Compensation of Fault Current and Over voltage in a Distribution System With Renewable Distributed Generation Units Through an Active type SFCL

k.Prabhakar reddy ,V.Pratapa Rao ,P.Padmavathi

-

Abstract— In Today's World Electric Energy Utilization is increasing day by day ,The Utilization energy mainly in Industry, Home ,Business and Transportation ,To meet the demand Decentralizing Generating units are started .As a result there is increase in size of the generating station and inter connected network's.Due to increase in size of the Grids and Generating station also possible of abnormal operations in the system,Due to fault leads to decrese the impedance of power system network.There may be increase of current known as Fault current and based on type of fault the voltage value changes. In this paper, the influence on the voltage compensation type, active superconducting fault current limiter (ASFCL) is investigated under symmetrical and asymmetrical fault conditions. ASFCL is consisting of air-core superconducting transformers and a three-phase voltage source converter. In the normal (no fault) state the flux in air core is compensated to zero. so the ASFCL has no influence on the main circuit. Using MATLAB SIMULINK, model of the three phase AC system with ASFCL is created andcontrol strategies test, fault current limiting test, and distance relay operation is investigated. The utilization of fault current limiters (FCLs) in powersystem provides an effective way to suppress fault currents and result in considerable saving in the investment of high capacity circuit breakers. In this work a resistive superconducting fault current limiter designed.

Index Terms—Distributed Generation (DG), Distribution System, Overvoltage, Short-CircuitCurrent, *Voltage Compensation Type Active Superconducting Fault Current Limiter (SFCL).*

I. Introduction

In recent years, with the great development of interconnected power grid, the power network structure becomesincreasingly complicated, and the system short circuit capacity and short circuit current have reached a new level which could exceed the allowable currents of the circuit breakers. The introduction of DG into adistribution network may bring lots of advantages, such asemergency backup and peak shaving. However, the presence ofthese sources will lead the distribution network to lose its radialnature, and the fault current level will increase. whenasingle-phasegrounded fault happens in a distribution systemwith isolated neutral, overvoltages will be induced on the other two health phases, and in consideration of the installation ofmultiple DG units, the impacts of the induced overvoltageson the distribution network's insulation stability and operationsafety should be taken into account seriously. The increase of the fault current hasimposed a severe burden on the related machinery in the grid, and the stability of the power system is alsodamaged. The fault current limiters (FCL) are regarded as the suitable solution to solve excessive fault current problems.

Active superconducting fault current limiter (ASFCL) voltage compensation type is a noveltopology of FCL. This type SFCL not only preserves the merits of bridge type SFCL such as the automaticswitch to the current limiting mode and without the quench of the superconductor, but also has the particularabilities of controlling the steady fault current and compensating active and reactive power for AC main circuitin the normal state.

In view of that the introduction of a SFCL can impact the coefficient of grounding, which is a significant contributorto control the induced overvoltage's amplitude, the changeof the coefficient may bring positive effects on restraining over voltages. We have proposed a voltage compensation type active SFCL.in previous work and analyzed the active SFCL's controlstrategy and its influence on relay protection . In addition,a 800 V/30 A laboratory prototype was made, and its workingperformances were confirmed well

II. THEORETICAL ANALYSIS

A. Structure and Principle of the Active SFCL

As shown in Fig. 1(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.Ls1, Ls2 are the self-inductance of two superconducting windings, and Ms is the mutual inductance.Z1is the circuit impedance andZ2is the load impedance. Ld and Cd are used for filtering high order harmonics caused by theconverter. Since the voltage-type converter's capability of controlling power exchange is implemented by regulating the voltage of AC side, the converter can be thought as a controlled voltage

Manuscript received May, 2015.

***k.Prabhakar reddy**, EEE Department ,Sri Sai institute of technology and science Rayachoty Kadapa ,A.P ,INTUA. 9491903314.*

***V.Pratapa Rao** Asst Prof&HOD ,EEE Dept ,Sri Sai institute of technology and science.., Rayachoty, Kadapa A .P INDIA.9441433911*

***P.Padmavathi** Asst prof EEE Department Sri Sai institute of technology and science Rayachoty Kadapa ,A.P ,INTUA. 9491903314.*

ISSN: 2278 – 7798
All Rights Reserved © 2015 IJSETR

source Up. By neglectingthe losses of the transformer, the active SFCL's equivalent circuit is shown in Fig. 1(b).

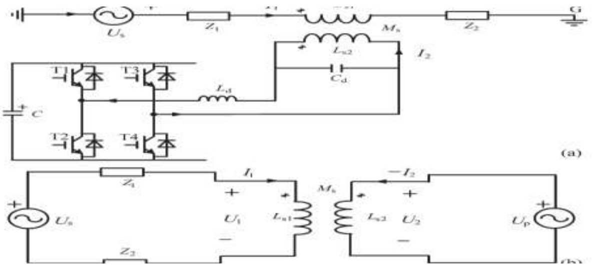

Fig. 1. Single-phase voltage compensation type active SFCL. (a) Circuit structure and (b) equivalent circuit.

In normal (no fault) state, the injected current (I2) in the secondary winding of the transformer will be controlled to keep a certain value, where the magnetic field in the air-core can be compensated to zero, so the active SFCL will have no influence on the main circuit. When the fault is detected, the injected current will be timely adjusted in amplitude or phase angle, so as to control the superconducting transformer's primary voltage which is in series with the main circuit, and further the fault current can be suppressed to some extent. Below, thesuggested SFCL's specific regulating mode is explained. In normal state, the two equations can be achieved.

$$U_s = I_1(Z_1 + Z_2) + \mathrm{j}\omega L_{s1} I_1 - \mathrm{j}\omega M_s I_2$$

$$\dot{U}_p = \mathrm{j}\omega M_s \dot{I}_1 - \mathrm{j}\omega L_{s2} \dot{I}_2.$$

Controlling I_2 to make $\mathrm{j}\omega L_{s1} \dot{I}_1 - \mathrm{j}\omega M_s \dot{I}_2 = 0$ and the primaryvoltage U_1 will be regulated to zero. Thereby, the equivalentlimiting impedance Z_{SFCL} is zero ($Z_{SFCL} = U_1/I_1$), andI_2 can be set as $\dot{I}_2 = \dot{U}_s\_L_{s1}/L_{s2}/(Z_1 + Z_2)k$, where k is thecoupling coefficient and it can be shown as $k = M_s/\sqrt{L_{s1}L_{s2}}$.Under fault condition ($Z_2$ is shorted), the main current will rise from I_1 to I_{1f}, and the primary voltage will increase to U_{1f}.

$\dot{I}_{1f} = (\dot{U}_s + \mathrm{j}\omega M_s \dot{I}_2)/(Z_1 + \mathrm{j}\omega L_{s1})$ (3)

$\dot{U}_{1f} = \mathrm{j}\omega L_{s1} \dot{I}_{1f} - \mathrm{j}\omega M_s \dot{I}_2$

$= \dot{U}_s(\mathrm{j}\omega L_{s1}) - \dot{I}_2 Z_1(\mathrm{j}\omega M_s) Z_1 + \mathrm{j}\omega L_{s1}.$ (4)

The current-limiting impedance Z_{SFCL} can be controlled in:

$Z_{SFCL} = \dot{U}_{1f} \dot{I}_{1f} = \mathrm{j}\omega L_{s1} - \mathrm{j}\omega M_s \dot{I}_2 (Z_1 + \mathrm{j}\omega L_{s1}) \dot{U}_s + \mathrm{j}\omega M \dot{I}_a$.(5)

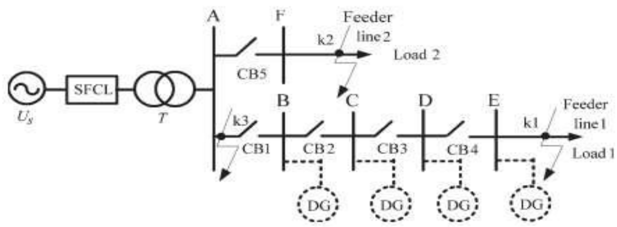

Fig. 2. Application of the active SFCL in a distribution system with DG units.

According to the difference in the regulating objectives of I2, there are three operation modes:

1) MakingI2 remain the original state, and the limiting impedanceZSFCL−1=Z2 (jωLs1)/(Z1+Z2+jωLs1).
2) ControllingI2to zero, andZSFCL−2=jωLs1.
3) Regulating the phase angle of I2 to make the angle difference between˙ Us and jωMs˙I2 be 180◦.Bysetting jωMs I2=−c˙Us, and ZSFCL−3=cZ1/(1−c)+jωLs1/(1−c).

The air-core superconducting transformer has many merits, such as absence of iron losses and magneticsaturation, and it has more possibility of reduction in size, weight and harmonic than the conventional iron-coresuperconducting transformer . Compared to the iron-core, the air-core can be more suitable forfunctioning as a shunt reactor because of the large magnetizing current , and it can also be applied in aninductive pulsed power supply to decrease energy loss for larger pulsed current and higher energy transferefficiency . There is no existence of transformer saturation in the air-core, and using it can ensure thelinearity of ZSFCL well.

B. Applying the SFCL into A Distribution Network with DG

As shown in Fig. 2, 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. When a single-phase grounded faultoccurs in the feeder line 1 (phase A, k1 point), the SFCL's mode 1 can be automatically triggered, and the faultcurrent'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.In order to calculate the over voltages induced in the other two phases (phase B and phase C), the symmetricalcomponent method and complex sequence networks can be used, and the coefficient of grounding G under thiscondition can be expressed as G=−1.5m/(2 +m)±j√3/2, where m=X0/X1, and X0 is the distribution network'szero-sequencereactance,X1is thepositive-sequence reactance [6]. Further, the amplitudes of the B-phase and Cphaseover voltages can be described as:

$$U_{BO} = U_{CO} = \sqrt{3}\left|\frac{\sqrt{G^2 + G + 1}}{G + 2}\right| U_{AN}$$

Where UAN is the phase-to-ground voltage's root mean square (RMS) under normal condition.

C. *SUPERCONDUCTING FAULT CURRENT LIMITER*

Superconducting Fault Current Limiter (SFCL) is innovative electric equipment which has the capability toreduce the fault current level within the first cycle of fault current [1]. The first-cycle suppression of faultcurrent by a SFCL results in an increased transient stability of the power system carrying higher power withgreater stability. The concept of using the superconductors to carry electric power and to limit peak currents hasbeen around since the discovery of superconductors and the realization that they possess highly non-linearproperties. More specifically, the current limiting behavior depends on their nonlinear response to

ISSN: 2278 – 7798 All Rights Reserved © 2015 IJSETR

temperature,current and magnetic field variations. Increasing any of these three parameters can cause a transition betweenthe superconducting and the normal conducting regime. The term “quench” is commonly used to describe the propagation of the normal zone through a superconductor. Once initiated, thequench process is often rapid and uncontrolled. Though once initiated the quench process is uncontrolled, theextent of the normal region and the temperature rise in the materials can be predicted.

III. MATLAB/SIMULINK RESULTS

For purpose of quantitatively evaluating the current-limiting and overvoltage-suppressing characteristics of theactive SFCL, the distribution system with DG units and the SFCL for the other DG, it can be installed in anarbitrary position among the Buses C–E (named as DG2). To reduce the converter’s design capacity, making theSFCL switch to the mode 2 after the fault is detected, and the detection method is based on measuring the maincurrent’s different components by Fast Fourier Transform (FFT) and harmonic analysis.

Case: 1 Without SFCL and with the active SFCL

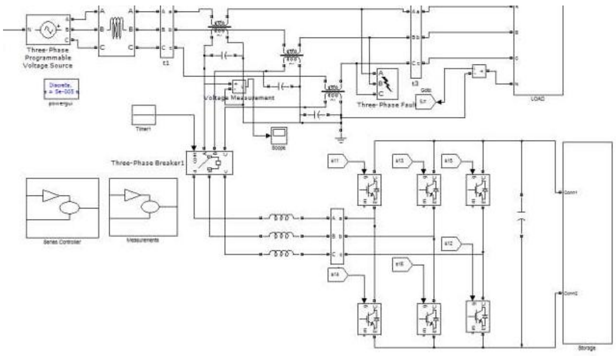

Fig. 3. Matlab/Simulink Model of Three Pahse the Short-Circuit Occurs A K3 Point. Without SFCL and With the Active SFCL.

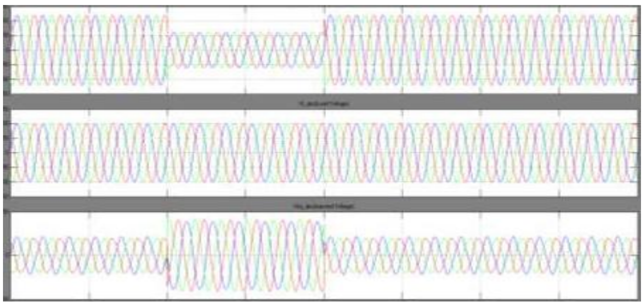

Fig. 4. Voltage Waveforms When The Three-Phase Short-Circuit Occurs A K3 Point. Without SFCL and With the Active SFCL.

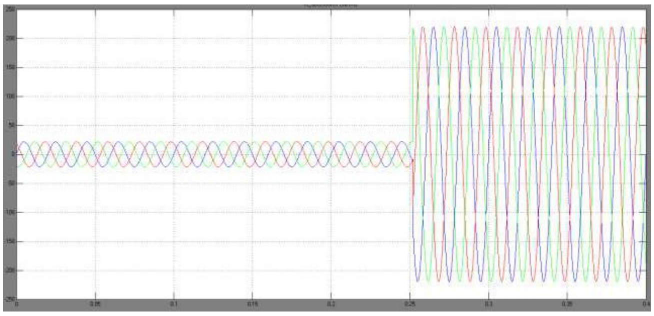

Fig. 5 Line Current Waveforms When The Three-Phase Short-Circuit Occurs A K3 Point.

Case: 2 Without SFCL and with the active SFCL with pv

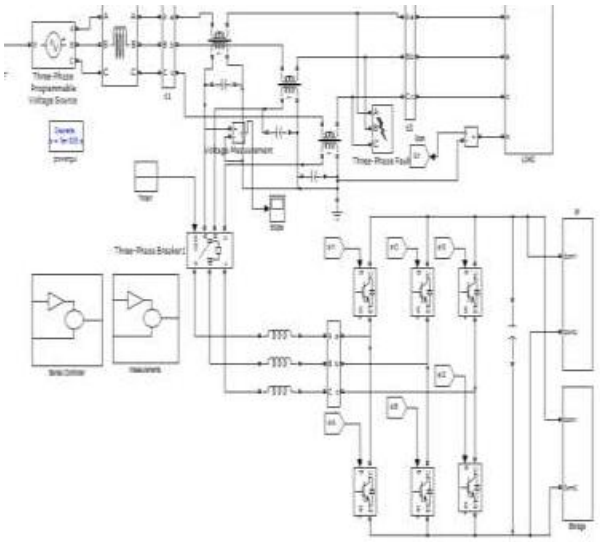

Fig. 6. Matlab/Simulink Model of Three Pahse the Short-Circuit Occurs A K3 Point. Without SFCL and With the Active SFCL with PV

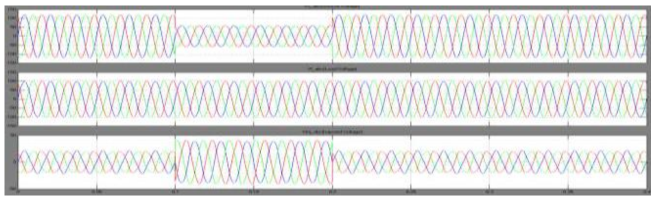

Fig. 7. Voltage Waveforms When The Three-Phase Short-Circuit Occurs A K3 Point. Without SFCL And With The Active SFCL With PV.

ISSN: 2278 – 7798 All Rights Reserved © 2015 IJSETR

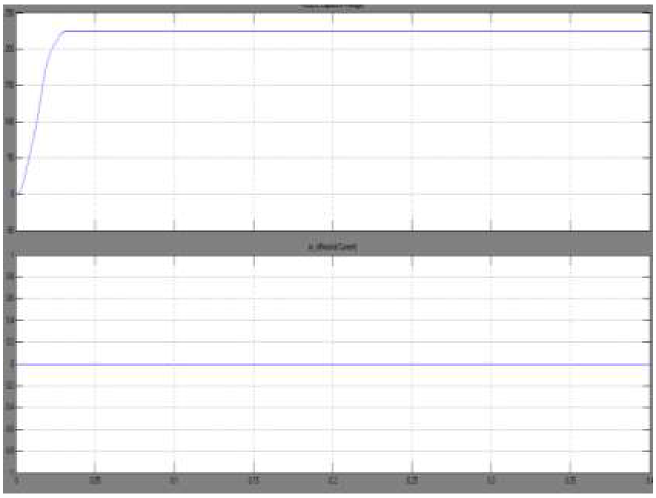

Fig. 8. Photovoltaic Voltage

Figure8 shows Without SFCL and with the active SFCL with photovoltaic voltage.

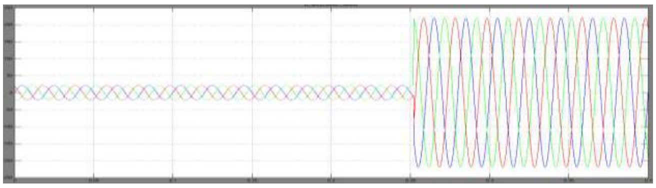

Fig. *9 Line Current Waveforms When the Three-Phase Short-Circuit Occurs A K3 Point with PV*

IV. CONCLUSION

In this paper, 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. 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. *in recent* years ,more and more dispersed energy 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 m

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

k.Prabhakar reddy, *EEE Department ,Sri Sai institute of technology and science Rayachoty Kadapa ,A.P ,INTUA. 9491903314.*

V.Pratapa Rao *Asst Prof&HOD ,EEE Dept ,Sri Sai institute of technology and science.., Rayachoty, Kadapa A .P INDIA.9441433911*

P.Padmavathi *Asst prof EEE Department Sri Sai institute of technology and science Rayachoty Kadapa ,A.P ,INTUA. 9491903314.*

ISSN: 2278 – 7798 All Rights Reserved © 2015 IJSETR