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OPTIMAL CONFIGURATION OF DG IN DISTRIBUTION SYSTEM

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Abstract

The distribution network has become more important due to distributed generating (DG). A deregulated power system, an overloaded transmission network, and an increase in electrical demand are the primary goals of distributed generation (DG) in circulation networks, all of which lead to a decline in system performance. A distribution network with more buses is more likely to see weak buses at certain locations. Weak bus sections have smaller voltage sizes and can't make up the tons effectively. In order to increase the bus voltage size, it would be highly recommended to install the DG units at these weak bus sites. Because the system efficiency will drop and losses will increase if the DG is not properly sized and placed. In fact, proper installation will prevent power loss, boost voltage security in the circulation system, and maintain voltage account. In order to analyze load flows, this research considers a conventional IEEE 14 bus linked distribution network. The voltage account using the Newton-Raphson tons circulation analysis tool in the 'power gui' of Simulink-MATLAB software program determines the weak buses. This article analyzes the 14 bus system parametrically both before and after DG systems are connected.

1 Introduction

A shortage of nonrenewable fuel sources, ecological problems, and ever-increasing electricity needs are major challenges for power providers. In most cases, the transmission and circulation networks that provide the electricity function within the optimal permitted constraints. To reduce the voltage profile and increase the power losses, an additional rise in tonnage is created. Low responsive power demand and high distribution line resistance are the primary causes of voltage drop and power loss reduction [1,2]. This voltage drop will undoubtedly cause voltage instability and power outages if it does not preserve at certain filling [3]. A growing number of blackouts have been documented on a global scale in recent years. Power loss, voltage stability, and power quality may all be greatly improved. The electricity system must construct a large, standardized nuclear power plant to meet the aforementioned requirement. electricity system safety and security are jeopardized when electricity is transported via an old and overloaded transmission network. However, due to economic and ecological concerns, constructing massive power stations or upgrading transmission networks are neither appropriate. Power utilities are now required to service the distribution system in an effort to decrease system losses due to the dependable and trustworthy power supply [4]. The ideal distribution of generators, network support, and the placement of capacitor banks are only a few of the many possible arrangements that may be put into action to enhance the system voltage account and decrease power losses. The goal of these methods is to reduce the amount of power that has to be transmitted from the transmission system and delivered to your region via the distribution system. Radial feeders connected to the customer side of the meter have traditionally been a part of the distribution system. These feeders feed from the substation. So, it's better than other approaches when you include distributed generation into it.

2 Distributed Generation(DG)

"According to IEEE the DG is the source for generation of power by facility that are adequately smaller sized than main power plant and connected at nearly any type of factor in a power system" [6] Power sources that are directly linked to the distribution network or that are located at the client site of the meter are known as scattered generation [2]. Typically, there are two main types of scattered generational technology: 1) Sustainable DG, also known as a wind turbine, with no restrictions on use, distribution, or reproduction in any form or medium so long as the original work is properly cited. This article is available under the Creative Commons Attribution License 4.0.

energy from solar panels, biogas, geothermal, small amounts of hydropower, and so forth. 2) Non-renewable distributed generation i.e. diesel motor, micro wind turbine, gas turbine and combine warmth and power (CHP) and so on. Those two numbers Once considered an energetic power source, DGs are now accessible in a variety of forms because to technological advancements. 1) incorporating active power sources, such as photovoltaics, microturbines, and fuel cells2) using just reactive power, in the form of capacitors, DSTATCOM 1) (3) using an induction generator to inject active power while consuming reactive power 4) injecting reactive and energetic power, i.e. generators that work in tandem [9] Modern distributed generating technology is long-lasting, non-polluting, and helpful in technical and economic modes. Lowering peak demand, increasing voltage security, reducing load aspect, and deferring transmission price are the key advantages of developing DGs. [10] The level of technical worry about DG links in circulation systems is proportional to their scores. Conventional distribution was not designed to support a generating centre [12], but new research shows that DG can help you get the most out of your distribution system and provide consumer loads in your region. Many power companies are now investing in distributed production on a smaller scale, whether it's wind turbines, solar batteries, micro generators, small-scale hydro, or combined heat and power (CHP). England and Wales recorded 1.2GW of distributed generation in 1993–1994, and according to [13], that number has now risen to 12GW. 2203MW of connected DG in the Fenosa distribution system in Spain is equivalent to 120% of the total peak demand in that region. There are a total of 6128 MW of renewable DG installed in Germany's southern region, 10 GW PV in Italy, and 307 MW of wind DG linked to the distribution system in northwest Ireland [14].

Analytical Method

[15] actually suggested an analytical method for optimal positioning and size of DG employing two or three variables. Mathematical formulae for DG size and location are driven by the author in this method. If the loads are balanced, the author suggests installing a 2/3 size DG at a distance of 2/3 from the feeder to maximize system voltage performance and minimize power loss. For various forms of load distribution with unity power factor, [16] used the analytical technique for optimal placement of DG. Minimizing the system's power losses was the main goal. In order to

determine the best location and size of DG, a precise loss formula has been suggested by [17,18] It was the author's principal goal to lessen the system's actual power loss. Author [13] For the purpose of DG size and placement, we propose a novel power security index (PSI). Reducing the radial circulation system's energetic and responsive power losses was the goal of the features. Lot circulation research on ordinary IEEE 12 and 69 buses also uncovered the prospect bus. Finally, the author suggests that energetic and responsive power needs in the area might be significantly reduced via the enhancement of voltage drops and the reduction of power losses. Research by [19] examined the rational method for determining the optimal placement and size of dispatchable and non-dispatch (biomass & wind) DGs while taking power element considerations into account.

Numerical Method

Optimal placement and scaling of DGs have been tackled using many approaches, including gradient search, sequential quadratic, linear programming, nonlinear programming, dynamic programming, ordinal optimization, and extensive search. The three most effective methods are ordinal optimization, nonlinear programming, and s equential square. In [20], DWG installation issue Before continuing with the formula for the IEEE 33 bus radial system, the writer first used model analysis and the constant power flow approach to identify potential buses for DG locations, all with an eye on voltage security assessment [3]. The findings were satisfactory, with a fixed DG size of 40% placed on the weakest bus.Results were better when compared to M. Etthadi's technique, which the author also compared. Optimal placement and size of distributed generation (DG) has been detailed in a distribution system with a voltage safety margin (VSM) enhancement approach ([21]). Consideration of the load as an IEEE RTS bus and of DG (solar and wind) as variable PQ buses is made by the writer. Mixed integer nonlinear programming was used to find the voltage stability margin, and degree of sensitivity assessment was also used. The limitations were the voltage limit, the capabilities of the feeder, and the infiltration of DG.
As DG becomes bidirectional power circulation, it bypasses many of the intricacies of the distribution system that were originally designed for unidirectional power circulation. In reality, proper use of circulation system performances is contingent upon satisfying two key budgetary and technological constraints. Power losses, voltage accounting, voltage security, carbon emissions, reliability, and so

on are some of the technical limitations. Costs associated with DGs, their installation, and system maintenance are examples of economic restrictions. Therefore, several strategies have been used in the literature for diverse objective purposes to appropriately locate and size the DG. More and more, people are turning to renewable energy sources in an effort to lessen their reliance on foreign oil and their impact on the environment. There are a lot of benefits to producing electricity via a distribution system that uses dispersed production, thus many nations are trying to implement it. The main drawback of environmentally friendly DG is that the power quality is affected by the unpredictability of its production due to its basic resources. Locating and scaling dispersed generating optimally is another complicated challenge with today's power systems.

SIMULATION AND RESULTS

Using the information gathered in Section II and the DG designs provided in Section III, the Simulink setting of the MATLAB software is used to simulate the whole IEEE 14 bus system in conjunction with DG systems. The ratings of the DG units' sources are shown in the table.

Table.6.1: DG unit ratings

Name of the source	**Ratings**
PV source	Np=60,Ns=7,Vmp=40.5V, Imp=5.93A,Voc=48.6V, Isc=6.3A.Ppv = 100kW.
Fuel cell	Vnom=300V, Inom=80A, Vend=125V, Iend=280A, V0=550V, V1=520V.

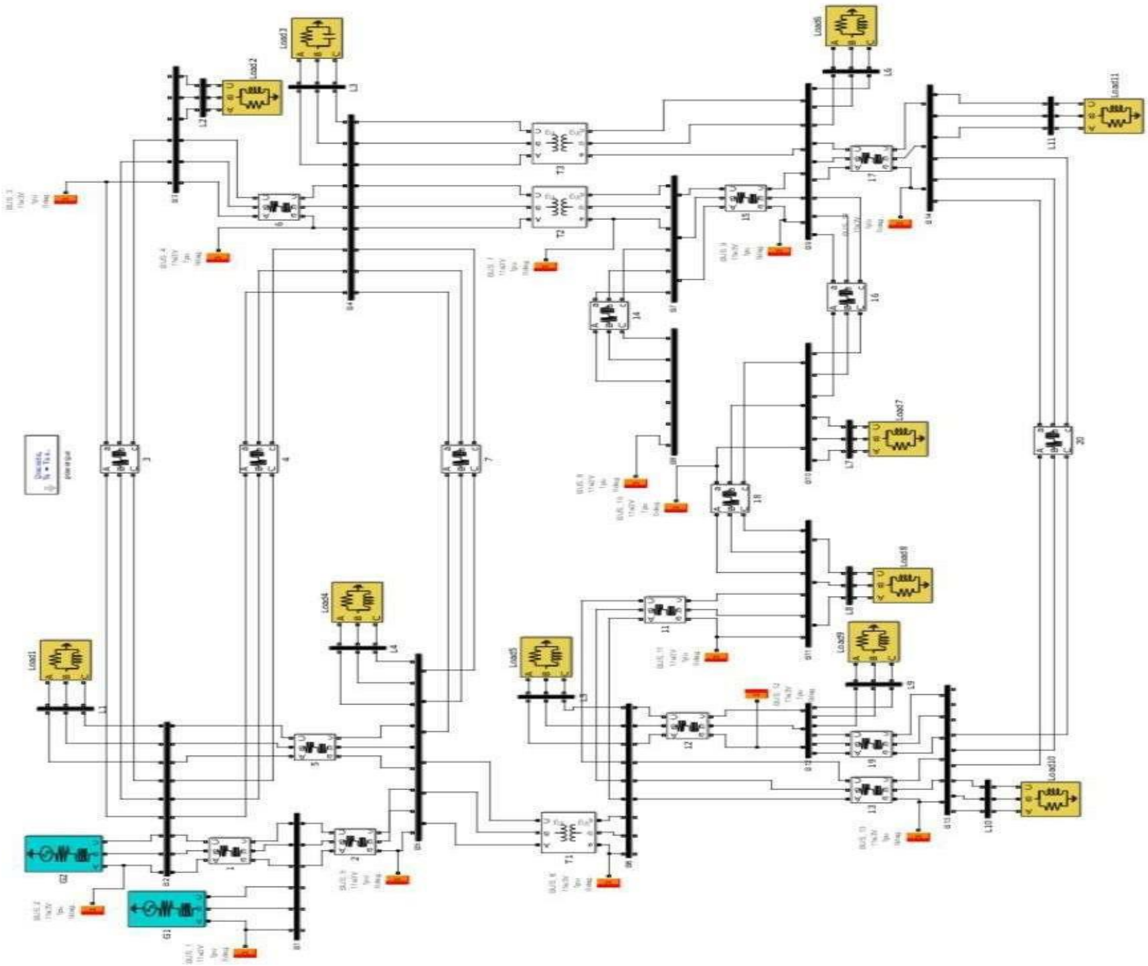

Fig.6.1: IEEE 14-bus network modeling

In the aforementioned bus system, each bus is connected to a lots bus that reads the data used for load circulation assessment from the local buses. You may find the load circulation assessment tool in the 'powergui' block. It uses the Newton-Raphson formula to determine the convergence of the loads. The following chart shows the characteristics of the before and after lots circulation study for all the buses that did not have DG units connected.

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Bus ID	Vbase (kV)	Vref (pu)	Vangle (deg)	P (MW)	Q (Mvar)	Qmin (Mvar)	Qmax (Mvar)	V_LF (pu)	Vangle_LF (deg)	P_LF (MW)	Q_LF (Mvar)
BUS_1	11.00	1	0.00	0.00	0.00	-Inf	Inf	1	0.00	0.04	0.02
BUS_2	11.00	1	0.00	0.02	0.01	-Inf	Inf	1	0.00	0.02	0.01
BUS_2	11.00	1	0.00	0.00	0.00	-Inf	Inf	1	0.00	0.21	0.07
BUS_11	11.00	1	0.00	0.00	0.00	-Inf	Inf	0.9517	-4.89	0.00	0.00
BUS_12	11.00	1	0.00	0.01	0.00	-Inf	Inf	0.9503	-5.02	0.01	0.00
BUS_13	11.00	1	0.00	0.01	0.01	-Inf	Inf	0.9497	-5.02	0.01	0.01
BUS_14	11.00	1	0.00	0.01	0.01	-Inf	Inf	0.9481	-5.11	0.01	0.00
BUS_3	11.00	1	0.00	0.09	0.02	-Inf	Inf	0.9848	-1.56	0.09	0.02
BUS_4	11.00	1	0.00	0.05	-0.00	-Inf	Inf	0.9869	-1.17	0.05	-0.00
BUS_5	11.00	1	0.00	0.01	0.00	-Inf	Inf	0.9889	-0.93	0.01	0.00
BUS_6	11.00	1	0.00	0.01	0.01	-Inf	Inf	0.9531	-4.84	0.01	0.01
BUS_7	11.00	1	0.00	0.00	0.00	0.00	0.00	0.9570	-4.35	0.00	0.00
BUS_8	11.00	1	0.00	0.00	0.00	0.00	0.00	0.9570	-4.35	0.00	0.00
BUS_9	11.00	1	0.00	0.03	0.02	-Inf	Inf	0.9531	-4.80	0.03	0.02
BUS_10	11.00	1	0.00	0.01	0.01	-Inf	Inf	0.9517	-4.87	0.01	0.01

Fig.6.2: Load flow report of IEEE 14 bus system

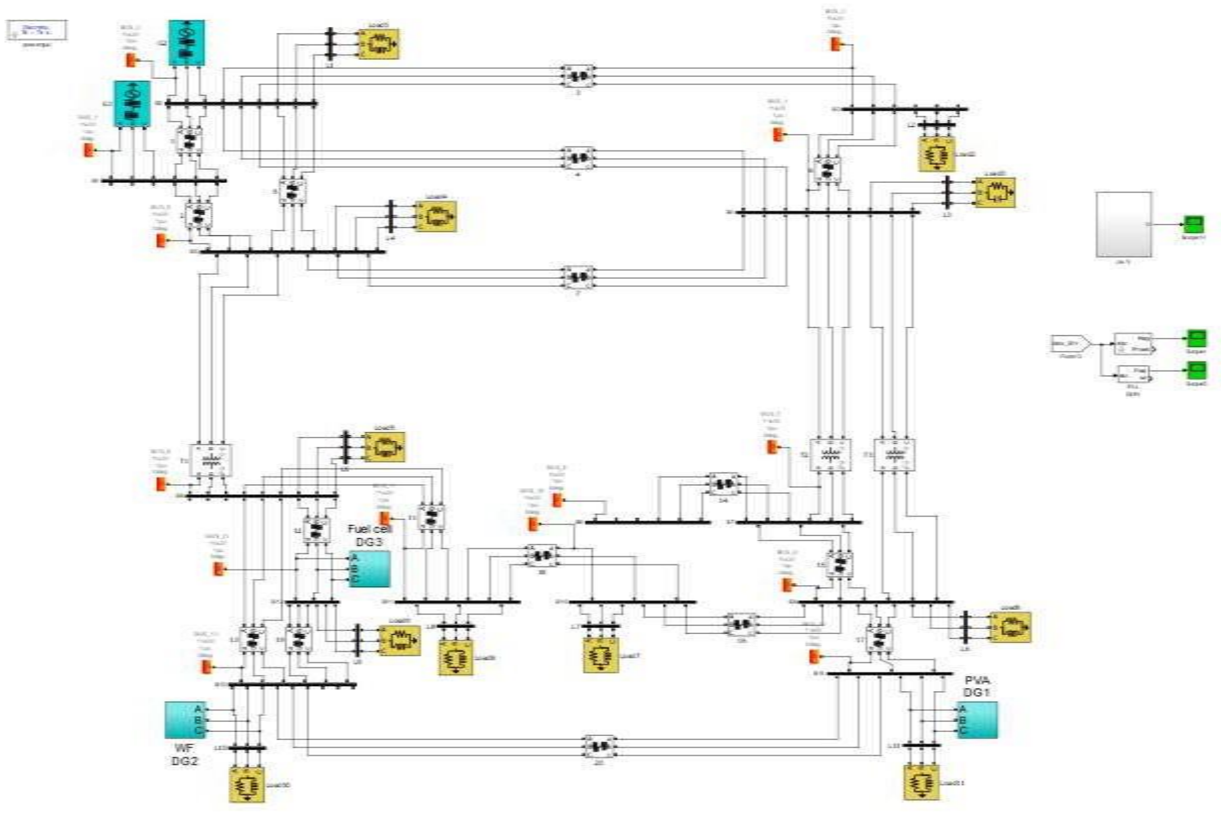

Fig.6.3: IEEE 14-bus network modelling with DGs

According to the previous analysis, a bus system that is adequate requires bus voltages of 1pu. Most of the buses had their voltage sizes reduced after the lots circulation examination. There

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are a few buses when it drops below 0.95 pu. The analysis shows that buses 12, 13, and 14 are the weakest ones, with magnitudes falling below 0.95. In order to increase the voltage that these buses have an effect on other buses, it is highly recommended that DG systems be installed in these locations. At present, DG devices are being integrated into the distribution network to improve its performance. The 14th bus has a 100kW PV plant, the 13th bus a 60kW wind ranch, and the 12th bus a 35kW fuel cell plant. Figure displays the results of a second assessment of the load flow performed using the powergui toolbox after the installation of these DG units.

Bus ID	Vbase (kV)	Vref (pu)	Vangle (deg)	P (MW)	Q (Mvar)	Qmin (Mvar)	Qmax (Mvar)	V_LF (pu)	Vangle_LF (deg)	P_LF (MW)	Q_LF (Mvar)	Block Name
BUS_1	11.00	1	0.00	0.00	0.00	-Inf	Inf	1	0.00	0.04	0.01	G1
BUS_2	11.00	1	0.00	0.02	0.01	-Inf	Inf	1	0.00	0.02	0.01	Load1
BUS_2	11.00	1	0.00	0.00	0.00	-Inf	Inf	1	0.00	0.21	0.04	G2
BUS_11	11.00	1	0.00	0.00	0.00	-Inf	Inf	0.9811	-5.16	0.00	0.00	Load8
BUS_12	11.00	1	0.00	0.01	0.00	-Inf	Inf	0.9843	-5.51	0.01	0.00	Load9
BUS_13	11.00	1	0.00	0.01	0.01	-Inf	Inf	0.9844	-5.46	0.01	0.01	Load10
BUS_14	11.00	1	0.00	0.01	0.01	-Inf	Inf	0.9814	-5.52	0.01	0.00	Load11
BUS_3	11.00	1	0.00	0.09	0.02	-Inf	Inf	0.9866	-1.41	0.09	0.02	Load2
BUS_4	11.00	1	0.00	0.05	-0.00	-Inf	Inf	0.9903	-1.27	0.05	-0.00	Load3
BUS_5	11.00	1	0.00	0.01	0.00	-Inf	Inf	0.9921	-1.03	0.01	0.00	Load4
BUS_6	11.00	1	0.00	0.01	0.01	-Inf	Inf	0.9848	-5.18	0.01	0.01	Load5
BUS_7	11.00	1	0.00	0.00	0.00	0.00	0.00	0.9806	-4.55	0.00	0.00	Load Flow Bus6
BUS_8	11.00	1	0.00	0.00	0.00	0.00	0.00	0.9806	-4.55	0.00	0.00	Load Flow Bus7
BUS_9	11.00	1	0.00	0.03	0.02	-Inf	Inf	0.9795	-5.00	0.03	0.02	Load6
BUS_10	11.00	1	0.00	0.01	0.01	-Inf	Inf	0.9789	-5.10	0.01	0.01	Load7
1	0.24	1	0.00	0.00	-0.01	-Inf	Inf	1.0760	-35.53	0.00	-0.01	Fuel cell DG3/10 kvar
2	0.24	1	0.00	0.00	-0.01	-Inf	Inf	1.0707	-35.54	0.00	-0.01	PVA DG1/10 kvar
3	0.24	1	0.00	0.00	-0.01	-Inf	Inf	1.0739	-35.48	0.00	-0.01	WT DG2/10 kvar

Fig.6.4: Load flow report of IEEE 14 bus system with DG units

The voltage magnitudes of buses 12, 13, and 14 are enhanced to 0.98 pu due to the connection of DG units, as shown in the table in the figure. The figure shows the values of the powers that were injected into the buses of each DG unit.

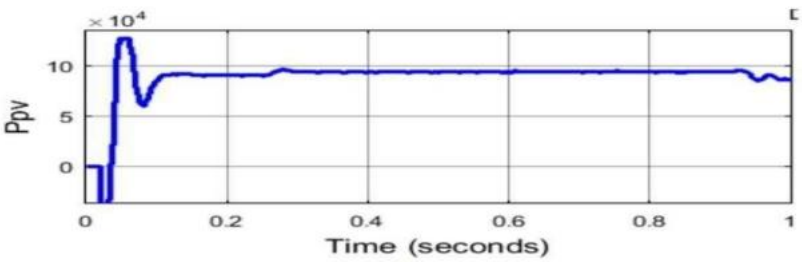

Fig.6.5: PV power

Fig.6.6: Fuel Cell power

A total of 96 kW of electricity is provided by the PV system, while 35 kW is supplied by the fuel cell. A large number of distribution network lots are compensated by the 166 kW of renewable electricity injected by the sustainable DG systems. Therefore, by connecting DG systems at these

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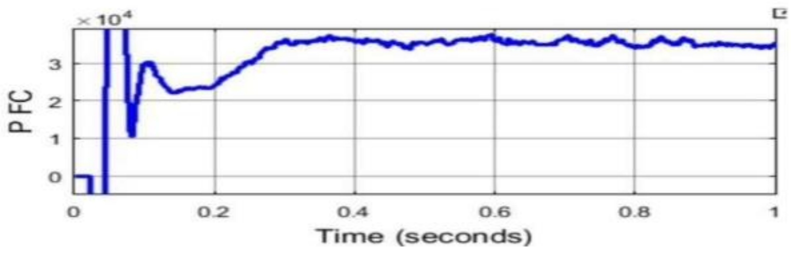
specific weakbus sites, the voltage accounts of all the buses in the system are improved. Further study may improve the diversity of buses available for analysis and allow for the integration of additional DG systems into the circulation network, resulting in a considerably more effective system. Each bus's voltage magnitude, with and without DG units, is shown in a parametric comparison table. According to the comparison table, all three bus voltages are enhanced when the three DG devices are positioned at bus positions 14, 13, and 12.



Bus No.	Vmag (pu) before connecting DG units	Vmag (pu) after connecting DG units
1	1	1
2	1	1
3	0.9848	0.9866
4	0.9869	0.9903
5	0.9889	0.9921
6	0.9531	0.9848
7	0.9570	0.9806
8	0.9570	0.9806
9	0.9531	0.9795
10	0.9517	0.9789
11	0.9517	0.9811
12	0.9503	0.9863
13	0.9497	0.9844
14	0.9497	0.9814

Table.6.2 Comparison table

Conclusion

Findings from recent advances in DG technology, as well as benefits and research priorities, are detailed in this article. The IEEE 18 standardized bus system's tons circulation assessment identifies weak buses based on voltage size specifications. The bus voltage magnitudes are determined using the Simulink powergui tool's lots circulation analysis, which is based on the Newton-Raphson method. The requirements specify the weak buses according to the voltage values that are considered sag, which are defined as levels below 0.95 pu. Buses 14, 13, and 12 have been equipped with PV plants, gas cells, and wind turbines since their voltage sizes are less than 0.95 pu. Finally, by connecting the PV, wind, and fuel cell plants at buses 14, 13, and 12, we can increase the voltage magnitude to around 0.98 pu.

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