Reducing the Fault Current and Overvoltage in a Distribution System with Distributed Generation Units through an Active Type SFCL

Sunke Ajay
Ht.no:14td1d0701
Clg:nigama engineering college,sambaiahpally,karimnagar

Abstract: **For a power distribution system with distributed generation (DG) units, its fault current and induced overvoltage under abnormal conditions should be taken into account seriously. In consideration that applying superconducting fault current limiter (SFCL) may be a feasible solution, in this project, the effects of a voltage compensation type active SFCL on them are studied through theoretical derivation and simulation. The active SFCL is composed of an air-core superconducting transformer and a PWM converter. The magnetic field in the air-core can be controlled by adjusting the converters output current, and then the active SFCLs equivalent impedance can be regulated for current limitation and possible overvoltage suppression. During the study process, in view of the changes in the locations of the DG units connected to the system, the DG units injection capacities and the fault positions, the active SFCLs current-limiting and overvoltage suppressing characteristics are both simulated in MATLAB. The simulation results show that the active SFCL can play an obvious role in restraining the fault current and overvoltage, and it can contribute to avoiding damage on the relevant distribution equipment and improve the systems safety and reliability.**

I Increasing fault current threats

In response to ever growing needs for electricity, power producers have been expanding the power grids continually, particularly with the proliferation of independent power producers (IPP's). Technical advancements and promotions of various types of renewable energy generation have also led to a large number of distributed generators (DG's) connected to the power grids. Fig 1.1 shows a diagram of added electricity generations to a power grid. However, this fast expansion of generation capacity obscures a hidden issue, which must be resolved: the potential fault current levels keep increasing as the source impedances are lowered due to the paralleled connections of the growing number of generators. Asa result, the potential short-circuit current levels increase substantially, approaching the limits of the devices in existing power systems, including the cables, switchgears, protection devices, and loads. Specifically, if the fault current levels exceed the interruption ratings of existing protection devices, such as fuses and circuit breakers, the equipment will suffer serious damage. In extreme cases, failure to interrupt fault current may destroy insulation of conductors and oil-filled equipment, causing fire or explosion.

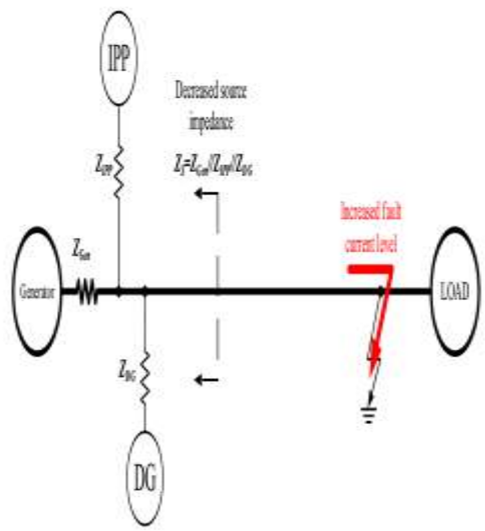


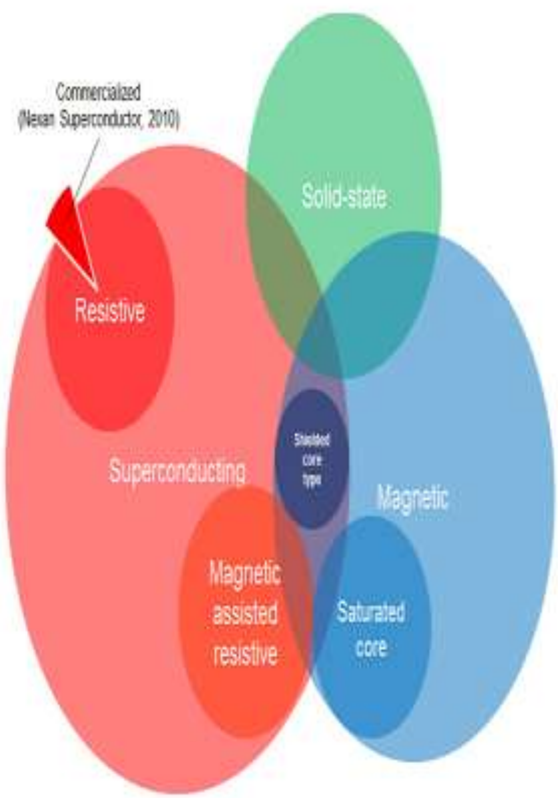
Fig 1.1 Parallel IPP and DG decrease source impedance and increase potential fault current level on the power system

II FAULT CURRENT LIMITERS

The aforementioned technologies are fault current interruption devices with fault current limiting features. Alternatively, fault current limiter (FCL) is another solution to the fault current crisis. Instead of interrupting the fault current, which usually needs to wait for the next zero crossing of current, an FCL inserts high impedance to the power line almost immediately after the fault occurrence and limits the fault current at a low level. During normal operations, the impedance is kept low enough to be negligible to the system. For more than two decades, various approaches in FCL technology have been explored. Research has provided classifications and insights to the FCL concepts in prior-art. In general, the FCL technologies can be classified into the following categories:

1) Superconducting FCL
2) Solid-state FCL
3) Magnetic FCL

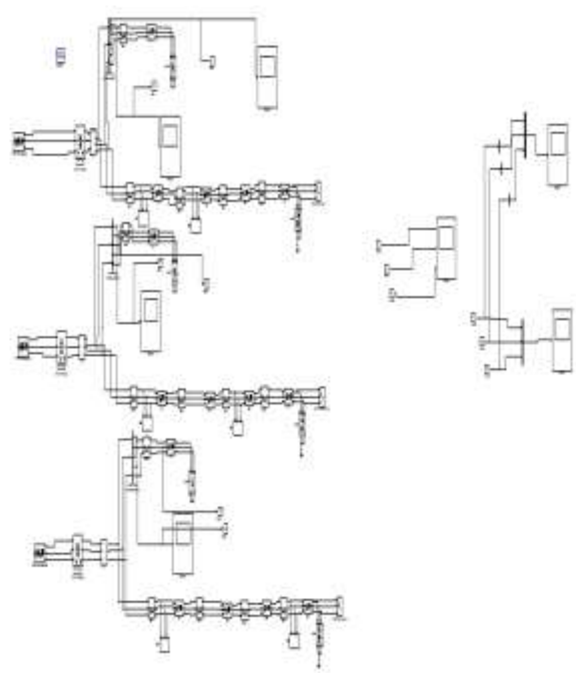
The categorization is based on the major techniques used by FCL's. Each of these techniques (solid-state switches, superconductors, magnetic, etc.) has their own characteristics that can provide favorable performance or features to the FCL. On the other hand, each of them as their own drawbacks or technical challenges. In this context, a number of different derivations of FCL topologies combining techniques have been studied and developed. It should be noted that although FCL's have been studied in the labs for more than two decades, it is a relatively new field in terms of R&D and applications. Multiple topologies have been proposed, but only a few have been put into field tests. Instead of interrupting the fault current, which usually needs to wait for the next zero crossing of current, an FCL inserts high impedance to the power line almost immediately after the fault occurrence and limits the fault current at a low level. During normal operations, the impedance is kept low enough to be negligible to the system. Therefore, there is no "prevailing" topology: new possible solutions are still being explored and tested. Fig 2.1 illustrates the most recognized FCL technologies and the relationships among them.

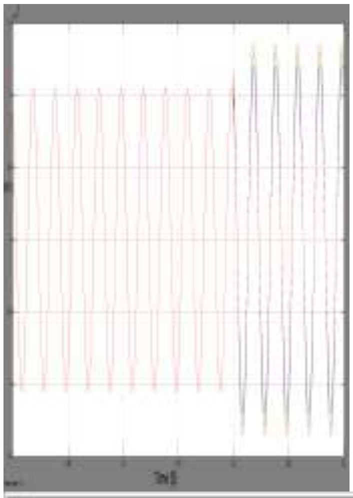


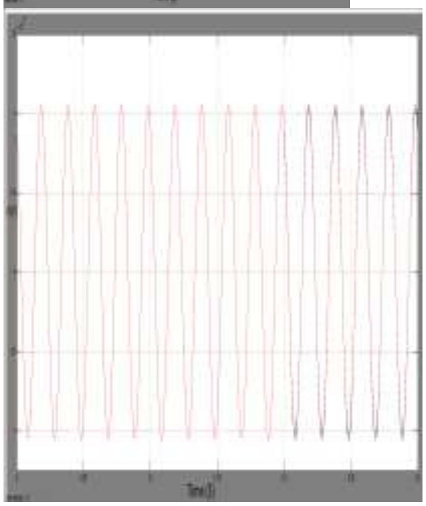
III PROPOSED CONCEPT

Due to increased consumption demand and high cost of natural gas and oil, distributed generation (DG), which generates electricity from many small energy sources, is becoming one of main components in distribution systems to feed electrical loads. The introduction of DG into a distribution network may bring lots of advantages, such as emergency backup and peak shaving. However, the presence of these sources will lead the distribution network to lose its radial nature, and the fault current level will increase. Besides, when a single-phase grounded fault happens in a distribution system with isolated neutral, over voltages will be induced on the other two health phases, and in consideration of the installation of multiple DG units, the impacts of the induced over voltages on the distribution network's insulation stability and operation safety should be taken into account seriously. Aiming at the mentioned technical problems, applying superconducting fault current limiter (SFCL) may be a feasible solution. For the application of some type of SFCL into a distribution network with DG units, a few works have been carried out, and their research scopes mainly focus on current-limitation and improvement of protection coordination of protective devices. Nevertheless, with regard to using a SFCL for suppressing the induced overvoltage, the study about it is relatively less. In view of that the introduction of a SFCL can impact the coefficient of grounding, which is a significant contributor to control the induced overvoltage's amplitude; the change of the coefficient may bring positive effects on restraining overvoltage. We have proposed voltage compensation type active SFCL in previous work, and analyzed the active SFCL's control strategy and its influence on relay protection. In addition, a 800 V/30 A laboratory prototype was made, and its working performances were confirmed well.

IV MATLAB







V CONCLUSION AND FUTURE SCOPE

This project provides how Traditional Generation is differing from Distributed Generation. In this project, a comparative analysis of the active SFCL and FCL in a power distribution network with DG units is investigated. For the power frequency overvoltage caused by a single-phase grounded fault, the active SFCL can help to reduce the overvoltage's amplitude and avoid damaging the relevant distribution equipment. But from the simulation analysis the FCL can as well suppress the short-circuit current induced by a three-phase grounded fault effectively compared to the Active SFCL, and the power system's safety and reliability can be improved. In recently years, more and more dispersed energy sources, such as wind power and photovoltaic solar power, are installed into distribution systems. This project is the quick review of Distributed Generation in India, its need, importance in near future. Therefore, the study of a coordinated control method for the renewable energy sources and the FCL becomes very meaningful, and it will be performed in future.

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