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EFFECT OF DISTRIBUTED GENERATION ON PROTECTION SYSTEM IN RADIAL DISTRIBUTION NETWORK CHALLENGES & SOLUTIONS

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ABSTRACT

Distributed generation (DG) is now crucial due to increasing demand for energy and growing need for unconventional energy sources. Within the framework of an electrical system, this kind of technology allows a bidirectional transfer of power. The successful integration of DG into a conventional power system creates a number of difficulties, one of which involves the protection of the system under DG sources. New technology always brings with it novel challenges. A large number of Distributed Networks (DNs) have radial feeders, that is a concern. Limited protection, that includes excess current and earth fault protection, is required for these radial networks. The radial characteristics of the network is lost and fault-current levels changes when a Distribution Generation (DG) is connected to a Distributed Network (DN). When the DG is connected to the DN, it's possible that the standard overcurrent and earth fault prevention won't find the faults. These sources present a considerable difficulty because of the bidirectional fluxes from DGs. In this research, existing overcurrent protection strategies are reviewed, along with their disadvantages and benefits for DG interfaced networks. A differential protection scheme is also suggested. It is simulated to have a small network with all forms of failures and both the standard overcurrent protection and differential protection scheme. In-depth MATLAB simulations are run to verify and explain the outcomes [1] [4].

Keywords: Differential Protection, Distributed Generation, Distributed Networks, Protection Schemes, Selectivity, Sensitivity.

I. INTRODUCTION

The production of energy from fossil fuels like coal, oil, and natural gas has a number of drawbacks, including the release of greenhouse gases that contribute to global warming. Distributed generation (DG) has become a viable alternative to fossil fuels as a result of the growing acceptance of and desire for cleaner, more sustainable energy sources, as well as significant blackout episodes around the world. The future of energy is in distributed generation (DG). Gas turbines, fuel cells, biomass, photovoltaic (PV), wind, and hydroelectric power are all examples of DG. The power network has always been radial by nature. The addition of DG makes it bidirectional because both the primary utility grid and DG can supply power. This raises a number of issues with relation to the frequency control and protection, power quality, security, power flow control, and system voltage profile. System protection in the face of DG has recently become an obvious problem that requires rapid attention[2] [3].

With regard to speed, selectivity, and sensitivity, adding current differential protection to the DN is therefore seen as preferable. The more DG that is linked to the radial network, the more fault currents that are delivered by the DG during faults, which might cause relays to underreach or overreach[1]. This study models and simulates a distributed generation interfaced network in MATLAB/SIMULINK and analyses the efficacy of various differential protection methods. The analysis of each approach, including conventional overcurrent protection and differential protection schemes for all fault kinds and fault levels with Simulink, is also provided.

II. METHODOLOGY

A microgrid is, in the words of the Department of Energy (DOE), "a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid and can connect and disconnect from the grid to enable it to operate in both grid-connected and islanded-mode[5]."

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Fault Type	Occurrence Probability (%)	Severity
Single Line to Ground (SLG)	85	Least
Line-Line (LL)	8	
Double Line to Ground (LLG)	5	
s Three Phase Bolted (LLL)	2	Most

Figure 1: Fault Statistics of various faults

Three-phase symmetrical faults and single line-to-ground faults are typically the two types of faults that are discussed in the literature. The most frequent fault is single line-to-ground, and three-phase faults are frequently the most serious. We have investigated Single Line to Ground fault because it is the most prevalent fault[8].We are going to study the three scenarios that will be used for the simulation study as follows:

1) Distributed Network without DG Connected
2) Differential protection with DG connected & fault between bus-bar B and C.
3) Differential protection with DG connected & a fault between busbar A and B.

Distributed Network without DG Connected

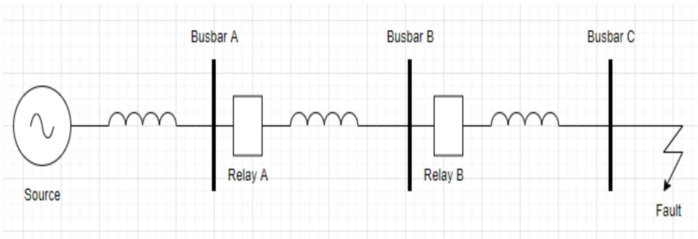

Figure 2 : DN without DG connected.

The relay at bus-bar A can be configured to act as a backup safeguard for the relay at bus-bar B when the DG is not connected. Based on the calculated fault current, relays A and B will be set. Relays at Bus-bar B will therefore trip, while relays at Bus-bar A will offer backup protection.

Overcurrent Protection with DG Connected

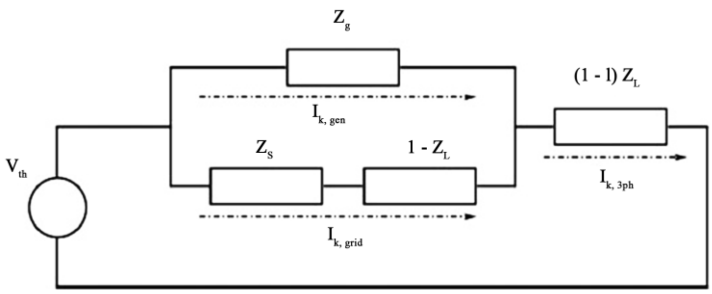

Figure 3: Equivalent Circuit with DG connected

The net impedance of the system will drop when a parallel DG source is added to the distribution network[2]. This may result in a network fault current that is extremely high. If the DG source is a synchronous generator, then these currents will be significantly higher. These fault currents have the potential to spread throughout the network and seriously harm many different components in the event that protection coordination is not done properly.

Case1: Under reaching of relays when using overcurrent protection.

In this simulation the DG is connected to the system. The fault is at bus-bar C, and the source feeding into the fault as well as the DG are both contributing to the fault current. The overcurrent failure at bus-bar C is seen in Figure 2. When the fault is applied at 0.1sec, the fault current measured rose from Ifault = 190 Amp to Ifault = 200.2 Amp. However, because the overcurrent relay is under reaching, the problem did not resolve. Since the fault current feeding from the source fell and is below the overcurrent protection setting pickup, this demonstrates that the overcurrent protection will not be enough in this situation.

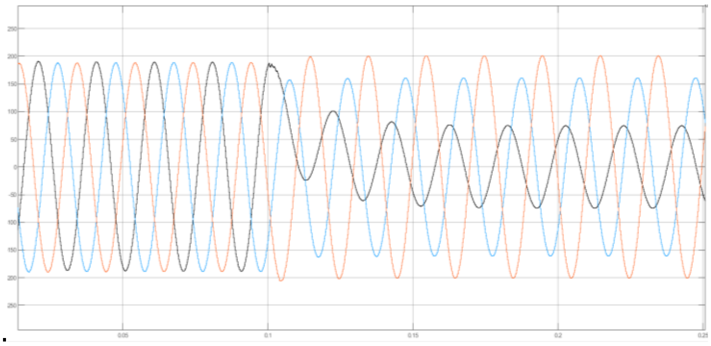

Figure 4: Overcurrent Protection; Fault while DG is connected.

Figure 3, displays the consequence of overcurrent fault at bus-bar C, measured by relay 4. The issue appeared at 0.1 seconds and disappeared after 3 seconds. It demonstrates that when the DG is not connected to the system, the typical overcurrent protection will be sufficient to fix the issue.

Differential Protection with DG Connected

The system fault level (and thus fault current) at point C will rise when DG is connected. The fault current contribution from the source will decrease as a result of the DG's fault current contribution. Therefore, if there is a failure at bus-bar C, the relay at bus-bar A might not trip in the requisite amount of time due to the drop in fault current.

Differential protection is suggested here to address this issue[1][6].

Fault between bus-bar B and C.

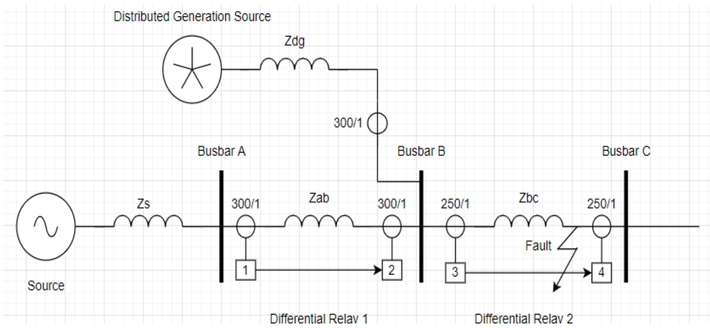

Figure 5: Fault Between Busbar B & C.

In this simulation, bus-bars B and C are where there is a failure. By turning on circuit breakers 3 and 4, the issue will be resolved. The source and DG pouring into the fault combine to form the fault current, which flows in a single direction. By isolating the issue on line 2, the source continued to supply the load on bus-bar B after the fault had been fixed. Unfortunately, the placement of the failure caused the load at bus-bar C to be lost.

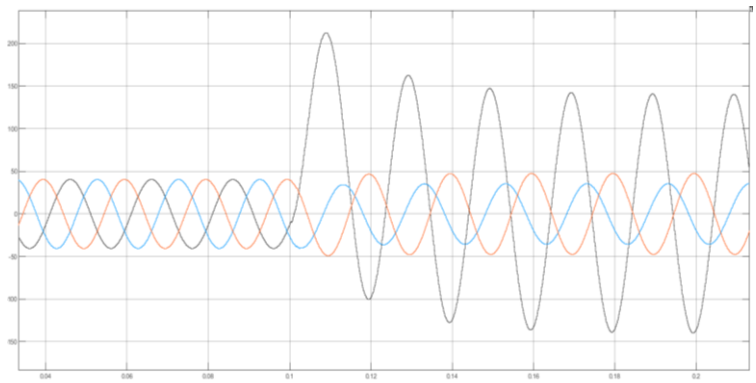

Figure 6: Differential Protection; Fault between bus-bar B and C while DG is connected.

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The overcurrent fault fed from the source is depicted in Figure 6. When the fault is applied, the current increases from 43 A to 210.5 A in 0.1 seconds. Ifault = 210.5 A is the contribution of the source's fault current. The issue was cleared within 0.3 seconds.

Fault between bus-bar A and B.

Two sources feed the fault current, which runs in two directions. By turning on circuit breakers 1 and 2, the issue will be resolved. There was no current flow from the source to the loads when the fault was fixed[2][1]. The load current will increase once the fault has been fixed since the DG will keep supplying the load.

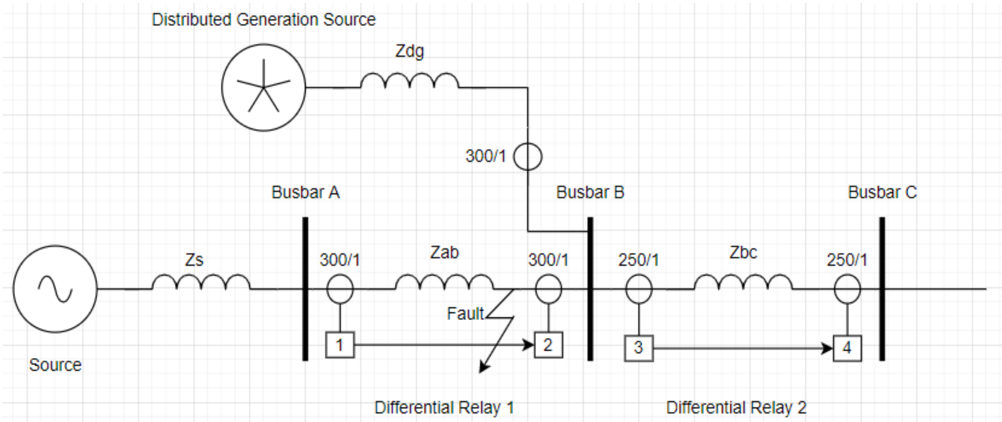

Figure 7: Fault Between Busbar A & B.

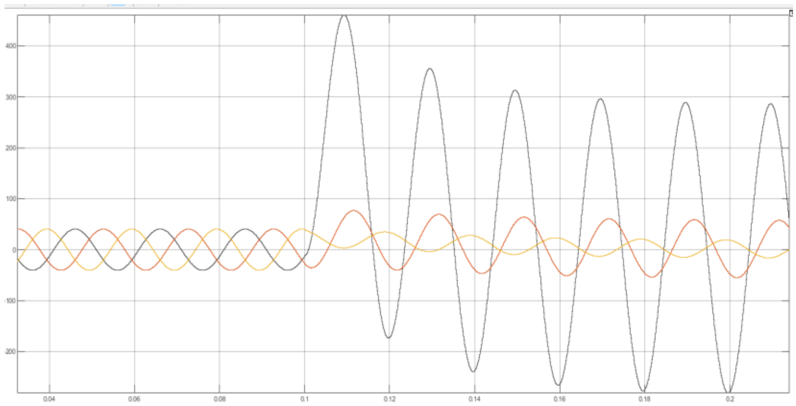

Figure 8: Differential Protection; Fault between bus-bar Aand B while DG is connected.

The total fault current contributions from the source and the DG are displayed in Fig. 8. Since the fault was located within the protected zone, the protection worked as intended, opening CBs 1 and 2. After 3 seconds, the issue was repaired. The measured fault current is 455.2 Amp, and the entire fault current flows in two directions. Fault is applied after 0.1 seconds, increasing current from 33 A to 451.5 A.

III. MODELING AND ANALYSIS

A tiny radial distribution network was developed and connected to a distributed generation source. Figure shows the differential protection method for DG interfaced network's detailed MATLAB/SIMULINK model. We examined fault levels at various fault locations using waveforms and analysed Single Line to Ground fault because to its high severity.

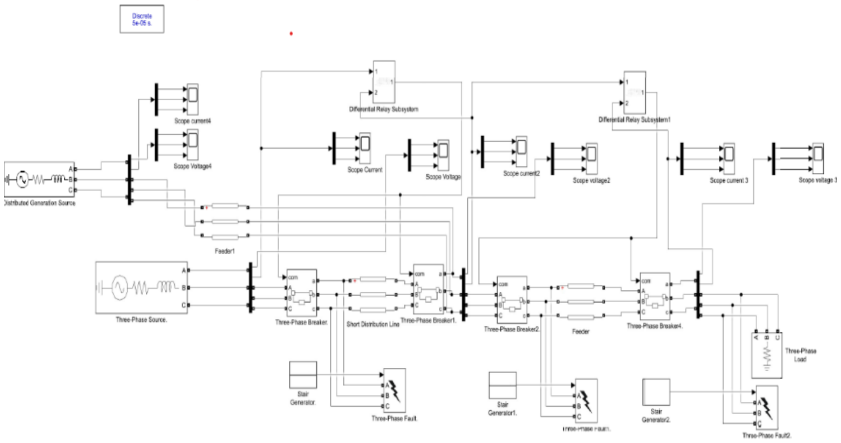

Figure 9: Differential Protection; DG interfaced network.

IV. RESULTS AND DISCUSSION

The table below contains a visualisation of the outcomes of various overcurrent and differential protection scheme scenarios. When there is a fault between busbars B and C, the fault current from the three-phase source is much lower than the pickup value required for overcurrent protection, which causes the overcurrent relays to underreach and fail to activate the circuit breakers[2]. When there is a fault between busbars B and C, differential protection is necessary because the fault currents from the three phase source and the DG source are the same and higher than the pickup value. As a result, relays turn on the circuit breakers. Since differential protection operates for all fault locations and differential relay sensitivity is strong, it is therefore best suited for DG interfaced networks.

Table 1. Fault Current Values at different Locations

SN.	Fault Location	Fault Current (Overcurrent Protection)			Fault Current(Differential Protection)		
		Relay Pickup Value	Three Phase Source	DG Source	Relay Pickup Value	Three Phase Source	DG Source
1	Between Busbars A & B	250 A	2100 A	530.2 A	100 A	455.24 A	180 A
2	Between Busbars B & C	250 A	180 A	650 A	100 A	210.54 A	210.54 A
3	Out Of Zone Fault	250 A	80 A	405 A	NA	110.45 A	110.45 A

V. CONCLUSION

In the presence of DG, protecting distribution networks is fraught with difficulties. Only radial systems are compatible with conventional over current protection. Bidirectional power flows in DG-connected distribution networks have an impact on protection coordination. The current study set out to conduct a thorough analysis of the protection programmes currently in place for DG linked distribution systems[3]. Studies have been done on the fault levels of differential protection schemes with defects at different locations and normal overcurrent fault levels. Although a lot of work has been done in this direction, much more has to be investigated in order to solve the major issues and enhance the already completed tasks. It's possible that standard overcurrent protection won't be enough to fix the problem. Because differential protection can be used to secure the network with or without the DG linked to it, it is perfect for DN with connected DG. The differential protection is also better since, when properly applied, it can only remove the network's defective portion and is virtually instantaneous[1]. The fault currents are computed in this paper using the fault at various network points. The differential protection successfully and accurately cleared the identical faults when the same faults were simulated.The communication between the two relays is a drawback of differential protection. The communication link between relays is susceptible to failure at any time, making it the weakest link in the protection system.

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