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Designing and Analysis of Power System with SFCL Module

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Abstract-In most highly developed electrical power system, there are several difficulties related from generation to distribution. Usually, power generation is located at remote area from the load center. Long transmission and distribution lines have to be constructed and maintained to meet required reliability, power quality and economic point of views. Reliable, cheap, efficient conductor is required to support desirable electric power systems. Now a days we are going for smart grid, so the distribution generation comes in electrical market or system. For such a upcoming smart grid, superconducting fault current limiters (SFCL) has important application on the reduction of abnormal fault current to its possible effect and the suitable location in the micro grids. Micro grids may not be connected with conventional power grid because of their modes of operation. The safety measures for integration with various kinds of distributed generation and loads are taken. However, newly emerging problems due to these integrations are also of severe expected by direct connection of distribution with the power grid are the excessive increase in fault current and the islanding issue which is caused when, despite a fault in the power grid, distributed generation keeps on providing power to fault-state network.

Thus in recent power system, fault current reduction research has been directed towards the super conducting fault current limiters. This paper presents a resistive type SFCL model is implemented by integrating in Simulink-Matlab. The various faults have been simulated at different locations in smart grid and the fault current analysis is done with SFCL and without SFCL.

Keywords*-SFCL, Smart grid, Power quality, THD*

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I. INTRODUCTION

Now days, there is increase in the electrical network to satisfy the energy demand with the help of not only smart grid but also distributed generation.Due to consumption of electrical energy and increment in demand energy leads to increase in the system fault levels and it crosses the rated capacity of the existing circuit breakers. To increase the installed electrical power, interconnection of electrical transport network is carried out. During interconnection it maylead to very high short-circuit currents. Such fault currents are usually momentary and originate from equipment failures, lightning and various abnormal environmental conditions, etc. The short-circuit fault current will increase beyond the rating of the existing protective components in the system. So, to avoid the short circuit current use of a current limiting device in the system is introduced. These devices are known as Fault Current Limiters (FCLs). The FCLs are made up of superconducting materials because superconducting materials have a highly non-linear behavior which is ideal for the application as FCLs. These FCLs have ability to make electrical power system effective by suppressing fault currents and result in considerable saving in the investment of high capacity circuit breakers. In this paper a resistive superconducting fault current limiter (RSFCL) proposed, to reduce the fault current and to overcome the drawback in the power system by placing or installing SFCL proposed system. Which is then results in the improvement in the stability of the system. Superconducting Fault Current Limiter (SFCL) is one of the most novel alternate solutions to avoid the problem of increasing fault current. It improves power system reliability and stability by reducing the fault current instantaneously. SFCLs have large impedance in fault conditions and have very low impedance in normal conditions and also instantaneous recovery to zero impedance post fault clearance. Superconducting materials have a highly non-linear behavior which is ideal for the application as FCLs.

The organization of this paper is as follows: Section II describes the SFCL Technology. Section III describes the development of SFCL model. Section IV describes the Resistive SFCL. Section V describes the Modeling and simulation networks and Section VI analyzes the simulation results. Finally, section VII provides conclusions regarding this paper.

II. SFCL TECHNOLOGY

Superconducting Fault Current Limiter (SFCL) have ability to overcome and suppression of short circuit fault current problems with manysignificant advantages.

There are various types of SFCLs, which can be classified in three types such as the resistive type, the inductive type and bridge type SFCL. 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. Superconducting Fault Current Limiter is innovative electric equipment which has the capability to reduce the fault current level within the first cycle of fault current

A Superconducting fault current limiter device reacts very rapidly, resets itself after a fault, and has minimal impact on system performance during normal operation. The SFCL

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have some features properties such as (i) High impedance in fault operation (ii) Low impedance in normal operation (iii) Limits fault current before first peak and (iv) operational before circuit breaker recloses, etc. The below Fig. 1 shows the relationship between fault current and normal current after SFCL.

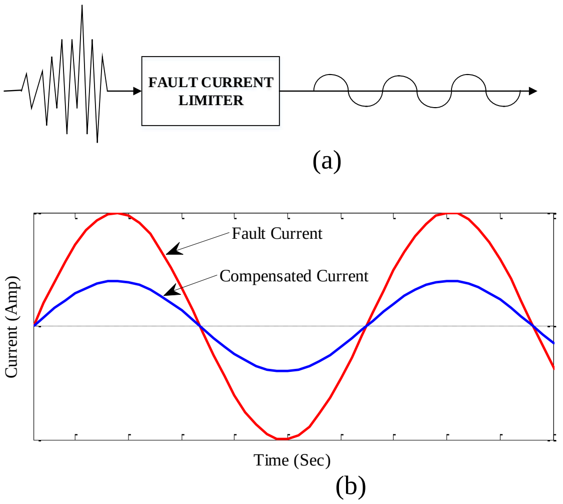

Fig. 1: (a) Fault Current Limiter Module Output(b) Fault Current Waveform and Compensated Fault Current Waveform Using SFCL

III. DEVELOPMENT OF RESISTIVE SFCL MODEL

The resistive type SFCL model developed in the matlab-simulink using SimPowerSystem block set. The parameters used to design such model are as: (i) Transition or response time = 2ms, (ii) maximum impedance = 20Ω, (iii) minimum impedance = 0.01Ω, (iv) Recovery time = 10ms and (v) Triggering current = 550 Amp. Fig. 2 shows the Resistive SFCL model, in which RMS block is used to calculate the RMS value of incoming current which then fed to subsystem of SFCL characteristic table block.

The SFCL characteristic table block is used to decide whether the impedance level goes maximum or minimum.

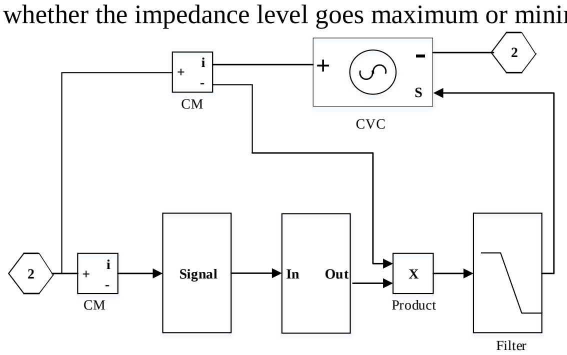

Fig. 2: SFCL Model

The comparison concludes the value of resistance of SFCL as: (a) if the incoming current is below the triggering current level, then the SFCL resistance is minimum. (b) if the incoming current is exceeds above the triggering value, then its resistance is maximum close to the impedance level. Which results in the reduction (limit) of the short circuit fault current?

Fig. 3: shows the characteristic table of SFCL. In which step input and transport delay are used to set the transition, response and recovery time of SFCL.

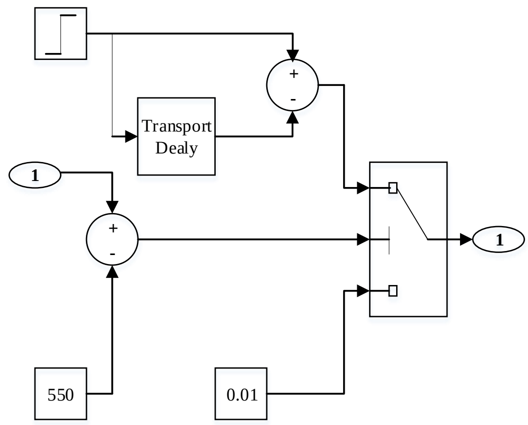

Fig. 3: Characteristic table of SFCL

The switch block is used to set the value of impedance to minimum or maximum. After SFCL characteristic subsystem there is an filter block and controlled voltage source block. These are used to reduce the harmonics and to compensation of voltage sag respectively.

IV. PROPOSED SFCL SYSTEM

In this system the fault current limiters are made up of superconducting materials. The resistance of the superconducting element is essentially zero, thus during normal operating the system, it operates without any limitations and it is possible to minimize the inductive impedance. Suppose any fault occur in system, fault current reaches many times the rated value, but due to the superconducting element it reverts rapidly to its normal state. This is because the increased in resistance/impedance which limits the fault current to the desired level.During normal operation the current flowing through the superconducting element dissipates low energy. If the current rise above the critical current value the resistance increases rapidly. The dissipated losses due to the rapid raise in resistance heats the superconductor above the critical temperature and the superconductor resistance changes its state from superconducting to Normal state and fault current is reduced instantaneously. This phenomenon is called quench of superconductors. When the fault current has been reduced, the resistance element recovers its superconducting state.

Fig. 4 shows the three phase system which is considered for the transient stability system. Here a machine rated as 150 MVA. The generating voltage is 33 kV. A step up transformer is used to step the voltage which will provide the voltage to the load and further distribution network. The step up transformer rated as 33/154 kV.

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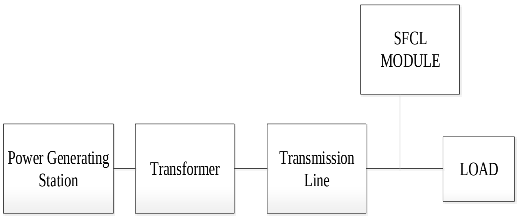

Fig. 4: Proposed 3-Phase system

V. SIMULATIONRESULTS

The simulation results are presented for the Line-Ground fault creating on transmission line as well as on distribution line.

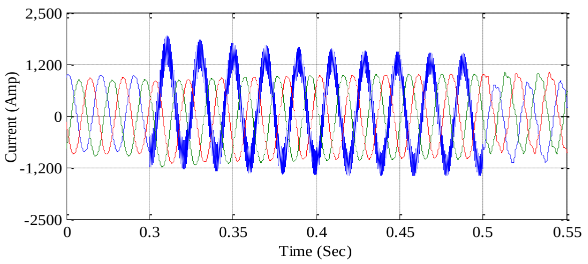

Fig .5: Fault Current Compensated in Transmission Line without SFCL

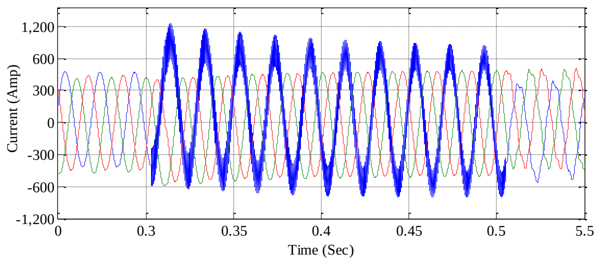

Fig. 6: Fault Current Compensated in Transmission Line with SFCL

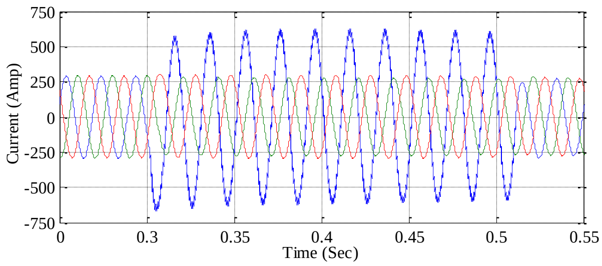

Fig. 7: Fault Current in Distribution Line without SFCL

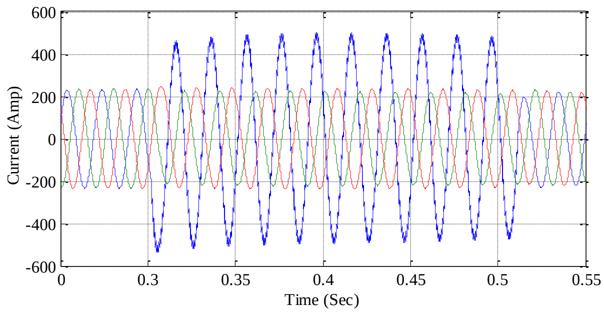

Fig. 8: Fault Current Compensated in Distribution Line with SFCL

Table 1: Values of Fault Current without and with SFCL

Type of Fault	**Single line to ground fault**	
Magnitude of Fault current	**Without SFCL**	**With SFCL**
Transmission Line	1500 Amp	1200 Amp
Distribution Line	600 Amp	500 Amp

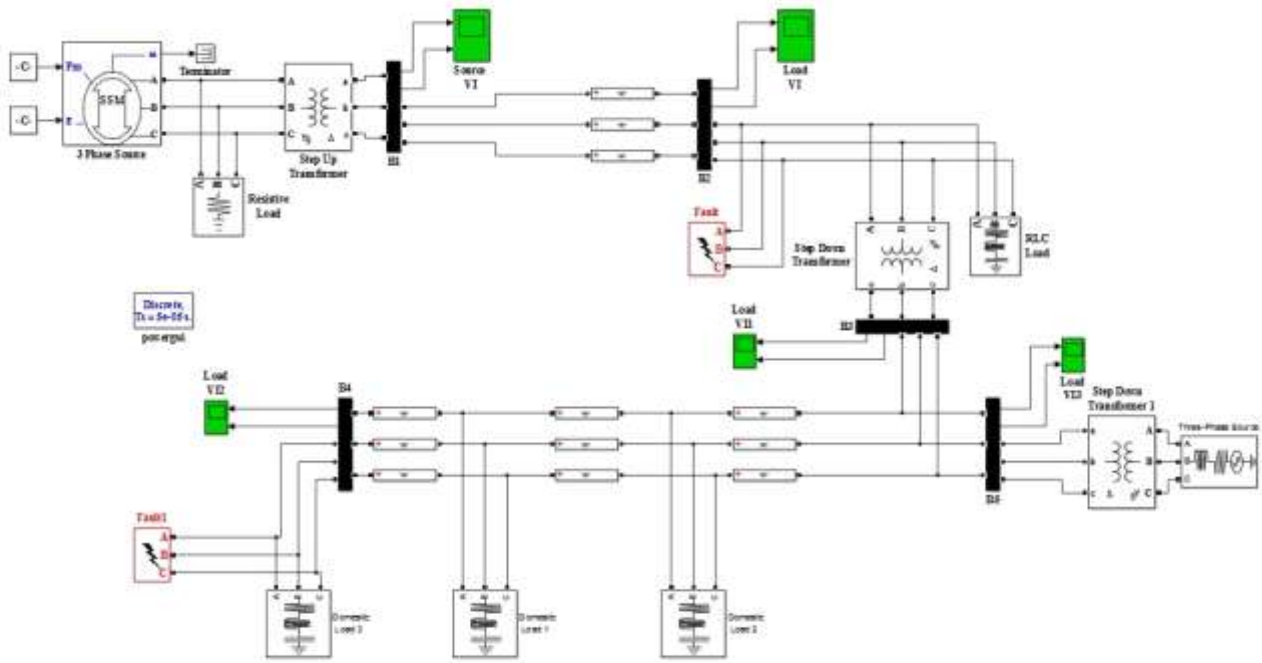

Fig. 9: Proposed System without SFCL Module

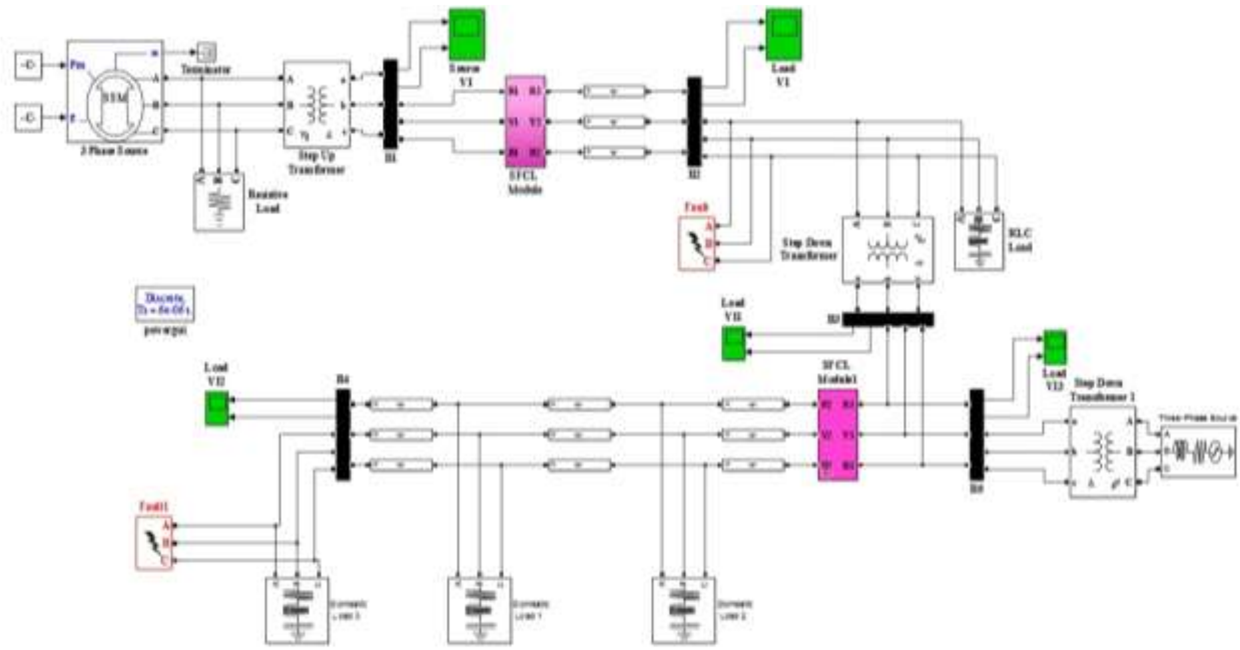

Fig. 10: Proposed System with SFCL Module

Fig. 9 and Fig. 10 shows the complete proposed simulation network without and with SFCL module respectively.

VI. CONCLUSION

This paper shows the design of resistive SFCL module and the results are carried out for single line to ground fault in transmission line as well as in distribution line. The results are tabulated in table which shows that, using SFCL module the transient rise in fault current are suppressed or limit to a desired value using SFCL. From table also conclude that, the resistive SFCL module have ability to limit the sudden rise in fault current by providing the sufficient value of resistance.

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