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Enhancement of Power System Performance with the Implementation of STATCOM Model

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ABSTRACT: This research introduces a hybrid-STATCOM in a three-phase power system and discusses its cost-effectiveness as a reactive power compensator for medium voltage applications. The system configuration of the hybrid-STATCOM will be examined, discussed, and compared to traditional STATCOM. In addition, a parameter design approach will be given that takes into account the reactive power compensation range. Finally, simulation results will be used to demonstrate the hybrid-STATCOM's large compensation range, low dc-link voltage characteristics, and good dynamic performance. For asymmetrical operation and performance optimisation, Hybrid STATCOM may be the perfect option. This system presented a hybrid STATCOM that may compensate as well as balance source current even with unbalanced loads and low voltage.

KEYWORDS: Hybrid-STATCOM, reactive power compensation, unbalanced loads

I. INTRODUCTION

Electrical energy is the most efficient and popular form of energy and the modern society is heavily dependent on the electric supply. The life cannot be imagined without the supply of electricity. At the same time the quality of the electric power supplied is also very important for the efficient functioning of the end user equipment. The term power quality became most prominent in the power sector and both the electric power supply company and the end users are concerned about it [1][2]. The quality of power delivered to the consumers depends on the voltage and frequency ranges of the power. If there is any deviation in the voltage and frequency of the electric power delivered from that of the standard values then the quality of power delivered is affected. Now-a-days with the advancement in technology there is a drastic improvement in the semi-conductor devices. With this development and advantages, the semi-conductor devices got a permanent place in the power sector helping to ease the control of overall system. Moreover, most of the loads are also semi-conductor based equipment. But the semi-conductor devices are non-linear in nature and draws non-linear current from the source. And also the semi-conductor devices are involved in power conversion, which is either AC to DC or from DC to AC. This power conversion contains lot of switching operations which may introduce discontinuity in the current [3]. Due to this discontinuity and non-linearity, harmonics are present which affect the quality of power delivered to the end user. In order to maintain the quality of power delivered, the harmonics should be filtered out [4] [5][6]. Thus, a device named Filter is used which serves this purpose. There are many filter topologies in the literature like- active, passive and hybrid. In this paper, the use of hybrid power filters for the improvement of electric power quality is studied and analyzed.

II. LITERATURE REVIEW

The Vasco Soares, Pedro Verdelho[12] proposed to evaluate its relative performance it is compared with the instantaneous active and reactive power - method under various mains voltage conditions and for different harmonic injection high-pass filters. Both methods are completely frequency independent, however under distorted mains voltages the proposed method presents a better harmonic compensation performance.

Thomas J. Dionise [13][14] presents the power quality measurements that were taken on the electrical distribution system to evaluate the performance of the SVC.

The authors [15][16] proposed the hybrid static synchronous compensator (hybrid-STATCOM) in a three-phase power transmission system that has a wide compensation range and low DC-link voltage. Because of these prominent characteristics, the system costs can be greatly reduced.

Juan Dixon [17] presents an overview of the state of the art in reactive power compensation technologies. The principles of operation, design characteristics and application examples of VAR compensators implemented with thyristors and self-commutated converters are presented static VAR generators to improve voltage regulation, stability, and power factor in ac transmission and distribution systems.

Hirofumi Akagi, Yoshihira Kanazawa [18] proposed instantaneous imaginary power was introduced on the same basis as the conventional instantaneous real power in three-phase circuits. The instantaneous reactive power was defined. The authors [19][20] proposed the harmonic cancellation in a multilevel STATCOM can be achieved through a decoupled and modular approach, using two types of power cells. Each set of cells can be controlled independently because the reactive power and the harmonic compensation present a decoupled behavior and describe the power quality measurements.

III. SYSTEM DESIGN

The three different loads are connected which is inductive light load, capacitive load and inductive high load respectively. When the loading inductive and light traditional STATCOM requires a high dc link voltage for compensation. The traditional STATCOM can compensate for both inductive and capacitive reactive currents with a high DC-link operating voltage due to a small coupling inductor. Due to its high DC-link voltage, the traditional STATCOM obtains the poor source current. MATLAB simulation model for three phase system of traditional STATCOM is shown in figure 1.

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A hybrid STATCOM is a power electronics-based device connected in 3-wire electric power systems in parallel with the equipment generating the power quality problems. Depending on design, a hybrid STATCOM is formed by a combination of STATCOM modules, switched compensation devices or thyristor switched compensation devices shown in figure 2.

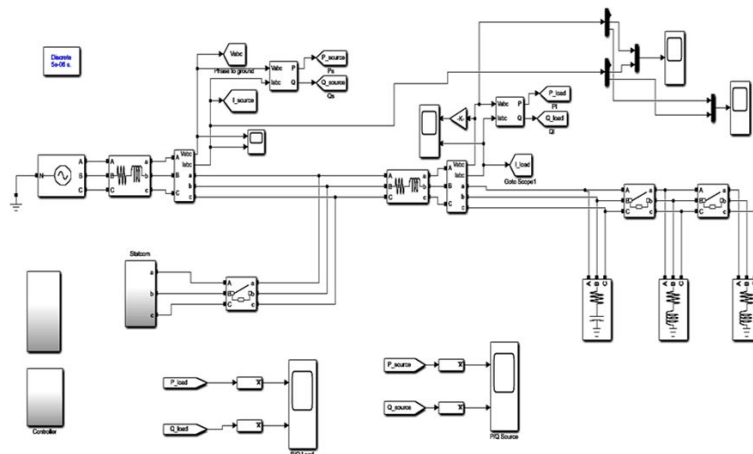


Fig. 1 Simulation model using MATLAB software

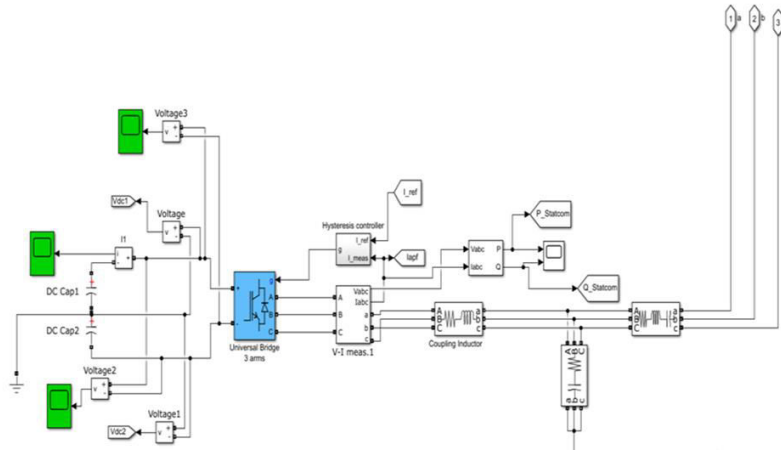


Fig. 2: Hybrid STATCOM

IV. PERFORMANCE ANALYSIS

In this chapter, the simulation results between traditional STATCOM and the proposed hybrid- STATCOM are discussed and compared. The previous discussions of the essential inverter for these three STATCOMs are also verified by simulations. The simulation studies are conducted out with MATLAB. When the loading is inductive and light, traditional STATCOM requires a high dc-link voltage for compensation. The Matlab simulation of traditional and hybrid STATCOM consist of voltage source of 600v then source resistance of 0.04 Ω and impedance of 0.02mH The MATLAB simulation of traditional STATCOM and hybrid STATCOM consist of three phase voltage source is connected to load. The three different loads are used.

- Capacitive loading
- Light Inductive loading
- High Inductive loading

The simulation results among traditional STATCOM and the proposed hybrid STATCOM are discussed and compared here.

Figure 3 and 4 shows the dynamic performance of traditional-STATCOM for different loadings compensation. In this system three load current consist of disturbance by using Hybrid STATCOM. The time is divided for three different zone light inductive (0.5 sec), capacitive (0.7 sec), and high inductive (0.9 sec).



Fig. 3: Dynamic compensation waveforms of load voltage

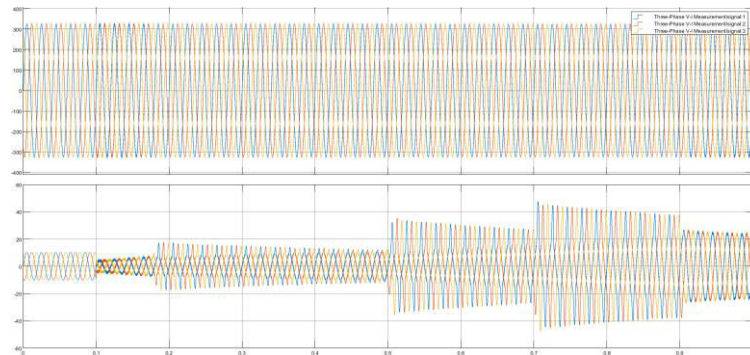


Fig. 4 Dynamic compensation waveforms of Source voltage

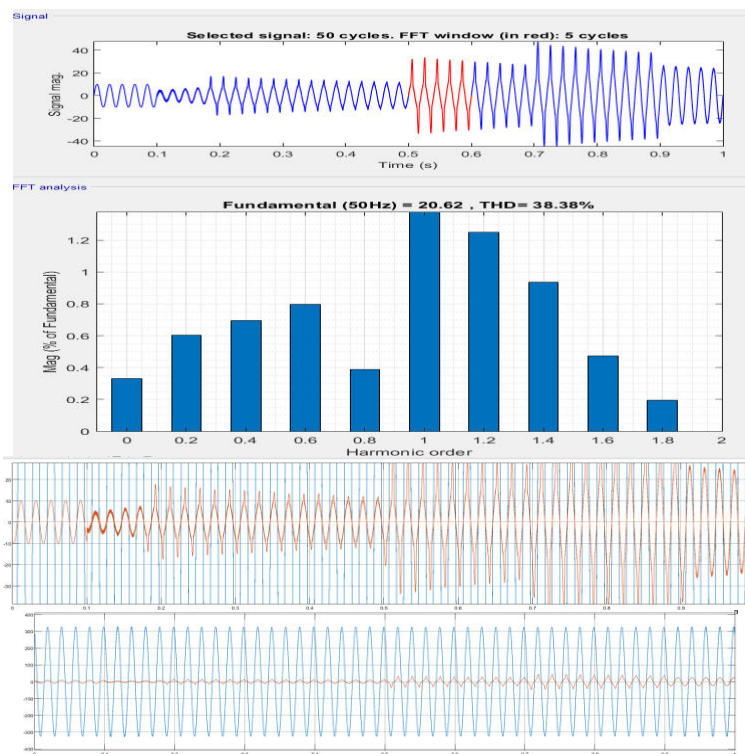


Fig. 5: Dynamic compensation waveforms by applying traditional STATCOM under different loadings cases

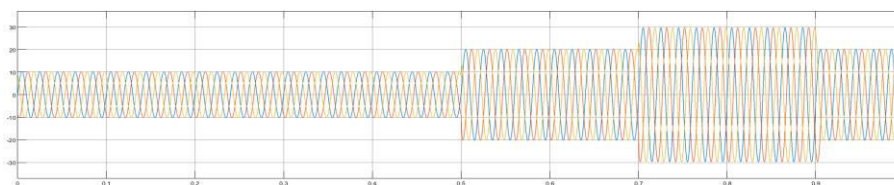


Fig. 6: Dynamic compensation waveforms of load voltage

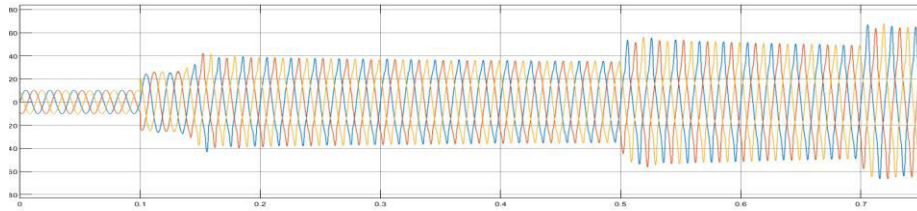


Fig. 7: Dynamic compensation waveforms of source current

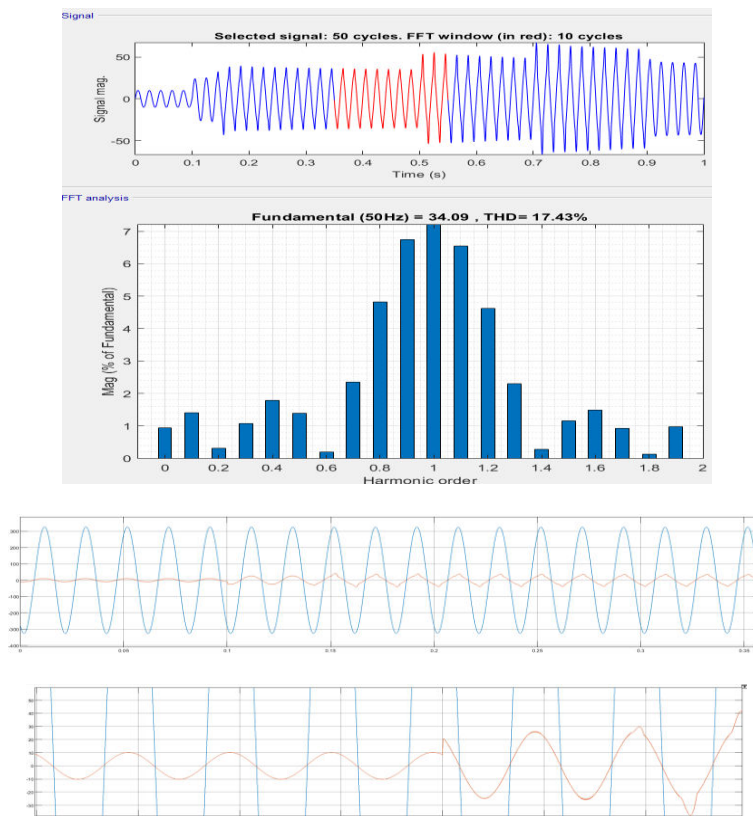


Fig. 8: Dynamic compensation waveforms by applying Hybrid STATCOM under different loadings cases

V. CONCLUSIONS

In this research, a hybrid STATCOM in a three-phase power system is proposed and described as cost-effective reactive power compensator especially medium voltage applications. The simulation of hybrid STATCOM for three distinct loads (low inductive, highly inductive, and capacitive) was conducted with MATLAB simulink. The simulation illustrates the notion of hybrid STATCOM. Its parameter design method is expected to take into account the reactive power compensation range while also preventing potential resonance problems. The traditional STATCOM employed the total harmonic distortion (THD) of 38.38% and hybrid STATCOM applied the total harmonic distortion (THD) of 17.39%.

Finally, the simulation results are presented with three different loading conditions, namely light inductive, capacitive, and strongly inductive. The hybrid STATCOM has a faster response time than other conventional reactive power compensators. Hybrid STATCOM achieves the best performance under both inductive and capacitive loads. The simulation results show that the hybrid-STATCOM has a large reactive power compensation range and good dynamic performance across a variety of voltage and current circumstances.

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