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SFCL Technology for Generator Protection

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ABSTRACT

Power is the basic need for the economic development of any country. The availability of electricity has been the most powerful vehicle of introducing economic development and social changes throughout the world. The aim of this paper is to present a simulation model to reduce the internal fault currents of large synchronous generators. Due to the increased fault-level currents, superconducting fault current limiter (SFCL) is more likely to penetrate into a low voltage and medium voltage transmission network to improve their stability and lower the electric devices capacity. In this paper, a simulation model for resistive type SFCL using Mat lab/Simulink software is shown.

Keywords: Brushless excitation, Fault current controllers (FCC), Superconducting fault current limiter (SFCL), High-temperature superconductivity (HTS).

1. Introduction

Power is the basic need for the economic development of any country. The availability of electricity has been the most powerful vehicle of introducing economic development and social changes throughout the world. The process of modernization increase in productivity in industry and agriculture, improvement in the standard of living of people depends upon the adequate supply of electric energy. Thus, national planning processes give priority to programs relating to the generation transmission and distribution of electric energy.

After independence, more importance has been laid on strengthening and modernization of transmission and distribution system along with growth of power generation facilities. Now the installed generating capacity in India has increased multifold from a level of 1300MW in 1947 to 115545MW today [1]. Also the per capita consumption is increased from a level 15.60KWh to 606.20KWh during the year 1950 to 2005 and the actual generation has also increased from 5 billion units in 1950 to 600 billion units today.

Synchronous generators are very important elements in power systems since they are in-charge of providing an uninterrupted power supply to the consumers. Therefore, their reliability and good functioning are crucial [1]. The construction as well as maintenance cost is high depending upon the complexity and the size of the generators. The important role of generators in the power system and the high cost of repair in case of damage require a good protection system against faults. It must be protected against the damage caused by abnormal conditions in the electrical network or in the generator itself. Generators are protected against external faults by several circuit breakers that isolate all faults that occur in the network (i.e. transformers, buses, lines, etc.). At the same time, the generators must be protected against faults that occur inside the machine. There are several ways to detect these faults and avoid the damages caused by them.

Detection of single line to ground faults depends on the generator grounding type, which can be classified into low and high impedance grounding. In case of low impedance grounding, a differential relay can detect and provide protection of only about, 95% of the windings [2]. However, for high impedance grounding, ground faults are not normally detectable by the differential relay because the fault current is usually less than the sensitivity of the relay. In such case, an over-voltage relay connected across the grounding resistor has been used to sense the zero sequence voltage. Various generation schemes like nano generators have been implemented as a part technological revolution to overcome power scarcity [8].

Conventional protection device installed for the protection of excessive fault current in electric power systems especially at the high voltage substation level, are the circuit breaker tripped by over current protection relay which has a responds time delay that allows initial two or three fault current cycle to pass through before getting activated [3,4]. Shunt reactors (inductors) are used in many cases to decrease fault current. These devices have fixed impedance so they introduce a continuous load, which reduces system efficiency and in some cases can impair system stability. Fault current limiters (FCLs) and fault current controllers (FCCs) with the capability of rapidly increasing their impedance, and thus limiting high fault currents are being developed. A significant advantage of proposed FCL technologies is the ability to remain virtually invisible to the grid under nominal operation, introducing negligible impedance in the power system until a fault event occurs. Ideally, once the limiting action is no longer needed, an FCL quickly returns to its nominal low impedance state [7].

New method is introduced as SFCL (Super conducting fault current limiter). In this, a lengthy super conductor wire inserted in series with transmission line or distribution feeder to limit fault current abruptly increasing resistance. The SFCL can limit fault current within first cycle of the fault current. The preliminary suppression of fault current by SFCL upshots in an amplified transient stability of power system carrying higher power with better stability set to avoid tripping of normal unbalance which yields reduced sensitivity.

2. GENERATOR EXCITATION AND EXISTING PROTECTION SCHEME

2.1 Brushless Excitation

The key purpose of excitation arrangement is to keep machine output voltage continuous regardless of the load. In this scheme, excitation is by slip ring and there are no brushes. For earthing determination and generator safeguard, a couple of brushes are casted off. As related to static excitation, its maintenance charge is a smaller amount [1].

Pilot Exciter: The three phase pilot exciter has a revolving field with permanent magnet poles. The controlled rectified D.C. is fed to the main exciter field. The induced three-phase A.C. voltage is rectified in the rotating rectifier bridge and fed to the generator rotor winding through the d.c. leads in the shaft.

Main exciter: The stator frame has the field poles with the damper windings. The pole shoes contain bars and damper windings are formed by shorting their ends. Quadrature axis coil is built-in amongst two poles to measure the exciter current. The slots of the rotor contain three-phase winding. Turbine oil system is used for bearing lubrication.

Rotating rectifier wheels: In three-phase configuration, silicon diodes are settled on the rectifier wheels. Identical pair of diode wheels are used but direction of the diodes vary. The RC suppression network contains one damping resistor and one capacitor each.

2.2 Circuit Breaker

Electrical circuit breaker is a switching device. It can be automatically operated or manually for protection and controlling of electrical power system. During current carrying condition, also the circuit breaker acts as the special device in performing required switching operations [3].

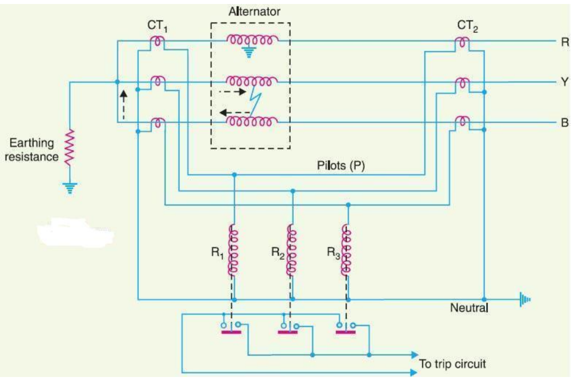

Fig no.1 Differential Protection of Alternator

3. EXISTING SYSTEM

3.1 Differential Relay Protection

It is one of the significant protections to defend generator winding against internal faults such as three phase-to-ground and phase-to-phase faults. This type of fault is very grave since very huge current can flow and create great extent of destruction to the winding if it is permitted to continue. Differential protection of an alternator is shown in fig no.1.

Whenever an internal fault occurs in generator high fault current is produced. Sometimes the relay sensitivity cannot handle this high value of fault current and may cause the interruption of power supply. Thus, a new technology has to be introduced in power system to tackle this difficulty. In this paper, SFCL technology has been explained which can overcome the above mentioned problem.

4. SFCL SYSTEM

4.1 Description

It employs superconducting constituents to stream a bias current (DC) that disturbs the magnetization. It also limits the current directly. Simple perception of SFCL is portrayed in fig no.2

Benefits

- The peak value of fault current decreases.
- Transient stability of the system increases.
- For low- frequency oscillations effective damping is delivered.
- No power loss in steady-state condition.

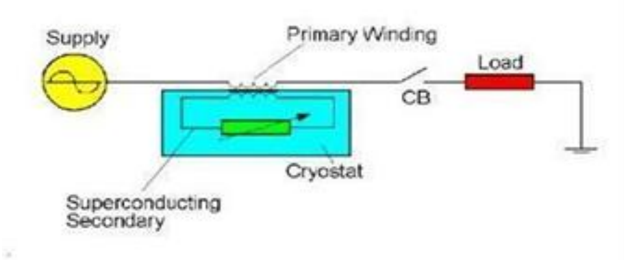

Fig no.2 SFCL Design Concept

4.2 Simulation

The diagram 3 shows the simulation of differential protection Relay. The relay continuously monitors the parity or ratio among the incoming currents and outgoing currents and internally computes the rms value of the differential current compensated for any CT ratio. On every occasion of fault, the proportion between incoming and outgoing current will fluctuate and no longer be equivalent.

Thus, we require a protective system in order to regain the preferred CT ratio. The existing solution for this problem is with the help of a differential protection Relay. Here, whenever a fault occurs, the high fault current can actuate the relay and thus tripping of the circuit takes place. The disadvantage with this scheme is that overheating can occur and continuity of supply cannot be assured.

The following simulation figure 4 shows SFCL technology. A Three-phase to ground fault has been triggered at time 0.2 s. The SFCL and its shunt resistor have been in series to the output side of the generator in order to protect the generator or other electric devices from overcurrent when any fault happens.

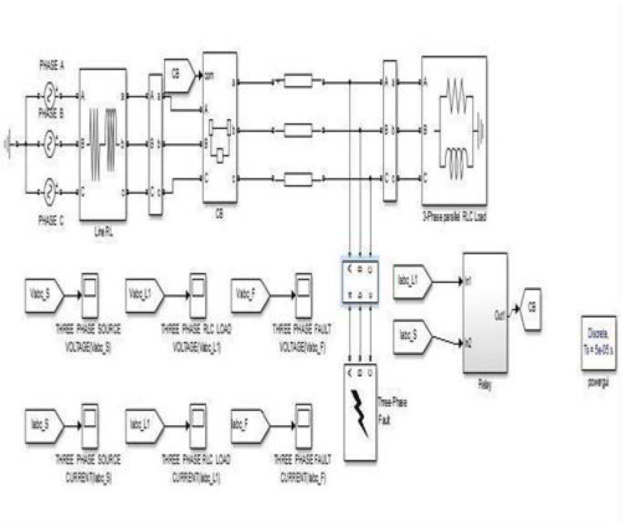

Fig. no.3 Differential Protection Relay

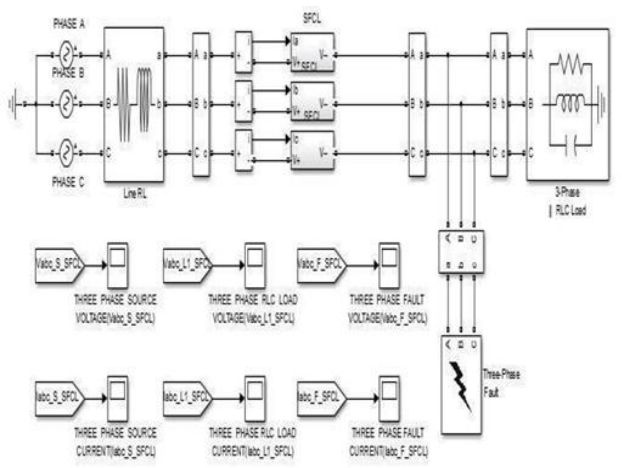

Fig no.4 Simulation of SFCL

5. Results

The simulation results of current waveforms in a power system with differential protection and SFCL technology are shown in fig no 5 & 6 respectively. From Figure 3, it could be noted that when there is no SFCL applied in the distribution power system, the fault current increases to a high value, which may cause damage to the system. Figure 6 shows the reduction of fault current by SFCL after the fault occurring instant 0.2s.The SFCL effectively limits the peak value of the fault current by about 20 %, which is within the limit.

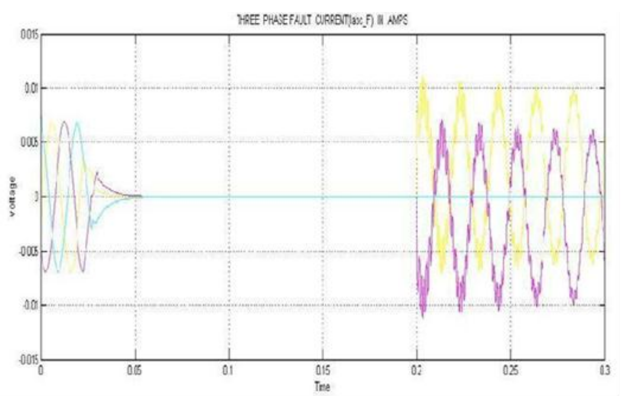

Fig no.5 Fault Current of Differential Protection

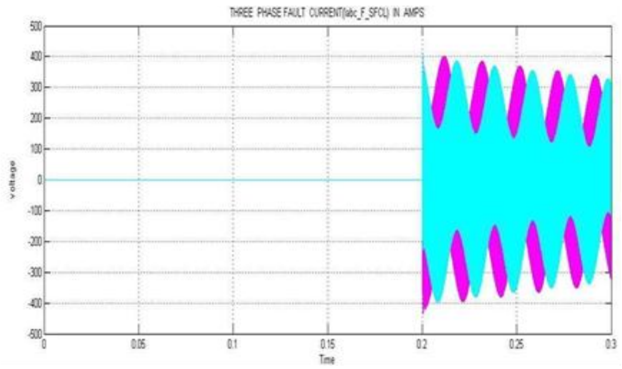

Fig no.6 Fault Current of SFCL

6. Conclusion

The protection system should provide adequate safety to all elements. Still the existing system sometime fails to provide a 100% full proof safety and protection. Introduction of SFCL helps to reduce the magnitude of fault current. Simulation results are shown for the relay and SFCL. From these results, it is clearly shown that the reduction in the fault current. These results show the application potential of SFCL in a power grid.

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