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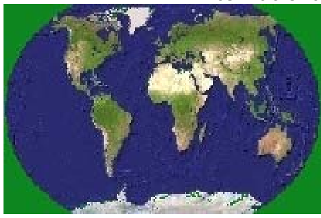

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M. Venkata Satish
B.tech student, EEE Department Andhra Loyola institute of eng.tech, AP, India

K. Venkateswara rao
B.tech student, EEE Department Andhra Loyola institute of eng.tech, AP, India

J.L.L.C.S. Sastry
B.tech student, EEE Department Andhra Loyola institute of eng.tech, AP, India

Reduction of fault current and voltage in a decentralized generation units through an active type SFCL

M. Venkata Satish, K. Venkateswara rao, J.L.L.C.S. Sastry

Abstract
Considering decentralized generation units, fault current and over voltages are taken in to seriously. It leads to effect on system and equipment damage may takes place. For feasible operation superconducting fault current limiter is applied in this paper, the voltage compensation active C is studied through theoretical derivation and simulation. The SFCL consist of a air core super conducting transformer and pulse width modulation inverter. The magnetic field in the air core can be controlled by PWM inverter output. Hence, the equivalent impedance can be maintained and overvoltage suppression is possible. The fault current and voltage suppression characteristics are simulated in mat lab. The simulation gives the result as reducing the fault current and over voltage; it can contribute to avoiding damage on the relevant distribution equipment and improve systems safety and reliability.

Keywords: generation (DG), Distributed system, Fault current, over voltage, voltage compensation Active type SFCL, quench, critical temperature.

1. Introduction:

In today’s world, electrical energy utilization is increasing day by day. The utilization of energy in industry, homes, businesses, and transportation. To meet the demand [1]-[2], decentralized generating units are started. As a result there is increase in the size of the generating station and the interconnected networks. Due to increase in the size of the grids and generating stations also possible of abnormal operation in the system, due to fault leads to decrease the impedance of the power system network, there may be an increase in current, known as fault current and based on type of fault the voltage value changes.

A single phase ground fault happens in a decentralized system with isolated neutral, fault voltages will be induced on the other two health phases, and considering the multiple decentralized generating units the impact of the fault voltages on the system. Insulation stability and operation safety should be taken in to account seriously. The problem is taking in to consideration, applying superconducting fault current limiter (SFCL) may be an accurate solution.

The superconducting elements mainly focused on the current limitation and improve the protection co-ordination [3] among the devices. The impact of the superconducting material on fault voltages is less compared to current .the magnitude of fault current is decreased to minimum value, these are depends on the length and operating temperature. If operating temperature exceeded, the SFCL comes in to operation the fault current bypass through resistor.

Correspondence:
M. Venkata Satish
B.tech student, EEE Department
Andhra Loyola institute of eng.tech, AP, India

2. Theoretical Analysis

A. Principle and operation of active SFCL

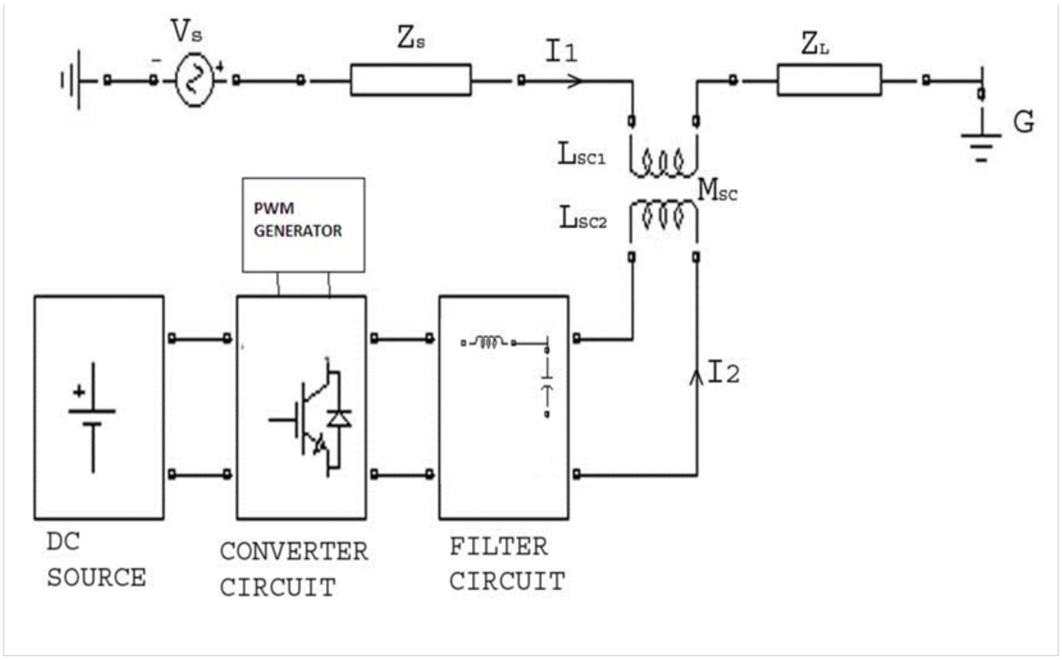

Fig.1: (a) shows circuit structure for SFCL

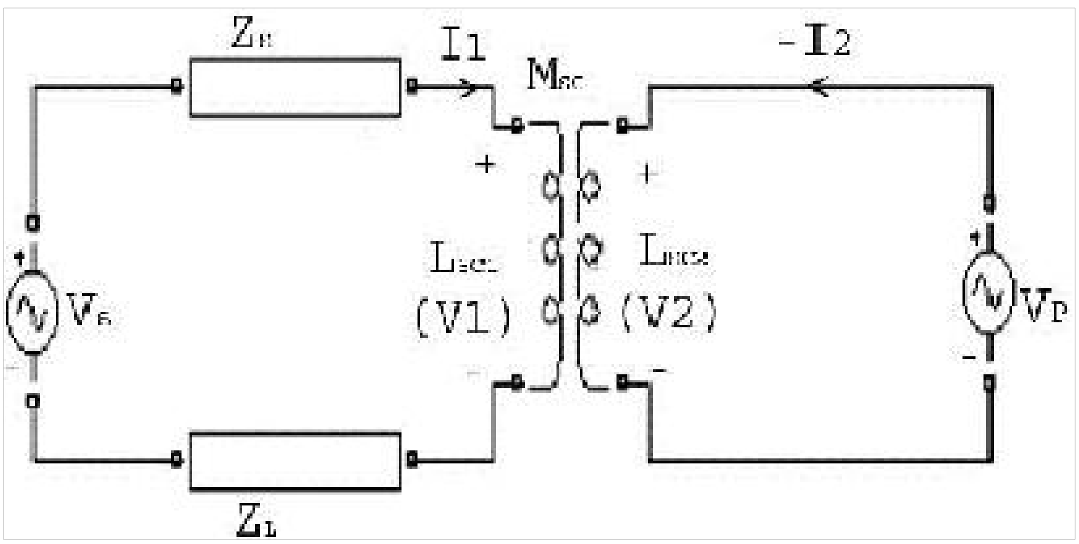

Fig. 1: (b) equivalent circuit

As shown in figure 1 a, it represents the circuit structure of the single phase voltage compensation type active SFCL [4]-[5] which consist of a air-core superconducting transformer and a voltage type PWM convertor lsc1, lsc2 are the self-inductance. Zs is the circuit impedance and Zl is load impedance ls and cs are used for filtering to remove higher order harmonics caused by conversion process. The voltage type converters capability of controlling power, is implemented by regulating the voltage of ac side, the converter can be through as a controlled voltage source vp by neglecting the losses of the transformer, the active SFCL equivalent circuit shown in figure 1 b.

In normal operation state, the value of current (I2) should be maintained such that the magnetic field in the air core can be compared to zero, so the SFCL will not have any influence on the main circuit. When the fault is sensed, the current (I2) will be timely adjusted in amplitude or phase angle, so as to control the superconducting transformers primary winding voltage. Which is in series with the main circuit and fatherly the fault current can be reduced to some extent.

The SFCLS specific regulation mode is explained below. In normal conduction two equations can be achieved

Vs = I1 (Zs+Zl) +jwLsc1I1-jwMscI2

VP = jwMscI12-jwLsc2I2

Controlling I2 to make jwLscLsc1I1- jwMscI2=0 and the primary voltage V1 will be regulated to zero. There by, the equivalent limiting impedance Zeq is zero (Zeq=V1/I1), and I2 can be set as

I2= Vs lsc1/Lsc2/ (Zs+Zl) k,
where k is the coupling coefficient and it can be shown as
K= Msc/ Lsc1 *Lsc2
Under fault condition (Zl is shorted), the main current will rise from I1 to I1f, and the primary voltage will increase to V1f

I1f= (Vs+jwMscI2)/ (Z1+jwLsc1)

V1f= jwLsc1I1f – jwMscI2

V1f= Vs (jwlsc1)-I2Zs (jwMsc)/Zs+jwlsc1

The current limiting impedance Zeq can be controlling in
Zeq=v1f/I1f=jwLsc1jwMscI2 (Zs+jwlsc1)/Vs+jwMscI
Based on the regulating objective current (I2) there are three operation modes.
I. By making secondary current (I2) remains in original state, and the limiting impedance.
Zeq_1 = Z1(jwLsc1)/(Zs+Zl+jwlsc1)
II. By controlling I2 to zero, the Zeq_2=jwLsc1.
III. By regulating the phase angle of I2 to make the angle difference between Vs and jwMscI2 be 180 degrees. i.e; phase shift by setting jwMscI2 =-cvs, and Zeq-3 = cZs/(1-C)+jwLsc1/(1-C).

The transformer used in this paper is air core superconducting transformer. It has many advantages, such as iron losses are negligible due to absence of core, magnetic saturation and it has possibility of reducing size, weight and harmonic than the compensational iron-core superconducting transformer [6]-[7].when compared with the iron-core, the air-core can be more suitable for shunting as a shunt reactor because of large magnetizing current and it can be controlled by pulse power supply [8] to decrease energy loss for larger pulsed current and higher energy transfer efficiently and it can ensure the linearity of Zeq-1well.

B. Applying the SFCL to decentralized generation system

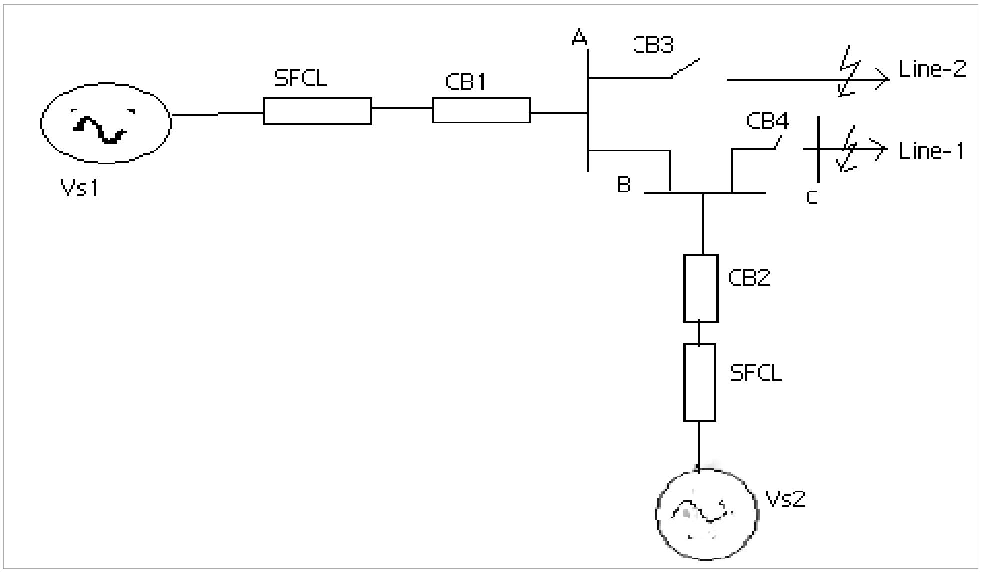

Fig 2: SFCL in a system with DG units

As shown in figure 2, it indicates the SFCL is applied to the distribution system with number of decentralized generating units. Whenever a single line to ground fault occurs in the feeder line1 (phase R, B points), the SFCL mode-1 can be automatically triggered the SFCL limits the fault automatically to low value. In consideration of the SFCL effects on the induced over voltage, the quantitative analysis is presented.

In order to calculate the over voltages induced in the other two phases (phase Y and B), the symmetrical component method and complex sequence networks can component method and complex sequence networks can be used, and the coeffi9cient of grounding G under this condition can be expressed, as G=-1.5m/ (2+m) +j3/2, where m=X0/X1, and X0 is the distribution system zero sequence reactance, X1 is the positive sequence reactance.

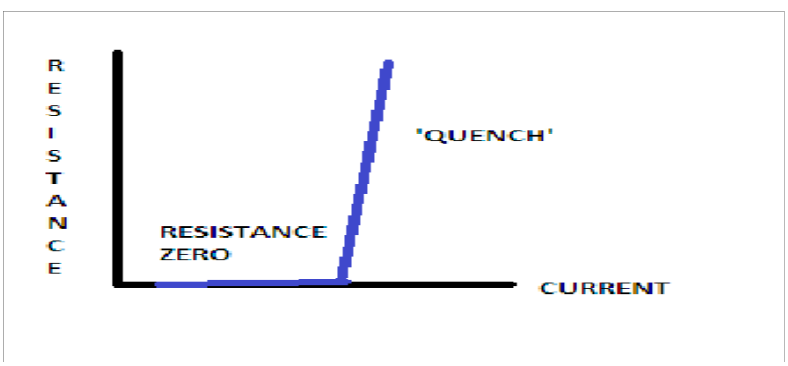

Fig. 3

The figure 3 shows the performance characteristics of SFCL, when normal operating condition the resistance or impedance of SFCL material is zero due to property of material made with yttrium barium copper oxide (YBCO). If it is placed in the cooled area in below 0 degrees. the impedance is zero, whenever this element placed in series with the network, the current passing through this element whenever the fault current are entering into the material, due to heat is directly proportional to current (If) the temperature reduces to critical temperature . The critical temperature is defined as "temperature at which the SFCL lose its property" and its acts as a high impedance. The property of impedance is to oppose the current , the fault current(If)try to divert in low impedance path from fig3 at normal condition the resistance zero after critical point the current quenching is can be observed.

3. Simulation Study

The implementation of over current and over voltage suppression using voltage compensation type active SFCL is developed in MATLAB Simulink. The figure4 shows the mat lab Simulink diagram. Here, the system consist of source of decentralized generation unit and transmission system the air core transformer of primary of SFCL material act as a sensing the fault current and secondary side is shunt reactor , which is mutually coupled . The primary is serially connected to the transmission line and secondary is connected to inverter circuit. The dc source is connected inverter circuit, the output of inverter is AC which consists of some ripples or harmonic which is reduced by the filters the passive filters are connected serially and parallel the harmonics are rectified and to maintained the pure sin wave across the shunt reactor. The fault is applied across the load the disturbance is created in the line. The fault current is reduced by SFCL and over voltage suppression by injecting the phase shift of 180 degrees voltage in to air core transformer

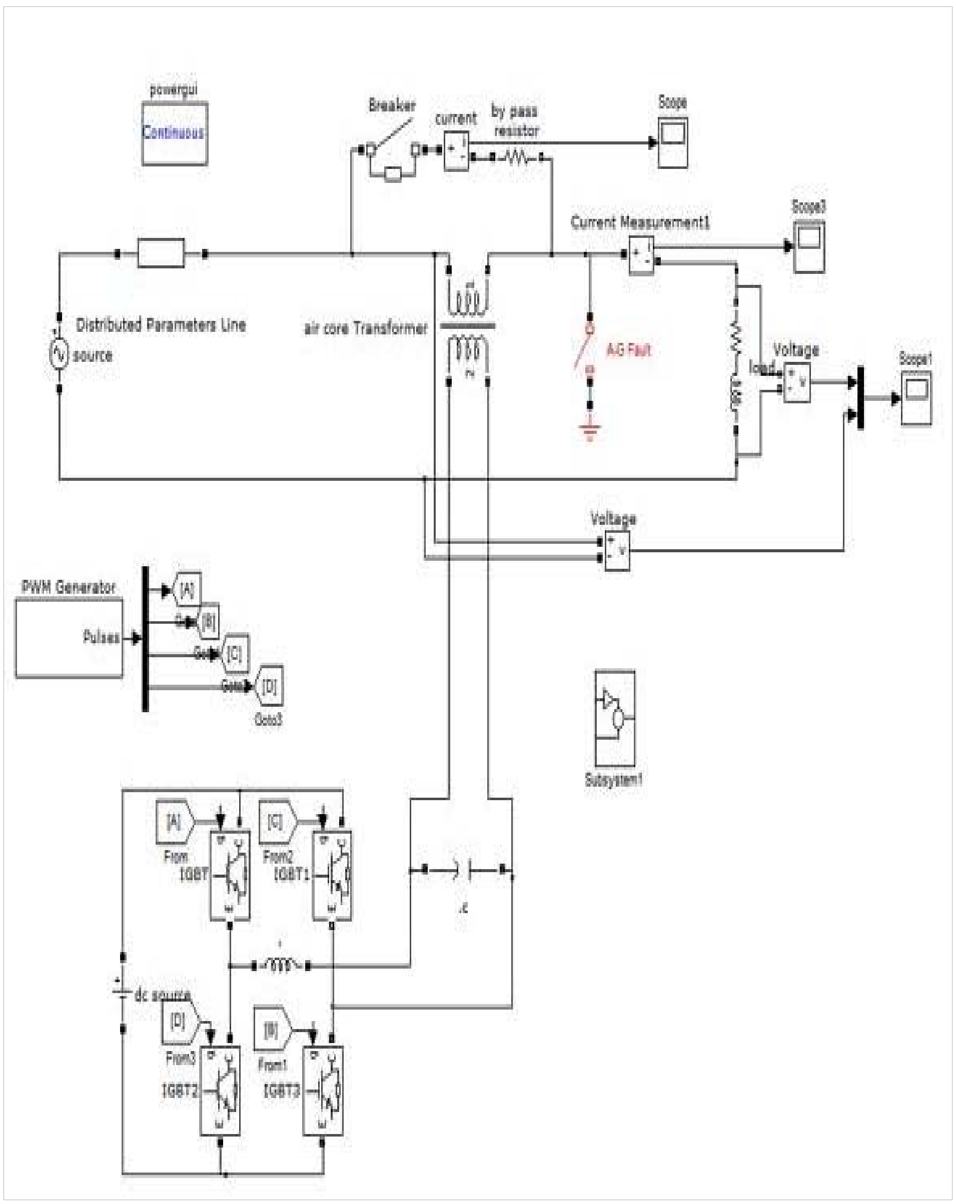

Fig 4: Simulation Diagram

Table 1: Simulation Parameters of Model

SFCL/ air core transformer	
Primary inductance	30mh
Secondary inductance	17mh
Mutual inductance	21mh
Transmission line parameters	
Line length	5Km
Line resistance	0.3864
Line inductance	4.12mh
Line capacitance	7.7nf
load	
Load	(5+j9)
Bypass resistor	5ohm

A .Overvoltage suppression using SFCL

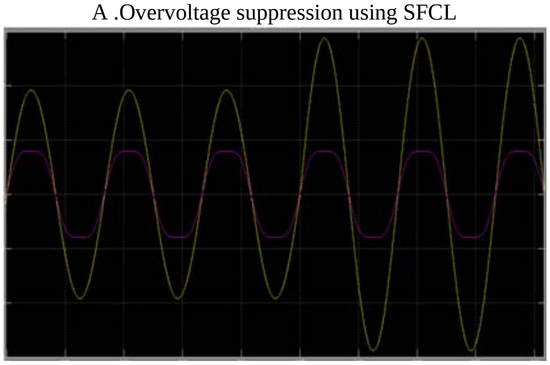

Fig. 5: Shows simulation result of over voltage

The overvoltage is occurred due to lightening and switching operations. The faults are taken at line-1 and line-2 at F1, F2and F3 the fault at F1 takes less time to impact on Vs2 system and more time on Vs1 system. The SFCL is placed at the both the busses to improve the performance. The figure 5 shows the simulation result of overvoltage suppression [9]-[10]. From the simulation result the two waveforms are showing one wave represents the during fault voltage increase in magnitude another wave represents the suppressed magnitude. The suppression of voltage is based on the injection percentage of air core transformer secondary. The secondary acts as a shunt reactor, then the secondary current (I2) is controlled by the sensing of subsystem circuit based on the injection capacity the suppression can be increases or decreases.

B .Over current suppression using SFCL

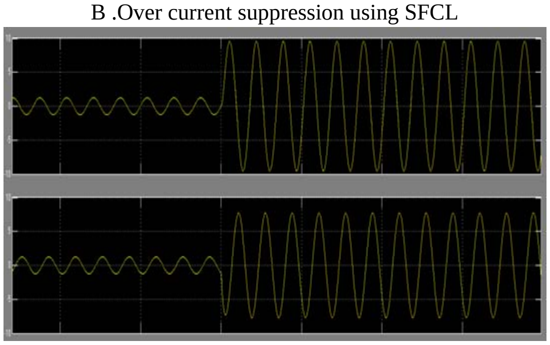

Fig6: showing the simulation result of with and without SFCL.

The over current suppression is made by SFCL, the SFCL play a keen role in reducing the fault current and increase the reliability of supply. The purpose of placing SFCL is when fault occurs on system the CB can be operated two or three times after that it goes to either open or close position only. Then the fault currents flow through the transformer and substation equipment, which damages the equipment in substation and utilizes. For suppose the operating time of CB is 0.3 sec the SFCL operating time is less than this value hence, the first peak value will be reduces to minimum value. The impact on CB will be reduced; the equipment damage can be less.

The fault current magnitude is high under without SFCL zone shown in figure 6.a the impact on system takes place. Whenever the SFCL is comes in to operation the magnitude of fault current is reduced shown in figure 6.b. Superconducting property is effective solution for fault current limitation.

4. Conclusion

In this paper, the application of active SFCL is implemented on decentralized generation with distribution networks. The frequent over voltage fault are reduced by the SFCL effectively by placing reactor element in circuit .the over current limitation also done through this SFCL. Hence, by placing the SFCL in the distribution network the over voltage and fault current can be reduced. The system reliability can be maintained, which increases the performance of the system.

In now a day, the world concentrating on the renewable energy sources such as, wind power and photovoltaic solar power are installed into distribution systems. Therefore, the study of SFCL is use full to the future and meaning full.

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