Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env.Pharmacol. Life Sci., Vol 4 [Spl issue 1] 2015: 410-415

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804

FULL LENGTH ARTICLE **OPEN ACCESS**

H-Bridge Inverter Based DSTATCOM for Micro Grid Voltage Quality improvement

Niloofar Perseh[1*], Asghar Taheri[2]
[1]Department of Electrical Engineering, Zanjan Branch, Islamic Azad University, Zanjan, Iran
[2]Department of Electrical Engineering, Zanjan University, Zanjan, Iran
n.perseh@gmail.com

ABSTRACT
Power electronic device, nonlinear and unbalanced loads have given rise to power quality problem in distribution systems. Due to factors like competitive generation patterns in a deregulated micro grid and an increasing level of sensitive end user devices, it has become necessary to ensure both reliable and power quality to the end customer. One way to improve the power quality is using a Distribution Static Compensator (DSTATCOM) to compensate active and reactive power, power factor correction and voltage stability. In this paper, the design of a DSTATCOM employing a Cascade H-Bridge Multilevel Inverter (CHBMLI) in a micro grid is presented. The control method is based on sinusoidal PWM and requires the measurement of the RMS voltage and reactive power at the load point. The proposed DSTATCOM is simulated using MATLAB/SIMULINK software and simulation results are presented to validate its effectiveness.
Keywords-CSCT, design,duality based model,parameter determinatin, simulation

INTRODUCTION

Recently, in distribution systems, major power consumption has been in reactive loads, such as industrial applications using large motors, fans, pumps, etc. These loads draw lagging power-factor currents and therefore give rise to reactive power burden in the distribution system. Also, frequent voltage sag and swell in power industry are highly undesirable and must be compensated [1-3].

A Distribution Static Compensator (DSTATCOM) is one of the most effective equipments to compensate the reactive power dynamically, and can be used to improve power quality by voltage regulation and power factor correction. This Custom Power equipment includes a Voltage Source Converter (VSC) and a DC link capacitor connected in shunt. The main function of a DSTATCOM is to inject or absorb reactive power to the grid for improving power factor and voltage regulation. Inverter Circuit is heart of DSTATCOM and various inverter topologies can be utilized in applications of DSTATCOM such as such as: cascaded H-bridge, neutral point clamped (NPC) and flying capacitor (FC) [4]. The performance of DSTATCOM depends on the control algorithm used for extraction of reference current components. For this purpose, many control schemes are reported in literature, and some of these are Phase Shift control, Instantaneous Reactive Power (IRP) theory, instantaneous symmetrical components, Synchronous Reference Frame (SRF) theory, and current compensation using DC bus regulation [3-5].

In this paper a novel configuration of DSTATCOM based on a 5-level full bridge 3-phase H-bridge converter is proposed. Indirect current control technique based on phase shifted control has been applied to DSTATCOM. The modulation method is based on sinusoidal PWM modulation. Simulation results are presented to validate the effectiveness and advantages of the novel configuration of DSTATCOM.

The rest of the paper is organized as follows. Section II describes the configuration and operating principle of the proposed compensator. In Section III, the control method is presented. Simulation of the H-bridge inverter based DSTATCOM in MATLAB/SIMULINK have been discussed in sections IV.Finally, conclusions are presented in section VII.

H-BRIDGE INVERTER BASED DSTATCOM

The DSTATCOM is a three phase and shunt connected power electronics based device. It is connected near the load at the distribution systems. In its most basic function, the DSTATCOM configuration consist of a voltage source converter (VSC), a dc energy storage device, a coupling transformer connected in shunt with the ac system, and associated control circuit The major components of the DSTATCOM are shown in Fig 1.

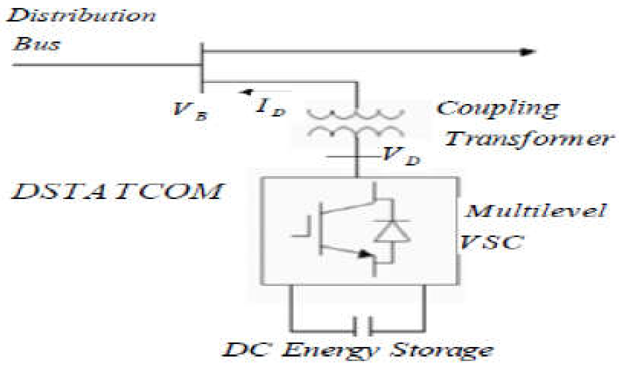


Figure 1- DSTATCOM schem

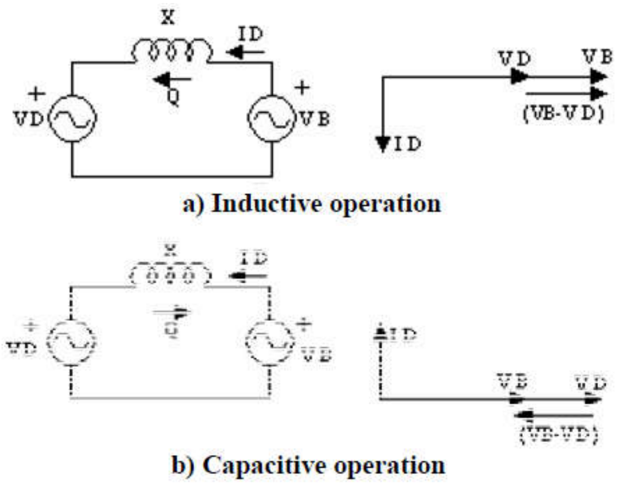


Figure 2- phasor diagram of DSTATCOM Operation

The DSTATCOM operation is illustrated by the Phasor diagrams shown in Fig2. When the secondary voltage (V_D) is lower than the bus voltage (V_B) the STATCOM acts like an inductance absorbing reactive power from the bus. When the secondary voltage (V_D) is higher than the bus voltage (V_B), DSTATCOM acts like a capacitor generating reactive power to the bus [7].

In this paper, a new configuration of DSTATCOM based on the H-Bridge inverter is proposed to increase the number of output voltage levels and as a result, reduce the output voltage THD. A 5-level single phase FCM converter is shown in Fig. 3.

DSTATCOM CONTROL STRATEGY CONSIDERATION

The proposed configuration has some IGBT switches. To control the interchanged reactive power with the network the control part of the compensator should control the triggering of the switches. For this, pulse width modulation strategy employing phase shifted carriers (PSPWM). The reference signal of the modulation is produced based on the measurement of the RMS voltage and reactive power at the load point.

H-bridge based modelation consideration

The modulation schemes for the multilevel CHB inverters can be generally assortment into carrier based modulation, space vector modulation and staircase modulation with selective harmonic elimination [8]. The carrier-based modulation schemes for multilevel inverters are classified to phase-shifted and level shifted modulations. In this paper, the inverter switches are controlled by pulse width modulation strategy employing phase shifted carriers (PSPWM). Multilevel inverter with m voltage levels needs m−1 triangular carriers. In the phase-shifted multicarrier modulation, all the triangular carriers have the equal frequency and the peak-peak amplitude with the phase shift between any two adjacent carrier waves given by (1):

$\varphi_{cr}=360/(m-1)$ (1)

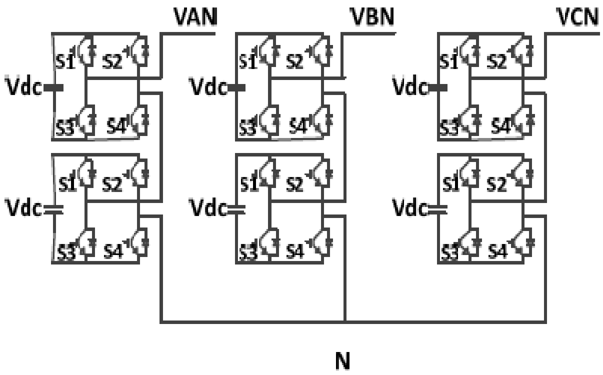


Figure 3- Five-level H-bridge inverter based DSTATCOM configuration

The frequency modulation index *mf* is given by (2):

$m_f = f_{cr} / f_m$ (2)

Where f_{cr} and f_m respectively mention to carrier signal frequency and fundamental signal frequency. The frequency of prevalent harmonic in the inverter output voltage is given by [10]:

$f_{sw,inv} = (m-1) \times f_{sw,dev}$ (3)

The modulated signal $V_{control}$ is compared with a phase shifted triangular signals in order to generate the switching signals. Figure 3 shows waveforms of carrier, modulating and command signals using phase shifted PWM method. The main parameters of the phase shifted PWM scheme are the amplitude modulation index of signal, and the frequency modulation index of the triangular signal [11]. In multilevel inverters, the amplitude modulation index ma defined as:

$m_a = V_{control} / V_{tri}$ (4)

Where $V_{control}$ is the peak amplitude of the control signal and V_{tri} is the peak amplitude of the triangular signals.

APPLIED CONTROL OF DSTATCOM

The main objective of any compensation scheme is that it should have a fast response, being flexible and easy to be implemented. The control algorithms of a DSTATCOM are mainly implemented in the following steps [5]:

- Measurements of system voltages and current
- signal conditioning
- Calculation of compensating signals
- Generating firing angles of switching devices.

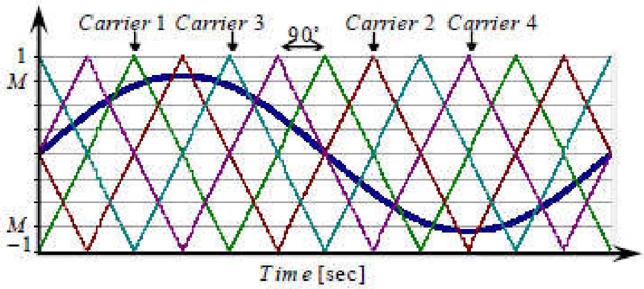
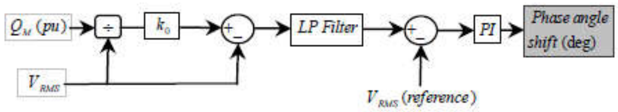


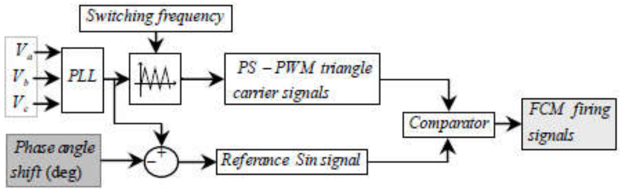
Figure 4- Phase shifted pulse width modulation for 5-level single phase converter.

Generation of proper PWM firing is the most important part of DSTATCOM control and has a great impact on the compensation objectives.

The block diagram of the main control system of the proposed DSTATCOM is shown in Fig.4. The aim of the control scheme is to compensate reactive power and maintain the constant voltage at the load point. The external control is done based on the measurement of the RMS voltage and reactive power at the load point. An error signal is generated by comparing the reference RMS voltage with the low pass filtered signal comes from measured RMS voltage and per unit of injected reactive power at the load point. The error signal is processed by the PI controller which generates the required angle shift between system voltage and voltage generated by STATCOM (δ) to drive the error to zero. In internal control part of DSTATCOM reference waveforms synchronized with system ac voltage and shifted by the angle order are generated and finally the firing angle are generated using comparison of reference signals to triangular signals[9].



a) External control of DSTACOM



b) Internal control of DSTACOM

Figure 5- Control block diagram of the proposed D-STATCOM

SIMULATION

In this section, in order to verify the good performance of the proposed DSTATCOM configuration as well as proposed reactive power compensation and voltage sag detection method, a computer simulation is provided. The system is simulated using MATLAB/SIMULINK software. The parameters used in the simulation are given in Table I. Also, for all the tests; a resistive-inductive load is used. The simulation results are presented for two different reactive power compensations, including absorbing and injecting reactive power for voltage swell and sag respectively.

Table 1- Main parameters of power system

Parameters Values	Parameters Values
Nominal source voltage	20 kV
Fundamental system frequency	50 Hz
Main Resistive-Inductive load	100Ω; 25mH
Energized heavy Inductive load	1Ω; 5mH
Energized heavy capacitive load	1Ω; 10µF
Main DC &flying capacitors	0.15µF
Switching frequency ofconverter	1kHz
Inductance & Capacitance of output series filter	10µF ; 5mH ;
Output RLC filters	10Ω ; 0.1mH ; 2.7µF
Proportional gain of PI controller	0.98
Time constant of PI controller	0.523sec

Reactive power compensation with voltage sag detection and elimination

In this case, the system is loaded with a heavy resistive-inductive load and since the power system is weak, the RMS of system voltage is less than unity. Furthermore, at t = 1.5s, a large inductive load is energized and thus a voltage sag occurs at the grid. Consequently, the grid voltages of phases a, b and c drop to 85% of their nominal values as shown in Fig 6. Installing and applying the proposed DSTATCOM to the system, as shown in Fig.7, the voltage drop and applied voltage sag of system are compensated to desired reference voltage with remarkable performance.

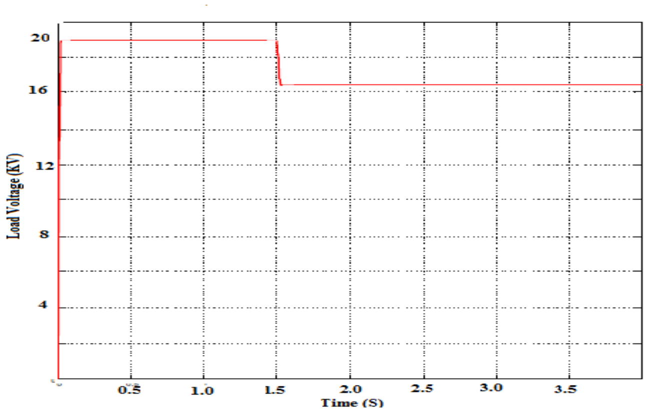


Figure 6- RMS of system voltage forsag compensation before applying the proposedDSTATCOM

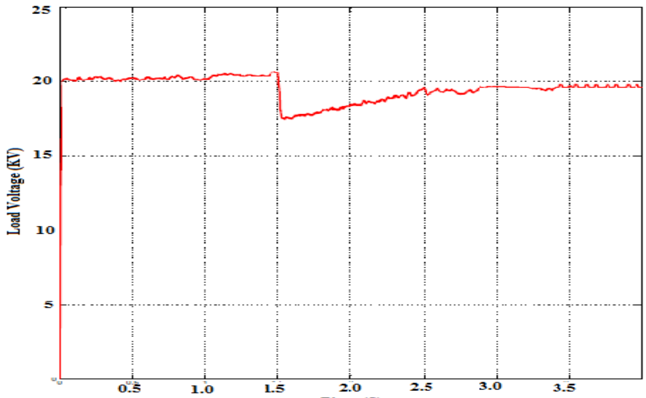


Figure 7- RMS of system voltage forsag compensation after applying the proposedDSTATCOM

Reactive power compensation withvoltage swell detection and elimination

In Figs. 8 and 9 the simulation results of the second case are depicted. In this case, insteadof voltage sag, a voltage swell occurs at the grid by energizing of a capacitive load att = 1.5s. So, the grid voltages of phases a, band c change from nominal values to 110% of them, as shown in Fig 8.As shown in Figs. 6, 7, 8 and 9, the proposed detection and determination strategies are able to detect voltage sags and swells and to properly compensate the reactive power as well as determining the three single-phase reference voltages of DSTATCOM and compensating long-duration and deep sags and swells with proper dynamic, without stopping the suitable operation of proposed DSTATCOM.

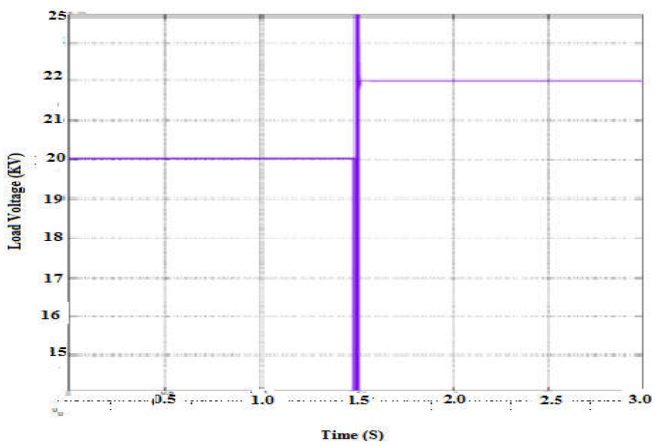


Figure 8- RMS of system voltage forswell compensation before applying the proposed DSTATCOM

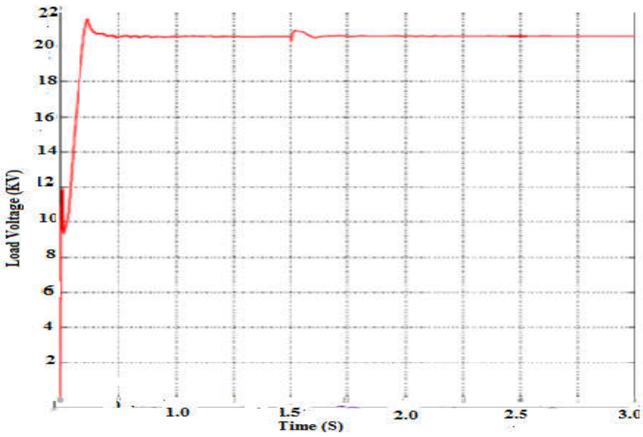


Figure 9- RMS of system voltage forsag compensation after applying the proposed DSTATCOM

CONCLUSION

Reactive Power Compensation in micro grid plays a vital role in improving power quality, correcting power factor and maintaining constant voltages. Since, the multi-level converters are very interesting for high-power/medium voltage applications, and also considerably improve the output voltage frequency spectrum, In this paper, a five-level H-bridge inverter based DSTATCOM in order to improve the power quality is studied. The advanced phase shift pulse width modulation technique is used for five-level CHB inverter.

As demonstrated in simulation results, the reactive power and voltage sag and swell compensation strategy and the applied detection and determination methods show desirable performance and good dynamic response time.

REFRENCES

1. Technologies in a Distributed Environment ,".London, U.K.: Springer- Verlag, 2007
2. Singh B., Solanki J. "A Comparison of Control Algorithms for DSTATCOM,"IEEE Trans. Industrial Electronics, vol. 56, Nno. 7, Jul. 2009.
3. Chen B.-S., Hsu Y.-Y., "A minimal harmonic controller for a STATCOM,"IEEE Trans. Industrial Electronics, vol. 55, no. 2, pp. 655–664, Feb. 2008.
4. M. Sadeghi, A. Nazarloo, S.H. Hosseini, E. Babaei,"A New DSTATCOM Topology Based on Stacked Multi-cell Converter", IEEE 2nd Power Electronics, Drive Systems and Technologies Conference, pp. 205-210,2011.
5. Deepika M., Shailendra J., Gayatri A.,"Control Algorithms for DistributionStatic Compensator," IEEE ISIE, Quebec, Canada 2006, July 9-12, 2006.
6. Tian-yuan T., Qi-rong J., Li G, YuxiangL., "Comparison of Direct andIndirect Current Control Strategy forDSTATCOM," International conference on Power System Technology, 2006. PowerCon.2006.
7. Hosseini, S.H.; Rahnavard, R.;Ebrahimi, Y.; "Reactive power compensation in distribution networkswith STATCOM by fuzzy logic theory application," IEEE 5th International Electronics and Motion Control Conference, IPEMC, 2006.
8. B.P. McGrath, D.G. Holmes, "Sinusoidal PWM of Multilevel Inverters in the Over Modulation Region", IEEE, pp. 485-490, 2002.
9. MeisamSadeghi,Seyed Hossein Hosseini, Ebrahim Babaei, Ali Agabeigi, "Flying Capacitor Multicell Converter Based D-STATCOM", 25th International Power System Conference, PSC 2010.