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A NOVEL APPROACH ON INSTANTANEOUS POWER CONTROL OF D-STATCOM WITH CONSIDERATION OF POWER FACTOR CORRECTION

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ABSTRACT

This paper presents a modified instantaneous power control scheme of D-STATCOM for power factor and harmonic compensation. The proposed control strategy has been introduced in order to enhance some steady-state performances besides its functional elimination of power quality disturbance. Power factor and harmonic current of a controlled feeder section are two vital roles in steady-state power distribution system operation. Utilizing an already installed D-STATCOM to achieve these additional control objectives can help system operators maximize overall system performances. In this paper, a control scheme with constant power and sinusoidal current compensation is exploited. In order to correct the power factor, a power factor control loop is required and therefore included in the control block. To verify its use, a 22kv power distribution feeder. With a three-phase rectifier load was tested. Results showed that integration of the proposed reactive power control loop can correct the power factor the controlled feeder to be unity power factor.

KEYWORDS: D-STATCOM, System Operators, Power Systems

INTRODUCTION

Electric power distribution network have become more increasingly important and plays an essential role in power system planning. This type of power system has a major function to serve distributed customer loads along a feeder line. Therefore under competitive environment of electricity market service of electric energy transfer must not be interrupted and at the same time there must provide reliable, stable and high quality of electric power. Such devices are one of capacitor bank, shunt reactor, series reactors, automatic voltage regulators and/or recently developed dynamic voltage restorers, distribution static compensator (D-STATCOM). Or combination is a voltage source converter (VSC) based custom power technology which can perform as a reactive power source in power systems. The d- statcom can regulate magnitude of voltage at a particular AC bus. At the point where it is connected, via generating or absorbing reactive power from the system. The distribution variations, e.g. voltage sags or swells.

DESCRIPTION OF D-STATCOM OPERATION

A d- statcom is a shunt device that regulates the system voltage by absorbing or generating reactive power at a point of coupling connection. The schematic diagram of a D- statcom. The d- statcom is a solid state DC/AC power switching converter that consists mainly of a three-phase PWM voltage source converter (VSC) bridge having six IGBTs with associated anti-parallel diodes. It is connected to the distribution network via the impedance of the coupling transformer. A DC-link capacitor provides constant DC link voltage. The output voltage of the D-STATCOM is generated by a DC/AC voltage source converter operated from an energy storage capacitor. From the DC input voltage. Provided by a charged capacitor.

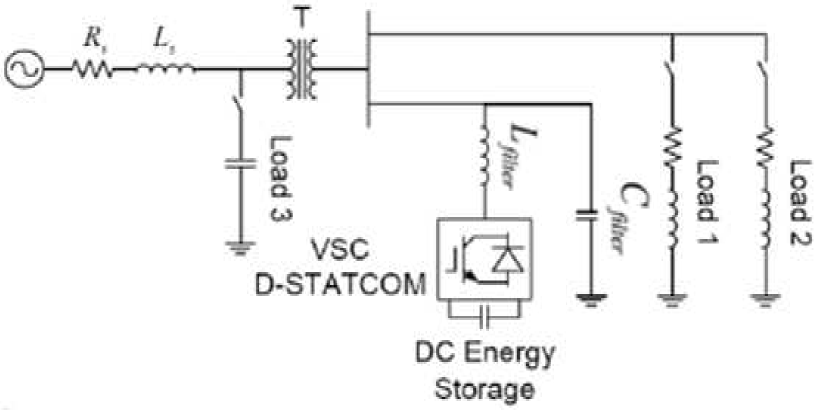

Figure 1: Simplified Power System Equipped with D-STATCOM

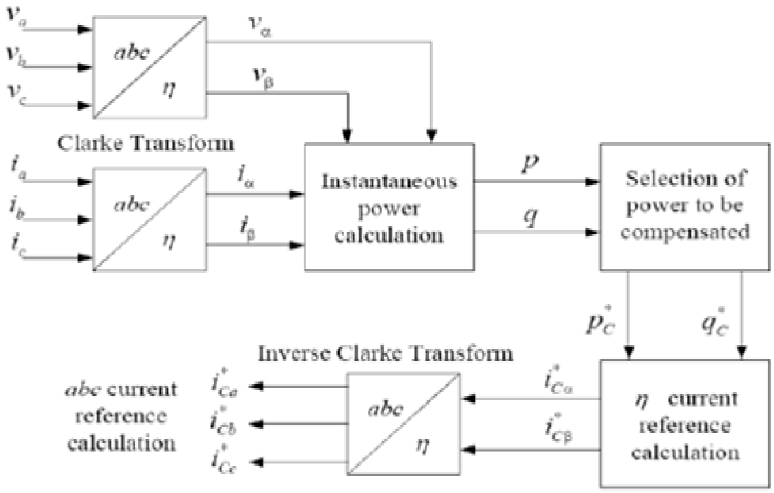

Figure 2: Current Compensation Based on Instantaneous Power Theory

$$\begin{pmatrix} v_o \\ v_\alpha \\ v_\beta \end{pmatrix} = \sqrt{2/3}\begin{pmatrix} 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \\ 1 & -1/\sqrt{2} & -1/\sqrt{2} \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{pmatrix}\begin{pmatrix} v_a \\ v_b \\ v_c \end{pmatrix} \quad (1)$$

$$\begin{pmatrix} i^*_{c\alpha} \\ i^*_{c\beta} \end{pmatrix} = \frac{1}{v^2_\alpha + v^2_\beta}\begin{pmatrix} v_\alpha & -v_\beta \\ v_\beta & v_\alpha \end{pmatrix}\begin{pmatrix} \bar{P} + \bar{P}_{loss} \\ -q \end{pmatrix}$$

$$P = \bar{P} + \tilde{P}$$

$$\begin{pmatrix} i_o \\ i_\alpha \\ i_\beta \end{pmatrix} = \sqrt{2/3}\begin{pmatrix} 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \\ 1 & -1/\sqrt{2} & -1/\sqrt{2} \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{pmatrix}\begin{pmatrix} i_a \\ i_b \\ i_c \end{pmatrix} \quad (2)$$

MATLAB MODEL

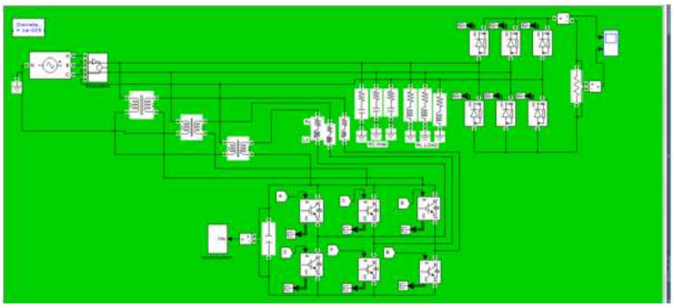

Figure 3: MATLAB Simulation Model of 22kv Power Distribution Feeder with 3 Phase Rectifier Loading

SIMULATION RESULTS

To verify the use of the proposed control scheme in order to correct power and compensate harmonic current, a 22kv power distribution feeder with three-phase rectifier loading in figure. Table gives information of the test system and D-STATCOM. The test was divided into two cases. The first case was used the control scheme introduced by (1). Whereas, the second case was the proposed control scheme given in this paper. Both test cases was assigned to be operated with the same instructions.

Case 1: With the control strategy proposed by the system response without D-STATCOM in the time interval "t=0.5"in figure 1. And at t=0.5 s, the D-STATCOM was connected to compensate the non-linear load as responses in next figure 2. It can be seen that the source current was shaped to be nearly sinusoidal. However, due to the PWM operation of the D-STATCOM, higher-order harmonic components were inevitably. At t=0.5s when the RL load switched, the source current was lagged the voltage at the point of coupling connection by 21.6 degree corresponding to 0.9298 power factor lagging in figure 3.

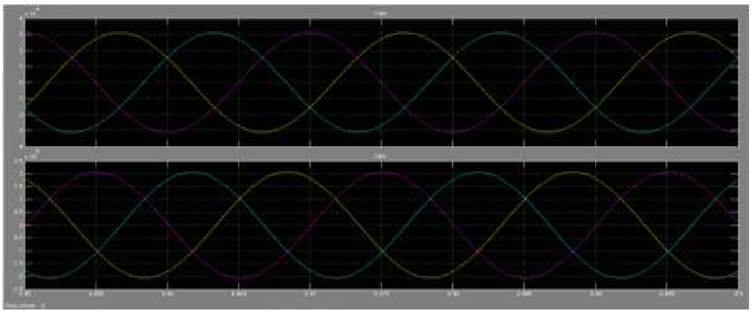

Figure 4: Simulation Results of 3 Phase Source Side VI Measurment Scope

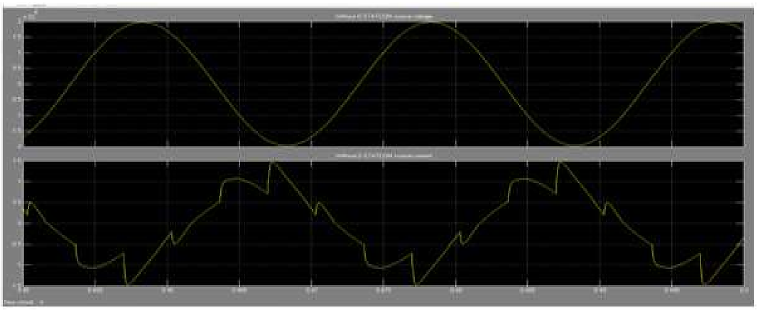

Figure 5: Simulation Results of Source Side VI Measurements without D-STATCOM

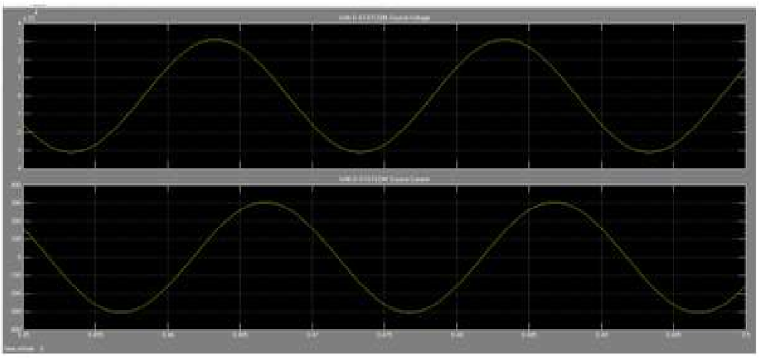

Figure 6: Simulation Results of Source Side VI Measurements with D-STATCOM

Case 2: With the control strategy proposed in this paper, the system response without D-STATCOM in the time interval "t=0.5 s" was shown in figure 1, and, at t=0.5s, the D-STATCOM was connected to compensate the non-linear load as responses in next figure 2. It can be seen that the source current was shaped to be nearly sinusoidal. However, due to the PWM operation of the D-STATCOM, higher order harmonic components were inevitably. At t>5s when the RL load switched, the source current that previously lagged the voltage at the point of coupling connection in case 1, was resumed to in-phase with the voltage waveform. This described the success of power factor correction by the reactive power control scheme made in this paper.

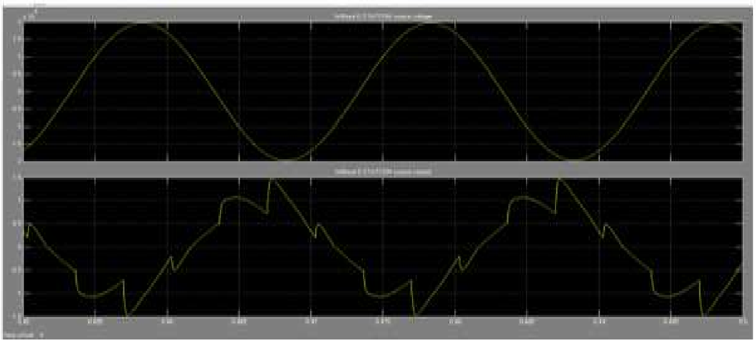

Figure 7: Simulation Results of Source Side VI Measurments without D-Statcom

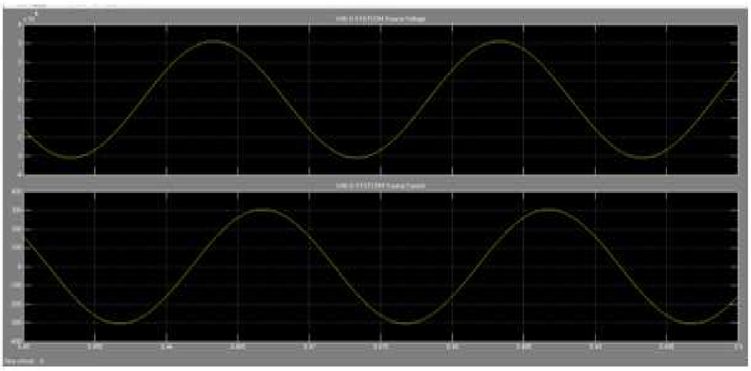

Figure 8: Simulation Results of Source Side VI Measurments with D-Statcom

STATCOM FEATURES

- A compact size.

- System voltage support and stabilization by smooth control over a wide range of operating conditions.
- Dynamic response following system contingencies.
- High reliability with redundant parallel converter design and modular construction.
- Flexibility of future reconfiguration to BTB (back to back) power transmission or UPFC (unified power flow controller) and other configuration.

CONCLUSIONS

This paper presents a modified control scheme to compensate a distribution feeder loading with non-linear loads. The compensation consists of three main objectives that are.

- Regulation of real powers delivering to loads.
- Regulation of DC link voltage to ensure PWM converter operation
- Correction of power factor

Modification of the control scheme made in this paper is to add the reactive power regulation into the control loop. With zero reactive power reference, unity power factor can be achieved. As a result, the modified control scheme can regulate DC link voltage and real power delivery at specified level while reactive power drawn from the load was cancelled by that injected from D-STATCOM.

REFERENCES

1. H. Akagi, instantaneous power theory and Applications to power conditioning, New Jersey, USA; Wiley, 2007.
2. J. A. Momoh, Electric power distribution, Automation, protection and control, New York, USA: CRC press, 2008.
3. N.G. Hingorani and L. GyuGyi, Understanding FACTS concept and technology of flexible AC transmission system, New York, USA.: IEEE press, 2000.
4. N.G. Hingorani," introducing custom power." IEEE spectrum, June 1995, pp. 41-48.
5. A.Ghosh and G. Ledwich, power quality enhancement using custom power devices, Massachusetts, USA.: Kluwer Academic publishers,2002.
6. A.L. Olmipo and E. Acha, Modeling and analysis of custom power systems by PSCAD/EMTDC," IEEE transmission power delivery, vol.17, no.1, pp.266-272, jan.2002.
7. P. Pohjanheimo and E. Lakervi, "Steady state modeling of custom power components in power distribution network," in IEEE power Engineering society winter meeting, vol.4, jan.2000.pp.2949-2954.
8. A. Adya, "Application of D-STATCOM for isolated systems". IEEE Region 10 Conference (TENCOM), vol.3, Nov.2004.pp. 351-354.
9. K. Somsai and T. Kulworawanichpong, Modeling, simulation and control of D-STATCOM using ATP/EMTP," In Harmonics and quality of power, 2008. ICHQP 2008. 13th International Conference on. pp. 1