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Research Article

THE REDUCTION OF DISTRIBUTED GENERATION UNITS' PRESENCE IMPACT ON DIMINISHING THE RANGE COVERED BY PROTECTIVE RELAYS

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ABSTRACT
Concerning Tavanir new policies, using distributed generation resources has increased. The connection of distributed generation units in addition to their undeniable benefits brings new and important provisions to the issues of utilizing the network. If these laws are not considered, they would lead to severe problems in network using while affecting its advantages. One of the most important changes brought to the network by distributed generation is logical alternation. This change is coordination loss among protective devices which is known as protective devices coring. The degree on distributed generation impact on coordination depends on the size, type, and the place of distributed generation resources. In this study, protection coring problem is modeled in the simulation software of MATLAB and the proposed solutions are implemented. Results showed using fault current limiter (FCL) and low power resources, the problem will be solved.

Keywords: *Feeder Current, Protection, One-phase Fault*

INTRODUCTION
Installing the distributed generation units in the distribution network has numerous merits. Among the all advantages, the most important ones are voltage controlling, reactive power capacity sustainability improvement, increasing the capacity of reactive and transmitting power as well as reducing investment and wasted energy in distribution lines. Despite of the all mentioned benefits, DG connection to the distribution network leads to protection problems (Zayandehroodi *et al.*, 2011). Some of these problems are protection coring (reducing the range covered by the relay), feeder wrong tripping, reducing and increasing the short circuit level, avoiding automatic and asynchronous reclosing (reclosing fault), and keys breakout power change after adding the DG (Zayandehroodi *et al.*, 2013). These troubles are related to the network's characteristics, and distributed generation resources' size and type. In most of the cases, protection system design should be altered thoroughly which is significantly complex (Zayandehroodi *et al.*, 2009). For this reason, an adaptive protection design was introduced in the circuit for optimal coordination of current's extra relays (Abdelaziz *et al.*, 2002). Due to the changes in the load, generation, and topology, this design caused so many problems. Recently, a considerable number of protective designs has been proposed for distribution networks in presence of DG which use neural networks to find the fault location (Zayandehroodi *et al.*, 2013; Zayandehroodi *et al.*, 2012; Zayandehroodi *et al.*, 2010). Presented in this survey, is the analysis of distribution network feeder protection coring trouble caused by DG units. First, the protection coring phenomenon is defined, second, the phenomenon will be studied in the surveying network and finally, solutions to this phenomenon will be proposed.

Introducing and Proving the Protection Coring Phenomenon
Relay range is anarea of feeder which should be protected by relay. Relay range is adjusted by the minimum relay pick-up current. Coring will be feasible if DG unit is connected to the network and it is because of simultaneous supplying of load by DG unit and the post. Protection coring is a critical phenomenon which reduces the relay range (Abd *et al.*, 2013). The network total resistance will be diminished upon connecting the DG unit to the network (Since DG is placed parallel to the network.). This work will increase short circuit current (Ifault) in addition to reducing the initial current (Ia), as a result, the relay will not function by this current and this state is called protection coring. Figure 1 shows the protection relays coring phenomenon.

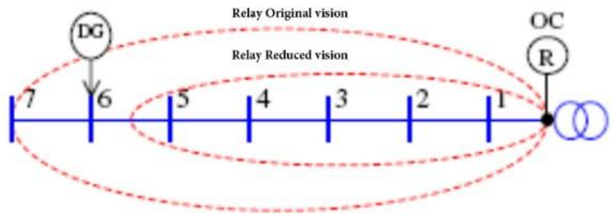

Figure 1: Protection relays coring

In order to clarify the relay view range reduction, feeder current in the fault instant before the connection of DG is assumed to be obtained by relation 1.

$$\mathrm{I_{feeder}} = \frac{U_{fault}}{\mathrm{Z_{net}} + \mathrm{Z_{fault-b}}} \quad (1)$$

If DG is connected, the network total impedance from the fault view can be furnished using relation 2.

$$\mathrm{Z_{th}} = \mathrm{Z_{fault-b}} + \left[\frac{\mathrm{Z_{gen}Z_{net}}}{\mathrm{Z_{gen}+Z_{net}}}\right] \quad (2)$$

By currents division we have in relation 3:

$$\mathrm{I_{feeder}} = \left[\frac{\mathrm{Z_{gen}}}{\mathrm{Z_{gen}} + \mathrm{Z_{net}}}\right]\left[\frac{U_{fault}}{Z_{th}}\right] \quad (3)$$

By substituting the Zth value in equation 3, we have equation 4.

$$\mathrm{I_{feeder}} = \left[\frac{\mathrm{Z_{gen}}}{\mathrm{Z_{gen}+Z_{net}}}\right]\left[\frac{\mathrm{U_{fault}}}{\mathrm{Z_{fault-b}}+\frac{\mathrm{Z_{gen}Z_{net}}}{\mathrm{Z_{gen}+Z_{net}}}}\right] \quad (4)$$

In equation 4, $\mathrm{I_{feeder}}$is the feeder current while Dg is connected to the network and it can be calculated using relation 5.

$$\mathrm{I_{feeder}} = \left[\frac{\mathrm{I}}{\mathrm{Z_{fault}}+\frac{\mathrm{Z_{fault-b}Z_{net}}}{\mathrm{Z_{gen}}}+\mathrm{Z_{net}}}\right]\mathrm{u_{fauit}} \quad (5)$$

Therefore, $\mathrm{I_{feeder}}$can be written as follows:

$$\mathrm{I_{feeder}} = [\frac{\mathrm{Z_{gen}}}{\mathrm{Z_{fault-b}}(\mathrm{Z_{gen}+Z_{net}})+\mathrm{Z_{gen}Z_{net}}}]U_{fault} \quad (6)$$

In equation 4, feeder current is while DG is connected and we can distinguish that the feeder current is lower in presence of DG in comparison with no DG connection. Based on equation 7, we have:

$$\frac{U_{fauit}}{\mathrm{Z_{fault-b}}+\frac{\mathrm{Z_{gen}Z_{net}}}{\mathrm{Z_{gen}+Z_{net}}}+\mathrm{Z_{net}}} < \frac{U_{fauit}}{\mathrm{Z_{net}+Z_{fault-b}}} \quad (7)$$

Thus, feeder current is lower when DG is connected compared to having no DG connection. According to equation 8:

$$I_{\mathrm{feeder.with-DG}} < \mathrm{I_{feeder-wlthout-DG}} \quad (8)$$

This phenomenon is called coring or reduction of protection relays view.

Protection Coring in the Surveying Network

In this article, medium voltage distribution network (20KV) has been studied which is shown in figure 2. This test system is simulated using MATLAB software.

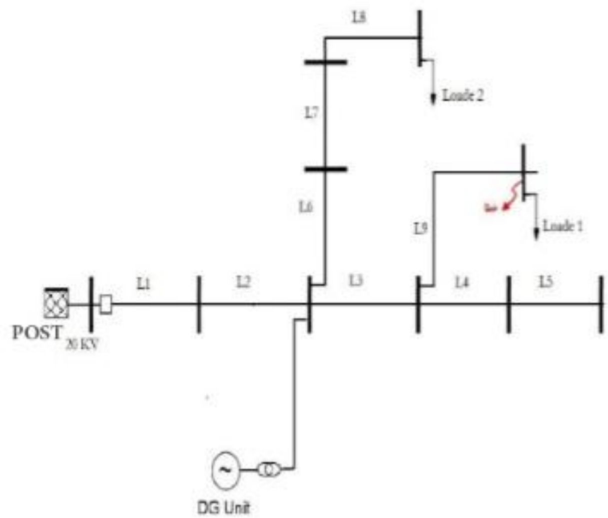

Figure 2: The surveying sample network

The surveying DG unit is simulated with a 3-phase source with production voltage of 3KV and a transformer with conversion ratio of 3KV/ 20KV. Furthermore, one-phase fault to ground (a phase) has been occurred in bus number 1.
First, the network is analyzed without the connection of DG. The simulation results of initial current (at the first of the line) and the fault current are as shown in table 1.

Table 1: Currents' values without the connection of DG in the time of one-phase fault occurrence to the ground in bus number 1

Initial current (Ia)	598 A
Fault point current (Ifault)	597.5A

It can be seen that the current at the fault point is roughly equal to the current at first of the line which leads the relay at first of the line to perform. In this stage DG unit is connected to the network. The DG unit transformer connection is in form of Y/Y in two sides of the field. The results of the initial current and the fault current simulation are brought in table 2.

Table 2: Currents' values with the connection of DG in the time of one-phase fault occurrence to the ground in bus number 1 (Y/Y)

Initial current (Ia)	430.3 A
Fault point current (Ifault)	745.27 A

It could be comprehended that initial current has decreased in the presence of DG unit compared to the first state. However, fault current has increased in terms of the first state. So, protection coring can be clearly seen. Initial relay may not perform properly in this state. In this mode, the phase of DG unit transformer is in form D/Y which the star side of the transformer is the ground. The simulation results are demonstrated in table 3.

Table 3: The values of current with the connection of DG in the time of one-phase fault occurrence to the ground in bus number 1 (D/Y)

Initial current (Ia)	491.37A
Fault point current (Ifault)	780.8 A

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Solving the Coring Problem in the Surveying Network
If the DG unit injecting voltage decreases in the instant of fault occurrence by any mean, the coring problem will be solved. Therefore, the initial and fault current will be equal.
Utilization of Small DG Resources (with Low Power)
Using low power DG resources will slightly influence the coring phenomenon. It is because the flowing will not decrease as much as DG resource power does. The simulation results of initial and fault current for DG unit with short-circuit level of 4MVA have been displayed in table 4 (Transformer connection is in Y/Y form at both sides of the field).

Table 4: The current values in presence of DG with low power in the instant of one-phase fault occurrence to the ground in bus number 1 (Y/Y)

Initial current (Ia)	575.02A
Fault point current (Ifault)	620.8 A

It is clear that the initial current and the fault point current are significantly different in presence of DG with low power. Thus, coring problem will be solved approximately. It means that if the presence of several DG units is needed, it is better to use low power DG units in order to solve the problem of protection coring. It is due to lower flow injection of DG source to the network in comparison with the presence of powerful DG resources.
Using Fault Current Limiter (F.C.L)
In this stage, the protection coring will be solved by placing a FCL after the DG unit. FCL will be placed in circuit at the instant of fault occurrence and as a result, it limits the output current of DG resource. In the surveying network, FCL is simulated with higher ohmic resistant. The simulation results of initial and fault current are demonstrated in table 5.

Table 5: Current values in presence of DG with FCL

Initial current (Ia)	599.47 A
Fault point current (Ifault)	597.54 A

It is obviously seen that the initial current has been increased and it is approximately equal to the fault current which solve the problem of coring. It means, if fault occurred, the relay at first of the line recognizes the fault current and it will perform its job.
Conclusion
In the case the DG resource is connected to the distribution network, feeder protection coring will be feasible and the initial relay performance may face interruptions (Reducing relay range). In this study, the protection coring phenomenon and its solution are surveyed in a sample network. Simulation results showed that one of these solutions to delete this phenomenon or reduce it to minimum is using low power DG resources in the system. Using these resources, the maximum current injecting will decreased. The other way to correct this phenomenon is utilization of FCLs after DG source (In the path of DG to the network). Using FCLs, the values to initial and short-circuit currents will be roughly as same as the state which DGs are not connected. As a result, protection coring problem will be corrected.

REFERENCES
Abd Ghani R, Mohamed A, Shareef H and Zayandehroodi H (2013). ANFIS Approach for Locating Precise Fault Points in Distribution System. *Intelligent Engineering System* **21**(3) 1-14.
Abdelaziz AY, Talaat HA, Nosseir I and Hajjar AA (2002). An adaptive protection scheme for optimal coordination of overcurrent relays. *Electric Power Systems Research* **61**(3) 1-9.
Zayandehroodi H, Mohamed A, Shareef H and Mohammadjafari M (2011). Impact of Distributed Generations on Power System Protection Performance. *International Journal of the Physical Sciences* **6**(2) 3873-3881.

Zayandehroodi H, Mohamed A, Shareef H, Farhoodnea M and Mohammadjafari M (2013). Effect of Renewable Distributed Generators on the Fault Current Level of the Power Distribution Systems. *Advanced Materials Research* **2**(8) 1882-1886.

Zayandehroodi H, Mohamed A, Shareef H and Mohammadjafari M (2009). An Overview of Protection Coordination Methods in Distribution Network with DGs, presented at the International conference electrical energy and industrial electronic systems (EEIES 2009), Penang, Malaysia.

Zayandehroodi H, Mohamed A, Farhoodnea M and Mohammadjafari M (2013). An Optimal Radial Basis Function Neural Network for Fault Location in a Distribution Network with High Penetration of DG Units. *Measurement* **46**(3) 3319–3327.

Zayandehroodi H, Mohamed A, Shareef H and Farhoodnea M (2012). A novel neural network and backtracking based protection coordination scheme for distribution system with distributed generation. *International Journal of Electrical Power & Energy Systems* **43**(4) 868–879.

Zayandehroodi H, Mohamed A, Shareef A and Mohammadjafari M (2010). Automated Fault Location in a Power System with Distributed Generations Using Radial Basis Function Neural Networks. *Journal of Applied Sciences* **10**(2) 3032-3041.