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# Sub-Synchronous Resonance Damping in Total Variation Ranges of Operating Conditions Using a STATCOM

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**Abstract** – *Sub-Synchronous Resonance (SSR) oscillations in long transmission line brings on failure of the turbine shaft if not damped properly. STATic COMpensator (STATCOM) is a multifunctional FACTS device which its abilities depend on its location on transmission line. The main purpose of this work is damping SSR using STATCOM. To reach this goal a controller is proposed and designed for a STATCOM in transformer bus. In addition to SSR damping, the STATCOM with proposed controller can improve power oscillations and first swing stability. Eigenvalues analyses and nonlinear simulations in PSCAD/EMTDC software are used to illustrate the proposed controller and STATCOM performance. The simulation results approve the proposed scheme capability to damp SSR in total variation ranges of operation.*

***Keywords***: *Sub-Synchronous Resonance (SSR), STATCOM, Control, Eigenvalues Analysis, Transformer bus.*

## I. Introduction

Series capacitors are one of the conventional series compensators in power systems which are applied to compensate for the inductive reactance of the transmission lines in addition to improving systems stability and load handling [1]. Series capacitors however, may increase the risk of an adverse phenomenon called Sub-Synchronous Resonance (SSR). SSR is an electric power system condition in which the electric network exchanges energy with the generator at some of the natural frequencies of the combined system below the synchronous frequency [2]. In this situation, the turbine-generator oscillates at a frequency corresponding to the torsional mode frequency. Thus the torsional oscillations are amplified and may result in the failure of the turbine shaft [3].

So far, several countermeasures for damping of torsional oscillations such as excitation control [4], and FACTS devices include SVC [5]-[7], TCSC [8], UPFC [9], SSSC [10], and STATCOM [11]-[12], were employed in power systems.

In this paper, a control system is proposed and designed for STATCOM to damp SSR in total variation ranges of the active power and series compensation level. In addition to SSR damping, the STATCOM with proposed controller can improve power oscillations damping. STATCOM is located in transformer bus. Thus regulation of terminal voltage by STATCOM improves first swing stability that might have been reduced by delay in reinsertion time of series capacitor at fault time. Thus Shunt compensation with STATCOM in transformer bus is a suitable complementary for passive series compensation that with each other improve steady state and dynamic performance of system. The benchmark is an IEEE first benchmark power system [13] which is equipped with a voltage source converter based STATCOM in the transformer bus. Eigenvalues analyses carried out to verify the excellent performance of the proposed controller in SSR damping in total variation ranges of the operating points. The active power flow and the series compensation ratio are the main variable parameters which are changed over their full scale ranges. Time domain simulations using the nonlinear system model are also carried out to demonstrate the effectiveness of the proposed scheme in the transient SSR damping when the system experiences a three-phase fault at its infinite bus.

## II. System Modeling

### *II.1. Power System Model*

The IEEE first benchmark system [13] is shown in Fig. 1. It consists of a synchronous generator connected to an infinite bus via a compensated 500 kV transmission line. The transmission line is represented by a resistance, a reactance $X_L$ and a series compensation capacitor $X_C$, which its value depends on the compensation level. The mechanical system consists of four-stage steam turbine, the generator and a rotating exciter. The output active power is changed from 0.01 p.u to 1.0 p.u in 0.9 power factor. The STATCOM operation is investigated in all of these operating conditions.

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