Journal of Futuristic Sciences and Applications
Vol. 5(1), Jan-Jun 2022, pp. 1-10
doi: 10.51976/jfsa.512201
www.gla.ac.in/journals/jfsa

Analyses of the Power Flow through Distributed Generator Based on Unsynchronized Measurements

Rajendra Prasad Verma and Sharad Chandra Srivastava***

ABSTRACT

This research proposes a one-of-a-kind method for analysing the load flow of distributed generation by using unsynchronized measurements for the data collected from the main substation and the connections of distributed generators and micro-grids. These findings are made using unsynchronized data from a distribution generator's Load Flow Analysis. Distributed generation is the foundation of this method. Measurements that have previously been done and a good communication architecture make this feasible. This objective may be achieved with the use of previously gathered measurements. The time-tested backward-forward sweep method is the method of choice for analysing power flow using unsynchronized data. This is the preferred approach. The angles of synchronisation are likely to be unknowns that must be estimated. On a smart grid system with a large number of distributed generation and microgrids, a range of mathematical computations are conducted to verify the correctness of performance predictions produced by the suggested theory. The classic backward-forward sweep was shown to be the most effective method for analysing power flow based on data that was not synchronised in many instances. This is the strategy that is presently being recommended. Because the angles of synchronisation are presumed to be unknown, a mathematical equation must be devised to determine them. If you require synchronised measurements in your microgrid, the projected synchronisation angles may be of value to you.

Keywords: *Distributed Generator; Power Flow; Microgrid; Non-conventional Energy Sources.*

1.0 Introduction

When analysing a power system, this is the foundation upon which other methods like as planning and optimization are developed. In contrast to transmission systems, which typically start at a substation and transmit power to end customers via various branches, distribution networks are commonly regional networks in the form of a tree and include tapped lines. Networks with several branches begin with substations, where voltages may be transferred in a more efficient manner. Transmission systems, many of which are regional networks, often include horizontal laterals. When these elements were brought together in transmission load flow algorithms, the Gauss-Seidel model was born. It is also possible to estimate the present real voltage and frequency characteristics of active and reactive load by using studies done at various distribution systems, such as lines.

**Corresponding author; Department of Mechanical Engineering, United University Rawatpur, Prayagraj, Uttar Pradesh, India (E-mail: rajendraverma62yahoo.com)*
***Department of Mechanical Engineering, Sam Higginbottom University of Agriculture and Sciences, Prayagraj, Uttar Pradesh, India (E-mail: sharad.ucer@gmail.com)*

Journal of Futuristic Sciences and Applications, Volume 5, Issue 1, Jan-Jun 2022
Doi: 10.51976/jfsa.512201

Data may be measured and analysed at any moment in time, no matter where you are. Phase frame techniques employ a variety of strategies when it comes to load flow in a distribution system. It is possible to shift the balance of power in our favour by implementing these strategies. Modified versions of the Newton method, or ways that are nearly equivalent to Newton's, are also included in these power flow methodologies. approaches to the sequencing structure of load flow Negative, positive, and zero sequence networks are used to manage three-phase unequal load flow in [1]. Because of this, it will be simpler to control the flow of material [1]. Distribution networks cannot employ these characteristics due to their high ratio and variable performance [2]. This is because the qualities have such a high ratio. This letter uses a linear approximation on the complex plane to provide a solution to the problem. It is not necessary at any moment to implement a radial topology in any way, shape, or form. If the grid code demands that distribution generators function at a power factor of unity, PV nodes are not considered. No attention is given to PV nodes. PV nodes do not need to be considered. At this moment, PV nodes are not required to be considered. There are two major driving forces behind the development of intelligent networks: the ever-increasing demand for power and a desire to slow down climate change. Some technologies have already shown their worth and are expected to find a position in the future distribution systems.. In the future, these technologies are sure to find a position. Distributed generating, digital metering, robots, and low-cost communication systems are just a few examples of how this concept is being used. These are only a few of the instances that may be found. [2-4] Because it has moved away from the traditional radial distribution system and toward a non-radial load flow structure, a smart grid can manage a broad range of power generation technologies. This adjustment was essential in order to accomplish this objective. This is because the load flow mechanism no longer incorporates radiation. Conventional techniques of distribution analysis, such as radial load flow algorithms, are unable to execute their intended roles when applied to these networks. There will still be computations based on the usage of the number [5].

Estimating the flow of load in DG distribution systems has been done in a variety of various ways thanks to the many diverse methodologies that have been developed. It has been shown that it is feasible to portray induction generator-based DGs by using either the Thevenin or the Norton equivalent in the way that is described in [4]. Numerous further articles that explore the penetration of distributed generation (DG) into distribution networks make use of the technique of modelling distributed generation nodes as PQ or PV nodes. the method outlined in reference number [6]. Distributed generators, often known as DGs, are said to be nothing more than photovoltaic nodes that inject reactive power in order to keep the voltage level constant, in accordance with this idea. The computed Distribution Generation reactive power is evaluated in respect to its lowest and maximum limits in order to compensate for the limitations that have been imposed on the Distribution Generation's reactive power. In reference number 7, DG measurements of a lesser size are handled as PQ nodes, whilst DG measurements of a bigger magnitude are dealt with as PV nodes. It is anticipated that every generating unit would have its very own one-of-a-kind model, which will be founded on data on the operation of the DG as well as the kind of transmission network. The authors [8] conduct research on a variety of alternatives for scattered generation and develop a photovoltaic strategy in addition to a power quality approach for each potential course of action. According to the findings of the researchers, a wide variety of DGs can be incorporated into load flow calculations by employing a method that keeps a constant power factor, voltage, or variable reactive power [9–12]. This can be accomplished by using a technique that maintains a constant power factor. In spite of the fact that a number of these strategies have shown that they are capable of providing good results, the inquiry into the design of distribution networks is where they are most usefully used.

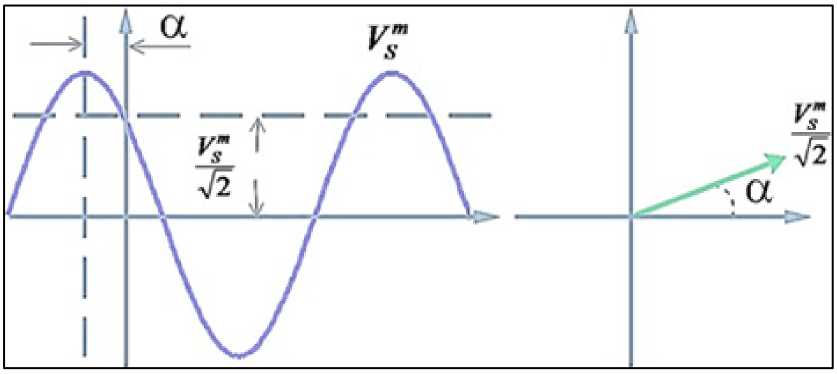
Recently, research and financial resources have been focused on analysing and improving distribution system monitoring architecture. In the EU's Horizon 2020 programme, one of the most notable endeavours is the FLEXMETER project. The main objective is to create and demonstrate the construction of a flexible smart metering system that can be used for a wide range of general-purpose services [10-15]. Current technology will be used to achieve this. If data is collected at DG terminals and communicated effectively, new opportunities for distribution analysis method development open up. It is possible to take use of these possibilities. Fault condition outputs of DGs and microgrids may be altered by both the technology utilised in DGs and the different interface mechanisms used. It is possible to do load flow calculations using current phasors for both distributed generation (DG) and microgrids, which simplifies the process. Clearly, the attributes and interfaces of the microgrids do not need to be disclosed. This technology has the potential to provide exceedingly accurate results, but it needs an extremely precise measurement synchronisation infrastructure. A network device or the Global Positioning System (GPS) may be used to establish synchronisation (GPS). Even with the most cutting-edge smart metering systems, synchronisation of readings is seldom achieved owing to cost considerations. How accurate they are imposing limits on how realistically the existing DG injection model may be used. Following is a phrase that outlines some of these restrictions.

2.0 Methodology

A sinusoidal waveform's amplitude may be expressed as a spinning complex number. amplitude, angular frequency, and starting phase are all characteristics of a sinusoidal waveform. a sinusoidal waveform What about taking a look at Figure 1 and seeing what we can learn from it? A distribution transformer installed near the client is responsible for distributing energy supply. The main substation voltage generates a sinusoidal signal, and the formula shown below may be used to describe this component:

$$V_s(t) = V_{sm}\cos(\omega t + \alpha) \quad \text{…(1)}$$

Figure 1: Voltage Waveform and Phasor at Substation



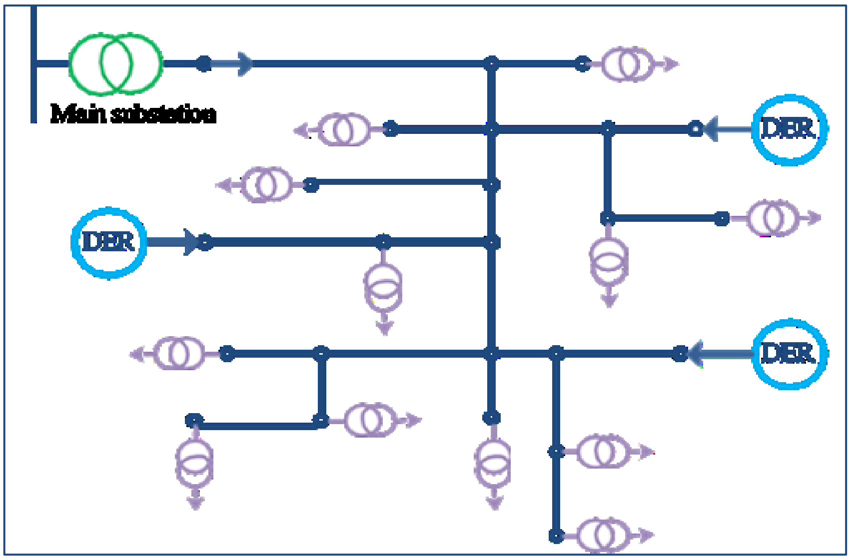
The notation V m is used to represent the amplitude of the voltage that is generated by the transformer, and the notation an is used to represent the rotational movement of the transformer. The

Doi: 10.51976/jfsa.512201

following equation may be used to characterise the waveforms of the currents and voltages produced by each generating unit or island, provided that the phase angle of the voltages produced by the main substation is utilised as the phasor reference (a = 0).

Regardless of whether it is done locally or via the use of GPS. Because of any one of these factors, each dispersed generating unit or island has the potential to be easily interpreted as a current injection at any point in the flow of the load. In spite of the fact that this approach is straightforward and does not need any previous knowledge of the characteristics of the Distribution Generation, it is vital to have an accurate measurement synchronisation model. Because of this characteristic, the use of the existing DG injection model in clinical settings is restricted.

Figure 2: Uncomplicated Energy Delivery System that Connects a Wide Range of Distributed Energy Sources



However, even if the metres are not synchronised, it is still possible to measure voltage magnitude and current angular difference (ijx). 8(0) = 0 indicates that the synchronisation angles are unimportant. For example, the load flow algorithm may regard every DG unit or island participation as a current injection in the system if extra variables (ijx, Vxm, or Vjx) have values.

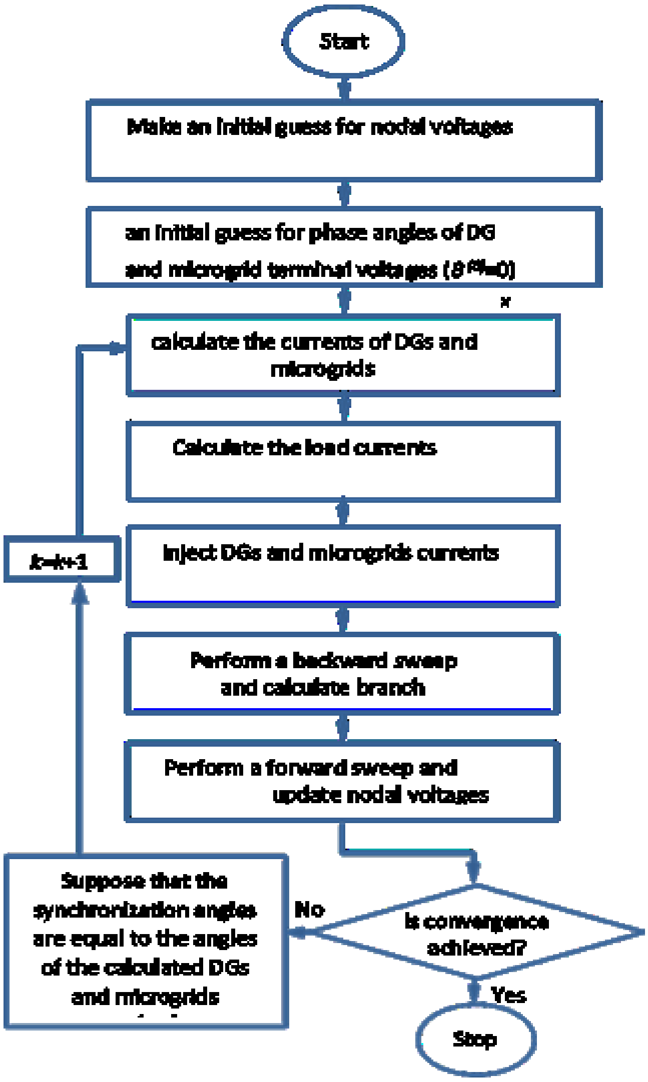
$I_x^{(k)} = I_x^{(m)} \angle(-\varphi_x - \theta_x^{(k-1)})$ …(2)

The load flow algorithm does a backward sweep for each iteration in order to calculate line currents and a forward sweep in order to update node voltages. It is accomplished in a manner quite similar to this by other power flow algorithms that make use of sweeps in both directions, backward and forward.

Adjusting matching current phasors at the conclusion of each reverse phase in accordance with the angle of estimated Distributed generating terminal voltages is required by the technique (i.e. x). After the completion of each phase, this step is carried out. The Nonsy load flow, in point of fact, considers synchronisation angles to be nothing more than unknown parameters that need to be located. This may be accomplished by making consistent adjustments to the present phasor as well as the backward and forward phasors until convergence is reached.

$\text{Max}\{|V^{(k)} - V^{(k-1)}|\} < \varepsilon$ …(3)

Figure 3: Demonstrates the Process of Load Flow Analysis Using an Algorithm and Flowchart



3.0 Case Study

As can be seen in Figure 4, simulation testing is carried out on a distribution feeder that is based on real life and contains a total of 98 nodes. A representation of the testing system that was modelled after it can also be seen in this graphic. In order to create a smart grid, it is necessary to model the system with a photovoltaic (PV) farm included. When it comes to microgrids, extremely extensive modelling is carried out whenever it’s necessary. Utilizing the discrete Fourier transform over the whole of the cycle is necessary in order to calculate the phase change of the primary voltage and current.

The load flow method calculates the amplitude and phase of node voltages in addition to power flow within each network, output injection in accordance with each source, and transmission losses by making use of the amplitude and angular variance of collected to quasi voltages and currents on each terminal. This information is then used to determine the power flow within each network, output injection in accordance with each source, and transmission losses. As a result, it is possible to compute the flow of power inside each network, as well as the output injection in accordance with

Doi: 10.51976/jfsa.512201

each source and the transmission losses. Because of this, it is now able to calculate the flow of power inside each network, as well as the output injection in accordance with each source, and the losses that were experienced during transmission. The approach that is proposed is tested in a variety of different loading scenarios to see how well it works in those scenarios. When calculating terminal voltages as well as the flow of branch current, the exact same fundamental assumptions are applied in each and every single case. that there is no divergence under the conditions that were tested, but that the approach may fail to converge if the error term is truly too high. The approach is unaffected by the initial estimate, and it takes about 0.15 seconds and fewer than six rounds to converge on a solution that is a DESKTOP-ILBF29F.

4.0 Results and Discussions

Throughout the course of the simulation, absolute numbers of the voltages at each node were gathered, and those numbers were used to calculate the voltages at each node. Fig. 6a displays the differences that were found between the voltages that were calculated using those absolute numbers

Table 1: Provides both Actual and Calculated Voltage (Pu) in Addition to Comparison

Node	Actual Voltage in pu	Calculated Voltage in pu	Error *1000
1	1	1	0
4	0.9842	0.9842	0.00461
7	0.9773	0.9773	0.00821
10	0.9713	0.9713	0.01010
13	0.9680	0.9685	0.00103
16	0.9681	0.9681	0.03862
19	0.9683	0.9682	0.03207
22	0.9670	0.9670	0.01065
25	0.9591	0.9591	0.01168
28	0.9621	0.9621	0.01254
31	0.9606	0.9606	0.09261
34	0.9571	0.9571	0.01310
37	0.9557	0.9557	0.01121
40	0.9541	0.9541	0.01359
43	0.9523	0.9529	0.17621
46	0.9514	0.9512	0.01432
49	0.9508	0.9503	0.00714
52	0.9496	0.9495	0.03992
55	0.9495	0.943	0.17658
58	0.9488	0.9487	0.11124
61	0.9493	0.9492	0.38780
64	0.9494	0.9514	0.47541
67	0.9489	0.9486	0.40486
70	0.9478	0.9478	0.01114
73	0.942	0.9412	0.02091
76	0.9466	0.947	0.14216
79	0.9474	0.9472	0.00531
82	0.9481	0.9485	0.25122
85	0.9462	0.9461	0.22453
88	0.9455	0.9453	0.48128
91	0.9446	0.9445	0.66465
94	0.9455	0.9465	0.57510
97	0.9495	0.9495	0.01495

The computed values completely match the genuine values, as can be seen in Figure 6b, and the difference between the two is so minute that it is less than 0.001 p.u. for each of the terminals. Table 1 presents a head-to-head comparison between the measured and calculated nodal voltages of some of the available network options.

Despite the fact that synchronised measurements have been conducted, the approach that has been shown is not only able to estimate the angles of synchronisation but also delivers conclusions that are consistent with one another. The nonsy load flow approach, which is shown in Figures 4 through 6, may be used to produce an accurate estimate of the synchronisation angles, and it can also fulfil the needs of a broad range of various smart grid applications that are reliant on synchronised data. When taking into consideration the scenario with a low load, the findings remain the same.

Figure 4: Display the Actual Voltage as well as the Calculated Value at Each Node

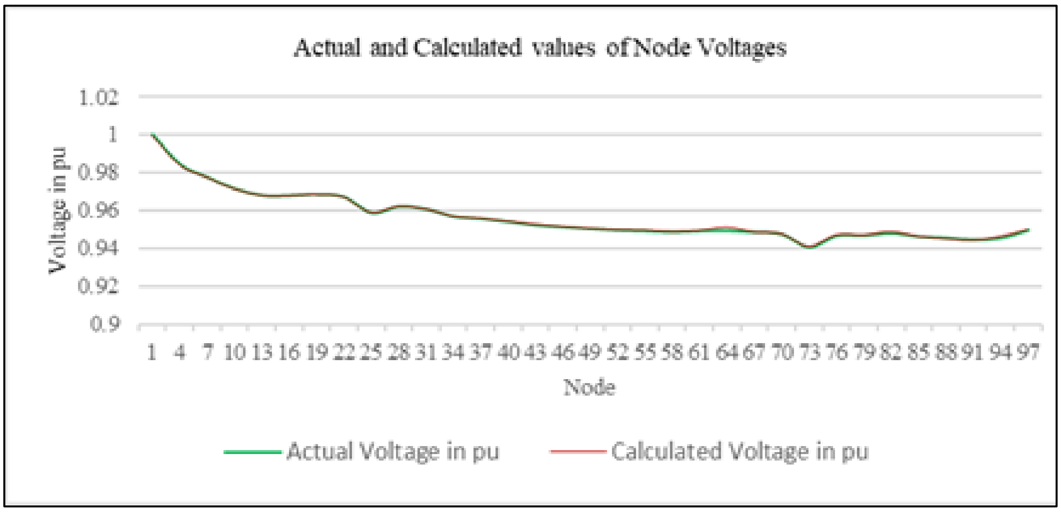
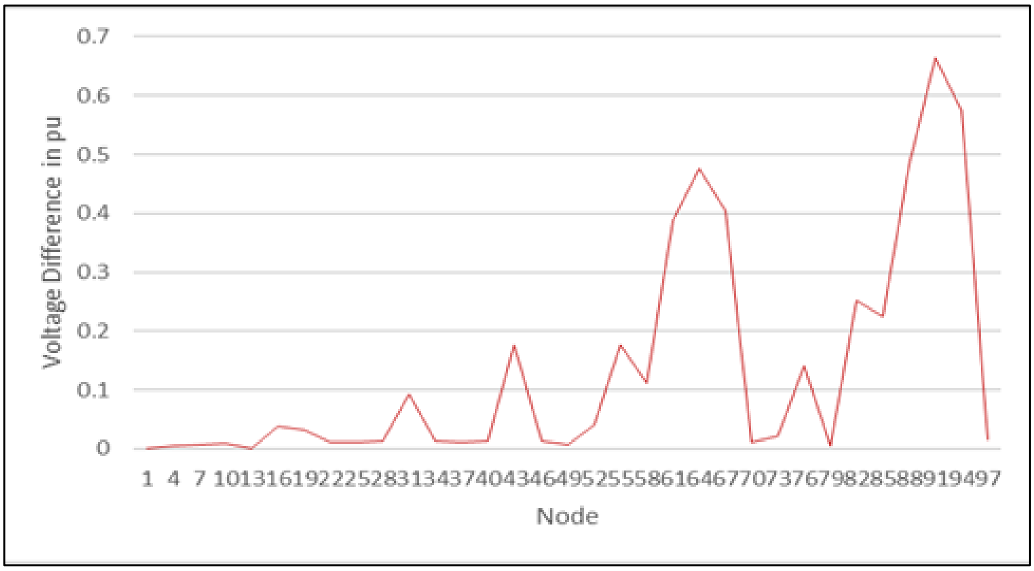
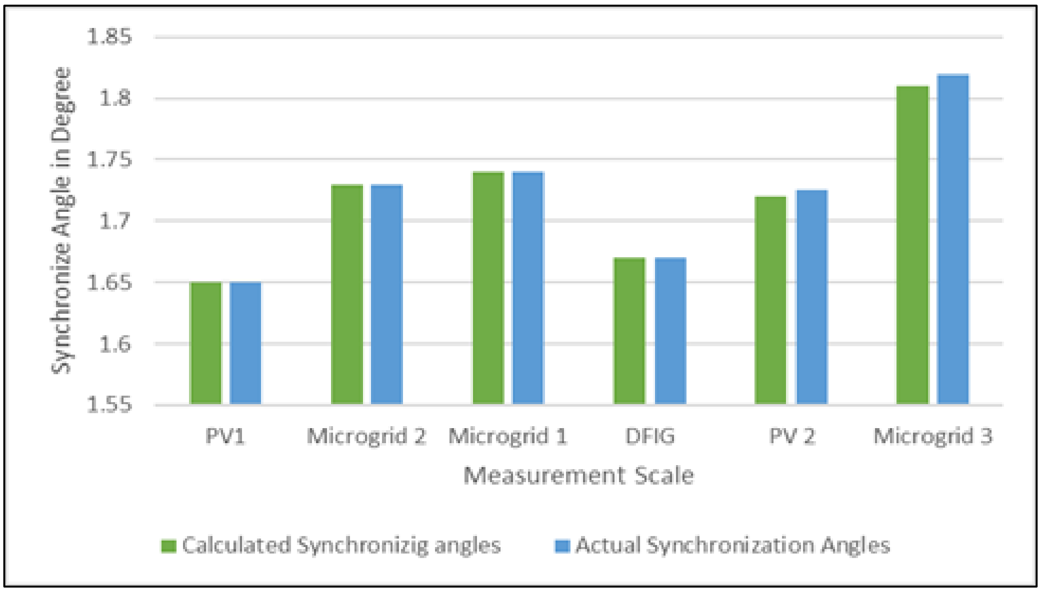


Figure 5: Shows the Difference between the Actual Voltage and the Calculated Voltage at Each Node



Doi: 10.51976/jfsa.512201

Figure 6: Comparison of Calculated and Observed Values for Synchronisation Angles



5.0 Conclusion

A strategy for anticipating load flow in scattered producing systems has been developed as a consequence of this study. The measurements that were obtained at the main substation, in addition to those that were taken at the terminals for both the DG and the microgrid, were not synchronised with one another. These metrics served as the basis for the approach that was developed to analyse the data and were included into its construction. The following is a detailed summary, in bullet point form, of the most significant contributions that a suggested load flow algorithm has made: The proposal is for a mechanism that, if implemented, would automatically simplify the operations. The proposal for a technique is one that, if implemented, would automatically simplify the operations. Distributed generation managers may find that the method is helpful in meeting the requirements of a variety of power system applications, particularly those that are reliant on synchronized measurement procedures. This is especially true of applications that are dependent on distributed generation managers. The results of the simulation, which assess the common mode of many types of distributed generation, provide a higher level of efficiency and give the green light to a model that has a high level of accuracy about distributed generation.

References

[1] K. Balamurugan and D. Srinivasan, "Review of power flow studies on distribution network with distributed generation," in IEEE Ninth International Conference on Power Electronics and Drive Systems (PEDS), 2011, pp. 411-417.

[2] R. E. Brown, "Impact of smart grid on distribution system design," in IEEE Power and Energy Society General Meeting-Conversion and Delivery of Electrical Energy in the 21st Century, 2008, pp. 1-4.

[3] Y. Kumar, A. Saxena and M. Goyal, "Integration of Hybrid Cascaded Multilevel Inverter Configuration in a PV based Applications with Multicarrier PWM Technology," 2021 International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies (ICAECT), 2021, pp. 1-5, doi: 10.1109/ICAECT49130.2021.9392521.

[4] Y. Kumar, M. Pushkarna and G. Gupta, "Microgrid Implementation in Unbalanced Nature of Feeder using Conventional Technique," 2020 3rd International Conference on Intelligent Sustainable Systems (ICISS), 2020, pp. 1489-1494, doi: 10.1109/ICISS49785.2020.9316024.

[5] J. A. Martinez and J. Mahseredjian, "Load flow calculations in distribution systems with distributed resources. A review," in IEEE Power and Energy Society General Meeting, 2011, pp. 1-8.

[6] T.-H. Chen, M.-S. Chen, T. Inoue, P. Kotas, and E. A. Chebli, "Three- phase cogenerator and transformer models for distribution system analysis," IEEE Transactions on Power Delivery, vol. 6, pp. 1671-1681, 1991.

[7] H. E. Farag, E. El-Saadany, R. El Shatshat, and A. Zidan, "A generalized power flow analysis for distribution systems with high penetration of distributed generation," Electric Power Systems Research, vol. 81, pp. 1499-1506, 2011.

[8] S. Khushalani, J. M. Solanki, and N. N. Schulz, "Development of three- phase unbalanced power flow using PV and PQ models for distributed generation and study of the impact of DG models," IEEE Transactions on Power Systems, vol. 22, pp. 1019-1025, 2007.

[9] S. Moghaddas-Tafreshi and E. Mashhour, "Distributed generation modeling for power flow studies and a three-phase unbalanced power flow solution for radial distribution systems considering distributed generation," Electric Power Systems Research, vol. 79, pp. 680-686, 2009.

[10] P. Kaur, S. Kaur and R. Khanna, "Optimal placement and sizing of DG comparison of different techniques of DG placement," 2016 IEEE 1st International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES), 2016, pp. 1-4, doi: 10.1109/ICPEICES.2016.7853653.

[11] J.-H. Teng, "Modelling distributed generations in three-phase distribution load flow," IET generation, transmission & distribution, vol. 2, pp. 330-340, 2008.

[12] Pouya Zolfi, Sina Vahid, Ayman EL-Refaie, "A Multi-Input Solar Converter Interface for AC Microgrid Architecture", Industrial Electronics Society (IECON) 2021 47th Annual Conference of the IEEE, pp. 1-7, 2021.

[13] A. Bahmanyar, A. Estebsari, E. Pons, E. Patti, S. Jamali, E. Bompard, et al., "Emerging smart meters in electrical distribution systems: Opportunities and challenges," in 24th Iranian Conference on Electrical Engineering (ICEE), 2016, pp. 1082-1087.

Doi: 10.51976/jfsa.512201

[14] Sharma, N., Sharma, P., & Parashar, A. K. (2022). Incorporation of Silica Fume and Waste Corn Cob Ash in Cement and Concrete for Sustainable Environment. Materials Today: Proceedings.

[15] Parashar, A. K., Sharma, P., & Sharma, N. (2022). Effect on the strength of GGBS and fly ash based geopolymer concrete. Materials Today: Proceedings.

[16] A. Bahmanyar, S. Jamali, A. Estebsari, and E. Bompard, "A comparison framework for distribution system outage and fault location methods," Electric Power Systems Research, vol. 145, pp. 19-34, 2017.

[17] Kumar, Y., Mishra, R.N. and Anwar, A., 2020, February. Enhancement of Small Signal Stability of SMIB System using PSS and TCSC. In 2020 International Conference on Power Electronics & IoT Applications in Renewable Energy and its Control (PARC) (pp. 102-106). IEEE.

[18] S. Papathanassiou, N. Hatziargyriou and K. Strunz, "A benchmark low voltage microgrid network," Proceedings of the CIGRE symposium: power systems with dispersed generation, 2005, pp. 1-8.

[19] Improvement in mechanical and thermal properties of epoxy hybrid composites by functionalized graphene and carbon-nanotubes, MK Shukla, K Sharma, Materials Research Express 6 (12), 125323.

[20] Investigate the optimal combination of process parameters for EDM by using a grey relational analysis, M Tiwari, K Mausam, K Sharma, RP Singh, Procedia Materials Science 5, 1736-1744.

[21] Performance comparison of innovative spiral shaped solar collector design with conventional flat plate solar collector, SK Verma, K Sharma, NK Gupta, P Soni, N Upadhyay, Energy 194, 116853.