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Operation and Control of an Improved Performance Interactive DSTATCOM

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Abstract: In modern power system, the switching devices are generally used in combination with unbalanced reactive loads which produces current related Power Quality (PQ) problems by making source currents distorted and unbalanced. Usually a STATCOM is installed to support electricity networks that have a poor power factor and often poor voltage regulation. A Distribution Static Compensator (DSTATCOM) operating in Current Control Mode (CCM) is used to mitigate current related PQ problems. The main objective is to improve the performance of interactive distribution static compensator for address limitations of conventional Current Control Mode (CCM) and Voltage Control Mode (VCM) operations. In CCM operation, the DSTATCOM supplies reactive and harmonic component of load currents to make source currents balanced, sinusoidal, and in-phase with respective phase load voltages In the previous research, the compensator with three single-phase H-bridge Voltage Source Inverters (VSIs), driven by a single DC storage capacitor was used and passive filter capacitor is also used to provide the path for high frequency components for current. Thus the operation and control of the improved performance interactive DSTATCOM is proposed for the continuous and stable load operation. Using the control algorithm, the range of source voltage within which a DSTATCOM should operate in CCM is computed. The advantage of the proposed is that the algorithm depends upon the supply voltage, maximum and minimum feeder impedance and load current. Outside this range, operational mode of DSTATCOM is transferred to VCM. Losses in feeder and VSI are reduced which improves efficiency of the system. The proposed method is implemented in MATLAB/Simulink and shows that the performance is improved with reduced loss, cost, and power rating VSI as compared to the conventional CCM and VCM DSTATCOM operation.

Keywords: Voltage Control Mode, Current Control Mode, Power Factor.

I. INTRODUCTION

Switching devices in combination with unbalanced reactive loads produce current related power quality (PQ) problems by making source currents distorted and unbalanced.A distribution static compensator (DSTATCOM) operating in current control mode (CCM) is used to mitigate current related PQ problems. In CCM operation, the DSTATCOM supplies reactive and harmonic component of load currents to make source currents balanced, sinusoidal, and in-phase with respective phase load voltages. Generally, faults in power system and energization of larger loads create voltage disturbances like sag and swell. Also, integration of intermittent distributed generation causes voltage fluctuations in the distribution system. These voltage disturbances significantly affect the power transfer from the source to load and degrade the performance of sensitive loads. However, conventional CCM operation of DSTATCOM cannot improve the load voltage. This is major limitation of CCM operation of DSTATCOM which considerably restricts its utilization. A DSTATCOM, when operated in voltage control mode (VCM), is one of the most effective device used for load voltage regulation. In VCM operation, the DSTATCOM regulates load voltage at a constant reference value by supplying appropriate fundamental reactive current into the source.

Therefore, VCM operation of DSTATCOM provides stable and continuous operation of the load. However, conventional VCM operation of DSTATCOM maintains an arbitrary chosen voltage of 1.0 p.u. at the load terminal. For this voltage at load terminal, source exchanges reactive power even at normal operating conditions this continuous reactive power exchange results in more reactive current flow in the voltage source inverter (VSI) as well as feeder. Consequently, losses in the VSI and feeder increase. Therefore, VCM operation of DSTATCOM is not required during normal supply conditions. Aforementioned analysis brings the fact that the conventional CCM and VCM operations of DSTATCOM are not required during voltage disturbances and normal disturbances, respectively. This greatly limits utilization of the DSTATCOM. Moreover, recent advancements in device topologies and control algorithms have encouraged customers to look for devices which can provide various operational characteristics with less number of components, reduced cost, weight, and space This paper proposes operation and control of an improved performance interactive DSTATCOM for continuous and stable load operation while addressing aforementioned issues. In this work, a control algorithm is proposed to compute range of source voltage within which a DSTATCOM should operate in CCM is shown in Fig1. This algorithm depends upon the supply voltage, maximum and minimum feeder impedance, and load current. Outside this range, operational mode of DSTATCOM is transferred to VCM. This interactive DSTATCOM pro- vides several operational features which are not possible in conventional DSTATCOM operation i.e., 1) Advantages of CCM during normal supply conditions, 2) Advantages of VCM during voltage disturbances, 3) Unlike conventional VCM, no reactive power exchanges with the supply during normal supply conditions, 4) Reduced losses in VSI and feeder compared to conventional VCM, and 5) Requires reduced rating VSI for sag mitigation compared to conventional VCM.

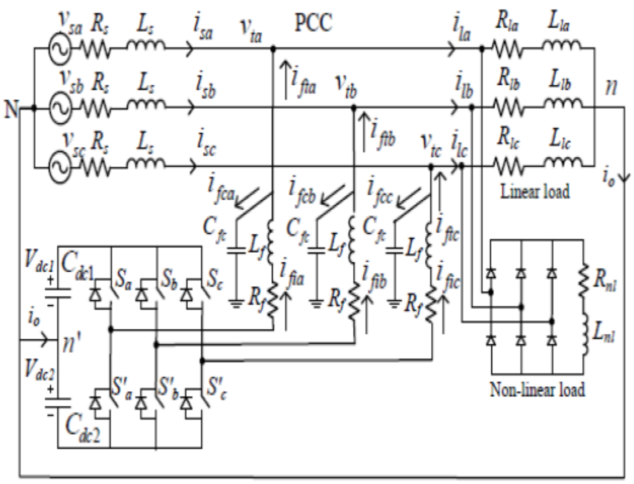

Fig.1.Three phase circuit of DSTATCOM in a distribution system.

II. CONTROLLER DESIGN IN CCM AND VCM

The DSTATCOM remains operational without taking any real power from the source. However, dc link voltage decreases continuously due to the losses in the inverter. Therefore, a control loop is required to maintain the capacitor voltage at a reference value by compensating its losses. It is achieved by taking small real power from the source. The capacitor voltage control in CCM and VCM is achieved as following.

A. Control of DC Link Voltage in CCM

Let the total losses in the VSI be represented by PLOSS. These losses must be supplied by the source for keeping dc link voltage constant. These are computed using a proportional-integral (PI) controller at positive zero crossing of phase-a voltage. It helps in maintaining the dc link voltage ($V_{DC1}+V_{DC2}$) at a predefined reference value ($2v_{dcref}$) by drawing a set of balanced currents from the source and is given as

$$P_{loss} = K_{pc}e_{vdc} + K_{ic}\int e_{vdc}\,dt \quad (1)$$

Are proportional gain, integral gain, and voltage error of the PI controller, respectively.

B. Control of DC Link Voltage in VCM

Average real power at the PCC (Ppcc) is sum of average load power (Plavg) and VSI losses (Ploss). The power, Ppcc, is taken from the source depending upon the angle between source and load voltages i.e., load angle _. The VSI losses are compensated by taking small real power, Ploss, from the source. If capacitor voltage is regulated to a reference value, then in steady state condition Ploss is a constant value and forms a fraction of Ppcc. Thus, δ is also a constant value. Once operation mode of DSTATCOM is transferred to VCM, dc link voltage is regulated by generating a suitable value of δ The total dc link voltage (vdc1 + vdc2) is compared with a reference voltage and error is passed through a PI controller. Output of the PI controller, δ, is given as

$$\delta = K_{pv}e_{vdc} + K_{iv}\int e_{vdc}\,dt \quad (2)$$

where Kpv and Kiv are proportional and integral gains of the PI controller, respectively. For stable operation, the value of δ must lie from 0 to 90 degree. Consequently, controller gains are quite small and are chosen carefully.

III. PROPOSED SCHEMES

AC source block and linear load block are the main power transmission areas. Statcom Switches which convert DC current to AC current is connected to the power line is shown in Fig2. The conversion of AC to DC is performed by PWM pluses which are given by the controller. Generally, loads perform satisfactorily within the 10%range of the nominal voltage (i.e., 0.9 to 1.1 p.u.), are also called normal operating conditions.

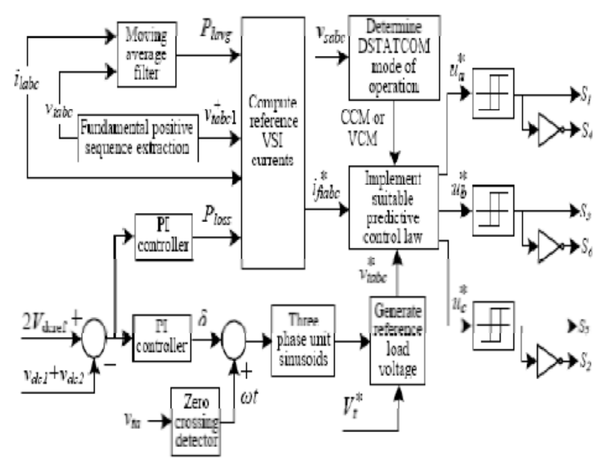

Fig2. Control block diagram of interactive DSTATCOM.

In these conditions, current related PQ problems are of the main concern. Therefore, the DSTATCOM is operated in CCM for load harmonic and reactive current compensation. It results in balanced and sinusoidal source currents with unity power factor at the PCC. However, the load voltage can change at any time due to voltage disturbances. This will result in performance deterioration of the sensitive loads making CCM operation of DSTATCOM redundant. In this case, DSTATCOM must switch to VCM from CCM to protect sensitive loads from these unwanted variations in voltage by maintaining a constant voltage at the load terminal. In this section, a control algorithm for flexible mode transfer between CCM to VCM and vice versa has been presented. Several schemes have been presented to estimate source voltage for different applications like grid connected inverters, rectifier operation, motor drive application, renewable energy applications, power quality control, etc.

The source voltage measurement schemes used in above applications are equally applicable for DSTATCOM application as well. Therefore, it is assumed that the measurement of source voltage is available. Based on, a source voltage range is derived for CCM operation of the DSTATCOM. Any voltage deviation from this range is an indication of the voltage disturbance and the DSTATCOM mode will be transferred to VCM load voltage is 0.9748 p.u, for a source voltage of 1.0 p.u, under the worst normal operating conditions the voltage sag refers to reduction in load voltage from 0.9 to 0.1 p.u. of nominal value for half cycle to one minute It means that if Vs is 0.9232 p.u. then PCC will experience sag. Thus, it is possible to set limit for sag occurrence as Vs = 0.9232 p.u. and is denoted as lower limit. A swell is defined as increase in terminal voltage from 1.1 to 1.8 p.u, From nominal voltage for half cycle to one minute from, Vs = 1.1 p.u. will produce a swell at PCC at worst normal operating condition and is denoted by upper limit. Thus, it can be concluded that:

- If Vs is less than 0.9232 p.u and greater than 1.1 p.u. then the DSTATCOM can operate in VCM to regulate load voltage.
- If source voltage lies between 0.9232 to 1.1 p.u then the DSTATCOM can operate in CCM.

IV. EXPERIMENTAL RESULTS

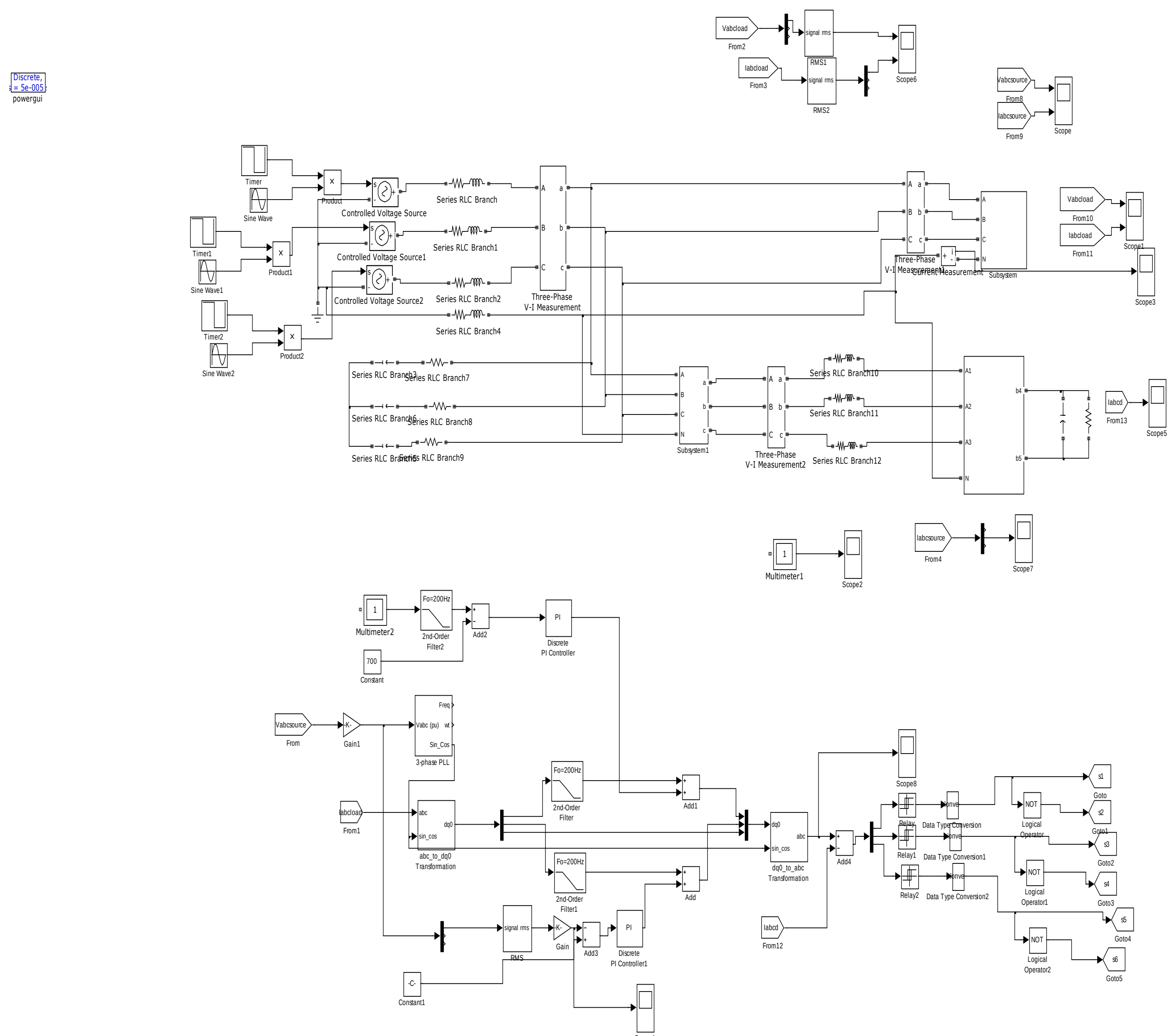

Fig3. Simulink Model.

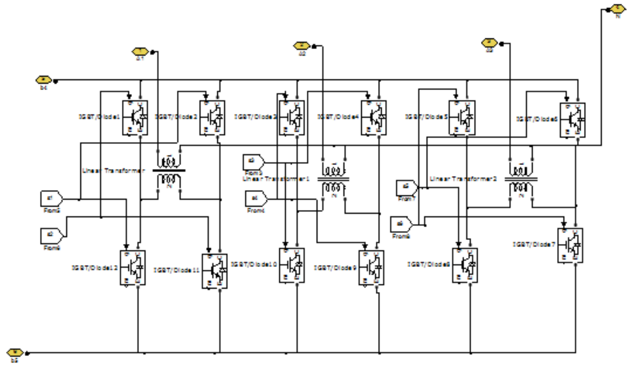

Fig4. Converter Implementation.

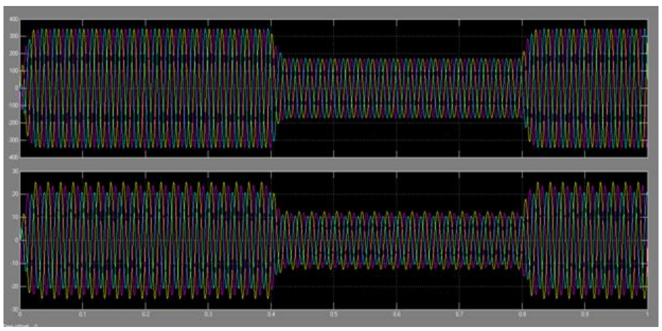

Fig5. Source Voltage & Current.

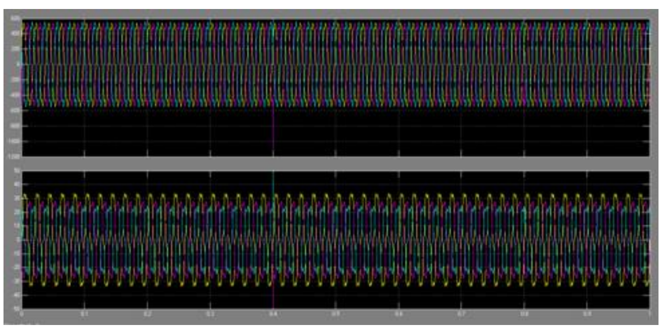

Fig6. Load Voltage & Current.

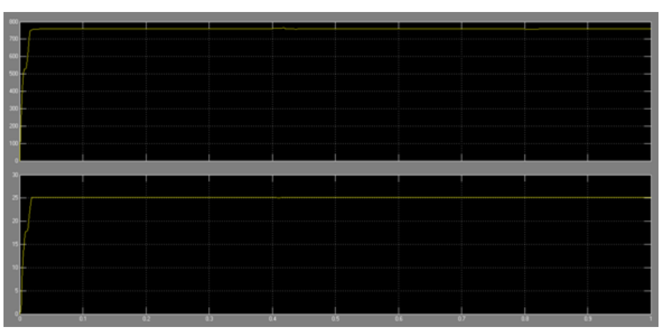

Fig7. RMS of Load Voltage & Current.

V. CONCLUSION

Operation and control of an improved performance interactive DSTATCOM has been proposed in this paper. The simple control algorithm proposed here, defines a range of supply voltage for which DSTATCOM operates in CCM to mitigate current related PQ problems. During voltage disturbances, operational mode of the DSTATCOM is transferred into VCM from CCM to protect the sensitive loads. The scheme ensures continuous operation of the load. Moreover, losses in feeder and VSI are reduced which improves efficiency of the system. Additionally, these advantages are achieved using a reduced power rating VSI. Therefore, the proposed interactive DSTATCOM has improved performance with reduced loss, cost, and power rating VSI as compared to the conventional CCM and VCM DSTATCOM operation. The simulation and experimental results confirm the effectiveness of the proposed is achieved during the mode change over.

VI. REFERENCES

[1] Chandan Kumar, Student Member, IEEE, and Mahesh K. Mishra, Senior Member, IEEE, "Operation and Control of an Improved Performance Interactive DSTATCOM", IEEE Transactions on Industrial Electronics.

[2] M. Bollen, Understanding power quality problems. IEEE press New York,, 2000, ch. 1, pp. 1-35.

[3] A. Ghosh and G. F. Ledwich, Power quality enhancement using custom power devices. Kluwer Publications, 2002.

[4] H. Akagi and K. Isozaki, "A hybrid active filter for a three-phase 12- pulse diode rectifier used as the front end of a medium-voltage motor drive," IEEE Trans. Power. Electron., vol. 27, no. 1, pp. 69–77, Jan. 2012.

[5]B.Singh and S.Arya, "Back-propagation control algorithm for power quality improvement using DSTATCOM," IEEE Trans. Ind. Electron., vol. 61, no. 3, pp. 1204–1212, Mar. 2014.

[6] K. Karanki, G. Geddada, Mahesh K. Mishra, and B. Kumar, "A modified three-phase four-wire UPQC topology with reduced DC-link voltage rating," IEEE Trans. Ind. Electron., vol. 60, no. 9, pp. 3555–3566, Sep. 2013.

[7] A. Bhattacharya, C. Chakraborty, and S. Bhattacharya, "Parallel connected shunt hybrid active power filters operating at different switching frequencies for improved performance," IEEE Trans. Ind. Electron, vol. 59, no. 11, pp. 4007–4019, Nov. 2012.

[8] S. Rahmani, A. Hamadi, K. Al-Haddad, and L. Dessaint, "A combination of shunt hybrid power filter and thyristor-controlled reactor for power quality," IEEE Trans. Ind. Electron., vol. 61, no. 5, pp. 2152–2164, May 2014.

[9] A. Bhattacharya and C. Chakraborty, "A shunt active power filter with enhanced performance using ANN-based predictive and adaptive controllers," IEEE Trans. Ind. Electron., vol. 58, no. 2, pp. 421–428, Feb. 2011.

[10] B. Singh, C. Jain, and S. Goel, "Ilst control algorithm of single-stage dual purpose grid connected solar pv system," IEEE Trans. Power Electron., vol. 29, no. 10, pp. 5347–5357, Oct. 2014.

[11]H.Fujita and H. Akagi, "Voltage-regulation performance of a shunt active filter intended for installation on a power distribution system," IEEE Trans. Power. Electron., vol. 22, no. 3, pp. 1046–1053, May 2007.

[12] Mahesh K. Mishra, A. Ghosh, and A. Joshi, "Operation of a DSTATCOM in voltage control mode," IEEE Trans. Power Del., vol. 18, no. 1, pp. 258–264, Jan. 2003.

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