C6-109- Cigre2016
Protection Coordination for Distribution Systems Containing Distributed generation units

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Introduction

- **DG insertion in radial systems affects coordination between protective devices in traditional protection scheems.**

- **Due to change of power flow, change of magnitude and direction of fault current.**

Goal of the paper

- **Description and analysis of impacts due to DG insertion**
- **Suggestion of a practical solution to solve problems of DG insertion**

Traditional protection scheems

- **Primarily consists of fuses, reclosers and relays.**

- **Designed and coordinated for radial systems.**

Impact of DG insertion in distribution systems

- **Causes sensitivity and selectivity problems.**
- **Sensitivity considers faults that are not detected or detected after time delay.**

- **Selectivity considers the cases that DG or the feeder containing DG may be tripped unnecessarily.**

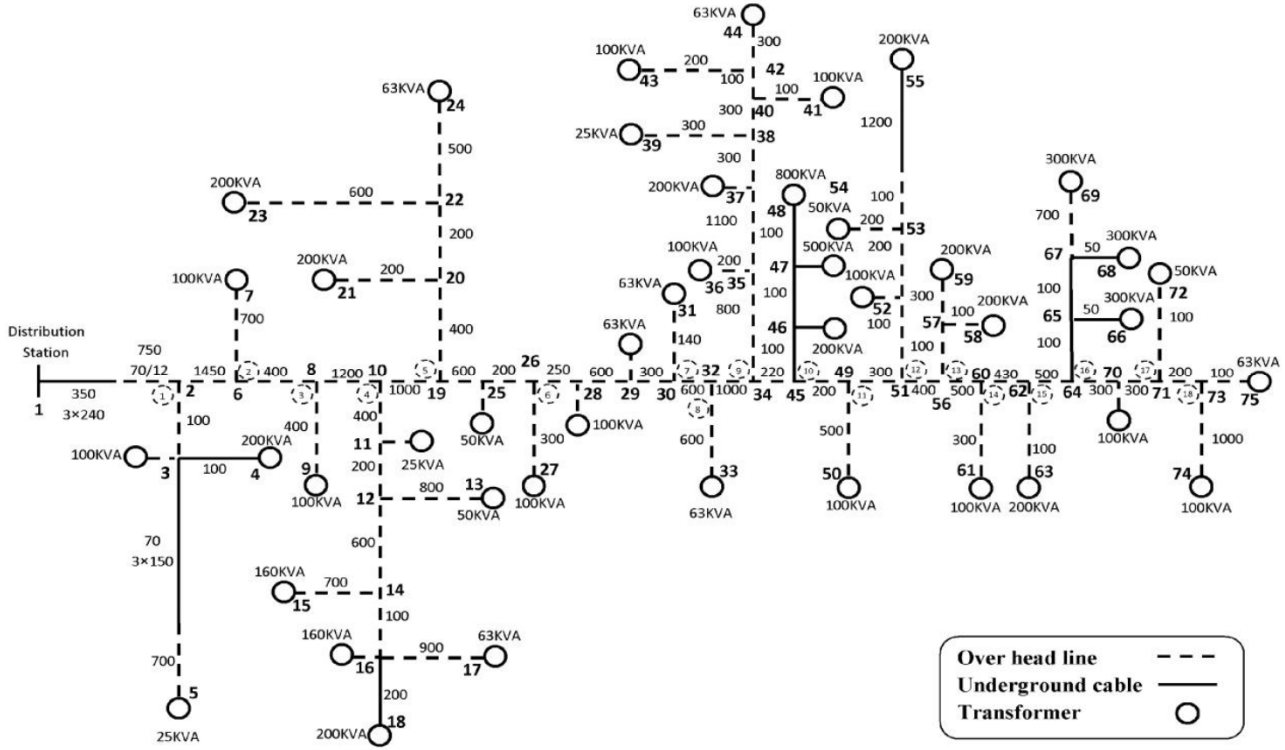
Loss of coordination

- **Loss of coordination occurs from the increase of fault current level beyond the coordination range of two successive protective devices in the same coordination path.**
- **DG insertion may increase maximum short circuit current beyond the coordination range limit.**
- **may cause the backup device operates before the primary device.**
- **To avoid this impact, protective devices plug settings (PS) in this coordination path should be increased with the same percent by which the fault current level is increased.**

Bidirectionality problems

- **Directional problems occur from the direction reversal of the fault current seen by two successive protective devices in the same coordination path due to DG insertion.**
- **Insertion of DG into distribution changes its direction.**
- **Reversing the fault current direction may cause malfunctioning of the protective devices.**
- **And as a result, a healthy part from the distribution feeder may be unnecessarily interrupted.**
- **For such situation, directional protection becomes the suitable choice for better selectivity**

Description of case study distribution feeder



Description of case study distribution feeder

- **Operating voltage: 11KV.**
- **Main feeder length: 12Km.**
- **Lateral total length: 18Km.**
- **No. of buses:75**
- **Main O.H.L :70mm^2 , ACSR.**
- **lateral O.H.L :35mm^2 , ACSR.**
- **Under ground cables: 3*70 mm2 ,Al , XLPE.**
- **Between buses 1,2 :3*240 mm2 ,Al , XLPE.**
- **Between buses 5,6 :3*150 mm2 ,Al , XLPE.**
- **Transformers: 11/0.4KV, delta/star (solidly earthed).**
- **Optimal DG rating: 2.5 Mw.**
- **Optimal zone of installation: between buses 45,51.**

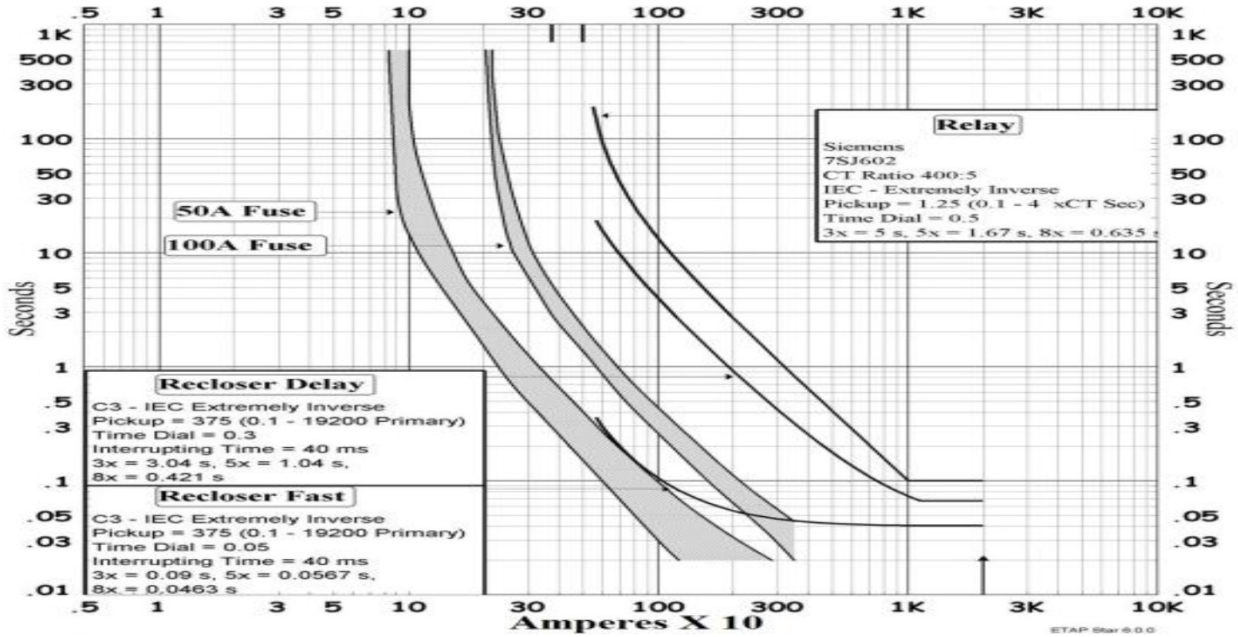
Existing protection coordination for the distribution Feeder before DG insertion

- **The system under study is protected by an overcurrent protection system consisting of an inverse time overcurrent relay (51) located at substation switchgear.**

- **Near the middle of the main feeder a recloser is installed to present the primary protection for the second half of the main feeder against short-circuit faults and to save the laterals fuses from blowing for temporary faults.**

- **At the beginning of each lateral, a fuse is installed to protect the laterals against short-circuit faults and to prevent the relay and the recloser from tripping for permanent faults on laterals.**

DG insertion impacts on existing protection coordination



Time-current characteristics of relay, recloser and fuses

Impact on loss of coordination in the feeder under study

The distribution feeder case study has three different protective coordination paths. These paths are:

- **Recloser path: the recloser is the primary protective device for the main feeder zone downstream bus 32 and the main feeder relay is its back up.**
- **The 50 A fuse path: the 50 A fuses are the primary protective devices for the laterals upstream the recloser and the main feeder relay is their backup.**
- **The 100 A fuse path: the 100 A fuses are the primary protective devices for the laterals downstream the recloser and the main feeder recloser is their backup and the main feeder relay is the recloser's backup.**
- **if the DG insertion increases the fault current level at any lateral downstream the recloser to a value greater than 2150 A then a case of loss of coordination will occur**

Impact on the bidirectionality in the feeder under study

- **After DG insertion, any fault current in the system will consist of two shares: DG share and distribution station share.**

- **These two shares are different in magnitude and direction depending on the DG and the fault locations.**

Conclusion

- **Insertion of DG into distribution feeder causes selectivity problems.**
- **These problems are greatly dependent on DG contribution in the fault current and DG location with respect to protective devices in the system.**
- **A solution was proposed to avoid these problems.**
- **The proposed solution is based on obtaining a new protection coordination status capable of holding selectivity of the protection system even after**

DG insertion by combining the use of directional protection feature in reclosers with updating the existing protective devices settings.

- **The advantages of this approach over any other approach are it supports very high DG penetration capacities and it doesn't require extra costs or equipment.**
- **The proposed solution has been tested through the application on a real distribution system model and the simulation results show the effectiveness and the validity of the proposed solution.**