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EFFECT OF DISTRIBUTED GENERATION ON DISTRIBUTION SYSTEM PROTECTION

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ABSTRACT

The operation and paradigm of distribution system is changing with the integration of distributed generation, based on alternative energy sources, including renewable energy sources (wind, solar etc.). This paper explains the effect of distributed generation (DG) on power system protection. With the DG penetration into the power system network, it has become necessary to evaluate the potential impacts of DG on the existing protection schemes through detailed simulation and protection studies to ensure consistency and security of the system. Basically, the major impact on the power system is that due to the addition of the Distribution Generation the short circuit current level increases. Along with this some other parameters are also discussed in this paper like the impact of DG on voltage regulation, harmonics, and losses.

Keywords: *Distributed Generation (DG), fault level, Harmonics, PSCAD.*

I. INTRODUCTION

Distributed generation uses small-scale technologies to generate electricity in close proximity to the consumers.
It normally consists of modular and renewable-energy generators which can provide more economical, reliable and secure power with less environmental issues.
However incorporation of DG in distribution network affects power quality and protective device co-ordination.The severity of impact depends on the location (site) and size (penetration level) of the distributed generating sources.

With the increasing dependence on electricity supplies, the need to achieve an acceptable level of reliability, quality and safety economically is very important to customers. A supply system should be well designed and efficiently maintained in order to limit the number of faults that might occur.

Most of the protection schemes are designed for radial networks with uni-directional power flow. The penetration of DG unit modifies the radial characteristics of distribution systems into non-radial and multi-source systems [10]. This paper addresses the issue of impact of integration of DG on the short circuit current level and its effect on relay co-ordination of distribution system. [14].

The paper is organized as follows:
The principle of distribution feeder and DG protection are summarized in Section II, while Section III explains the impact of DG on various factors of power system. Section IV consists of real time 32 bus distribution system under study. Finally, comparison of normal current and fault current with and without DG is given in Section V.

II. DISTRIBUTION FEEDER AND PROTECTION

A. Distribution Feeder Protection
Distribution systems are generally radial in design, with overcurrent protection matching with characteristics of the distribution. [11], [12]

- Any protective device has a maximum distance or reach for which the device works. For large distribution networks, to protect the network from the sub-station many protective devices are installed
- Relay co-ordination gets modified due to introduction of DG in distribution system [8].

- The transient currents caused by, events like transformer inrush and cold load pickup, can exceed the pickup current of protective relays which must be considered while selecting the time-current characteristics.

B. DG Integration and Protection
Interconnection protection provides the protection that allows DG units to operate in parallel with the utility grid. Properly designed interconnection protection should address the concerns of both the DG owner and the utility, and satisfy utility requirements to allow the DG to be connected to the grid and is established at the point of common coupling (PCC) between the utility and the DG. Overcurrent protection is affected by the DG characteristics like, rating and type, in addition to its location and configuration of network.

III. IMPACT OF DG ON POWER SYSTEM

A. Impact of DG on feeder losses
DG location affects the losses in a feeder. Hence its optimum location must be decided.[2] Locating DG units to minimize losses is similar to locating capacitor banks to reduce losses. DG may contribute to both active and reactive power flow, while capacitor banks will only contribute to the reactive power flow.

B. Impact of DG on Harmonics
DG can be a source of harmonics for the distribution network. Harmonics can be injected into the network by the DG and inverters. The old inverter technologies that were based on SCR produced high levels of harmonics, while the use of IGBT in new inverters has reduced the amount of harmonics. [2]

C. DG Impact on Regulation
Load tap changing (LTC) transformers at substations, line regulators on distribution feeders and switched capacitor banks on feeders are used for keeping the voltage within the tolerable band. DG connection modifies the radial characteristics and the system loses its radiality. [6]

An unsuitable DG can result in low and high terminal voltage at different locations. The power injected into the system by the DG may result in an acceptable within limits voltage at the DG side, however on the downstream side it may cause over voltages.

D. Impact of DG on short circuit level
Introduction of DG modifies the network configuration which leads to rise in the fault level near the PCC (Point of common coupling). The new fault current and setting should be calculated for the relays in the system. [4]

IV. SYSTEM UNDER STUDY

The system comprises of one radial feeder, feeding number of residential, commercial and industrial loads on an 11 KV distribution system. This system is simulated with different buses using PSCAD 4.2 simulation software. Total number of buses for the radial system are thirty two out of which twelve buses are the load buses and one is source bus. Four buses are selected randomly and fault is created at these buses in presence and absence of DG. Fault type is line to ground fault for duration of 0.26 sec. The fault is created on low voltage side (load side) of transformer at different buses i.e. bus 8, 15, 23 and 32 individually. All these buses are located at some distance from each other. The DG is a photovoltaic solar system having a generating capacity of 60 KW which is added in the system on bus 23.

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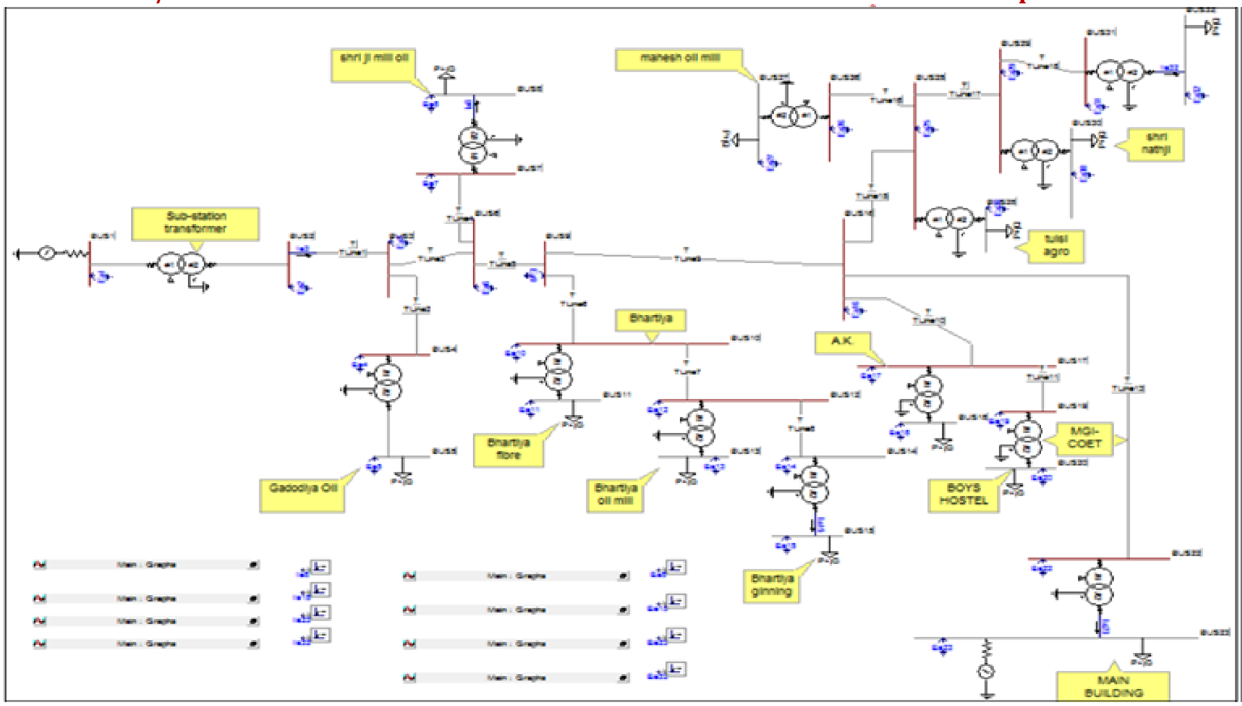

Fig.1 11KV 32 bus radial distribution feeder of MSEDCL

V. RESULTS AND DISCUSSION

CASE I: Comparison between normal current & fault current with & without DG when fault is on bus 8.
The percentage change in current is given by,

% change in I_{nwDG} w.r. to I_{fwDG} = $$\frac{I_{nwDG} - I_{fwDG}}{I_{nwDG}} \quad (1)$$

% change in I_{nwoDG} w. r. to I_{fwwoDG}= $$\frac{I_{nwoDG} - I_{fwoDG}}{I_{nwoDG}} \quad (2)$$

Where, I_{nwoDG} = Normal current without DG
I_{fwoDG} = Fault current without DG
I_{nwDG} = Normal current with DG
I_{fwDG} = Fault current with DG
E.g. (1), Fault is on bus 8 and then % change in

I_{nwoDG} w.r.to I_{fwoDG} for bus 15 =

[(0.3167-0.2946)/0.3167]*100= 6.97% (from (1))

When fault is on bus 8 and then % change in
I_{nwDG} w.r. to I_{fwDG} for bus 15 =
[(0.3184-0.2976)/0.3184]*100= 6.56% (from (2))

In this case current at bus 8, 15, 23 & 32 were taken into consideration with DG (at bus 23) and without DG and fault was created at bus number 8.The results with analysis are shown in fig. 2.

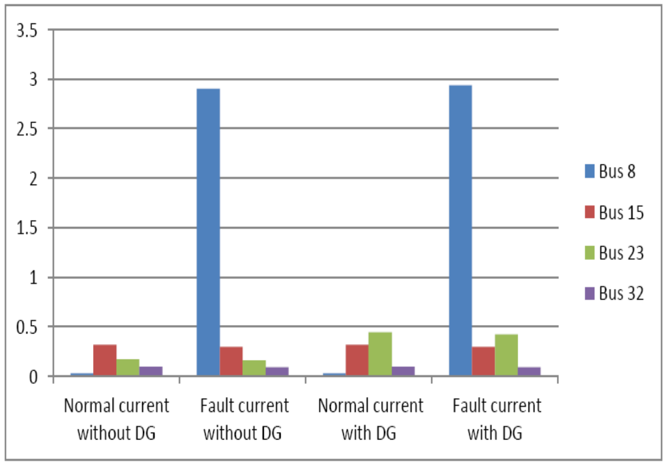

Fig. 2 Comparison between normal current & fault current with & without DG when fault is on bus 8

CASE II: Comparison between normal current & fault current with & without DG when fault is on bus 15

In this case bus 8, bus 15, bus 23 & bus 32 are studied with DG and without DG and fault is at bus number 15 and the results with analysis are shown in fig. 3. The DG is connected on bus 23.

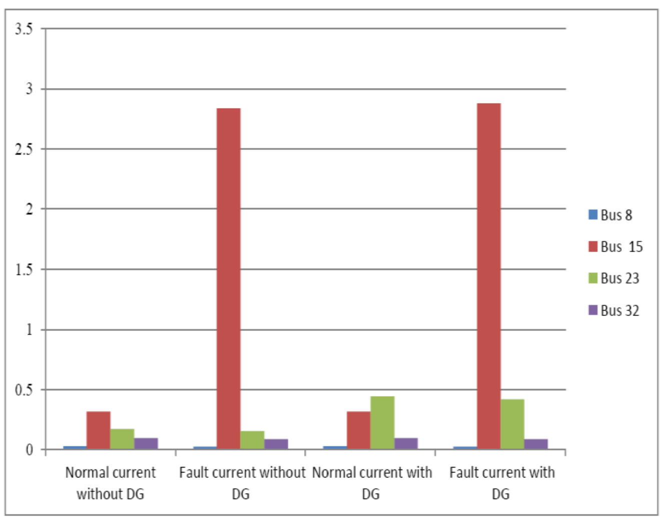

Fig. 3 Comparison between normal current & fault current with & without DG when fault is on bus 15

From above observation it is found that the fault current is increasing in presence of DG as compared to fault current without DG similar to case I.

CASE III: Comparison between normal current & fault current with & without DG when fault is on bus 23
In this case bus 8, 15, 23 & 32 were taken into consideration with DG (at bus 23) and without DG. Fault was created at bus number 23.

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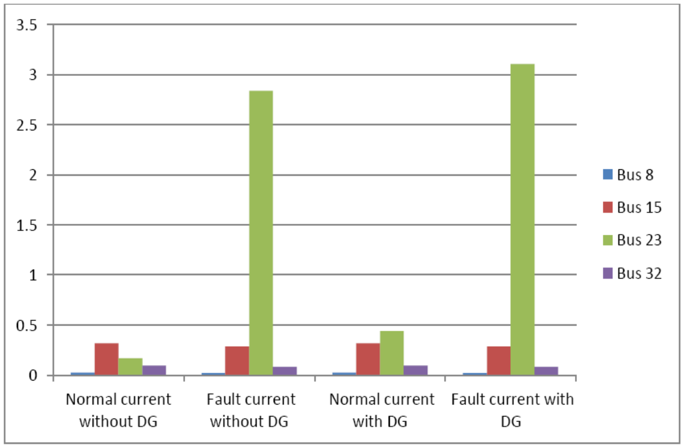

Fig. 4 Comparison between normal current & fault current with & without DG when fault is on bus 23

CASE IV: Comparison between Normal Current & Fault Current with & without DG when fault is on bus 32
In this case bus 8, bus 15, bus 23 & bus 32 were taken into consideration with DG (bus 23) and without DG. Fault was created at bus number 32.

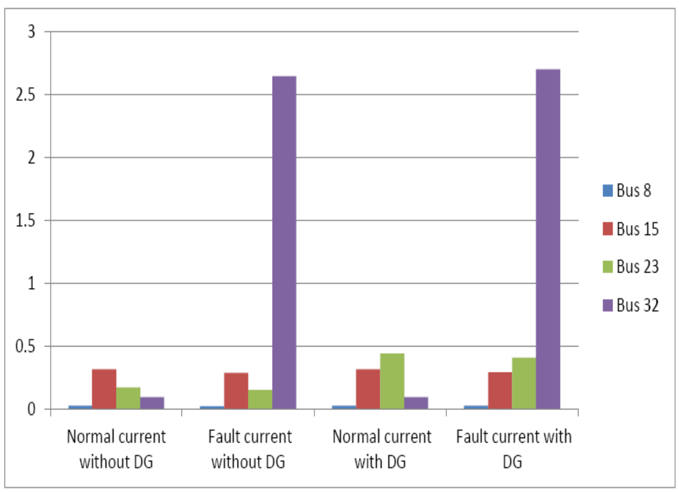

Fig. 5 Comparison between normal current & fault current with & without DG when fault is on bus 32

From above observation it is found that the fault current was increasing in presence of DG as compared to fault current without DG.

CASE V: Comparison of fault current without DG and fault current with DG
With fault on bus 8,

% change in I_{nwoDG} w. r. to I_{fwDG} = $$\frac{I_{nwoDG} - I_{fwDG}}{I_{nwoDG}} \quad (3)$$

Where, I_{fwoDG} = Fault Current without DG
I_{fwDG}= Fault current with DG

$$\frac{2.9036 - 2.9365}{2.9036} * 100 = 1.10\%$$

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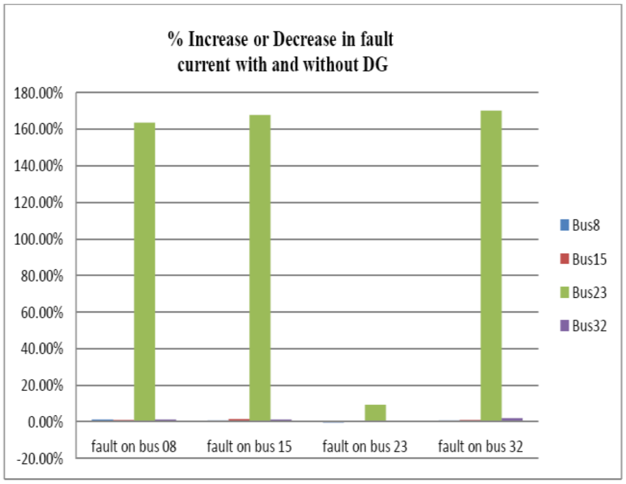

Fig. 6 Percentage increase/decrease in fault current with and without DG

From Fig. 6 it is clear that the difference in fault current without DG with respect to fault current with DG is very high on bus 23 where DG is connected as compared to all other buses. From this we can say that there is very high effect of fault on the bus having DG connection.

CASE VI: Effect of fault distance from DG on different buses

TABLE NO. 1 Effect of distance of fault from DG on fault current level of bus 23

Bus	Distance of fault from bus 23	% Increase in fault current on bus 23
Bus 8	2.62(km)	163.52%
Bus 15	1.78(km)	167.73%
Bus 23	0(km)	9.28%
Bus 32	0.9(km)	169.97%

From above table no. 1 it is clear that as the distance of fault from bus 23 where DG is connected increases then the percentage increase in fault current without DG with respect to fault current with DG decreases at bus 23.

VI. CONCLUSION

In this paper PV based DG, and its effect on fault current has been studied. The distributed generation is small scale electrical power generation. An actual 11KV radial distribution feeder of MSEDCL is simulated using PSCAD software. Line to ground fault has been created at various buses in the system with and without distributed generation. From the analysis it is observed that there is an increment in fault current with distributed generation. The current increases by a large amount on the bus where distributed generation is connected for fault anywhere in the system. The severity of the fault current depend on the distance of the fault from the distributed generation, lesser the distance between fault location and DG more severe will be the fault. As distance increases the fault current contribution of DG bus decreases. Hence the setting of overcurrent relays must be changed after induction of DG in the grid.

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