ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Special Issue , August 2019
International Conference on Recent Advances in Science, Engineering, Technology and Management at Sree Vahini Institute of Science and Technology-Tiruvuru, Krishna Dist, A.P

Simulation of Mega Conduction FCL to Transmission System Safeguard Energy Storage

Bavana , K.Nageswara rao

P.G. Student, Power System Engineering, Sree Vahini Institute of Science and Tech, Tiruvuru, Krishna (Dist.),
Assistant Professor, Department of EEE, Sree Vahini Institute of Science and Tech, Tiruvuru, A.P

ABSTRACT: For many years, superconducting fault current limiters (SFCLs) have been the topic of research and development and give an appealing alternative to the issue of increasing levels of fault in electrical distribution systems. SFCLs can significantly decrease fault currents and harm at the fault point and help enhance an energy system's stability. An SFCL's resistance should be selected to restrict as much as possible the fault currents. This not only benefits an electrical system by lowering the potentially dangerous impacts of elevated fault currents, which is the main objective of the SFCL but increasing the restriction of fault currents also results in shortening the SFCL retrieval time by lowering the dissipated energy in the SFCL resistance. Superconducting fault-current limiters (SFCL) provide a fresh and effective approach to the safe handling of such faults. (SCFLs) can be used for different nominal voltages and currents and can be tailored to specific limiting features for short circuits. Electrical instrumentation that controls high fault currents will increase the security of the network and allow power equipment to be designed more cost-effectively.

KEY WORDS: Superconducting Fault Current limiters (SFCL), Power Quality, Voltage Sag.

I.INTRODUCTION

In a contemporary energy scheme, growing loads and nonlinear equipment have demanded compensation for the disturbances they have caused. These non-linear loads can result in bad power factor and elevated harmonics. Active power filter can fix harmonic and reactive power issues at the same time. Apf s consisting of voltage source inverters and a dc capacitor has been studied and created to improve the power factor and transmission system stability. APF has the capacity to adjust the amplitude of the inverter's synthesized ac voltage by modulating the pulse width or by controlling the dc-link voltage, resulting in either guiding or lagging reactive voltage from the supply. APF's are a state-of - the-art solution to issues with power quality. Shunt APF allows for the compensation of present harmonics and unbalance along with the correction of power factor and can be a much better option than standard method (capacitors and passive filters). Using passive LC filters is the easiest way to eliminate line present harmonics and improve the system energy factor. However, the primary drawbacks of passive LC filters are bulk passive components, series and parallel resonance and a fixed compensation feature.

Different mitigation solutions have been proposed and used, e.g., passive filter, Active power line conditioner, and also hybrid filter. Recent technological development of switching systems and accessibility of cheaper control systems, e.g., DSP / field-programmable-gate-array-based system, Make active power line conditioner a natural option Active Power Filter (APF) of the shunt type is used to eliminate the present harmonics.

II. MODELING AND SIMULATION

A. The design of the SFCL

The limiter was designed to work in a 15 kV power system. A constructed inductive type superconducting fault current limiter is presented in Figs. 1 and 2. The main parameters of SFCL are presented in Table I, electrical schematic of the limiter is presented in Fig. 1. The limiter has two primary windings and six shorted secondary

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windings. The copper winding was wound onto an external bobbin and the superconducting windings on an internal bobbin. The primary winding, placed on the external bobbin, is made of a copper wire. The second primary winding is made of a 2G superconducting tape. The primary winding made of 2G tape is connected in parallel with the copper primary winding. The secondary HTS winding was shorted and made of a 2G superconducting tape. The primary and secondary superconducting windings were divided into twelve pancake coils. The length of HTS tape in one coil was 19 m. The coils of the primary HTS windings were connected in series. All windings are magnetically coupled. The magnetic coupling between the 2G tape windings in the inner bobbin is greater than the magnetic between the 2G tape winding and the copper winding in the outer bobbin..

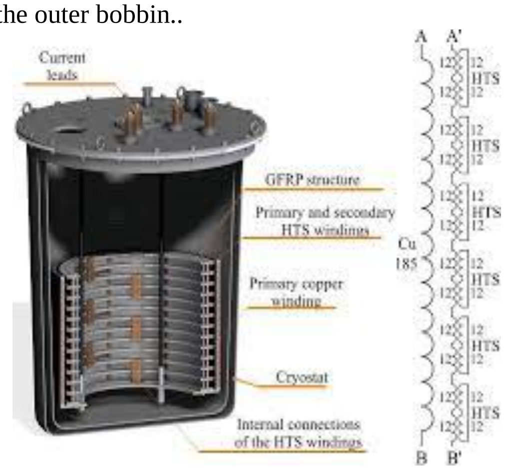

Fig. 1. Design of the SFCL.

The coupling coefficient between primary HTS and secondary HTS windings is 0.97 and between primary copper winding and secondary HTS winding is about 0.52. The primary copper winding has 185 turns. The primary superconducting windings have 12 turns each and are connected in series. The secondary superconducting windings consist of two shorted superconducting windings, each with 12 turns. Both the primary and the secondary superconducting windings are wound onto a single bobbin in such a way that their turns are positioned one on top of the other, which provides a very good magnetic coupling between the windings and this, in turn, reduces the voltage during the SFCL's performance in nominal conditions

Fig. 2. Coreless inductive superconducting fault current limiter with winding made of Super Power SF12050 second Generation superconducting tape

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B.Resistive SFCL Model

Simulink/Power system is chose to design resistive SFCL. Four fundamental parameters is used for modelling resistive-type SFCL The parameters and their values are: Transition or response time = 2ms, minimum impedance=0.01Ω & maximum impedance= 20Ω, triggering current=550A, recovery time =10ms.

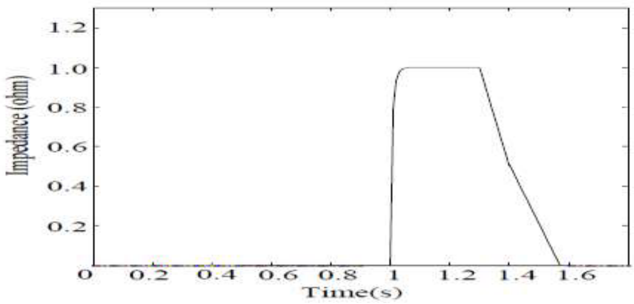

Fig 3 Quench and Recovery characteristics of SFCL

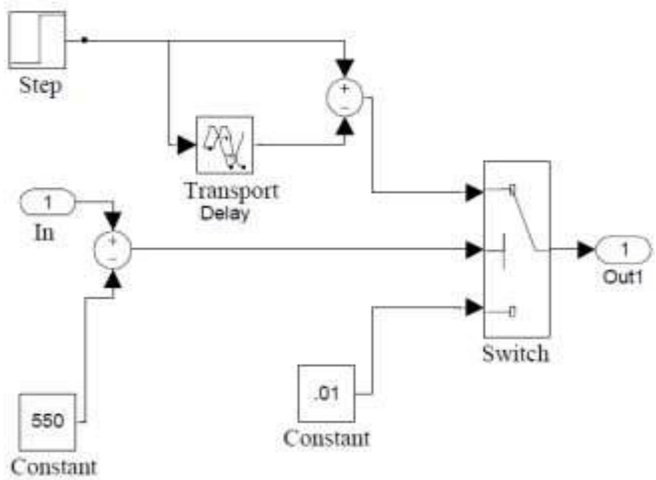

Fig.4 Implementation of Resistive SFCL Characteristics in Simulink

These parameters are used for implementing resistive SFCL characteristic is shown in Fig. 3. Quenching and recovery time of SFCL are specified using step and transport block respectively. A Switch block is used to give minimum or maximum impedance in output which is determined considering the incoming current. The simulation model of SFCL for a single phase system is shown in Fig4. The working principle of the SFCL model developed in Simulink/Power system is described below. Firstly, RMS value of incoming current (passing through current measurement block) is measured by RMS block. Then it compares the current with the specified current in the SFCL subsystem. SFCL gives minimum resistance, if the incoming current is less than the triggering current level. But if the current is larger than the triggering current, SFCL's impedance rises to maximum state. It ultimately raises the total impedance of the system which results in limiting the fault current. Finally, the SFCL's resistance will be minimum when the limited fault current is below the triggering values.

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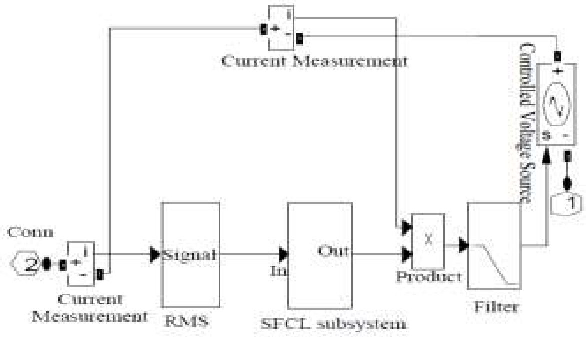

Fig.5 Resistive SFCL model in Simulink

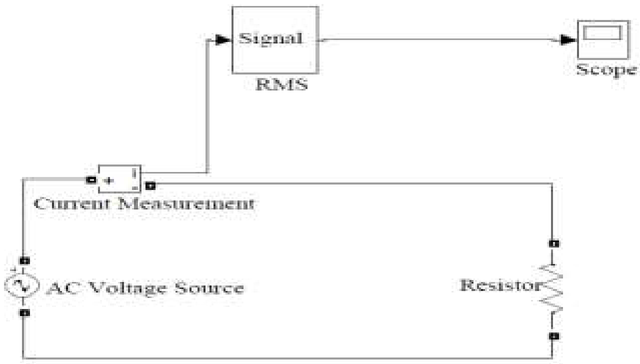

Fig. 5 Simulation model of single phase system without SFCL

C. Modelling of SFCL to demonstrate Current Limiting Characteristics

The designed model of SFCL is implemented in single phase system and fault current characteristics are taken with and without SFCL. The simulation model for this purpose is shown in fig.5 and fig.6 respectively. The fault is introduced directly through AC source in order to decrease the difficulty of simulation. An RMS block is used to calculate the RMS value of the incoming current and scope is used to see the output o the system.

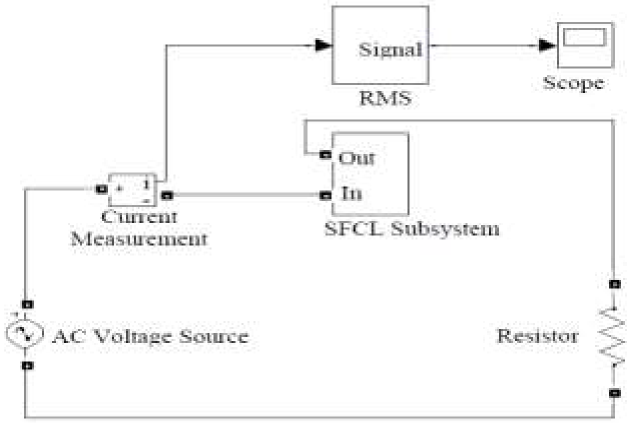

Fig 6. Simulation model of single phase system without SFCL

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III. VOLAGE SAGS IN POWER TRANSMISSION SYSTEM

When faults occur in power Transmission system, the automatic recloser or circuit breaker with over-current relay (OCR)and reclosing relay will open to clear the fault and automatically reclose after a time delay. This reclosing behaviour can take place several times in an effort to establish a continuous service when a temporary fault occurs. The voltage sag generally happens from fault.

A.VOLTAGE SAG WITHOUT FCL:

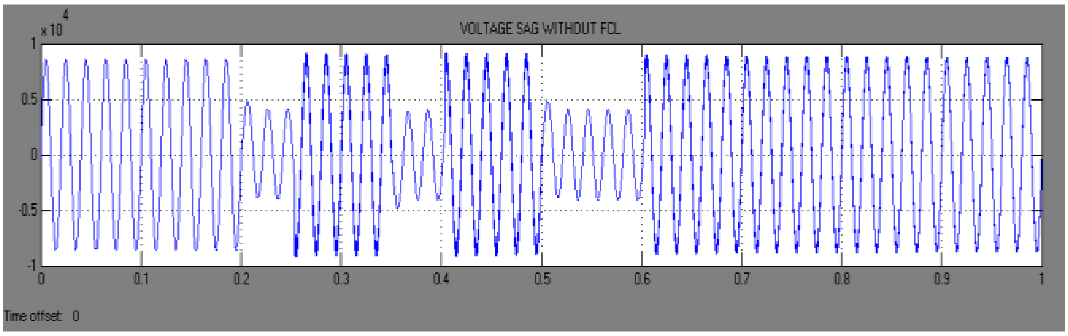

Fig .7 Voltage SAG without FCL

B.VOLTAGE SAG WITH FCL:

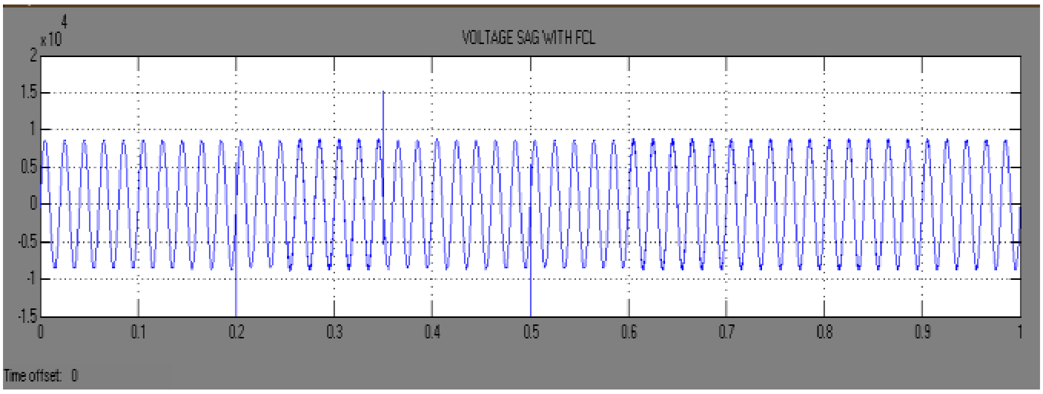

Fig .8 Voltage SAG with FCL

IV. EXPERIMENTAL RESULTS

Here the simulation is carried out by different cases

1) Single phase with and without SFCL under fault condition.
2) Three phase with and without SFCL

Cases- 1 Single phase with and without SFCL under fault condition

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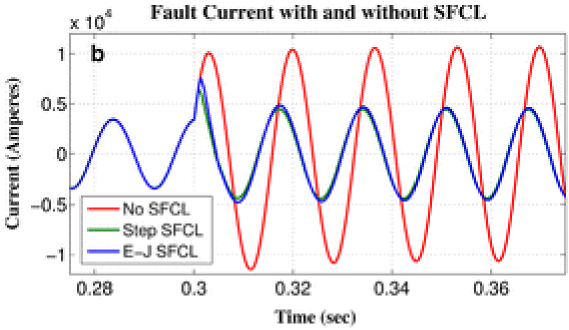

Fig .9 Fault current with and without SFCL

Cases - 3 three phase with and without SFCL

Three phase fault or balance fault is the most severe fault that occurs in the power systems. Figure (10) envisages the current waveforms of the radial distribution system without SFCL when three phase fault occurred in the system. It can be seen from Figure (10) that, for three phase fault, all three phases experiences high current flowing through the lines. Figure (11) shows the similar system and condition of Fault with inclusion of SFCL in the system.

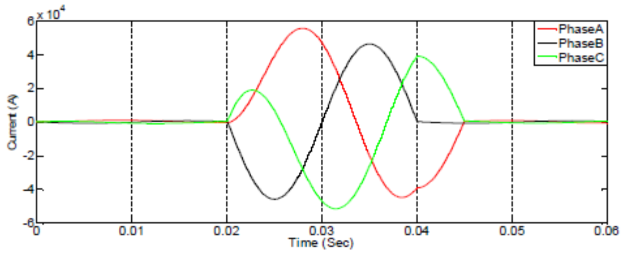

Fig .10 Three phase fault without SFCL

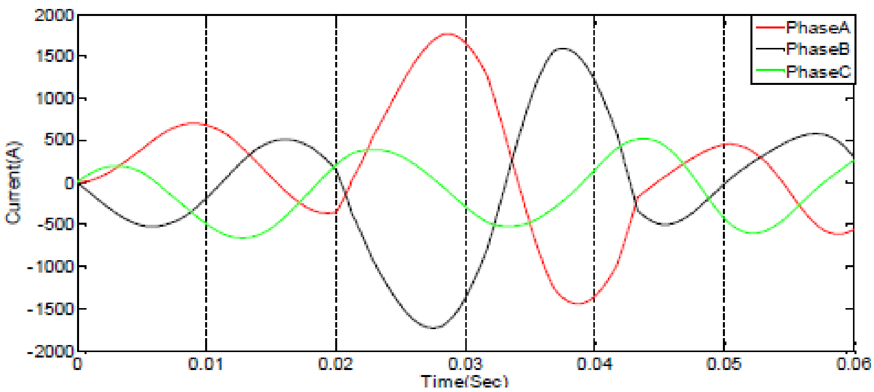

Fig .11 Three phase fault with SFCL

V. CONCLUSION AND FUTURE WORK

The SCFL is a tool like that.in case of a short circuit it does not unplug the line, as opposed to a high-voltage fuse, but limits the very high currents to specified values. Furthermore, it enables the electrical interconnections of current structures that would not be feasible without limiters. Finally, the SFCL is implemented into the greater capacity scheme. It is therefore disclosed that SFCL's exceptional present limiting efficiency can be used to restrict the fault to

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the present switchgear stage. Using Mat lab / Simulink software, the simulation outcomes are provided. The proposed concept can be implemented to protect the distribution system.

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