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# Power Fluctuations and Voltage Persistence in SMES Based on an Evolutionary Strategy

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**Abstract:** Recognized as a key issue in power system operation, oscillations in the power system are the primary topic of this research. Power systems are inherently susceptible to low-frequency electromechanical oscillations, which have a significant impact on the stability of the system and the capacity to transmit power over transmission lines. Stabilizers for electricity systems have long been the go-to for taming such fluctuations. One famous FACTS device that may regulate power flow in transmission lines is the unified power flow controller. The primary application of a facts controller is the resolution of stability control issues in power systems. Powering the system's actual, real-time power needs, energy storage devices are a huge aid. More research is being done to commercialize the Superconducting Magnetic Energy Storage (SMES) technology, which is a relatively new energy storage device. The analysis is accomplished by creating a program in MATLAB.

**Keywords:** voltage variations, SMES (Superconducting Magnetic Energy Storage)Program

Overview

The Indian government has a plan of installed generation of 78,000MW by2012. The total demand capacity of India is expected to cross 950,000MW by 2030. By the year 2011- 12, the expected peak demand is 157GW and the per capita energy consumption is going to increase to an amount of 932kWh. With the exploitation of efficiency measures, a reduction in energy demand can be achieved in particular by introducing highly efficient electronic devices using the best available technology in all demand sectors. Flexible AC Transmission System (FACTS) technologies have been introduced recently in India to improve the efficiency of the transmission lines, to improve the quality of the power supply and reduce the cost of energy. Already SVC has been installed at Kanpur (2X±140MVAr), TCSC on Rourkela – Raipur 400kV line (40% fixed and 5 – 15% variable) and Kanpur – Ballabhgargh 400kV line. And many more are in planning level.

According to IEEE, FACTS, is defined as "alternating current transmission systems which incorporate power electronics based and other static controllers to enhance controllability and power transfer capability" . High power electronic devices play an important role in improving grid reliability with the use of energy storage systems, FACTS, distributed energy,

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Vol-09 Issue-01 May 2014

and HVDC. The challenge facing the power system engineer today is 4 the usage of existing transmission facilities to a greater effect and efficiency which is very effectively obtained through FACTS technology. FACTS provide proven technical solutions to address new operating challenges which are presented today. The applications of FACTS devices in power systems are in the areas of power flow control, system stability and security enhancement, improving efficiency, power quality and protection.

## 1. General symbol of Facts Controller

Storage systems can be used to protect sensitive production equipments from shutdown which is caused by voltage sag or temporary interruptions. These are generally DC storageystems such as UPS, batteries, superconducting magnet energy storage (SMES), storage capacitors or even fly wheels driving DC generators are used. The output of these devices can be supplied to the system through an inverter on a momentary basis by a fast performing electronic switch like GTO or IGBT etc. Sufficient energy is fed to the system to compensate for the energy that would be lost by the fault conditions like voltage sag or interruption.

However there are many different methods to mitigate voltage sags and swells, but the use of a custom Power device is considered to be the most efficient method. Flexible AC Transmission Systems (FACTS) for transmission systems, the term custom power pertains to the use of power electronics controllers in a distribution system, particularly, to deal with a variety of power quality problems. Just as FACTS improves the power transfer capabilities and stability limits, custom power makes sure customers get pre-specified quality and reliability of supply.

There are many types of Custom Power devices like Active Power Filters (APF), Battery Energy Storage Systems (BESS), Distribution static synchronous compensators (DSTATCOM), Dynamic Voltage Restorer (DVR), Surge Arresters (SA), Super conducting Magnetic Energy Systems (SMES), Static Electronic Tap Changers (SETC), Solid- State Transfer Switches (SSTS), Solid State Fault Current Limiter (SSFCL), and unified power quality conditioner (UPQC).

## 2. SMES

**S**uperconductivity was discovered in 1911. In 1970s SMES was first proposed as an energy storage technology for power systems. SMES systems have fast response and high efficiency. Hence, electric utilities and military are focusing their attention towards SMES system. When compared with other energy storage technologies, SMES systems are costly. However, the integration of an SMES coil into the FACTS devices eliminates the cost for the inverter unit, which is the largest portion of the cost for the entire SMES system. Recently, high temperature superconductors are in the
research stage. Such type is cost effective due to the reductions in.

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Vol-09 Issue-01 May 2014

There are a number of ongoing SMES projects currently installed or in development throughout the world. In the SMES system the energy is stored in the magnetic field generated by the dc current flowing through superconducting coil. The inductively stored energy (E in joules) and rated power (P in watts) are the commonly given specifications for SMES devices. The energy and power are expressed as in equation

$$E = \frac{1}{2}LI^2; \quad P = \frac{dE}{dt} = LI\frac{dI}{dt} = VI$$

Where „L" is the inductance of the superconducting coil, „I" is the dc current flowing through the coil and V is the voltage across the coil. The energy is stored as circulating current. The energy can be drawn from an SMES unit with almost instantaneous response with energy stored or delivered over periods ranging from a fraction of a second to several hours. An SMES unit consists of a large superconducting coil at the cryogenic temperature. Figure 2.1 represents the block diagram of the SMES system. The superconducting coil is maintained at cryogenic temperature. This temperature is maintained by a cryostat that contains helium or nitrogen liquid vessels. A power conversion/conditioning system connects the SMES unit to an ac power system and it is used to charge/discharge the coil.

There are two types of power conversion systems. First one uses a Current Source Converter (CSC) to both interface to the ac system and charge/discharge the coil and the second type uses a Voltage Source Converter (SC) to interface to the ac system and a dc-dc chopper to charge/discharge the coil. The VSC and dc-dc chopper share a common dc bus.

The SMES coil is charged or discharged by applying a positive or negative voltage across the superconducting coil. The SMES system enters a standby mode operation when the average voltage across the coil is zero, resulting in a constant average coil current.

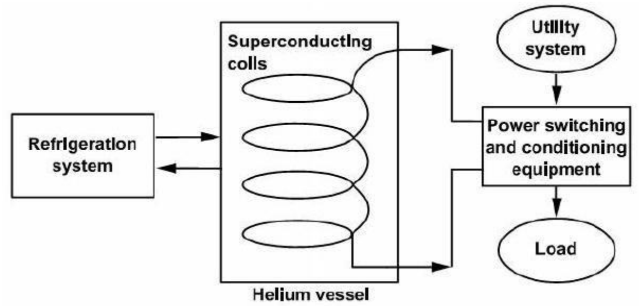



**Figure 3.1:** Block diagram of SMES system

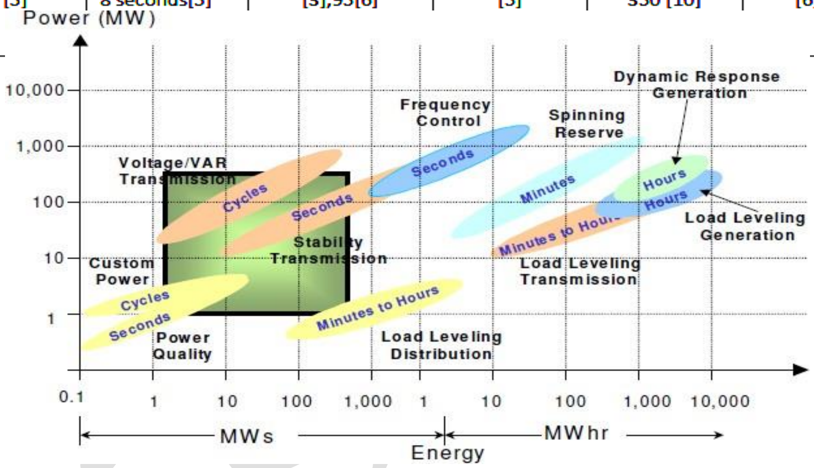
Several factors such as coil configuration, energy capability, structure and operating temperature are taken into account in the design of the coil to achieve the best possible performance of an SMES system at the least cost. A compromise is made between each factor considering the parameters of energy/mass ratio, stray magnetic field and minimizing the losses for a reliable, stable and economic SMES system. The coil configuration can be a solenoid or a toroid.

ISSN: 1934--9955 www.ijise.net

Vol-09 Issue-01 May 2014

The solenoid type is simple and cost effective. The operating temperature used for a superconducting device is a compromise between the cost and the operational requirements. An important possibility to reduce costs and increase competitiveness of SMES is the integration into existing FACTS, since this combination eliminates the cost for the inverter unit (part of the PCS), which is typically the largest portion of the cost for the entire SMES system. The development of higher temperature superconductors should also make SMES cost effective due to reductions in refrigeration needs.

| Energy and power Density (Wh/L –W/L) | Rated Capacity (MW) | Duration (hours) | Cycle Efficiency [%] | Energy Cost [$/kWh] | Power Capacity cost [$/kW] | Life (years) |
|---|---|---|---|---|---|---|
| 0.2-2.5 Wh/L, 1000-4000 W/L [5], 0.5-5 Wh/L [8] | 0.1-10 [4], [5] | milliseconds – 8 seconds[5] | 97+[5], 90 [3],95[6] | 1,000-10,000 [5] | 200-300 [5], 350 [10] | 20+ [5], 30 [6] |




## 3. Simulation and Results

**Figure 3.2: Technical/Economic Data**

the transmission system. First the system has been simulated in MATLAB/SIMULINK environment. The converter

The performance of SSSC is investigated by voltage and current waveforms using simulation. The simulation diagram for SMES is used for controlling the power flow in circuit of SSSC is usually a multi-pulse and/or multilevel configuration.

SMES with two quadrant chopper control plays an important role in real power exchange. SSSC with and without has been developed to improve transient stability performance of the power system. It is inferred from the results that the SSSC with SMES is very efficient in transient stabilityenhancement and effective in damping power oscillations and to maintain power flow through transmission lines after the disturbances.

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Vol-09 Issue-01 May 2014

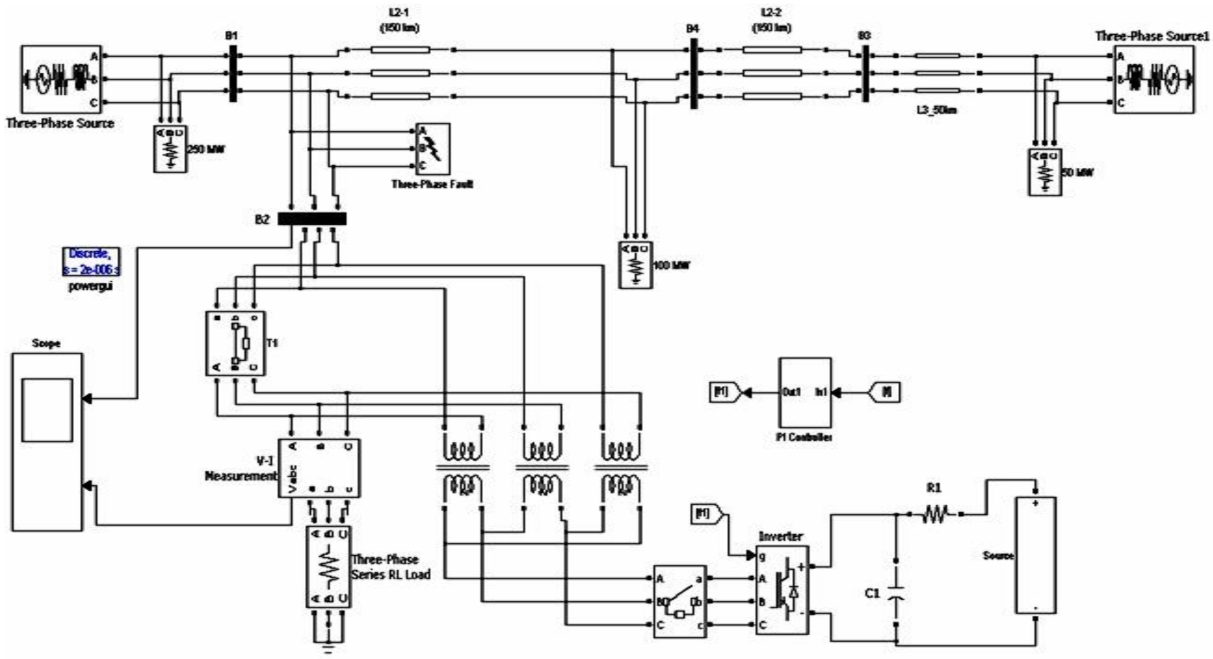


**Figure 4.1:** Simulation for SMES Power Flow control

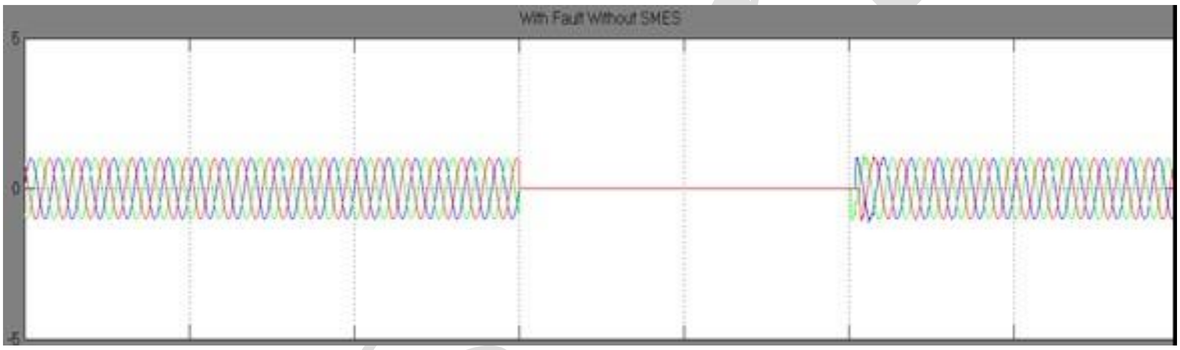


**Figure 4.2:** Simulation of Fault without SMES

## 4. Conclusion

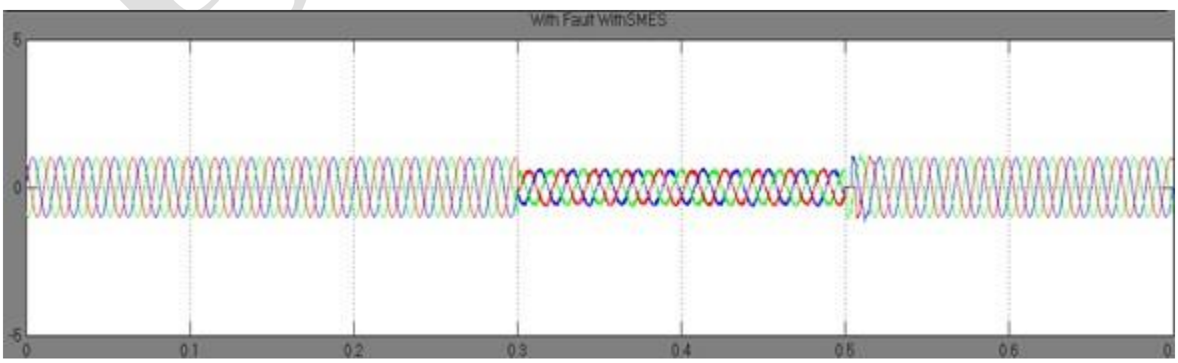


**Figure 4.3:** Simulation of Fault with SMES

important role. When even the most robust equipment is affected, then other measures must be taken, such as

The availability of electric power with high quality is crucial for the running of the modern society. If some sectors are satisfied with the quality of the power provided by utilities, some others are more demanding. To avoid the huge losses related to PQ problems, the most demanding consumers must take action to prevent the problems. Among the various measures, selection of less sensitive equipment can play an installation of restoring technologies, distributed generation or an interface device to prevent PQ problems. The dynamic performance of the SSSC with and without SMES for the test system are analysed with Matlab/simulink. In this SMES is used to maintain the power flow and to reduce the system damping. Also various FACTS controllers like Static Var Compensator (SVC), Static Synchronous Compensator (STATCOM), Unified Power Flow Controller (UPFC) etc., also to be incorporated likely.

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ISSN: 1934--9955 www.ijise.net

Vol-09 Issue-01 May 2014

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ISSN: 1934--9955 www.ijise.net

Vol-09 Issue-01 May 2014

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