Effect of Distributed Generator on Over Current Relay Behaviour

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Abstract. Integration of Distributed Generator (DG) to the distribution network feeder causes its power flow to bidirectional in place of unidirectional influencing the feeder protection. The analysis of chapter presents the influence of Distributed Generator on the over current relay behaviour. The behaviour of the scheme is evaluated for an 8-bus radial distribution feeder in PSCAD/EMTDC software and the characteristics of over current relay are tested on MATLAB software. The simulation result indicates the effects of DG on feeder protection as the current from Distributed Generator reduces relay reach.

Keywords: Distributed generator · Distribution network feeder · Over current relay

1 Introduction

Distributed generators are small size units that directly connected to the distribution feeder or on the consumer site which provides an alternate solution for delivering power to some customers [1–3]. Generally distributed generators are synchronous generators, induction generators powered by wind, fuel cells, hydro, and photo-voltaic. They offer various applications including backup generation, utmost shaving, and smart metering. Apart from the applications, the benefits include voltage support, a decrease of energy-loss, and release of system capacity and enhancement of reliability [4, 5].

Previously the distribution feeder was incorporated for the transmission of power from the transmission feeder to the load centre. There was no provision for incorporating the DGs directly to the feeder. The protection of the distribution feeder is well equipped considering one-way power flow, i.e. point of transmission to the load centre. The distribution system feeder causes the power flow to be two-way in place of one-way affecting the behaviour and stability of the network in so many methods with the connection of DGs to it [6]. The tremendous effects that remain unresolved deploying traditional methods found to be the influence of Distributed Generator on regulation and feeder protection [7–9].

The chapter emphasizes the influence of Distributed Generator on protection of the feeder. Protection scheme essentially consists of protective relay and circuit breaker for

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the protection of power system elements against unusual faulty conditions. Protective relay is a sensing device that directs the circuit breaker to open when current through the relay is more than the set current of the relay. Circuit breaker after getting a signal from the protective relay isolates the faulty part from the rest of the feeder.

The motivation behind the research is relay mal-operates if the fault current magnitude is less than the set current of the relay in-cooperating the over current protection. But it becomes more difficult for the relay if distributed generators are connected to it as it reduces the reach of the relay.

But the integration of a DG affects the over current relay behaviour that has been discussed in this chapter. This chapter is organized as follows. The mathematical modelling of an 8 bus radial distribution system is simulated in PSCAD/EMTDC software has been discussed in Sect. 2. The detailed description of the impact of DG on over current relay behaviour and simulation results are provided in Sect. 3. Finally, the conclusion part is discussed in Sect. 4.

2 System Modelling

An 11 kV, 8 bus radial distribution system with DG integrated at bus 6 is simulated in PSCAD/EMTDC software in this chapter. A linear load of each 0.851 MVA at a power factor of 0.76 per phase is equally distributed along the feeder.

Distribution line Segment connected are of $R = 0.38\ \Omega$, $X = 0.4084\ \Omega$. The DG connected to bus 6 is a constant current source and a line to ground fault of fault resistance 10 Ω is applied to bus 8. The schematic diagram of the test model is shown in Fig. 1.

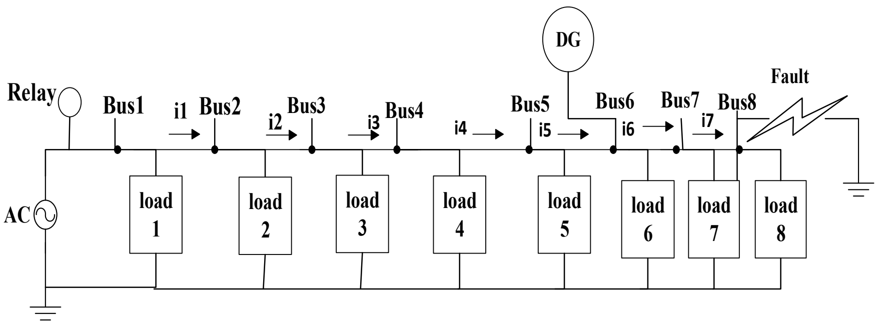

Fig. 1. Line diagram of 8-bus radial distribution network

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Apart from others, one reason affecting the DG on feeder protection is "reach" of relay which gets affected due to current contribution from DG. OC relays are used for protecting a definite portion of the feeder, which is called "*reach*". It is calculated by the pick-up current which is the minimum fault current at which the relay operates. The "reach" of OC relay will get lessened due to Distributed Generator subsequently, faults at the feeder end remain undetected. The main cause for reduction in reach is due to Distributed Generator which contributes current, which causes a decrease in fault current sense by the relay.

For understanding the effect of Distributed generator on over current relay behaviour of the feeder, Fig. 1 is simulated in PSCAD/EMTDC software with and without DG with a fault resistance of 10 Ω at the feeder end. Fault current at bus1, bus4, bus6, bus7 are calculated for a fault resistance of 10 Ω at the feeder end before connecting DG.

When DG is connected at bus 6 fault current at bus1, bus4, bus6, bus7 are calculated for a fault resistance of 10 Ω at the feeder end with DG.

Figure 2 shows fault current seen by the relay at the grid after few transients reaches to a constant value of 1186 amp after 20 ms when there is no DG connected to the feeder. Figure 3 shows that the fault current subsidies to a constant current of 768 amp few milliseconds after when DG is connected to bus 6.

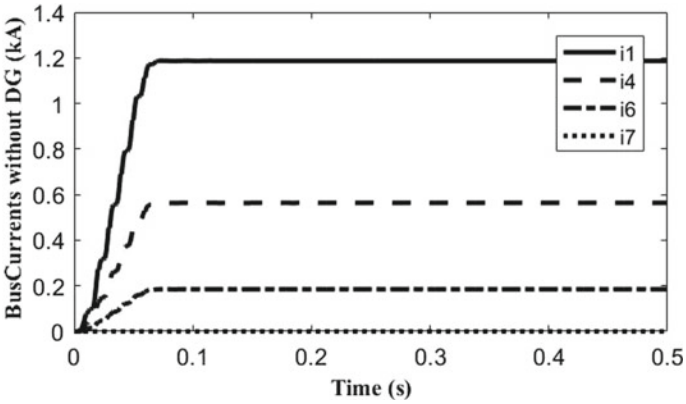

Fig. 2. Current at different buses without DG

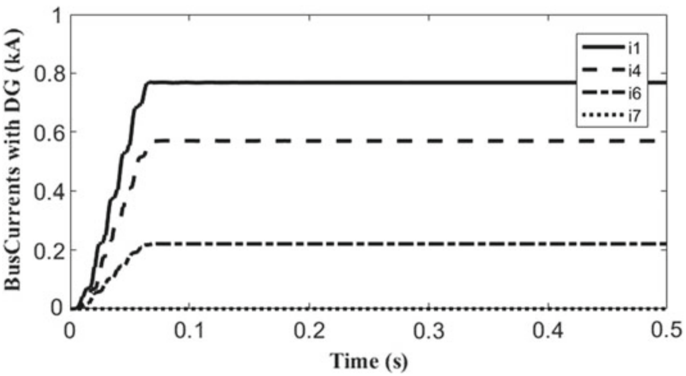

Fig. 3. Current at different buses with DG

As seen from Fig. 4 the fault current seen by the relay is 1186 amp when the feeder is not connected by DG. But, however, current decreases at relay point when the feeder is connected to DG. The relay characteristics algorithm is tested on MATLAB software to see the relay nature.

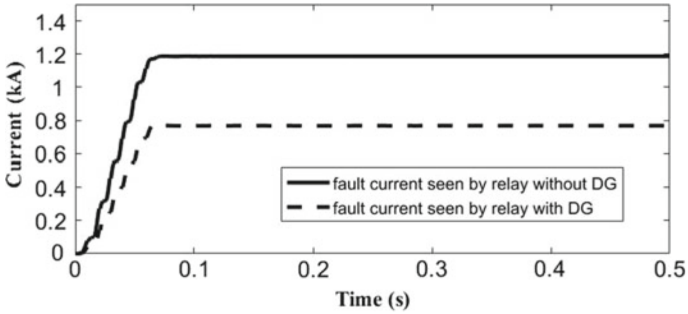

Fig. 4. Current sense by relay before and after integration of DG with fault at the feeder end

Figure 5 shows the relay characteristic is rectangular hyperbola whose characteristic is inverse in the initial part and as the current becomes very high it operates at a definite minimum value. This is due to the fact at high values of current in the electromagnetic relay the flux saturates and maintains a constant value due to saturation. So if the fault current is higher, relay takes a minimum time to operate.

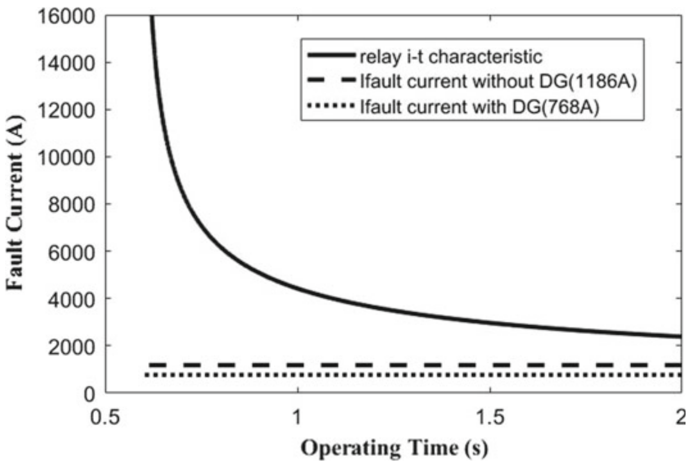

Fig. 5. Relay I–T characteristics

4 Conclusion

With the integration DG in the feeder no doubt it provides various operational benefits to the system at the same time it affects the feeder protection. The analysis of this chapter presents the effect of Distributed Generator on feeder over current relay behaviour. Simulation results clearly show the integration of DG reduces the over current relay reach.

One algorithm is to be developed which will assist over current relay with and without distributed generators under faulty condition.

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