REDUCING THE FAULT CURRENT AND OVERVOLTAGE FOR POWER SYSTEM PROTECTION THROUGH AN ACTIVE TYPE SFCL

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Abstract

Utilization of renewable energy resources is the demand of today and the necessity of tomorrow. For a power distribution system with 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. Distributed Generation Resources are increasingly used in distribution systems due to their great advantages. The presence of DG, however, can cause various problems such as miss-coordination, false tripping, blinding and reduction of reach of protective devices. Using superconducting fault current limiters (SFCLs) is one of the best methods to minimize these problems comparing to the other conventional methods. The active SFCL can as well suppress the short-circuit current induced by a three-phase grounded fault effectively, and the power system's safety and reliability can be improved and it 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 unit's injection capacities and the fault positions, the active SFCLs current limiting and over voltages suppressing characteristics are presented by using Matlab/Simulink software.

Keywords: *Distributed Generation (DG), Distribution System, Short-Circuit Current, Voltage Compensation Type Active Superconducting Fault Current Limiter (SFCL).*

I. INTRODUCTION

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 . 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, overvoltage 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. 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.

II.SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL)

Superconducting fault current limiters are used as effective way of fault current limiting. Most of the problems or failures in system are due to overloading of system lines thus flashover or fire hazards. This all will occur mostly at the time of fault because fault current will be of a large value than system can withstand. By expanding system, we have to increase the fault current level also. Otherwise system will collapse soon. The better way is to use current limiters. The fault current limiters limit current at the event of fault. Superconducting fault current limiters use superconducting material for current limiting. Electric power systems are designed such that the impedances between generation and loads are low. However, a significant drawback of the low interconnection impedance is that large fault currents (5 to 20 times nominal) can develop during power system disturbances. In addition, the maximum fault current in a system tends to increase over time for a variety of reasons, Main reasons are-

- Demand increases, so we have to expand system capacity, generation
- Parallel conducting paths are added to accommodate higher demand.
- Interconnections the grid increases.
- Sources of distributed generation are added to an already complex system.

We have to maximum prevent the damage to the system and customer blackout time. Nowadays fault detectors and isolators are used effectively in the system. But if we want to expand our system, we have to make changes in whole equipment like we have to use high capacity lines; we have to use high capacity isolators etc. Here comes the role of FCL (Fault Current Limiters). Proposed Fault current limiters are having capability of rapidly increasing impedance to fault current. These devices will control/limit current to the value which devices can withstand. Proposed FCL is Superconducting Fault Current Limiter. It has the ability to be invisible (nil resistance/impedance) during normal operation and can exert high impedance on the occasion of fault to reduce/limit fault current. This will go back to its nominal zero impedance condition automatically depend on the physical condition. Superconducting FCL uses super conducting materials for conductors. Proposed is high temperature superconducting material. This is the future technology. This superconducting technology is in growing state. Many research studies are going on this subject.

A. Fault Current Limiters Fault-current problems are commonly faced when expanding existing buses. Larger transformers result in higher fault levels, this in turn needs the replacement of existing bus work and switchgear because of changed fault level. Alternatively, the existing bus can be broken and served by two or more smaller transformers. Another alternative is use of a single, large, high-impedance transformer, resulting in degraded voltage regulation for all the customers on the bus.

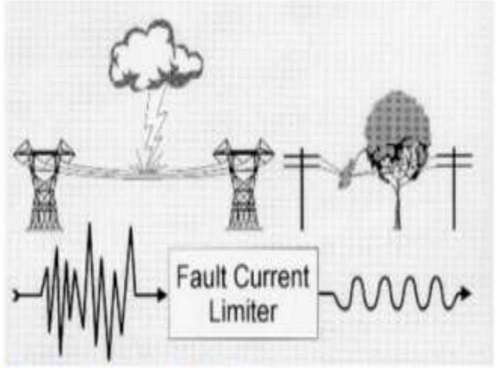

Fig1. Fault current limiter location

B. Superconducting technology The concept of using the superconductors to carry electric power and to limit peak currents has been around since the discovery of superconductors and the realization that they possess highly non-linear properties. The current limiting behavior depends on their nonlinearresponse to temperature, current and magnetic field variations. Increasing any of these three parameters can cause a transition between the superconducting and the normal conducting regime. The curve in the lower half of Figure is a normalized plot showing the non-linear relation between current flow in a superconductor and its resistance. The data for the curve was measured while the superconductor was in a constant magnetic field and a constant temperature. Similar curves can be produced for changes in temperature and magnetic field. The current increase can cause a section of superconductor to become so resistive that the heat generated cannot be removed locally. This excess heat is transferred along the conductor, causing the temperature of adjacent sections to increase.

III. SYSTEM MODELING

The concept of using the superconductors to carry electric power and to limit peak currents has been around since the discovery of superconductors and the realization that they possess highly non-linear properties. More specifically, the current limiting behavior depends on their nonlinear response to temperature, current and magnetic field variations. Increasing any of these three parameters can cause a transition between the superconducting and the normal conducting regime. Resistive SFCLs utilize the superconducting material as the main current carrying conductor under normal grid operation.

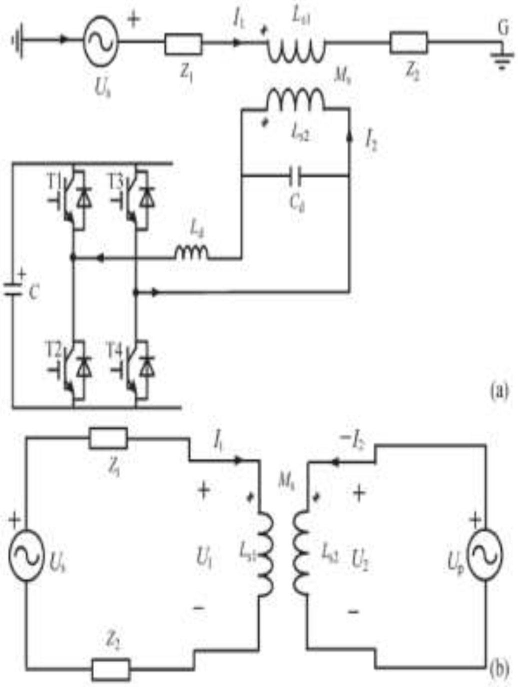

Fig.2. Single-phase voltage compensation type active SFCL.

(a) Circuit structure and (b) equivalent circuit.

One of the first SFCL designs developed for grid deployment was the shielded-core design, a variation of the resistive type of limiter that allows the HTS cryogenic environment to remain mechanically isolated from the rest of the circuit. An electrical connection is made between the line and the HTS element through mutual coupling of AC coils via a magnetic field.

Unlike resistive and shielded-core SFCLs, which rely on the quenching of superconductors to achieve increased impedance, saturable-core SFCLs utilize the dynamic behavior of the magnetic properties of iron to change the inductive reactance on the AC line. As shown in Fig. 4(a), it denotes the circuit structure of the single-phase voltage compensation type active SFCL, which is composed of an air-core superconducting transformer and a voltage type PWM converter. By neglecting the losses of the transformer, the active SFCL's equivalent circuit is shown in Fig. 2(b). As shown in Fig. 3, it indicates the application of the active SFCL in a distribution network with multiple DG units, and the buses B-E are the DG units' probable installation locations

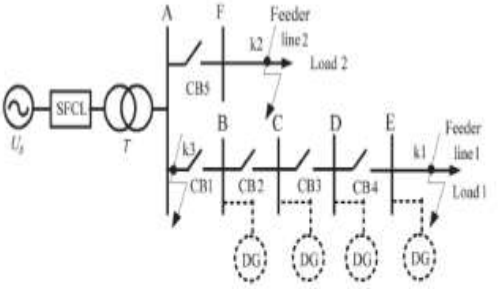

Fig 3. Application of the active SFCL in a distribution system with DG units.

When a single-phase grounded fault occurs in the feeder line 1 (phase A, k1 point), the SFCL's mode 1 can be automatically triggered, and the fault current's rising rate can be timely controlled. Along with the mode switching, its amplitude can be limited further. In consideration of the SFCL's effects on the induced overvoltage, the qualitative analysis is presented. Superconducting materials have improved considerably over the past few decades. As a result, several applications have developed to a stage where superconductivity is the enabling technology. These include high-energy particle accelerators, magnetic resonance imaging systems, and highly sensitive RF detectors for cell phone towers, high magnetic field magnets for scientific research, and so on. As superconductors became available for commercial devices, the need for standards became clear. The initial effort on standards—under the auspices of the International Electro technical Commission (IEC)—was in the areas of measurements and conductor performance. This activity has continued to the present by the IEC Technical Committee 90 (TC-90) and has expanded from the initial critical current measurements on low temperature superconductors so that it now includes some measurements and procedures for high-temperature superconductive materials. IEC TC-90 is chaired by Dr. Loren Goodrich of the U.S. National Institute of Standards and Technology (NIST). The major player in each IEC TC is the secretariat, which for TC-90 is hosted by Japan. Efforts are in place by the IEC to establish other types of standards in the superconducting arena, for example in the area of current leads. Otherwise, there has been little activity until now on developing standards for superconductor-based applications. There are several reasons for this situation. First, the high-energy physics world has been the driver for the use of low temperature superconductors (LTS). They use thousands of superconducting magnets, but they all operate in a laboratory environment and are either one-of-a-kind devices or a single system that uses hundreds or even thousands of identical magnets that work in concert. Specifications are written for these applications, but they do not require general standards. However, it is significant that the high-energy physics community supports a broad-based collaborative effort to improve the capabilities of some of these materials and has been instrumental in developing standards for LTS wire. Standards for magnetic resonance imaging (MRI) technology have been under the control of the organizations that regulate the safety of medical systems. As a result, they have been designed to meet stringent safety requirements, but performance and component standards have mostly been company proprietary. There has been little demand for additional standards on the superconductive materials used in the magnets.

IV. SIMULATION RESULTS

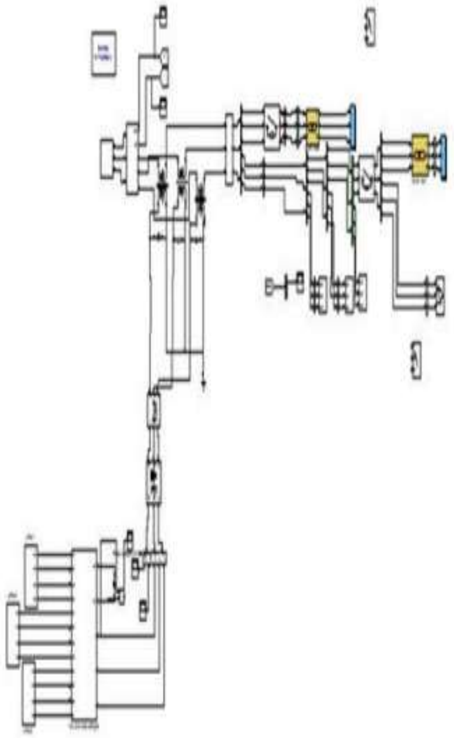

Fig.4. Simulation Circuit.

The graph shown in fig.5, represents the over voltage suppression with SFCL during fault condition.

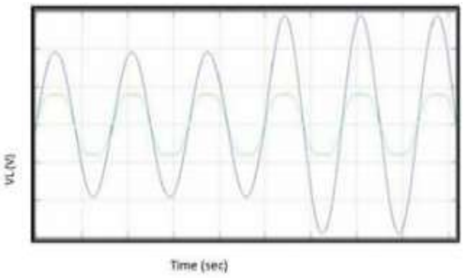

Fig.5.Overvoltage suppression using SFCL.

To get the current limiting characteristics of the Active SFCL the injection capacity of each DG is taken 100% to50% of the capacity of load1. The two DG units are connected separately in the Buses B and C. The current limiting characteristics of the Active SFCL has been observed for single phase to ground fault at k1 point and the fault occurring time is from 0.2 s to .3s. By observing the voltage compensation type active SFCL's installation location, it can be found out that this device's current-limiting function should mainly reflect in suppressing the line current through the distribution transformer. Thereupon, to estimate the most serious fault characteristics, the following conditions are designed: the injection capacity of each DG is about 100% of the load capacity (load 1), and the two DG units are separately installed in the Buses B and E. Moreover, the three-phase fault occurs at k1, k2, and k3 points respectively, and the fault occurring time is t = 0.2 s. Hereby, the line current characteristics are imitated.

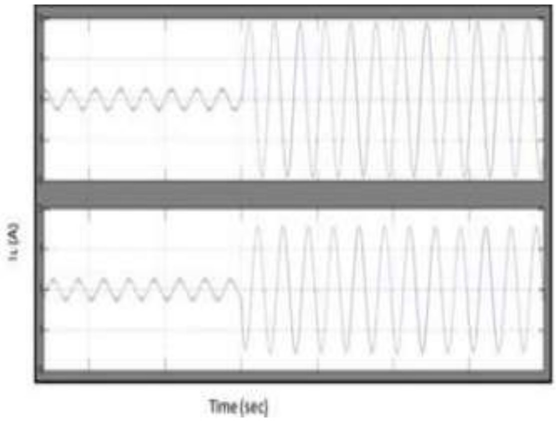

Fig.6. Simulation result of current with SFCL in three phase system.

As shown in Fig.6, it indicates the line current waveforms with and without the active SFCL when the three-phase short circuit occurs at k1k2 point, fault occurs at 0.2 sec.

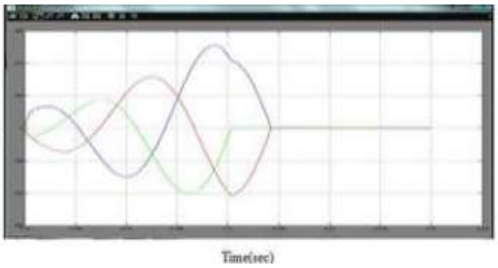

Fig.7. Simulation result of line current with SFCL in single phase at k3 point.

As shown in Fig.7, it indicates the line current waveforms with and without the active SFCL when the three-phase short circuit occurs at k3 point, fault occurs at 0.2 sec.

V. CONCLUSION The application of the active SFCL into 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. The active SFCL can as well suppress the short-circuit current induced by a three-phase grounded fault effectively, and the power system's safety and reliability can be improved. Moreover, along with the decrease of the distance between the fault location and the SFCL's installation position, the current-limiting performance will increase. In recently years, more and more dispersed energy sources, such as wind power and photovoltaic solar power, are installed into distribution systems. Therefore, the study of a coordinated control method for the renewable energy sources and the SFCL becomes very meaningful, and it will be performed in future.

VI. REFERENCES

[1] S. Conti, "Analysis of distribution network protection issues in presence of dispersed generation," Elect. Power Syst. Res., vol. 79, no. 1, pp. 49–56, Jan. 2009.

[2] A. S. Emhemed, R. M. Tumilty, N. K. Singh, G. M. Burt, and J. R. McDonald, "Analysis of transient stability enhancement of LV connected induction micro generators by using resistive-type fault current limiters," IEEE Trans. Power Syst., vol. 25, no. 2, pp. 885–893, May 2010.

[3] S.-Y. Kim and J.-O. Kim, "Reliability evaluation of distribution network with DG considering the reliability of protective devices affected by SFCL," IEEE Trans. Appl. Supercond., vol. 21, no. 5, pp. 3561–3569, Oct. 2011.

[4] S. A. A. Shahriari, A. Yazdian, and M. R. Haghifam, "Fault current limiter allocation and sizing in distribution system in presence of distributed generation," in Proc. IEEE Power Energy Soc. Gen. Meet., Calgary, AB, Canada, Jul. 2009, pp. 1–6.

[5] S. Hemmati and J. Sadeh, "Applying superconductive fault current limiter to minimize the impacts of distributed generation on the distribution protection systems," in Proc. Int. Conf. Environ. Electr. Eng., Venice, Italy, May 2012, pp. 808–813.

[6] S.-H. Lim, J.-S. Kim, M.-H. Kim, and J.-C. Kim, "Improvement of protection coordination of protective devices through application of a SFCL in a power distribution system with a dispersed generation," IEEE Trans. Appl.

Supercond., vol. 22, no. 3, p. 5601004, Jun. 2012.

[7] L. Chen, Y. Tang, J. Shi, and Z. Sun, "Simulations and experimental analyses of the active superconducting fault current limiter," Phys. C, vol. 459, no. 1/2, pp. 27–32, Aug. 2007.