Implementation of PI-controller based D-STATCOM for harmonics and reactive power compensation

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Abstract:
This paper presents the implementation of PI-controller based D-STATCOM for harmonics and reactive power compensation. Using the instantaneous active and reactive power theory for calculate the reference currents. The simulation results using MATLAB/Simulink and the experimental results with the prototype D-STATCOM have been implemented.

Keywords: *D-STATCOM; harmonics; reactive power compensation*

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1. Introduction

Nowadays, the power system distribution network is facing challenges with reactive and harmonic loading from nonlinear loads, caused some serious problem in power quality such as additional losses and heat which will decrease machinery efficiency and lifetime. Many researches in load compensation have been increased where the power electronics based compensator is considered as the most effective way to mitigate these problems (Akdag et al., 2001; Dixon et al., 2005).

This paper presents the implementation of PI-controller based D-STATCOM for harmonics and reactive power compensation. The control algorithm is based on the instantaneous active and reactive power theory, also called as "*p-q* Theory" (Agaki et al., 2007), to calculate reference currents. These components are regulated by decoupling controller via the three-leg PWM inverter. The simulation results using MATLAB/Simulink and the experimental results with the prototype D-STATCOM have been implemented.

1.1 D-STATCOM for harmonics and reactive power compensation

The configuration of the D-STATCOM for harmonics and reactive compensations is shown in Fig.1. This three-phase three-wire voltage source PWM inverter is connected in shunt to the distribution network through a limiting reactor or coupling transformer.

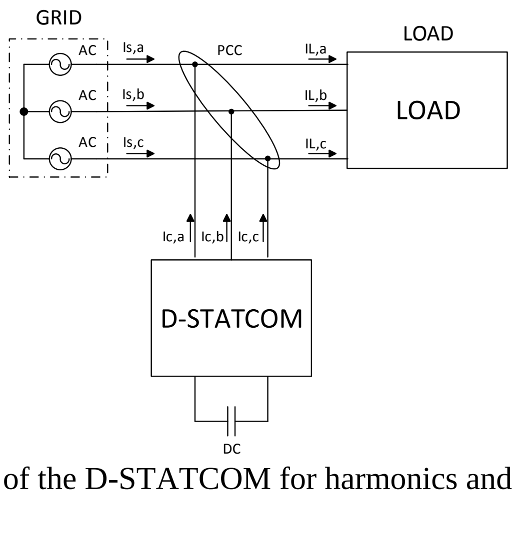


Fig.1 The configuration of the D-STATCOM for harmonics and reactive compensations.

1.2 Harmonic and reactive power calculation

In order to calculate reference currents, load currents and source voltages are detected and transformed to dq0 variables via synchronous reference frame, also known as "*d-q* Frame", then calculated for the instantaneous active and reactive power. All positive sequence fundamental quantities will appear as dc in *d-q* frame, and other harmonics will appear as ripples and there are no zero sequence component in three-phase, three-wired system. By using the low-pass filter to extract the fundamental component, the commanded current for reactive power compensation will appear only in *q*-axis where the commanded current for harmonics compensation will be in both *d*- and *q*-axes as shown in Fig. 2. The $\hat{\theta}$ is the estimate value of utility voltage angle from the phase-locked loop (PLL).

1.3 DC-Bus voltage controller

The DC-bus voltage is expected to be a constant in steady state, then a proportional integral (PI) controller can be used for regulate the DC-bus voltage.

1.4 Decoupling Controller

The commanded currents are decoupled and regulated by the proportional integral (PI) controller with feedforward utility voltage (Akdag et al., 2001). The compensator voltages are generated by means of pulsewidth modulation.

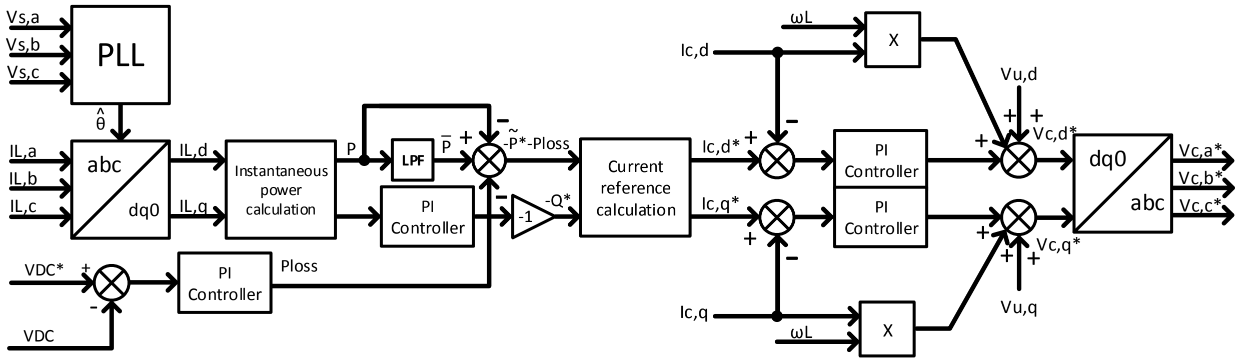


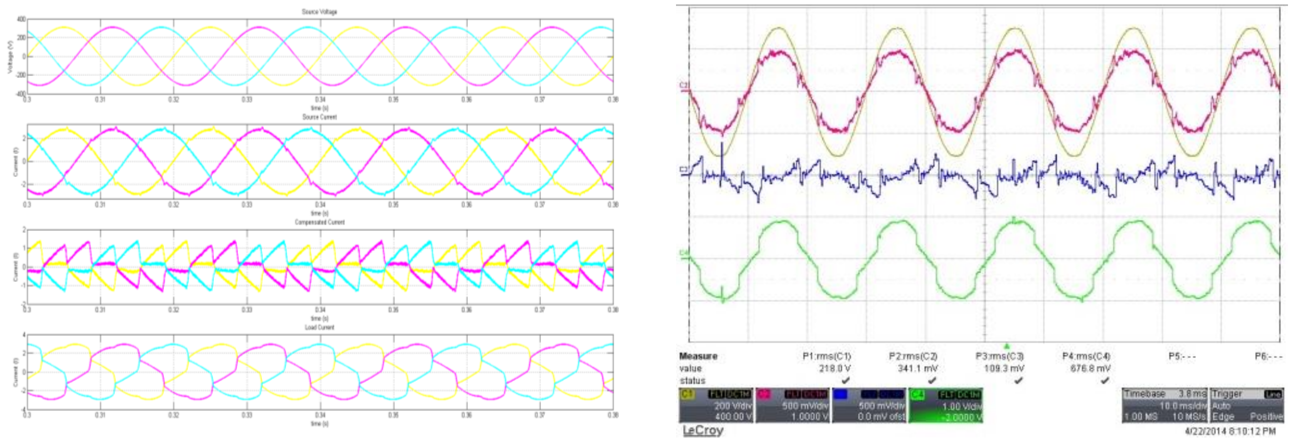
Fig. 2 The overall calculation block diagram of three-phase, three-wired D-STATCOM.

2. Experimental setup and result

The parameters of the prototype D-STATCOM is shown in Table 1. The system is simulated in MATLAB/ Simulink by using SimPowerSystems blockset where the controller for the experiment will be applied with the dSPACE-1104-based software. The inverter switching frequency of the inverter is set as 10 kHz with 2-μs dead time. Simulation and experimentation have been conducted for balanced nonlinear loads. A three-phase diode bridge feeding an inductive load parallel with a highly inductive load is considered. Fig. 3 shows the performance of the system with D-STATCOM in the simulation and experimental results. Fig. 3(a) shows source voltage, source current, compensating current and load current, respectively. Fig. 3 (b) shows source voltage in yellow color and source current in red color, compensating current and load current, respectively. The source-side power factor has been improved from 0.936 to 0.997 where the current total harmonic distortion is reduced from 15.2 % to 3 %.

Table 1 Parameters of the prototype D-STATCOM

Line-to-line voltage	50 V, 50Hz	Sampling time	10 μs
Current controller	PI controller	Model of dSPACE	dS-1104
dc-bus capacitor	2200 μF	Load type	balanced nonlinear loads
Shunt inductor	5 mH		



(a) Simulation results (b) Experimental results

Fig. 3 The performance of the system with D-STATCOM.

3. Conclusion

This paper presents an implementation of PI-controller based D-STATCOM for harmonics and reactive power compensation. The control algorithm is based on the instantaneous active and reactive power theory and decoupled control of *d*- and *q*-axes currents. The simulation and experimental results confirm the better performance of the system.

4. References

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