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FAULT CHARACTERISTICS AND PROTECTION OF DISTRIBUTED SOLAR GENERATION

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Abstract

Low current defect, insignificant negative, and zero series currents are the characteristics of inverter-based distributed energy sources (DERs). Knowledge of the fault characteristics of DER is required for the investigation and protection of relays. For the most part, no studies have been done to examine how faults affect the DER model. This article focuses on Dominion Energy's flaws. Of illustrate that the real reaction to DER mistakes may be different than previously thought, stopper defects are studied. It was necessary to model any possible MATLAB-related impact on this study using an advanced simulation environment. There must be a way for the simulation results to be compared to other published results. There is still a lot of work that has to be done to completely test the ideas created using real-world networks so that this thesis may be thoroughly analysed.

Keywords: Inverter-based distributed energy sources, Relay, Dominion Energy, fault properties, null series currents.

1. INTRODUCTION

Traditional feeders are radial systems of which the user is the key fault point. Mainstream mistake detection schemes are used. When the measured value crosses the default value momentarily or time lag,

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an over-current device operates in schemes that overflow. The duration between major and backup defensive systems is matched in order to allow the first to safely clear a malfunction before the least disruption. They are another cause of loss, as energy distributions Resources (DER), as they are put on delivery circuits. The DER fault current partially compensates for the tool's current charge, which tends to slow relay operations. Therefore, a detailed definition of the characteristics of DER fault is necessary with the impact of DER on the current fault analysis and safety relay environment. [1]

1.1. Distributed Generation Background

As a whole, the phrase "distributed or distributed generation" refers to any technique for generating electric power that is applied to distribution networks. Conventional central power generating systems, in which power is generated and transferred to clients through transmission and distribution lines, provide a direct comparison to the DG concept. Although central power networks remain crucial to the worldwide energy supply, their flexibility has been reduced in order to meet the needs of the ever-changing global power market. Large capital-intensive power plants and the T&D system for energy distribution form the core of central power.[2]

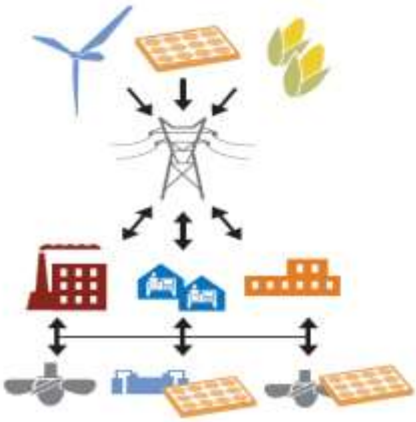

Figure 1: A Distributed Electricity System

In addition, few experiments were carried out to examine the behavior of DER faults during real fault events despite the abundance of work on DER modeling. In this study, Dominion Energy will examine recorded fault events. Dominion Energy obtained fault case reports at points of interconnection (POI). There are seven fault events analyzed at three solar DER locations. Temporary and irreversible fault answers can be captured. The study would rely on steady states in which relays are conducted. [3]

1.2. Research Objective

The following are the objectives of this thesis:

- To study the Inverter-based distributed energy sources (DERs) by using MATLAB Simulink Software.

- Implementation of Circuit breaker with counter set recloser over current relay by replacing overcurrent relay
- Comparison of no relay model, over current relay and Circuit breaker with counter set recloser over current relay.
- Triggering pulses, PVA voltages and Sequence currents are analyzed in this study.

2. LITERATURE REVIEW

Analysis of distributed solar production faults, the safety gaps in old solutions and current techniques for failure detection and classification are discussed in this chapter. The merits and disadvantages of the various existing approaches are also discussed and contrasted.

(Kuna et al., 2020) [4] Dominion Energy has been blamed for a number of incidents in the past. Low current loss is a property of the power supply used by inverters, DERs, and the Zero negative and 0-series. The understanding of DER fault attributes is essential in the case of fault analysis and secure relay implementation. The vast majority of the DER modelling effort was focused on DER performance.

(Alsafasfeh *et al.*, 2019) [5] Useful capability maximisation concerns are addressed by developing the core node-system and power-system analysis principles of the IEEE for photovoltaic energy sources with voltage fluctuation limits. The MATLAB R2017B simulator is used for performance review and evaluation of the job done. The 33-node IEEE system is used to simulate the integration spectrum of PV electric power, and the total integration potential of PV power is assessed at each node, providing a logical decision-making system for preparing the integration of distributed PV energy into a constrained power grid.

(Adnan, Yusoff and Hashim, 2018) [6] The transmission of electrical power generated from renewable sources and located close to customers or loads is known as "Distributed Generation." In addition to increasing voltage and energy efficiency, distributed generating installations may also reduce stress slumps and congestion while also supplying more competitive renewable energy resources electricity. High levels of distributed generation in the existing national grid system may have a number of negative repercussions, including failure rates and the effectiveness of power protection systems, for example.

(Bangash, Farrag and Osman, 2017) [7] Explores the effect on the security of distribution networks of the growing degree of Distributed Generation (DG). Studies have started to minimize the impact on the device failure stage of small-scale embedded generation (SSEG). The penetration level of Residential DG is modular on the Low Voltage (LV) network common in the UK, taking into account the stability of the faults. The loading and discharge, according to the regular charging period, are determined by the penetration level of DG energy storage in the shape of a battery bench.

(sudhakar, Malaji and Sarvesh, 2014) [8] Addresses a simple understanding of how these power flows can impact the power system efficiency and reliability of a photovoltaic (PV) injection power system-dependent distributed generation. The harmonic currents injected into the energy grid can be of significant concern since they may result in undesirable deformity, power reversal, and voltage control.

(Camacho *et al.*, 2007b) [9] Gives a survey of the various advanced automotive control methods used in the last 25 years in the control of solar plant outlet temperature using dispersed collectors. The key characteristics of each technique are explained in a classification of the modeling and control methods mentioned in the first part of this survey. The techniques covered differ from traditional advanced control to those that have little industrial implementations.

3. METHODOLOGY

3-phase transmission line: one of the core elements of an electrical power grid is the power transmission line. It primarily transmits electrical energy from energy sources to charging centers, normally separated by long distances, with limited losses. Three-phase electricity is the standard way to produce, transfer, and deliver electricity in alternating current. For power transmission, it's the most popular method used by electric grids globally and a kind of polyphase system. It is also used for driving big and other heavy engines. A three-wire, three-phase circuit is normally more economical to transfer a specified quantity of energy than an analogous two-wire single-phase circuit at the same line of the ground voltage. [10]

DER is steadily adding to the energy efficiency and reliability of the economy today. DER may also play a vital role, as a result of concentrations of consumer influence, in preventing dysfunctions in dynamic markets for electricity. The newly formed independent grid operators are starting to engage in demand control projects to better handle summer's peak loads. The DER Interconnection Mechanism consists of every device that forms a physical connection between the DER and the EPS, typically the local electrical distribution network (hardware and software). Since the interconnection mechanism is an electrical connection between the DER device and the EPS, it governs energy movement in one or both directions and is capable of providing separate and foundational functions to benefit EPS as well as DER operations.

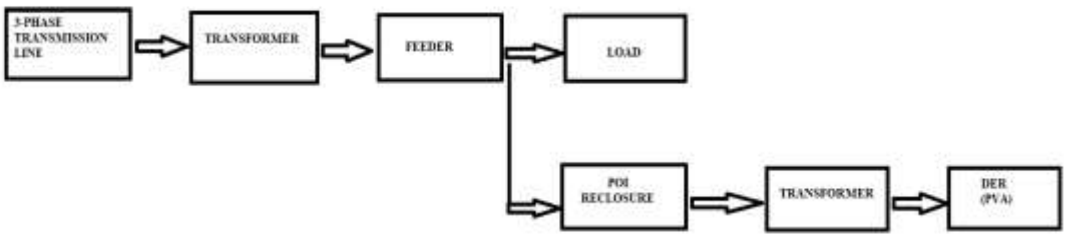

Figure 2: Different components used in proposed methodology

4. SIMULATION RESULTS AND DISCUSSION

Algorithm development is carried out in MATLAB (R2016). It is possible to utilise the signal processing toolbox in MATLAB Library functions for various techniques, including windows, rotation and scaling.

4.1. Simulation Parameter

Sim Power System Toolbox is also used to construct the project for this test. The table below displays different parameters used in this analysis, and their values will also appear in the table. Several parameters include the voltage supplied, energy, transformer step-up, frequency, temperature, capacitor, resistance, etc. For this study, Simulation is done using MATLAB.

Table 1 Different simulation parameters

Name of parameter	Unit and Value
Supply Voltage	132KV
Power	2500KVA
Step-up down Transformer	132KV/34.5KV
Power rating of step-up transformer	47MVA
Frequency	50Hz
Phase to phase voltage	34.5KV
Active Power	100KW
Reactive Power	50KVAR
Circuit Breaker Resistance	0.01 Ohm
Solar irradiation	1000 W/m^2
Temperature	35 Degree
Duty Cycle	0.5
Capacitor	1000 Micro Farad
Resistance	0.005 Ohm
Inductor	5Mh

4.2. Simulation result and discussion

The studied faults are located on feeder and outside of a solar farm. Data on faults are obtained by the POI recorder, which calculates DER inverters' fault current contribution. Figure shown below depicts the components of a coordinated control system, which include sensors, equipment controllers, data input devices, and systems. Sites that had power outages weren't running at full capacity.

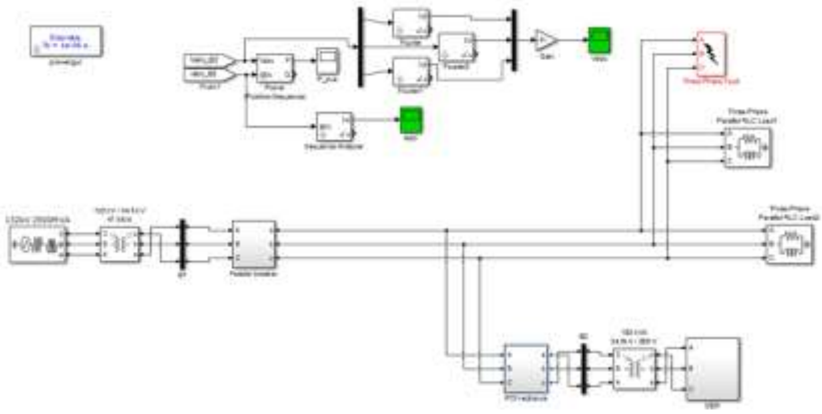

Figure 3: Simulation model without relay

Devices that protect low-voltage circuits or single home appliances up to huge switchgear that regulates high-voltage circuits feeding a whole area are all forms of breakers. Circuit breakers and fuses are sometimes referred to as OCPDs because of their ability to automatically disconnect power from an improper device.

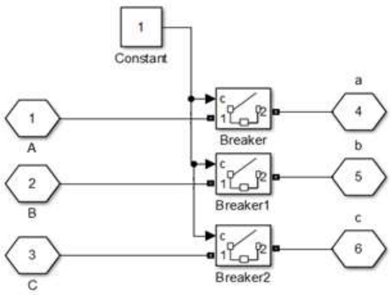

Figure 4: Circuit breaker with no relay protection system

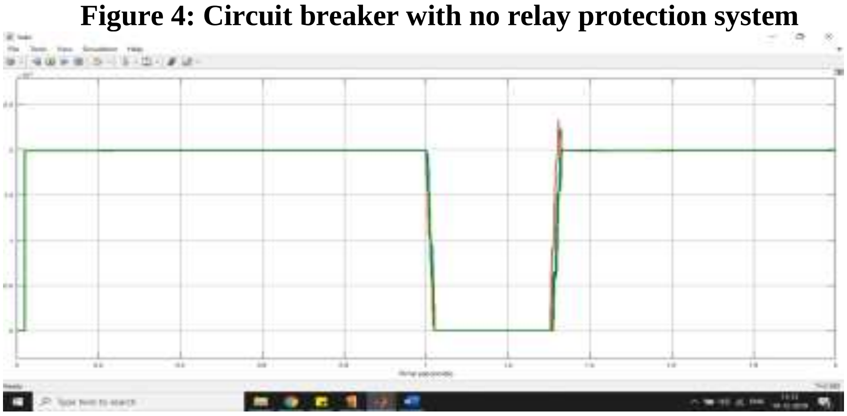

Figure 5: PVA voltages with no relay protection with fault from 1 to 1.3sec

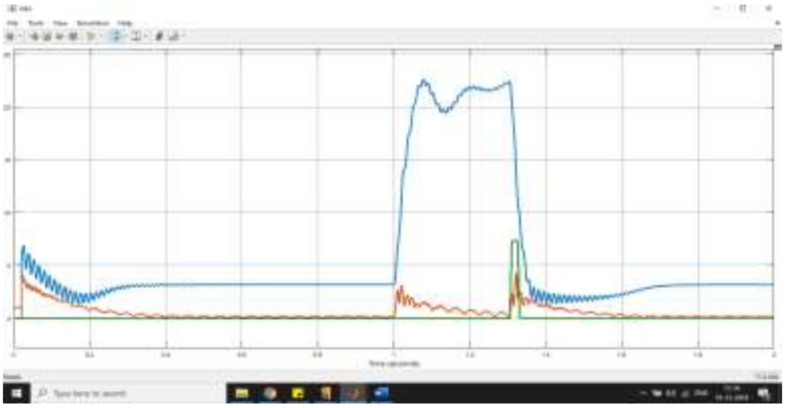

Figure 6: Sequence currents with no relay protection with fault from 1 to 1.3sec

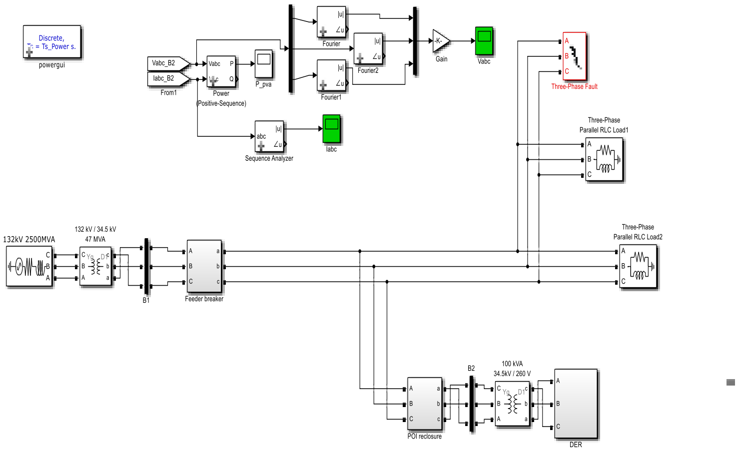

Figure 7: Simulation model with over current relay

The over-current relay is an important relay for the security of feeders, transformers, bus couplers, etc. It may be used for the security of main or backup relays. In the research into the effects of network parameters and configurations on the performance of these relays, the modeling of overcurrent relays and other safety relays is relevant. The present relay using the MatLab/Simulink program is explored in this study shows in the image. The simulation model over the current relay shown above shows the simulation model.

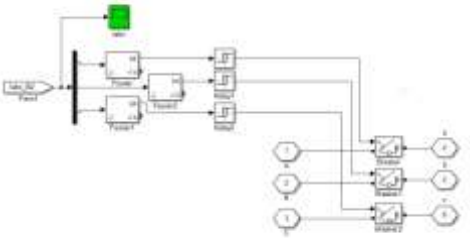

Figure 8: Circuit breaker with over current relay

Circuit breaking is a mechanical system composed of two functions that are open, defective or pathological, and closed connections with regular or stable circumstances in compliance with normal and abnormal conditions. The Circuit Breaker works automatically via the relays and sends a travel signal to the circuit breaker when the relay coil is activated. And the operative unit such as the engine, generator, transformer, and light electronic equipment or devices with circuit breaker contacts is open and secure.

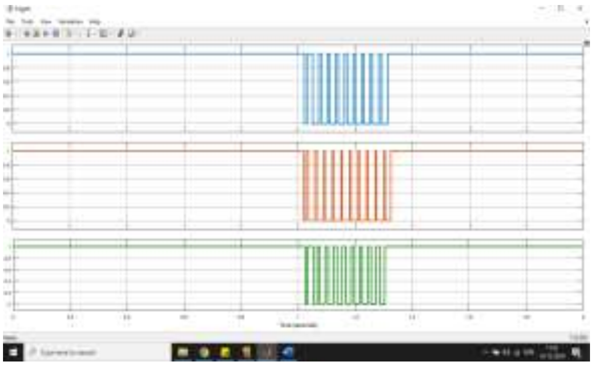

Figure 9: Triggering pulses of over current relay

The number of triggers is very high as the fault is persistent the relay cannot eliminate the fault permanently.

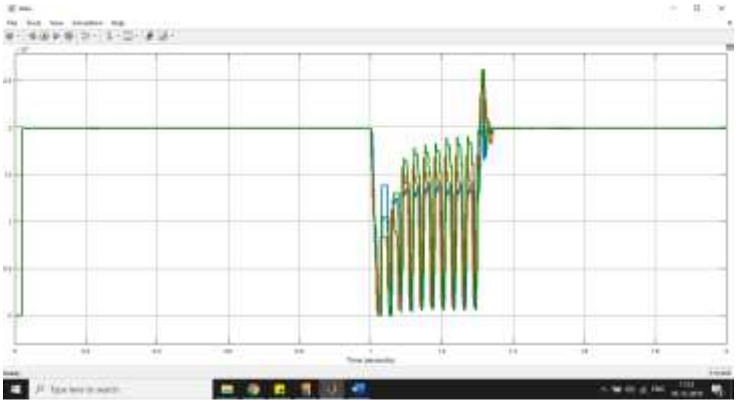

Figure 10: PVA voltages with over current relay protection with fault from 1 to 1.3sec

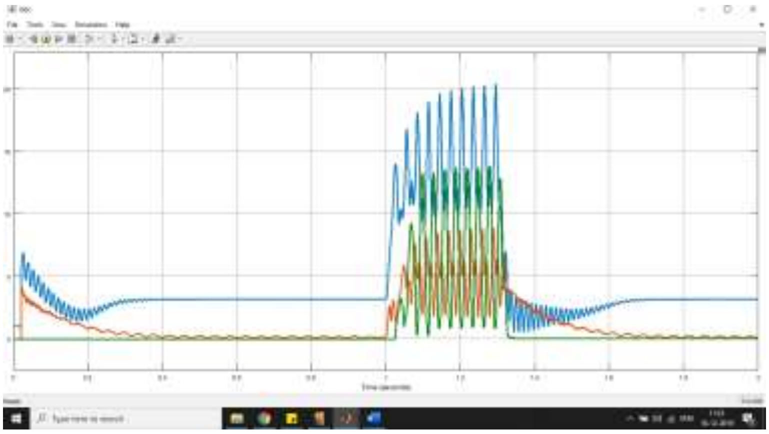

Figure 11: Sequence currents with over current relay protection with fault from 1 to 1.3sec

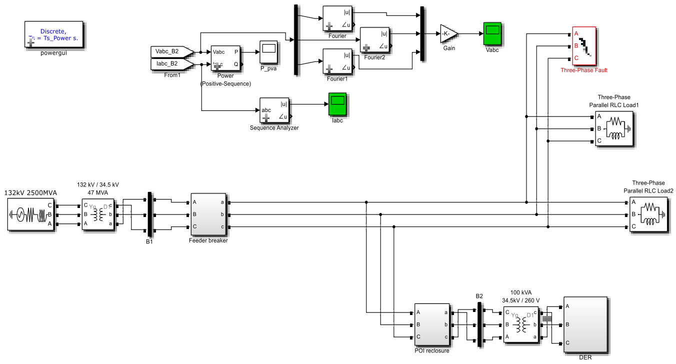

Figure 12: Proposed simulation model of counter set reclosure over current relay

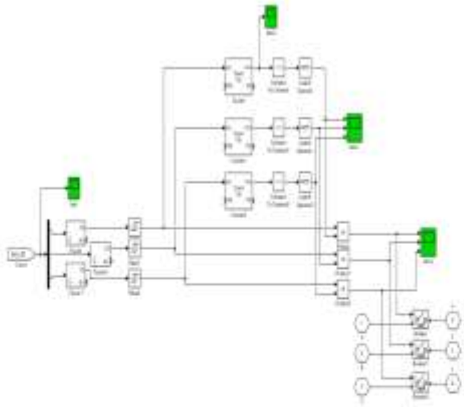

Figure 13: Circuit breaker with counter set reclosure over current relay

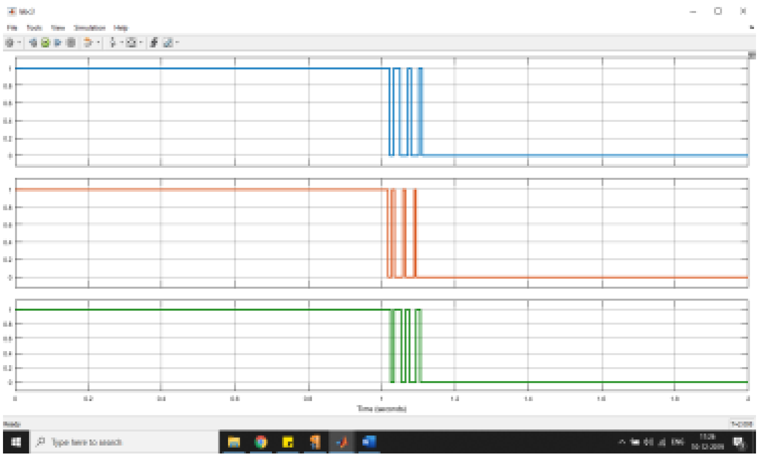

Figure 14: Triggering pulses of over current relay

Three times is the maximum number of times the relay may be set to trigger OFF and remove the defect from DER.

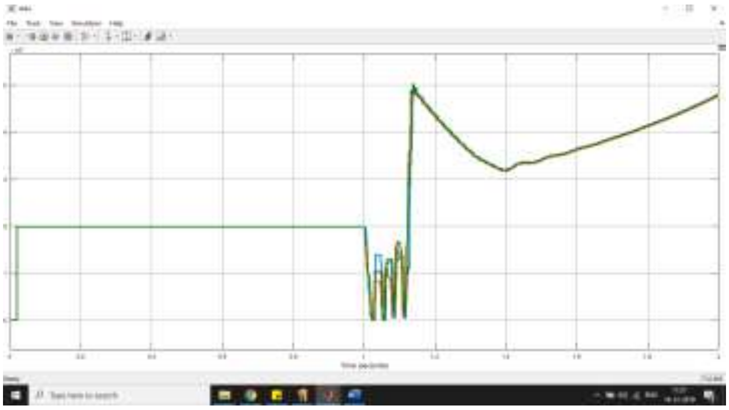

Figure 15: PVA voltages with over current relay protection with fault from 1 to 1.3sec

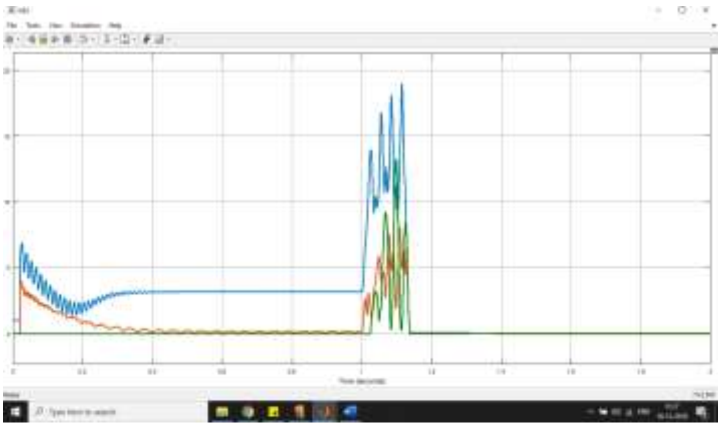

Figure 16: Sequence currents with over current relay protection with fault from 1 to 1.3sec

In figure, the number of constraints is seen with the counter set reclosure over the current relay to three cycles, which activates the circuit breaker OFF entirely while the loss persists beyond three recloser times.

5. CONCLUSION

Distributed generation in the coming decades, especially close to the low-voltage consumer side, is expected to play a greater role in power generation. Power users are increasingly interested in building their own generation capacity in order to benefit from versatile DG technology to generate electricity in desirable times, increase energy efficiency and quality, or provide heating/cooling. The variety of DG technologies, as well as their diversity in scale, efficiency, and appropriate applications suggests that in many different manufacturing, commercial and residential environments, DG may provide energy supply solutions. This will improve the reliability of the power supply that DG contributes.

References

[1] G. Kou, L. Chen, P. Vansant, F. Velez-Cedeno, and Y. Liu, "Fault Characteristics of Distributed Solar Generation," *IEEE Trans. Power Deliv.*, vol. 35, no. 2, pp. 1062–1064, 2020, doi: 10.1109/TPWRD.2019.2907462.

[2] Z. Cheng, Z. Li, J. Liang, J. Si, L. Dong, and J. Gao, "Distributed coordination control strategy for multiple residential solar PV systems in distribution networks," *Int. J. Electr. Power Energy Syst.*, vol. 117, no. September 2019, p. 105660, 2020, doi: 10.1016/j.ijepes.2019.105660.

[3] M. H. Athari, Z. Wang, and S. H. Eylas, "Time-series analysis of photovoltaic distributed generation impacts on a local distributed network," *2017 IEEE Manchester PowerTech, Powertech 2017*, 2017, doi: 10.1109/PTC.2017.7980908.

[4] S. Kuna, K. Nandini, N. V. N. Reddy, and K. H. Reddy, "Simulation and Analysis of Fault Characteristics of Distributed Solar Generation," *Int. J. Innov. Technol. Explor. Eng.*, vol. 9, no. 8, pp. 305–310, 2020, doi: 10.35940/ijitee.h6350.069820.

[5] Q. Alsafasfeh, O. A. Saraereh, I. Khan, and S. Kim, "Solar PV grid power flow analysis," *Sustain.*, vol. 11, no. 6, pp. 1–25, 2019, doi: 10.3390/su11061744.

[6] A. Z. Adnan, M. E. Yusoff, and H. Hashim, "Analysis on the impact of renewable energy to power system fault level," *Indones. J. Electr. Eng. Comput. Sci.*, vol. 11, no. 2, pp. 652–657, 2018, doi: 10.11591/ijeecs.v11.i2.pp652-657.

[7] K. N. Bangash, M. E. A. Farrag, and A. H. Osman, "Impact of energy storage systems on the management of fault current at LV network with high penetration of distributed generation," *Int. J. Smart Grid Clean Energy*, vol. 6, no. 3, pp. 195–206, 2017, doi: 10.12720/sgce.6.3.195-206.

[8] P. sudhakar, D. S. Malaji, and D. . Sarvesh, "Protection issues of Power Systems with PV Systems Based Distributed Generation," *IOSR J. Electr. Electron. Eng.*, vol. 9, no. 3, pp. 18–27, 2014, doi: 10.9790/1676-09351827.

[9] E. F. Camacho, F. R. Rubio, M. Berenguel, and L. Valenzuela, "A survey on control schemes for distributed solar collector fields. Part II: Advanced control approaches," *Sol. Energy*, vol. 81, no. 10, pp. 1252–1272, 2007, doi: 10.1016/j.solener.2007.01.001.

[10] R. Cleber da Silva and S. Kurokawa, "Model of Three-Phase Transmission Line with the Theory of Modal Decomposition Implied," *Energy Power Eng.*, vol. 05, no. 04, pp. 1139–1146, 2013, doi: 10.4236/epe.2013.54b217.