minimizing power losses using ETAP [7]. Firefly algorithm is presented with the objective of determining the optimal location and size of distributed generation (DG) in radial distribution network [8]. PCLONALG method used in Khoda-Bande-Loo distribution test feeders of Tehran city [9]. A load flow base algorithm for reducing line loss and improving voltage profile [10]. Load flow algorithm is combined appropriately with GA [11]. Planning and operation of active distribution networks, with respect to placement and sizing of Distributed Generators are discussed with the help of a fuzzy logic methodology in [12]. Renewable energy source DG location based on voltage sensitivity index [13]. ANN technique [14]. optimal DG unit and capacitor placements in distribution systems are studied [15]. In this paper, the Reciprocating Engines (diesel generator) will be used as a distributed generator to improve voltage profile and reduce power losses. This paper is organized as follows: At first, diesel generator as a distributed generator. Then, a fast voltage stability indicator (FVSI) is developed from conventional power flow equation to determine the stability condition of buses and to identify the weakest bus to allocate DG units. In the next section, simulated annealing as artificial intelligence method is used to determine the optimal location and the proper size of the DG. After that, a proposed methodology is tested on a 14-bus network, and the impact of the DG units on voltage profile and power losses is illustrated. In the last section, some relevant conclusions are given.

2 Diesel generator.

In compression-ignited engines (diesel engine), air alone is drawn into the cylinder and is compressed to a much smaller volume, resulting in heated air [16]. High-power diesel engines are used in many industrial purposes such as power plants or transportation.

The diesel engine has many advantages including:

- The diesel engine is more than the quality of the others engines; it generates when burning a certain amount of fuel, more energy than can be generated by other types.
- Safe to use because when the fuel used less susceptible to rapid ignition such as gasoline.
- Retain high quality with increasing duration of use.
- A diesel fuel cheaper than fuel for the gasoline engine.

Also. The diesel engine has some drawbacks, including:

- More expensive compared to other types.
- When it runs at high speeds produce noise.

3 FAST VOLTAGE STABILITY INDEX.

The voltage stability index is the appliance used to indicate the voltage stability status formulated based on a line or a bus. Fast Voltage Stability Index (FVSI) is the important method which is used to finding out the most sensitive line in the power system [17].

The fast voltage stability index (FVSI) can be defined by;

$FVSI_{ij} = (4Z_{ij}^2 Q_J) / (V_i^2 X_{ij})$. ………… (1).

Where:

Z_{ij}= line impedance.

X_{ij} = line reactance.

Q_j = reactive power at the receiving end.

V_i = sending end voltage.

The value of VSI that is evaluated close to 1.00 indicates that the particular line is closed to its instability point. Therefore, VSI has to be maintained less than 1.00 in order to maintain a stable system [18].

4 SIMULATED ANNEALING.

Simulated annealing (SA) is a random investigation mechanism for global optimization problems, and it simulate the annealing process in material processing when a metal cools and freezes into a crystalline case with the minimum energy and considerable crystal size so as to minimize the impurity in metallic frame.

The basic idea of the simulated annealing algorithm is to use random search in terms of a Markov chain [19]. The simulated annealing will concur to its global optimality if sufficient randomness is used in combination with cooling very slowly.

4.1 The Cooling schedule.

The cooling schedule of a simulated annealing algorithm contains four components [19].

[A] Starting Temperature.

The starting temperature must be hot adequate to give a move to any neighbourhood state On the off chance that this is not done then the consummation arrangement will be the same (or close) to the beginning arrangement, the search will be irregular until

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the temperature is sufficiently cool to begin going about as a simulated annealing algorithm.

[B] Final Temperature

It is regular to permit the temperature diminish until it arrives to zero. In some basic running of the SA algorithm the final temperature is dictated by altering

i. The number of temperature values to be used.

ii. The total number of solutions to be generated.

[C] Temperature Decrement

The path in which we decrement our temperature is basic to the accomplishment of the algorithm. Notion states that we must permit sufficient reiteration at each temperature so that the system stabilises at that temperature.

[D] Iterations at each temperature

The final resolution we need to make is what number of cycles we make at every temperature. A fixed number of repetitions at each temperature is an evident scheme. At low temperatures it is significant that a large number of iterations are done so that the local optimum can be fully examined. At higher temperatures, the number of repetitions can be less.

4.2 SA Algorithm

The following flowchart is used to describe the sequence of steps for SA algorithm.

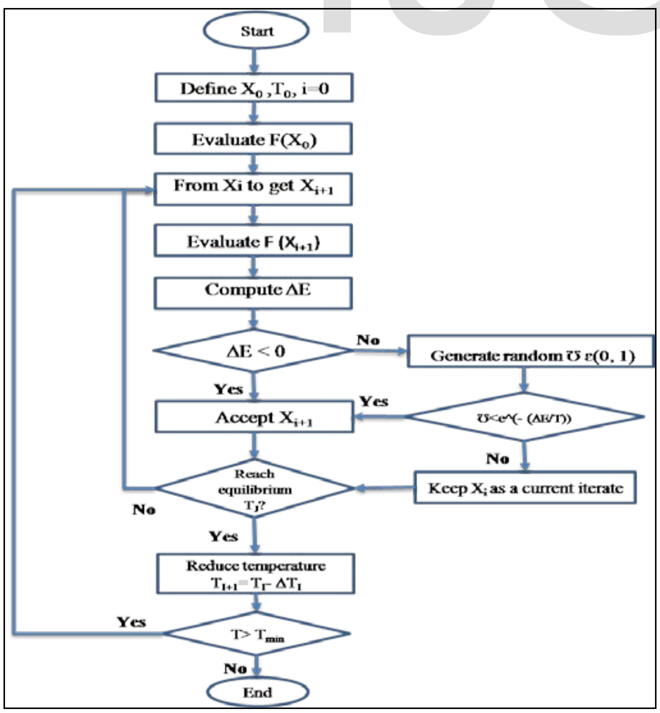

Fig. 1: The flow chart for simulated annealing Optimization Algorithm

…d the global minimum of a function of several variables. In this paper simulated annealing is used to determine the optimal location and optimal size of (DG) to reduce power losses and to improve voltage profile.

5 CASE STUDY AND ANALYSIS RESULTS.

5.1 Test system

The test system is 14-bus system. System data are based on 100 MVA. The 14-bus system shown in fig 2, which consists of three generator buses (bus 1 is slack bus 2, and 6 are PV buses), the system has 11 loads totaling 300.02 MW, 73.50 MVAr, real and reactive power loads, respectively. The algorithm of this method was programmed in MATLAB. System Data is given in Appendix-A.

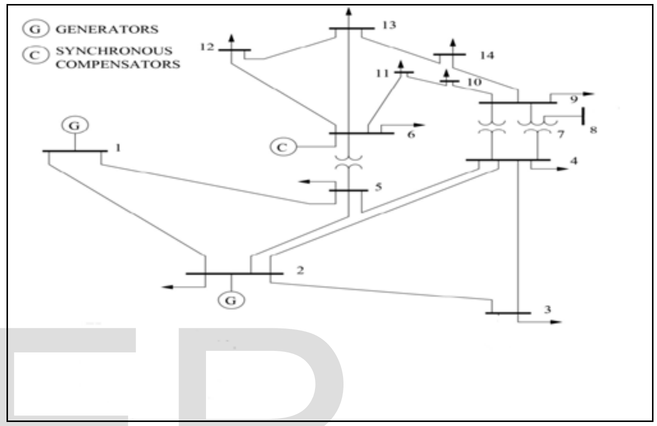

Fig2: 14 bus test system

According to the load flow results, the active and reactive power losses of the system are obtained as 22.838 MW and 90.36 MVAr, respectively. Voltage magnitudes of the system are shown in Fig. 3.

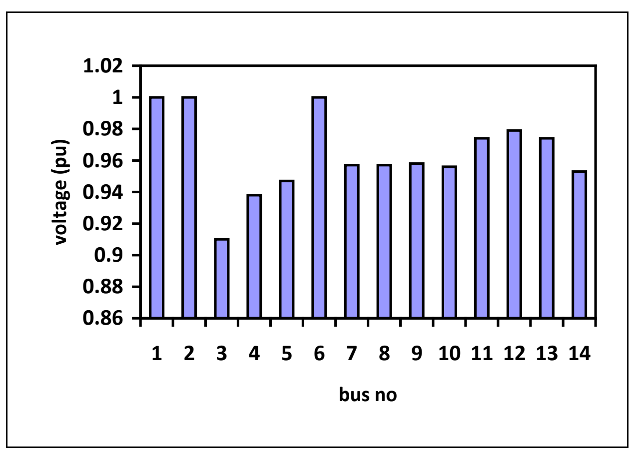

Fig3: voltage at each bus without DG.

It is seen that many buses (bus-3, bus-4, and bus-5.) incur with low voltage problem and having a voltage lower than 0.95 pu.

5.2 Optimal location of (DG)

This paper compare between two methods to determine the optimal location of (DG).

- Voltage stability index.
- Simulated annealing.

5.2.1 Voltage stability index

Using Equation 1 the weakest bus is selected to locate DG.

The flow chart for optimum DG location using FVSI is shown in Fig. 4.

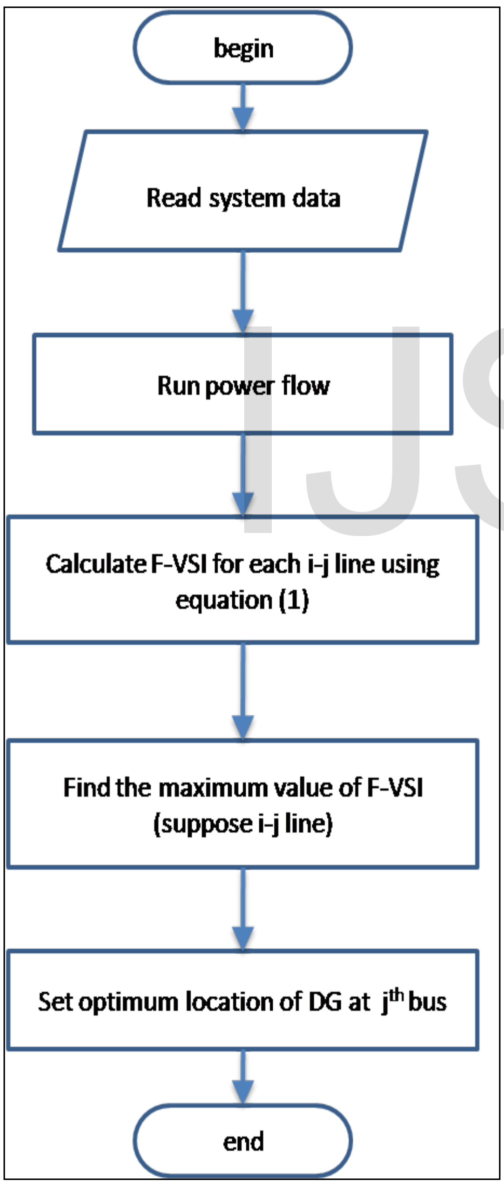

Fig. 4: Flow chart for optimum DG placement based on F-VSI

According to the fast voltage stability index (FVSI), the DG unit is placed at bus-3 because it is with highest value of FVSI.

TABLE 2

TABLE -1: VOLTAGE STABILITY INDEXES

Line	FVSI
01— 02	.03328
01— 05	.01511
02— 03	.1589
02— 04	.0304
02— 05	.0123
03— 04	.03716
04— 05	.00337
06— 11	.0175
06— 12	.02015
06— 13	.03801
07— 09	.0797
09— 10	.0243
09— 14	.05951
10— 11	.01789
12— 13	.0489
13— 14	.0764

5.2.2 Simulated annealing.

Using (SA) code under matlap program with a specific value of distributed generators (10% from total load) to determine the best Location of distributed generators based on the power losses. A minimum power loss occurs when (DG) locate at bus 3.

5.3 **Optimal size of (DG)**.

According to (FVSI) and simulated annealing, the DG unit is placed at bus-3. The size of the DG unit should not be so small or so large with relationship with the total load value.

Therefore, the DG range is between 30.88 MVA (10% of total load) and 77.2 MVA (25% of total load) for this system. The optimal size of the DG unit is quantified to get minimum power losses. The appropriate size of the DG unit at bus-3 is calculated using simulated annealing. The appropriate DG size at bus-3 is 77.2MVA, i.e., 25% of the total load. After the allocation of the DG unit at bus-3, it is seen that the voltage profile of all the buses are raised above 0.95 pu. as shown in Figure 5. From Figure 5, it is seen that the voltage magnitudes of bus-3, bus-4, and bus-5 are increased by 9 %, 2.8%, and 1.8% respectively.

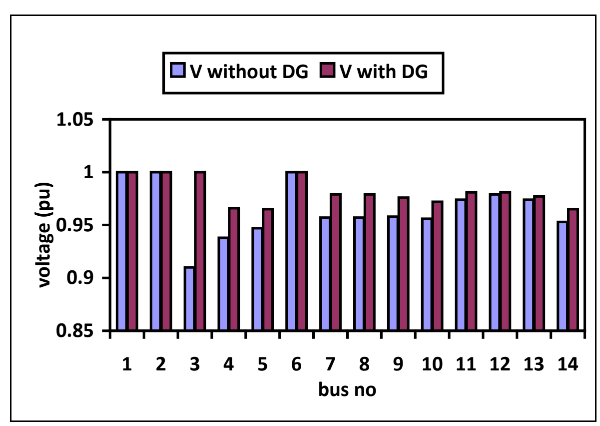

Fig5: voltage at each bus with and without DG

The active and reactive power losses of the network are reduced significantly as shown in Table 2. Table 2 show Comparative study of power losses before and after allocation of DG units. It is noted that the active and reactive power losses are reduced by 48.13% and 42.51%, respectively, after proper allocation of DG unit in the test system.

CONCLUSION

In this study, Comparison between conventional method such as the fast voltage stability index and artificial intelligent such as SA method has been done to find the Optimal location of DG. According to the results obtained. It is seen that of the DG unit has been done easily using the fast voltage stability index. But determining the best location using simulated annealing will be faster and easier and also give results with high accuracy. Also, suggested methodology for the determination of suitable size of DG units for desired voltage profile and reduction of losses using simulated annealing technique has elicited as a very fast, easily and efficient tool. The outcomes uncover that the combination of DG units is highly successful in reducing power losses in the electrical network. It is possible to get the best place DG and the best size in economic terms easily in the case of the development of the study.

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Appendix-A.

Table A.1: Line data- IEEE 14 bus system

Sending bus	Receiving bus	R (p.u)	X (p.u)	Loading at receiving bus	
				P(MW)	Q(MVAr)
1	2	0.01938	0.05917	0	0
1	5	0.05403	0.22304	21.80	12.70
2	3	0.04699	0.19797	113.64	19.00
2	4	0.05811	0.17632	57.36	-3.90
2	5	0.05695	0.17388	7.60	1.60
3	4	0.06701	0.17103	57.36	-3.90
4	5	0.01335	0.04211	7.60	1.60
4	7	0	0.20912	0	0
4	9	0	0.55618	35.40	16.60
5	6	0	0.25202	11.20	7.50
6	11	0.09498	0.1989	4.20	1.80
6	12	0.12291	0.25581	7.32	1.60
6	13	0.06615	0.13027	16.20	5.80
7	8	0	0.17615	0	0
7	9	0	0.11001	35.40	16.60
9	10	0.03181	0.03181	10.80	5.80
9	14	0.02711	0.27038	14.50	5.00
10	11	0.08205	0.19207	4.20	1.80
12	13	0.02092	0.19988	16.20	5.80
13	14	0.07093	0.34802	14.50	5.00