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Enhancement Of Power System Stability By STATCOM Via Reactive Current Stabilize And Review

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ABSTRACT

Recent developments in power electronics have led to the development of the Flexible AC Transmission Systems (FACTS) devices in power systems. FACTS devices are capable of controlling the network condition in a very fast manner even with signal delay and this feature of FACTS can be exploited to improve the stability of a power system. To damp electromechanical oscillations in the power system, the supplementary controller can be applied with FACTS devices to increase the system damping. In this dissertation work, design a coordinated control of Wide-area Power System Stabilizer (PSS) and SSSC to damp-out the inter-area oscillations of signal delay (50ms) in a large scale power system by using Static Synchronous Series Compensator (SSSC). Genetic Algorithm (GA) is used in order to find the controller parameters.

Keywords: Grid system, Power System Stabilizer (PSS),Static Synchronous Series Compensator (SSSC). Genetic Algorithm (GA).

1. INTRODUCTION

STATCOMs are particularly effective in hybrid renewable energy systems with wind and photovoltaic sources. Research on STATCOM controllers in Single Machine Infinite Bus (SMIB) systems, with and without energy storage, focuses on enhancing dynamic stability and voltage regulation. The study uses multi-objective optimization to address impacts on system performance, with an emphasis on speed and voltage deviation damping under various conditions. The optimization problem involves robustness criteriawith solutions provided by Particle Swarm optimization.Steady-state voltage stability outcomes have been used in various planning studies. For example, in the authors used steady-state voltage stability results obtained via QV modal analysis to integrate wind generation into a power network. The study concluded that if voltage-controlled PEC-interfaced wind generators (e.g., DFIG and PMSG) are integrated into weak nodes in the network, they could improve the VQ stability margin significantly compared to integrating them at strong nodes in the network. The work presented in proved that optimization of voltage control resources at the distribution network could achieve improved voltage stability in the transmissionnetwork.

1.1 Small-Disturbance Voltage Stability

The operational status of a power system is often described in terms of small disturbances. Voltage stability is achieved when minor disruptions do not cause significant variations in the voltage close to the loads, keeping it relatively constant. To examine how minor disturbance stability relates to the steady state, one can use the small-signal model of the system.

1.2 Large-Disturbance Voltage Stability

Controlling voltages after significant disruptions, such as system faults, load losses, or generation failures, is a key aspect of system stability. To evaluate this stability, one must study the system's dynamic performance over a sufficiently long duration to identify changes in components such as current limiters, generator fields, and transformers under load. Nonlinear time-domain simulations with accurate models are employed to investigate voltage responses to major disturbances.

2.Equal Area Criteria

To ensure the secure operation of the power system, Transmission System Operators (TSOs) perform offline Transient Stability Analysis (TSA) for a few dangerous scenarios and design remedial actions for the critical ones, i.e., the ones with lower Critical Clearing Time (CCT) (CCT is the maximum fault elimination time without the system losing its capability to recover a normal operating condition (Tang et al., 2022) [16]. The reference technique for TSA is time-domain simulation using numerical integration of the nonlinear differential equations representing the system dynamic model. Time-domain simulation is flexible, and it can be considered a detailed model for almost any component of the power system. However, this detail comes at a cost, a high computational time. Moreover, the time-domain simulation cannot provide a direct indication of the CCT.

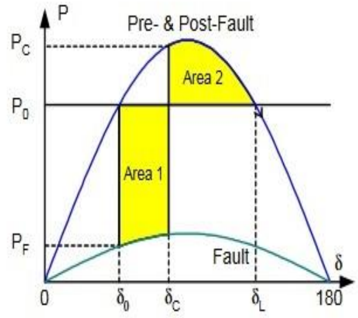

Figure 0.Equal Area Criteria.

2.1 Power quality issue

Power quality issues are of vital concern generally in most industries today, due to the surge in the quantity of loads sensitive to power disturbances. The electricity quality is usually an index to the quality of current and voltage offered to industrial, commercial, and household consumers of electricity. The condition regards both utilities and customers. With the utilities, offering adequate power quality is a moving objective because of changes in user equipment as well. For consumers, problems stemming from the sensitivity of electrical equipment to voltage quality have often very heavy consequences (Rao et al., 2020) [19]. Power quality is usually a topic embracing a substantial field. On one side, several different events are going to complete power quality: spikes or surges, sags, swells, outages, under or higher voltages, harmonics, flicker, frequency deviations, and electrical noise

3. Background of study

The introduction of high-power gate-turn-off thyristors (GTOs) has led to the development of the Static Synchronous Compensator (STATCOM). This second-generation FACTS equipment, based on voltage source inverters, offers improvements over the Static Var Compensator (SVC) by using self-commutating devices such as GTOs. STATCOMs provide notable advantages over traditional SVCs, including a reduced physical footprint due to fewer passive components and the ability to deliver required reactive power at lower bus voltages.

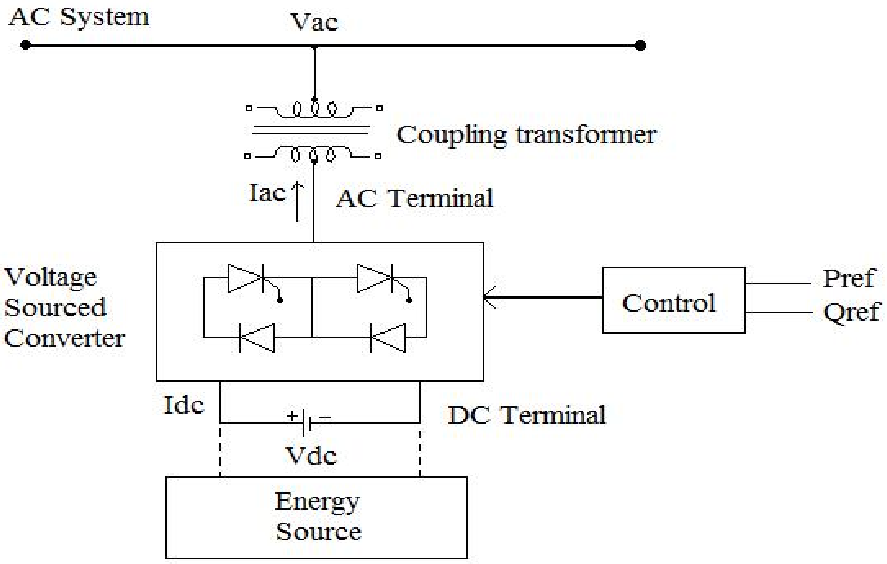

Figure2:Functional Block Diagram of STATCOM.

3.1. Problem with Proposed Optimization:

Multi-objective optimization, also known as multi-criteria or vector optimization, aims to find solutions that meet the acceptable criteria for multiple objectives as determined by the decision-maker. This process can be part of a decision support system to aid in making decisions. Various approaches have been used to tackle multi-objective problems, from aggregating objectives into a single goal to applying game theory for prioritization. Traditional methods usually provide a single optimal solution per run, whereas modern methods offer a range of trade-off options. In the 1960s, Rosenberg proposed using Genetic Algorithms (GAs) for these types of problems. Today, multi-objective genetic algorithms like NSGA-II are used for complex engineering optimizations. NSGA-II is known for its efficiency in distribution and operational tasks, though it has a time complexity of $O(rN^2)$ for generating a non-dominated set, which is still computationally demanding

4. Simulation Result

Simulation Model of Robust STATCOM Controller (Scenario 3)

Shows the control actions performed in the system. It can be observed that stability of the micro grid is not lost due to primary control action of the sources.

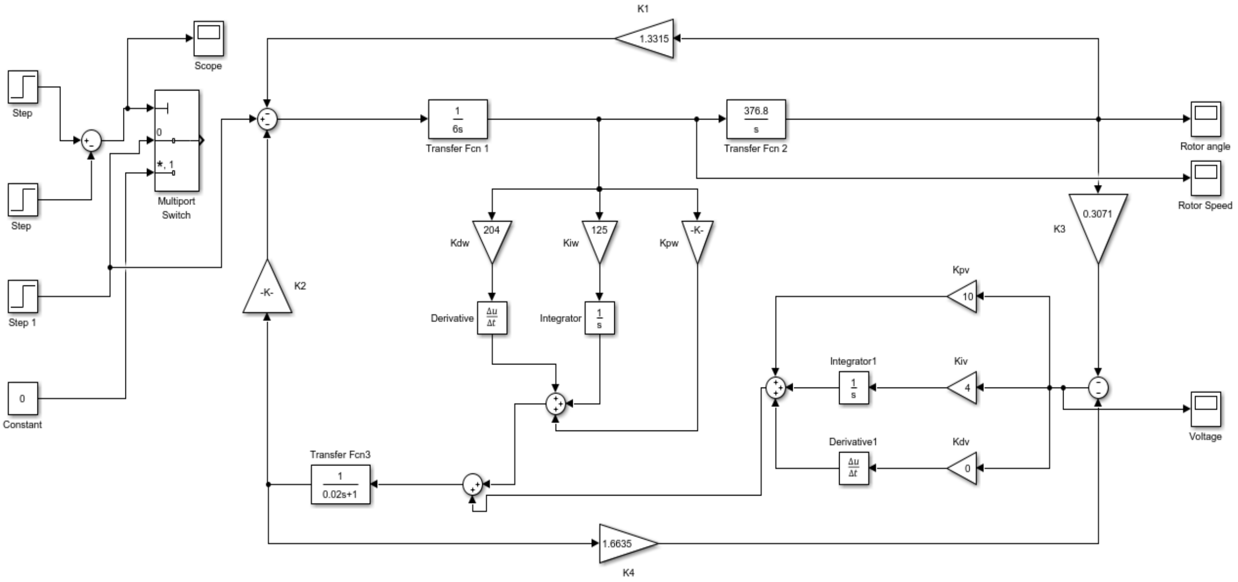

Figure 3 Simulation Model of Robust STATCOM Controller (Scenario 3)

Simulation Result of Scenario 3

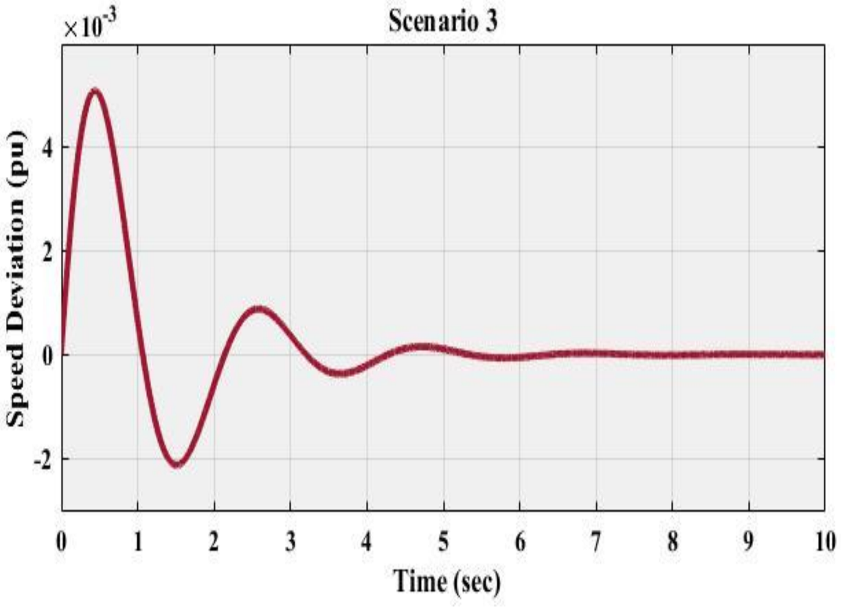

Figure 4 Simulation Result of Scenario 3(Speed deviation)

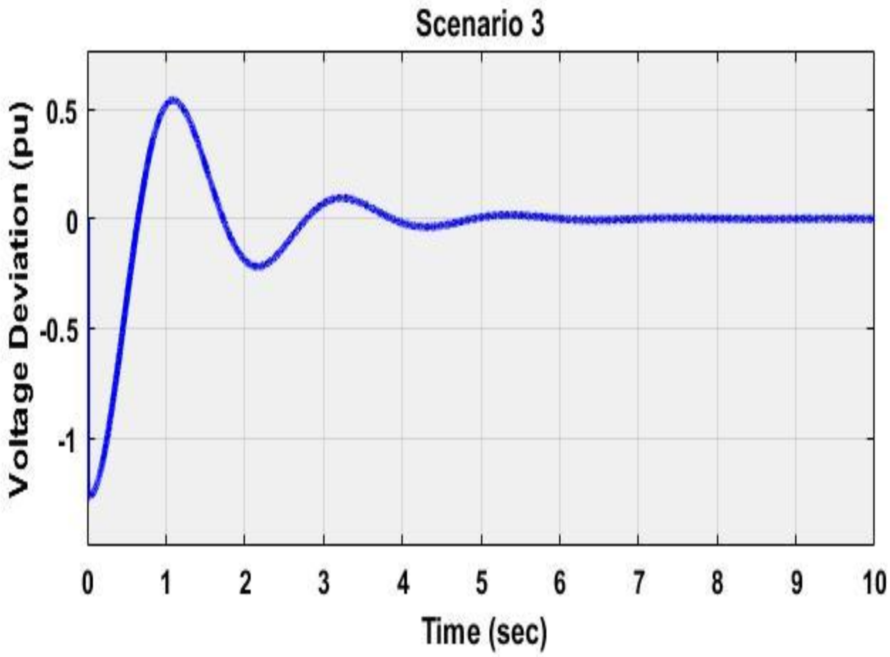

Figure 5. Simulation Result of Scenario 3(Voltage deviation)

Figure 5 clarifies the results related to the voltage magnitude deviations after applying disturbance for each scenario. In comparison with other designed controllers in different scenarios, the controller designed in S2 has better performance than others because both magnitudes of overshoot and oscillation are damped steadily. As seen, the proposed multi-objective problem has more effect on the voltage deviations damping.

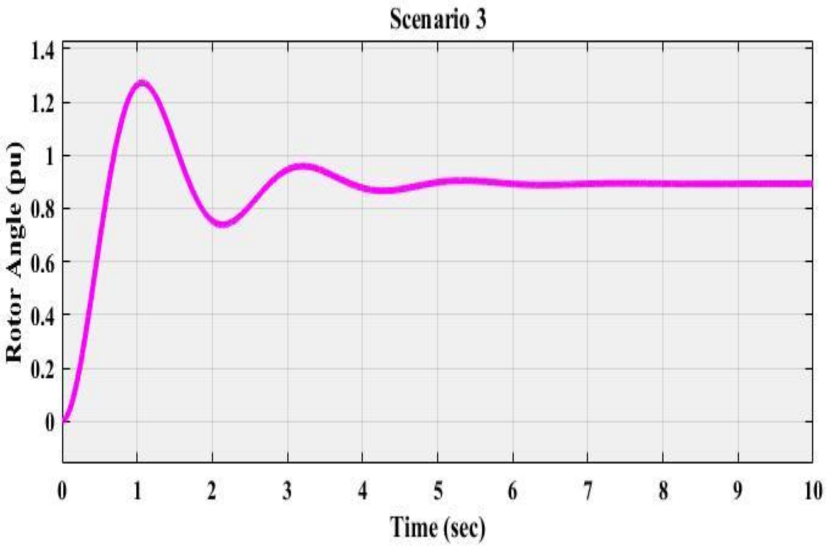

Figure 6. Simulation Result of Scenario 3(Rotor angle)

5. Conclusions

The results demonstrated a substantial improvement in system stability and damping with the robust STATCOM controller. The S2 controller particularly excelled in managing voltage magnitude deviations, while the S1 controller was effective in damping speed magnitude deviations. This robust design is highly effective under a range of operating conditions in power systems. Finally, we conclude

1.STATCOMs are primarily used for maintaining voltage levels within the desired range.

2.STATCOMs can operate over a wide range of voltages and frequencies, providing flexibility in various power system configurations and conditions.

In Micro grids, STATCOMs offer localized voltage control and reactive power compensation, which is critical for the stability and reliability of these smaller, self-contained power systems.

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