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Voltage Balancing Technique in Multilevel Inverter based STATCOM: A Review

Y.Alexander Jeevanantham
Assistant Professor II, Department of Electrical and Electronics Engineering,
R.M.K. Engineering College, Chennai, Tamil Nadu, India. ajm.eee@rmkec.ac.in
K.Naresh Kumar
Assistant Professor, Department of Electrical and Electronics Engineering,
R.M.K. Engineering College, Chennai, Tamil Nadu, India. nkr.eee@rmkec.ac.in
L.Annie Isabella
Assistant Professor, Department of Electrical and Electronics Engineering,
R.M.K. Engineering College, Chennai, Tamil Nadu, India. lai.eee@rmkec.ac.in
M.Thiyagesan
Assistant Professor, Department of Electrical and Electronics Engineering,
R.M.K. Engineering College, Chennai, Tamil Nadu, India.mtn.eee@rmkec.ac.in

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Abstract

In electrical power system, when compared to traditional controller Flexible AC Transmission System (FACTS) Devices provides better performance. Static Synchronous Compensator (STATCOM) implemented with Multilevel Inverter (MLI) superior among various FACTS controllers. In most recent years, there are distinct control techniques been proposed for controlling the capacitance voltage of MLI based STATCOM. In this paper, authors have reviewed three major control schemes that are more familiar. Hysteresis based control technique gives better performance and the variation of capacitor voltage is below 0.5%.

***Keywords:** Flexible AC Transmission System (FACTS), Static Synchronous Compensator (STATCOM), Multilevel Inverter (MLI*

I. INTRODUCTION

Power grid shakiness and power superiority are the major issues in power production, transmission and distribution systems. These issues arise usually as a result of unmanaged power flow, voltage disturbances, harmonic content and low power factor are implications of connecting nonlinear, unbalanced and/or reactive loads to the grid. Integration of sustainable and unsustainable power sources in the electrical network to meet out the increasing demand in the power also contributes to the development of power quality issues. In majority of the electrical network prime purpose of STATCOM is to increase the power transfer capacity and to shrink the oscillations in the voltage and power. Use of STATCOM is promising task due to increase in control challenges.

Several works reported to enhance power flow capability in the transmission system and to decrease the transients. In reality, in wind farms this device may be very vital considering the fact that in most instances they keep away from the loss of generation capacity in case of a fault within the transmission grid. This device is now extensively utilized in commercial applications. This device can also be seen in arc furnace or mining industry to reduce flicker and to compensate reactive power.

Improvement of performance in transmission network can be done by connecting VSI based compensator is the best and valuable FACTS controller. Comparing traditional VSI, MLI present numerous reward inclusive of, decreased harmonic distortion, increase of output levels, reduction of stress on devices, operation with decreased operating frequency, and excessive trustworthiness. Due to those features, multilevel inverters at the moment are very essential in medium and excessive-power applications.

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Multilevel inverter excessive voltage capability together with low distortion voltages favours them in FACTS. One such device that uses the multilevel inverter will be STATCOM. Several topologies were tested in STATCOMs, being the notable cascaded H-bridge, diode clamped and flying capacitor multilevel converters there are some disadvantages in MLI such as power loss, switching stress and probability of fault due to availability of more number of components. Another important problem in these types of compensators is the control techniques.

Increasing the stages of the inverter is accomplished at the expense of divergence of the capacitor voltages. This may result in horrific voltage outputs, affecting the manipulate performance, inflicting violation in the safe running limits main to inverter malfunctioning. This paper reviewed the three important DC capacitance voltage balancing techniques for Multilevel Inverter based STATCOM.

II. STATCOM

In STATCOM it is possible to control the po wer glide by injecting or absorbing reactive power. If the potential at PCC collapse below set value then STATCOM resources the reactive power to grid. When potential at PCC becomes inflated than the set value then STATCOM absorbs reactive power. STATCOM can act as capacitive or inductive reactance by injecting current 90 degree phase shifted from the voltage. Either CSI or VSI can be realized in STATCOM but due to high voltage rating, high losses and additional protection in current source inverter, Voltage source inverter is most popular in STATCOM. Inverter injects three phase voltage through proper switch operation. Power flow between the STATCOM and electrical network depends on the capacitance voltage of the STATCOM and it will be in phase with electrical network voltage. STATCOM operation is carried out by two stage Voltage source Inverter but nowadays because of modular configuration and high capacity power control MLI are used. Fig.1 shows the connection diagram of Multilevel Inverter STATCOM. Using MLI in STATCOM has may advantage like lesser total harmonic distortion, higher efficiency and higher power rating. In any other scenario, each power plant needs to have a reliable reactive po wer source that would have a negative impact on the po wer system's stability.

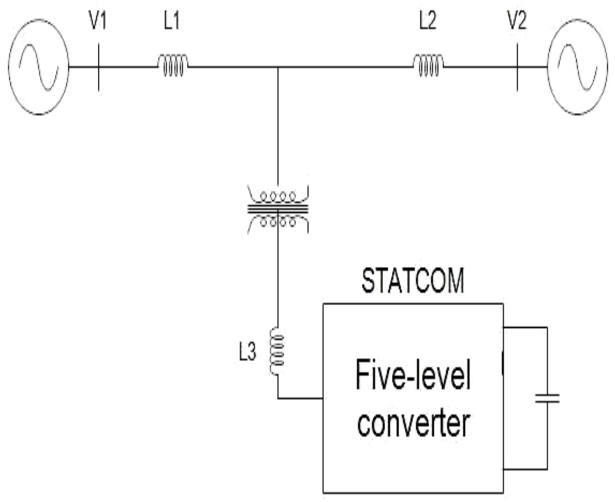

Fig. 1. Grid Connected STATCOM

III. CAPACITOR VOLATGE BALANCING TECHNIQUES

Anshuman Shukla, et al., has proposed control technique for maintaining the capacitance voltage of the five level based STATCOM. Proportional Integral (PI) control scheme has been used for controlling the STATCOM and Sinusoidal Pulse Width Modulation (SPWM) technique has been used for the control of MLI as it provides Inverter output voltage with lower THD. The proposed control scheme check the current direction of the inverter and the voltage level of the capacitor based on which switching combinations for the inverter will be chosen. The fluctuations in capacitor voltages are small and within 3.0%. Fig.2 shows the proposed control technique [10].

Anshuman Shukla, et al., they have presented a control technique for controlling the capacitor voltage in capacitor clamped five level inverter. The controller has three sections a) Voltage level identifier b) Capacitor voltage identification c) Load current direction finder. The load current is compared with reference current to get the error value and passed through hysteresis comparators that will help us to know the required voltage level at each instant.

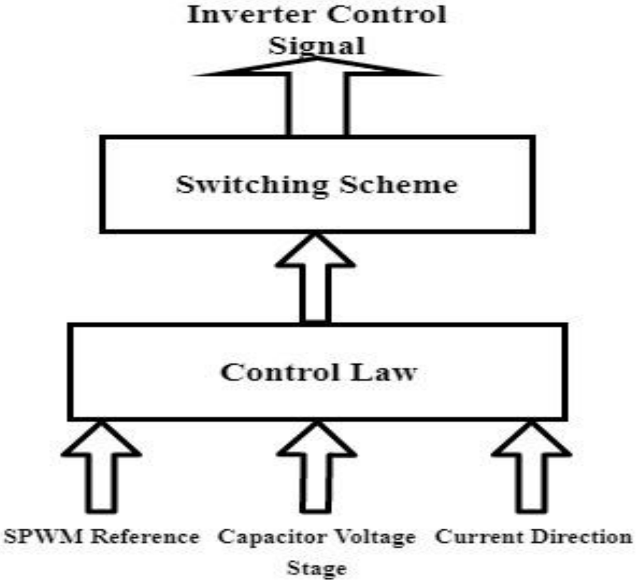

Fig.2. PI and SPWM Based Control Circuit

Also each clamping capacitor voltages (V_c) has been compared with their reference values (V_{Cref}) and then passed through the zero-band comparator. The output of each comparator has been sampled to a constant frequency. If the capacitor error voltage is positive then the capacitor has to discharge, if it is negative, then charging and if zero, no need for any change in the capacitor voltage. Now with the output voltage level, desired clamping capacitor voltage level and with current direction a particular switching combination will be chosen from the switching states of the five level inverter so that the anticipated output can be attained. The accepted voltage variation of capacitor is 0.1167 % and 0.5% for the clamping capacitors. This method of controlling clamping capacitor is almost independent of load parameters and the capacitance voltage [11]. Fig.3 shows the hysteresis current controller.

Anshuman Shukla, et al., they have worked on five level DCMLI and FCMLI based STATCOM has been tested with state feedback switching controller. STATCOM reference signals are obtained by linear quadratic regulator design. Two controllers have been suggested to maintain the capacitor voltage, one for FCMLI and the other for DCMLI.

FCMLI will be controlled with the aid of hysteresis current controller with four bands each time the control signal crosses the earlier band the following parameters will be sensed (i) Direction of Inverter current (ii) needed output level of the inverter (iii) potential level of the capacitor. Based on the above inspection suitable switching combination will be selected from the switching states of the five level Inverter.

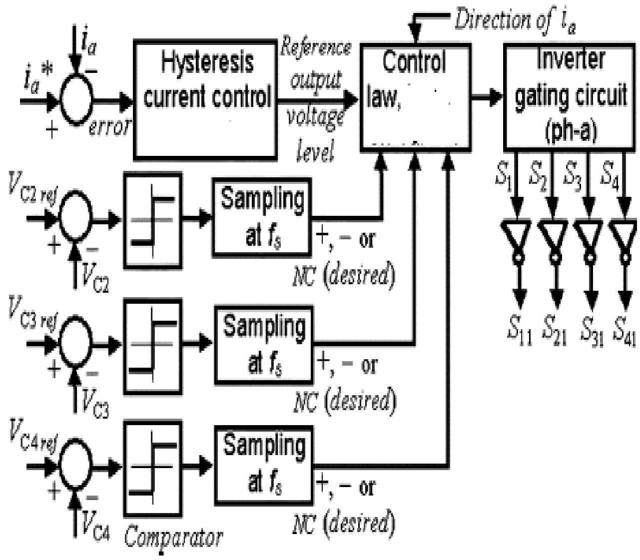

Fig.3. Hysteresis current controller [12]

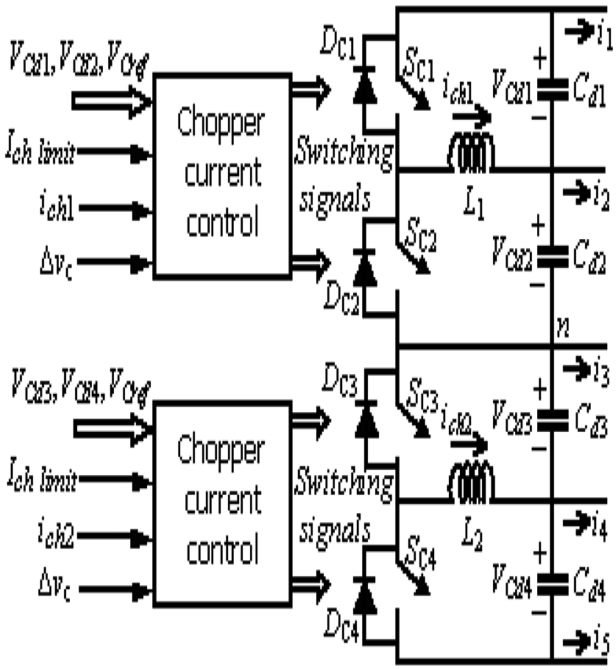

Fig.4. Chopper Control Circuit [13]

A control scheme has been suggested for DCMLI in which chopper circuits has been used. The chopper control circuit has shown above in Fig.4 shows the chopper control circuit. Capacitors voltage has been

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controlled within a band by exchanging the power from supercharged capacitor to an inductor and vice versa this control technique is more unswerving and forceful against line faults, transients, and disturbances. Comparing the above two control techniques that has been implemented for FCMLI and DCMLI based STATCOM it is found FCMLI has better performance since it has less power loss [12].

IV. CONCLUSION

This paper has addressed the three different control techniques for balancing the capacitor voltage in MLI when implemented in STATCOM in all the paper they have taken five level inverters. We that there are different controllers available for maintaining the capacitance voltage but the three controllers PI controller, Hysteresis controller and chopper circuit based controller are simple in achieving the batter capacitor balancing and to improve the performance of STATCOM. Hysteresis controller with four band of control has given better performance of controlling the capacitance voltage less with variation of less than 0.5%.The other two controllers shows higher percentage of voltage variation. The response of chopper based controller is good but the power loss in this circuit is very high. Author believe that this paper will be helpful to the researchers for choosing suitable the controller for their work in STATCOM.

REFERENCES

[1] Dixon, L. Moran, J. Rodriguez, and R. Domke, “Reactive power compensation technologies: State-of-the-art review,” *Proc. IEEE*, vol. 93, no. 12, pp. 2144–2164, Dec. 2005.

[2] R. K. Varma, “Introduction to FACTS Controllers,” in *Proc. Power Systems Conference and Exposition. PSCE’09.* IEEE/PES Vol, Issue, 15-18, pp.1 – 6, March 2009. .

[3] D. Soto, T. C. Green, “A comparison of high-power converter topologies for the implementation of FACTS controllers,” *IEEE Trans. Ind. Electron.*, vol. 49, no. 5, pp. 1072–1080, Oct. 2002.

[4] N. Hingorani and L. Gyugyi, “Understanding FACTS, Concepts and Technology of Flexible AC Transmission Systems”. New York: IEEE Press, 2000.

[5] B. Singh, R. Saha, A. Chandra, and K. Al-Haddad, “Static synchronous compensators (STATCOM): a review,” *IET Power Electronics*, vol. 2, no. 4, pp. 297–324, July 2009.

[6] J. Rodriguez, J.-S. Lai, and F. Z. Peng, “Multilevel inverters: a survey of topologies, controls, and applications,” *IEEE Tran. Ind. Electron*., vol. 49, no. 4, pp. 724–738, Aug 2002.

[7] S. Teleke, et al., “Application of STATCOM for Power Quality Improvement,” IEEE Power Systems Conference and Exposition, Phoenix, Arizona, USA, pp. 1-6, March, 2011.

[8] Anshuman Shukla, Arindam Ghosh, and Avinash Joshi, “Static Shunt and Series Compensations of an SMIB System Using Flying Capacitor Multilevel Inverter,” *IEEE Transactions on Power Delivery*, vol. 20, no. 4, pp.2613-2622, oct 2005.

[9] Anshuman Shukla, Arindam Ghosh, and Avinash Joshi,“Hysteresis Current Control Operation of Flying Capacitor Multilevel Inverter and Its Application in Shunt Compensation of Distribution Systems,” *IEEE Transactions on Power Delivery*, vol. 22, no. 1, pp.396-405, January 2007

[10] Anshuman Shukla, Arindam Ghosh, and Avinash Joshi, “State Feedback Control of Multilevel Inverters for DSTATCOM Applications,” *IEEE Transactions on Power Delivery*, vol. 22, no. 4, pp.2409-2418, October 2007

AUTHORS PROFILE

Y.Alexander Jeevanantham graduated from Sathyabama University with a M.E. degree and pursues a Ph.D. degree at Anna University. He is working as Assistant Professor-II in R.M.K Engineering College.

K.Naresh Kumar received the M.E Degree in Power system engineering from Anna University and is pursuing Ph.D. degree. He is working as Assistant Professor in R.M.K Engineering College.

L Annie Isabella received the M.E Degree in Power Electronics and Drives from the Anna University and is pursuing Ph.D. degree. She is working as Assistant Professor Grade II in R.M.K Engineering College.

M.Thiyagesan received the M.E Degree in Power Electronics and Drives from the Anna University. He is working as Assistant Professor in R.M.K Engineering College.