

# Reactive Power Compensation in Grid System using STATCOM with Closed Loop Control

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## Abstract

Grid is the interconnection of power injection and consumption. This grid suffers by deficient of reactive power and its quality of power supply. This quality is improved by injecting reactive power by a FACTS device, STATCOM. STATCOM is a reactive power controller device based on the requirement it will inject or absorbs reactive power from the grid. The performance of STATCOM is improved by closed loop control system. The power quality is measured by THD (Total Harmonic Distortion). Compared to open loop it improves power quality by minimizing THD, improving power factor and RMS voltage of the grid. The simulation is carried out using MATLAB software, various graphs and numerical results are presented to prove the ability of closed loop STATCOM in the grid connected power system.

**Keywords:** Closed Loop STATCOM, FACTS, Reactive Power Control, THD, Voltage Improvement

## 1. Introduction

Reactive power support is required to improve the stability of AC system by increasing the maximum active power that can be transmitted<sup>1-3</sup>. It is used to eliminate current harmonic components produced by large and fluctuating nonlinear industrial loads. The STATCOM is basically a converter which converts DC power into AC real and reactive power. This DC to AC voltage construction has various level of construction to replica AC sine wave form. Multi level construction of AC sine wave form gives better replica of sine wave form. For that 12 to 48 pulse converter are used. These converters need PWM pulse for the proper operation. Dynamic performance of STATCOM is better than the conventional reactive power support devices<sup>4-5</sup>. It does not have passive components such as capacitor or inductor instead it give reactive voltage into the power transmission line. By processing voltage wave form it circulates reactive power among the three phases and satisfies the demanded reactive power support<sup>7</sup>. If the injected power is in-phase or out-of-phase it exchange the real power and if the injected power is quadrature then the reactive power is exchanged between the transmission line and the STATCOM. Normally gate

turn OFF capability power switches are used for the construction of STATCOM. Hence IGBT or MOSFET or GTO are used for the construction of STATCOM<sup>6</sup>. The DC side of STATCOM has capacitor to store DC voltage and it should be capable of handling high power and frequent charge and discharge characteristic.

Anulekha Saha et al. (2012) investigates the enhancement in voltage stability margin as well as the improvement in the power transfer capability in a power system with the incorporation of fixed capacitors, Static Synchronous Compensator (STATCOM) and Static Var Compensator (SVC). A. Radha Krishnan and C. H. Kasi Rama Krishna Reddy (2013) explain the problems that are due to poor Power Quality in electrical systems and show the improvement of power quality. Flexible AC transmission systems or FACTS are devices which allow the flexible and dynamic control of power systems. Kapil Bodha and Aparna Chaturvedi (2013) presents the Reactive power compensation improves the voltage profile of the system using STATCOM. IEEE 14 bus and IEEE 30 bus systems with and without STATCOM and the results are then compared to show the effect of STATCOM on the system. Simulation is done using MATLAB.

The existing square wave inverter will be replaced

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with modified sine PWM or SVM inverter. The possibility of improving the power quality using grid system with STATCOM for closed loop system is explored.

## 2. STATCOM

The STATCOM is a FACTS device constructed using power electronic components. It is actually a Voltage-Source Converted (VSC). For the function of this VSC it has DC storage capacitor<sup>8</sup>. VSC converts this DC into AC voltage and injected into the transmission line. The main purpose of the STATCOM is to support reactive power requirement of the STATCOM seventh line transmission system<sup>12-13</sup> This reactive power support will adjust the voltage level and maintain the voltage at the desired value at the connected bus. When the bus voltage is less than the STATCOM terminal voltage reactive power is supplied by it. When STATCOM terminal voltage is greater than the bus voltage than it absorbs reactive power in the transmission line there by it maintains the voltage at the connected bus terminal<sup>9-10</sup>. STATCOM inject three phase reactive power into the transmission line to improve the voltage and it take reactive then it stored in DC capacitor when line has voltage swell<sup>11-12</sup>.

## 3. Results and Discussions

### 3.1 Without Compensation Circuit

The circuit model of grid system without controller is shown in Figure 1. The load voltage waveform of grid without compensation is shown in Figure 2. The reactive power waveform of grid without compensation is shown in Figure 3. The THD waveform of grid without compensation is shown in Figure 4.

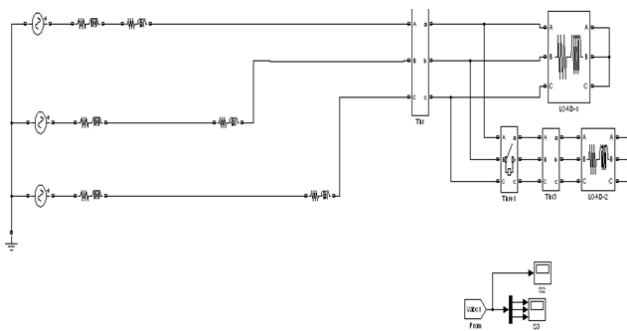


Figure 1. Circuit diagram of grid without compensation.

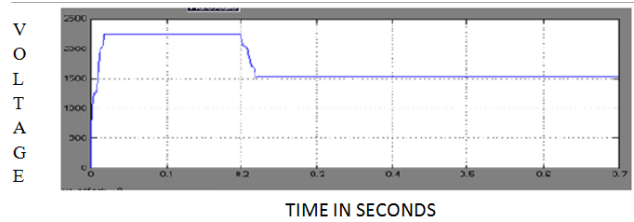


Figure 2. RMS load voltage waveform of grid without compensation.

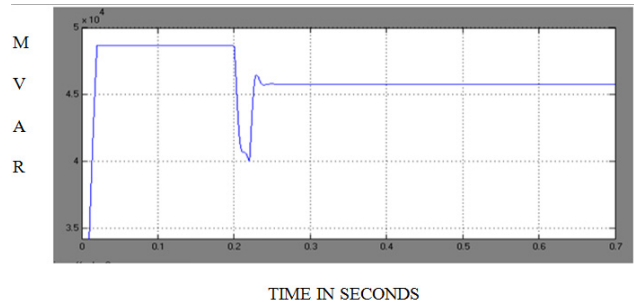


Figure 3. Reactive power waveform of grid without compensation.

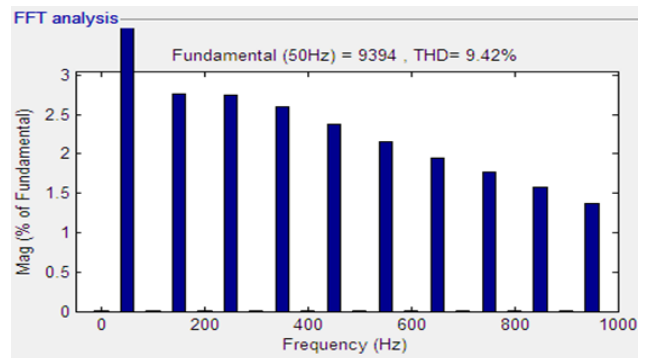
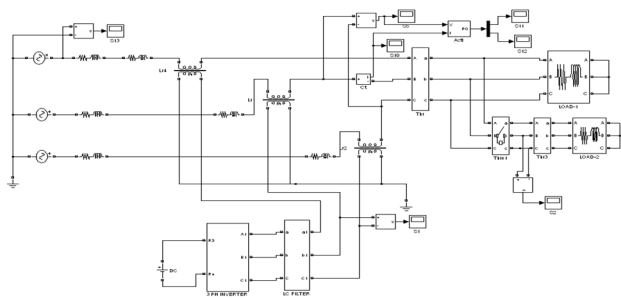


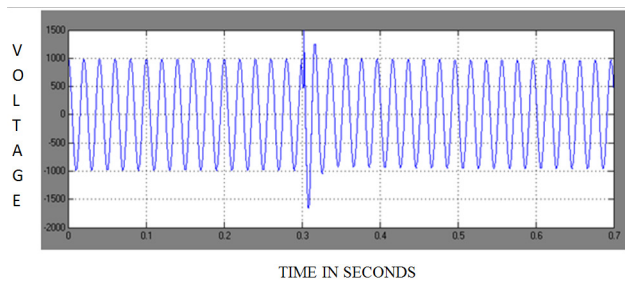
Figure 4. THD waveform of grid without compensation.

### 3.2. With Compensation Circuit Open Loop

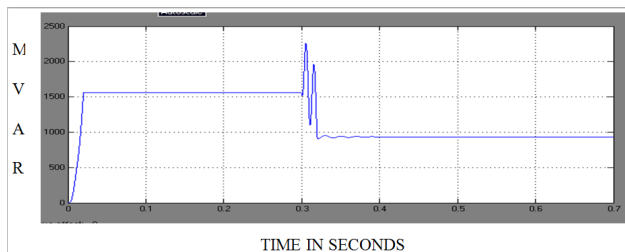
The circuit model of grid system with controller in open loop is shown in Figure 5. The load voltage waveform of grid without compensation is shown in Figure 6. The reactive power waveform of grid without compensation is shown in Figure 7. The THD waveform of grid without compensation is shown in Figure 8.



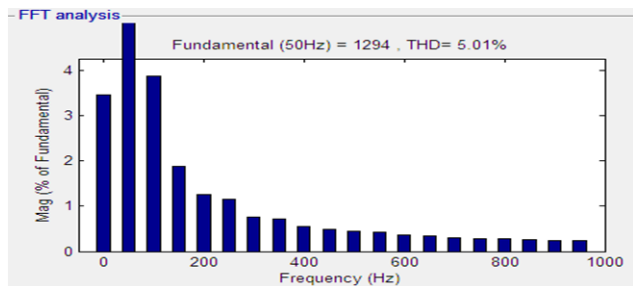
**Figure 5.** Circuit diagram of grid with compensation in open loop system.



**Figure 6.** Load voltage waveform of grid with compensation in open loop system.



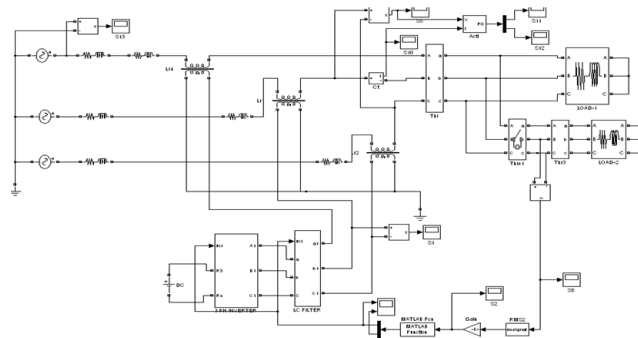
**Figure 7.** Reactive power waveform of grid with compensation in open loop system.



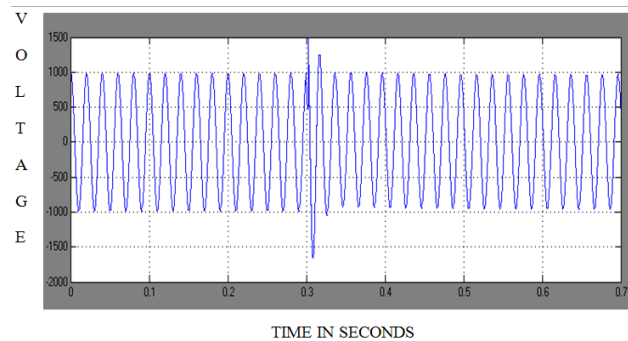
**Figure 8.** THD waveform of grid with compensation in open loop system.

### 3.3 With Compensation Circuit in Closed Loop System

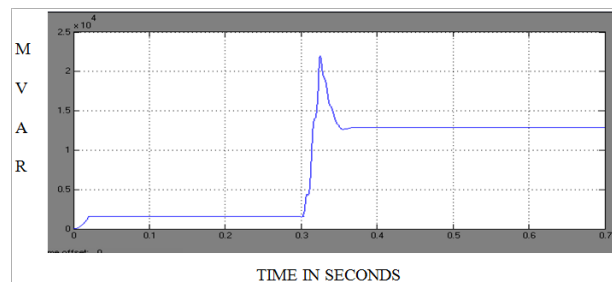
The circuit model of grid system with controller in closed loop is shown above Figure 9. The load voltage waveform of grid without compensation is shown in Figure 10. The reactive power waveform of grid without compensation is shown in Figure 11. The THD waveform of grid without compensation is shown in Figure 12.



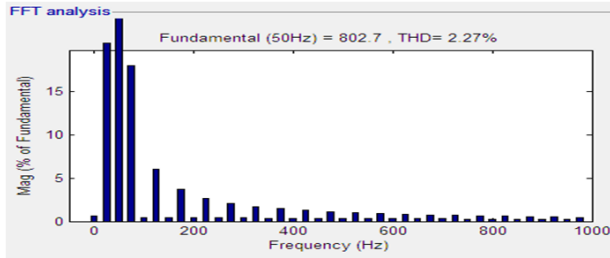
**Figure 9.** Circuit diagram of grid with compensation in closed loop system.



**Figure 10.** Load voltage waveform of grid with compensation in closed loop system.



**Figure 11.** Reactive power waveform of grid with compensation in closed loop system.



**Figure 12.** THD waveform of grid with compensation in closed loop system.

## 4. Conclusion

The performance of STATCOM is connected to a grid system has been designed and evaluated. It also describes the control strategy for reactive power, voltage, power factor and THD of the grid system using STATCOM. For the study of controllers, simulation using MATLAB and the hardware implementation of the controller were performed. The behaviour of STATCOM was analyzed in both open loop and closed loop control in grid system. STATCOM is connected in grid. After injecting STATCOM in grid the reactive power increased from 0.0242 to 0.0638. From the Table 1 it concludes that closed loop system of STATCOM shows 79.3% improvement than open loop system for the improvement of reactive power.

**Table 1.** Comparison of various parameters in grid with open and closed loop system

Parameters	Existing System	Proposed System	
		Open loop	Closed loop
VOLTGAE (RMS)(V)	2184	2272	2495
REACTIVE POWER(MVAR)	0.0201	0.0242	0.0638
POWER FACTOR	0.76	0.81	0.95
THD%	9.12%	5.01%	2.27%

## 5. References

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