International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 11, November - 2013

Voltage Control Strategy for Full-Bridge Multi Level Dc-Dc Converter

T.Yuvaraja [1]
Department of EEE, Research Scholar Meenakshi Academy of Higher Education and Research, (MEENAKSHI UNIVERSITY) India[1]

Ravi.V.Angadi [2]
Department of EEE, PG Scholar, JNTU University, Anantpur, India[2]

Abstract
For high input voltage application the full bridge multi level dc-dc converter is widely constructed according to the application. This contribution discusses the approach comprehensively with simulation results and guidelines for practical implementations. The methodology presented attains the objective of controlling the voltage in distribution networks with high shares of decentralized generation while maintaining a good compromise between simplicity and performance. Possibilities of implementation in a demonstration phase are also presented.

Keywords: *voltage control, half-bridge multi-level converter, voltage unbalance*

I.INTRODUCTION

The connection of more decentralized energy resources (DERs) to the distribution network may lead to a voltage and/or current problem in the distribution network. The “fix and forget” approach works well only if a small number of decentralized plants is connected to the network. If the number is increased, other measures have to be taken into account. As far as the voltage problem is concerned valuable counter measures are appropriate control strategies. These control strategies counteract the over- or under-voltage in the network by acting reasonably on the actuating elements. The actuating elements of the control loop are a 110kV/30kV on-load tap changer (OLTC), the produced reactive power of the decentralized plants and as an “ultimo ratio” measure the active power of the decentralized plants.

The control activity has to be carried out coherently, meaning that the control activities should not unnecessarily limit the sophisticated and through comprehensive control strategies have to be devised that work reliably under a variety of different in that network operating conditions. The control strategies here presented are based on an evaluation of the voltage of “critical” nodes in the distribution network. Critical nodes are nodes within the active power would limit the plant’s profitability. Therefore voltages of the critical nodes within the acceptable voltage band. Control actions are changing the tap of the on-load tap changer of the transformer, the production of additional reactive power at the plants, and the curtailment of the active power production of the plants.

The production of additional reactive power and the curtailment of active power of the plants are minimized as far as the time horizon of the control action is concerned and as far as the amount of production or curtailment is concerned. A very helpful method to determine the necessary control actions has been developed. It is based on contribution matrices for reactive and active power which reflect the effect of additional power generation or consumption of the decentralized plants on the voltages of the critical nodes. Critical nodes and the corresponding contribution matrices are determined by offline simulations of the distribution network under study.

The dynamic performance of an MMC-based back-to-back HVDC system under balanced and unbalanced grid conditions is investigated in [9], where a phase disposition (PD) sinusoidal PWM(SPWM)strategy, including a voltage-balancing method, for the operation of an MMC is also presented. A new PWM modulation scheme is introduced for MMCs, and the semiconductor losses and loss distribution are investigated in [10].An efficient modeling method for MMCs in electromagnetic transient simulation is proposed in [11]. A reduced switching-frequency voltage balancing algorithm is developed for MMCs, and a circulating current-suppressing controller is proposed for the three-phase MMC in [12]. The impact of sampling frequency on harmonic distortion for MMCs is investigated in [13]. The inner energy control of the MMC is discussed in [14]. The performance of MMCs operated with various multicarrier SPWM techniques is evaluated in [15].In this paper, a capacitor voltage-balancing control method is proposed for the MMC. The phase-shifted carrier-based PWM(PSC-PWM) scheme, which has been introduced in several studies[16], [17], is used for the MMC and generates the high frequency component in the arm current. The capacitor voltage balancing in the MMC can be achieved by assigning suitable PWM pulses to the corresponding SMs. In the proposed voltage balancing control method, it is not necessary to measure the arm current, which not only effectively reduces the number of the sensors and decreases the costs but also simplifies the algorithm for capacitor voltage-balancing control. Some of the generators are controllable, meaning that our controller can change their active and reactive power if necessary; these are denoted by thick circles on the schematic.

Within this distribution network the voltage of each bus bar should be within an acceptable band, for example between 0.94 p.u. and 1.03 p.u. (data provided by a network operator). In networks with a high share of DERs without counter measures this band may be violated. To prevent this, the CVCU changes the actuating elements (tap changer, and active and reactive power of the control.

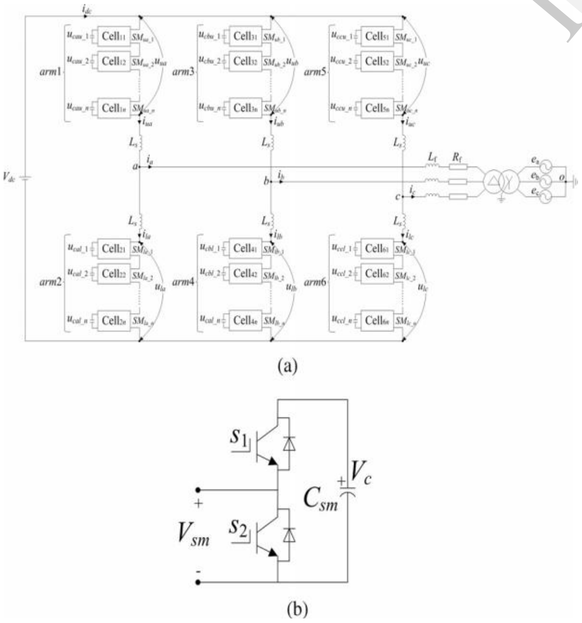


Fig. 1. (a) Block diagram of the three-phase MMC. (b) SM unit.

TABLE I
SM STATE

SM state	S1	S2	V_{sm}
On	On	Off	V_c
Off	Off	On	0

The distribution network is connected to the transmission network by a transformer usually with an on-load tap changer. This tap changer usually is for compensation of the voltage fluctuations in the transmission network. The controller of the on-load tap changer therefore measures the voltage of the bus bar in the transformer station and controls the set point of the on-load tap changer accordingly. For our purposes, the controller of the on-load tap changer gets the set point from our central coordinated voltage control unit (CVCU) and is used to optimize the voltage of all critical nodes in the distribution network. Critical nodes are nodes in the distribution network where the variation due to load and generation variation leads to critical node voltages for the operation of the network; they are typically found by simulation. Within the distribution network we have loads and generators, denoted on the schematic by dark and white dots, respectively.

II.THE CONTRIBUTION MATRIX APPROACH

In order to describe the variation of the voltages of the critical nodes with respect to the active and reactive power of the controllable DER, the contribution matrix approach is introduced. The contribution matrix is a linear mapping from the variation of the active and reactive power of the controllable DER:

CN PΔ≈Δ + QΔQAPAU (1)

where is the variation of the voltage vector.

The variation of the active power vector and the variation of the reactive power vector of the controllable DERs. and are the contribution matrices for active and reactive power respectively. m and n are the number of critical nodes and controllable DERs respectively. The coefficients of these matrices can be considered as voltage sensitivity factors. Eq. (1) holds only if all loads are constant and if the power variations are small enough. This means that we have a tool at hand where we can estimate what influence the controller-proposed power variation has on the voltages of the critical nodes. A very important question is whether or not the linearity that Eq.(1) describes holds for a broad variation range with constant coefficients of the contribution matrices. Therefore, we simulated a big distribution network in the westernmost state of Austria, Vorarlberg, and observed how the coefficients of the contribution matrices varied over one year using actual load and generation profiles. trip and close capacitor bank stages as needed to maintain the power factor and kVAR loading within the preset limits. If the kW loading drops below the kW trip threshold, the control logic will de-energize both capacitor banks as long as the bus voltage remains above the low-voltage dead-band threshold.

III. ANALYSIS OF VOLTAGE UNBALANCE

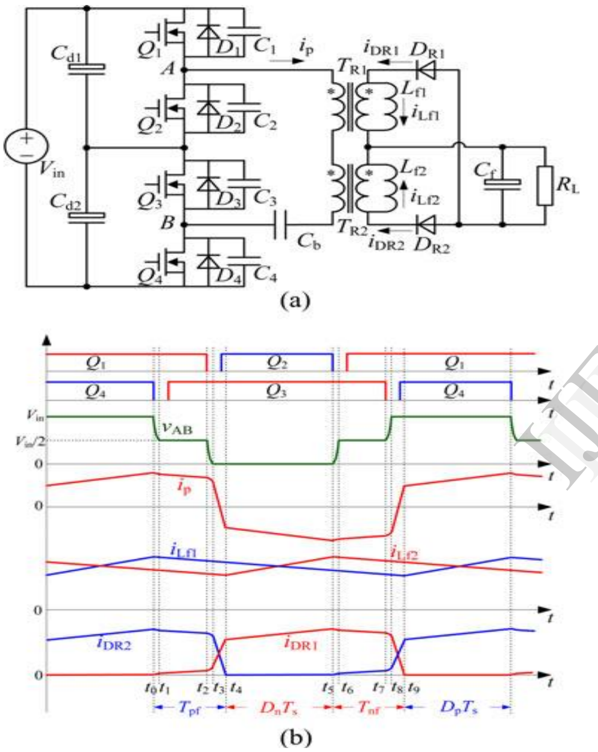


Fig.2. Four-switch full-bridge multi level converter. (a) Main circuit. (b) Key waveforms.

IV. SEL SOLUTION

Many capacitor bank controllers are configured solely for monitoring voltage magnitude, phase angle, and reactive power flow. This means existing controllers are not well suited for dc to ac interconnection applications that require switching capacitors when the power factor drops 0.90 or the total harmonic distortion (THD) exceeds 5 percent of the fundamental voltage. Both of these factors can significantly reduce the operating efficiency of motors, transformers, and electronics while creating problems for neighboring electrical customers. Retrofitting a new capacitor bank with advanced control, protection, and metering can be an expensive proposition, and a utility may not have the time for the retrofit. In addition to revenue and power quality metering, the SEL-734 Advanced Metering System provides advanced logic and control functions ideal for the control and protection of capacitor banks. This single low-cost meter provides advanced capacitor bank control and protection while reporting instantaneous data to SCADA (supervisory control and data acquisition) and collecting billing information in the load profile recorder. Many substations already have an SEL-734, so simply adding control logic to the settings provides the utility with a free capacitor bank controller. Figure 1 is an illustration of the capacitor bank control philosophy. The SEL-734 continuously monitors the bus voltage and load current to provide automatic control of two capacitor banks. When the bus voltage is above the voltage inhibit threshold and automatic control is enabled, the capacitor bank control logic is active. The SEL-734 begins timing to close capacitor banks when any phase of the bus voltage is below the low-voltage override threshold. Conversely, the control logic begins timing to trip energized capacitor banks when any phase of the bus voltage is above the high-voltage override threshold. Low- and high-voltage dead bands are provided to reduce the likelihood of hunting. When the bus voltage is in the high-voltage dead band, the control logic prevents the energization of capacitor banks on power factor and kVAR control. When the bus voltage is in the low-voltage dead band, capacitor bank tripping is prevented on low kW load, power factor.

V. PROPOSED VOLTAGE-Voltage Control Strategy

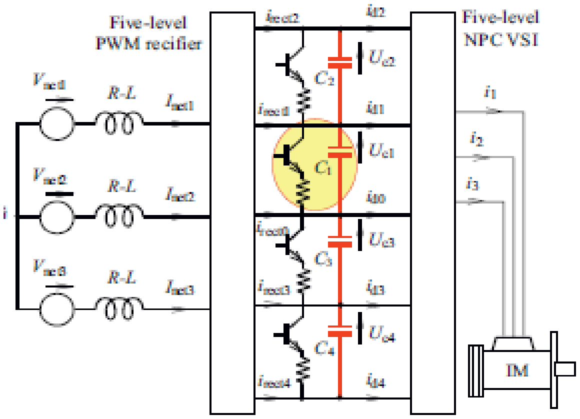
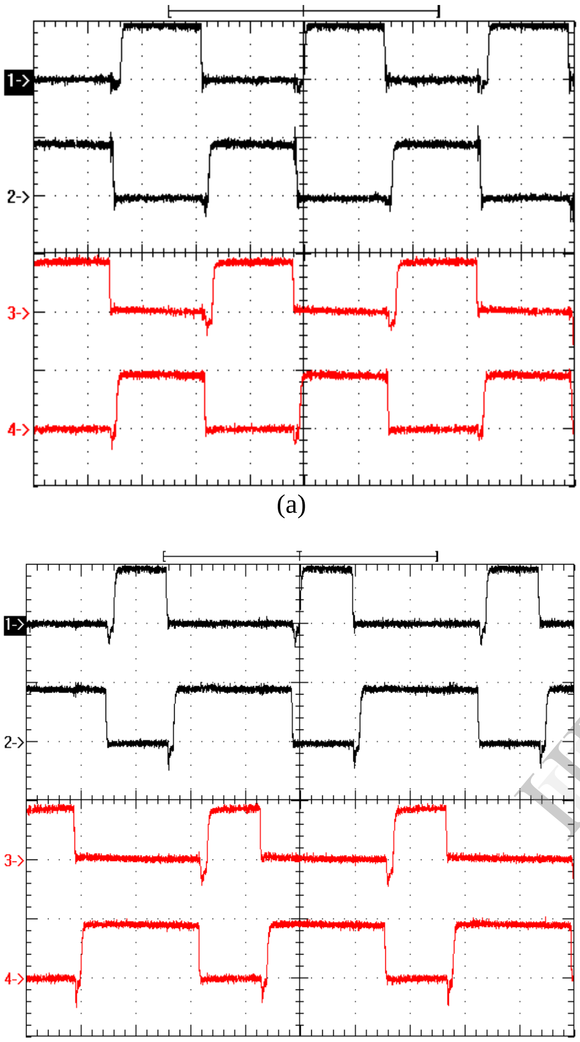


Fig.3. Full bridge Multilevel converter

Automatic control operation modes

1. Three-phase average power factor control
2. Three-phase average kVAR control
3. Bus voltage override control

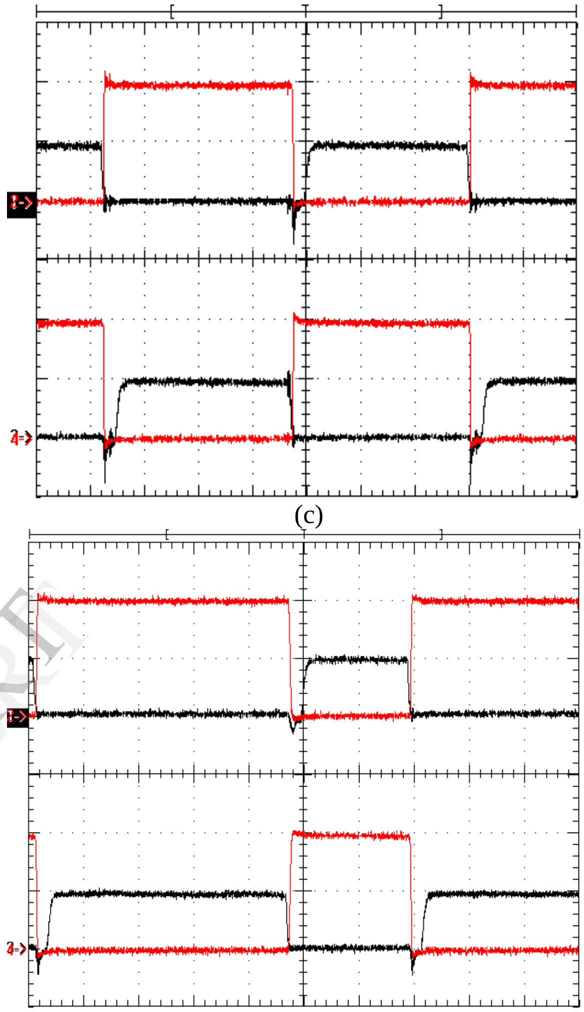


(a)

(b)

Fig. 4. Measured signals of *S1~S4* at (a) 100% load (b) 50% load.

Many renewable energy resources, such as solar and wind, utilize dc to ac converters for electrical grid interconnections. During the dc to ac conversion, an inverter produces harmonics due to switching and non ideal power factor. Typically, a utility installs a capacitor bank on a distribution system for voltage and VAR support, but these capacitors also provide harmonic isolation and power factor correction that are perfect for interconnecting renewable energy resources. This paper proposes a novel capacitor voltage control strategy to solve the issue of voltage unbalance among the blocking capacitor and the input-divided capacitors by regulating the duty cycle and phase shift. Intuitive front-panel displays and programmable LEDs (light-emitting diodes) that indicate all pending control actions of the capacitor



(c)

(d)

Fig. 5. Measured gate voltages and drain voltages of switches S_1 and S_2 at (a) 100% load (b) 50% load.

VI. CONCLUSION

In this paper, a voltage-balancing control method is proposed and a high-frequency component in the arm current is generated for the voltage-balancing control. It is not necessary to measure the current in each arm with the proposed voltage balancing control, which omits the current sensors, reduces the costs, and simplifies the voltage-balancing control algorithm. The high-frequency component in the arm current is analyzed. Based on the analysis, a voltage-balancing control method is presented that can be achieved by assigning suitable pulses to the different SMs of the MMC. An MMC system is modeled and simulated with PSCAD/EMTDC, and a small-scale MMC prototype was built and tested in the laboratory. The results show the effectiveness of the proposed voltage-balancing control method. More than one half of system energy loss is caused by the resistance of the feeders. To minimize energy losses it is, therefore, important to locate feeder capacitors as close to the loads as possible. Substation capacitors cannot do the job - the reactive load current has already heated feeder conductors downstream from the substation. Reducing reactive current at the substation cannot recover energy losses in the feeders. Another way to minimize energy losses is to use capacitor banks that are not too large. This makes it possible to put the banks on-line early in the load cycle.

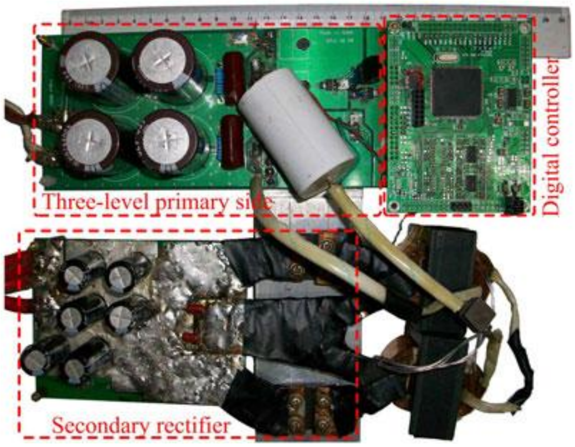


Fig.6. Pulsed Picture

VII. REFERENCES

[1] A. Nabae, I. Takahashi, and H. Akagi, “A new neutral-point-clamped PWM inverter,” *IEEE Trans. Ind. Appl.*, vol. IA-17, no. 5, pp. 518–523, Sep./Oct. 1981.

[2] D. Fu, F. C. Lee, Y. Qiu, and F. Wang, “A novel high-power-density three-level LCC resonant converter with constant-power-factor-control for charging applications,” *IEEE Trans. Power Electron*, vol. 23, no. 5,pp. 2411–2420, Sep. 2008.

[3] S. Byeong-Mun, R. McDowell, A. Bushnell, and J. Ennis, “A three-level dc–dc converter with wide-input voltage operations for ship-electricpower- distribution systems,” *IEEE Trans. Plasma Sci.*, vol. 32, no. 5pp. 1856–1863, Oct. 2004.

[4] A. D. Cheok, S. Kawamoto, T.Matsumoto, and H.Obi, “High power ac/dc converter and dc/ac inverter for high speed train applications,” in *IEEE TENCON*, Sep. 2000, vol. 1, pp. 423–428.

[5] X. Ruan, L. Zhou, and Y. Yan, “Soft switching PWM three-level converters,”*IEEE Trans. Power Electron.*, vol. 16, no. 5, pp. 612–622, Sep.2001.

[6] X. Ruan, B. Li, and Q. Chen, “Three-level converters-a new approach for high voltage and high power DC-to-DC conversion,” in *Proc. IEEE Power Electron. Spec. Conf.*, 2002, vol. 2, pp. 663–668.

[7] J. R. Pinheiro and I. Barbi, “The three-level ZVS-PWM DC-to-DC converter, *IEEE Trans. Power Electron.*, vol. 8, no. 4, pp. 486–492, Oct.1993.

[8] F. Canales, P. M. Barbosa, J. M. Burd´ıo, and F. C. Lee, “A zero-voltage switching three-level DC/DC converter,” in *Proc. INTELEC*, 2000, pp. 512–517.

[9] X. Ruan, B. Li, and J. Li, “Zero-voltage-switching PWM three-level converter with current-doubler-rectifier,” in *Proc. Appl. Power Electron. Conf.*, 2002, vol. 2, pp. 981–987.

[10] X. Ruan, D. Xu, L. Zhou, Bin Li, and Q. Chen, “Zero-voltage-switching PWM three-level converter with two clamping diodes,” *IEEE Trans. Ind Electron.*, vol. 49, no. 4, pp. 790–799, Aug. 2002.

[11] K. Jin, X. Ruan, and F. Liu, “An improved ZVS PWM three level converter, *IEEE Trans. Ind. Electron.*, vol. 54, no. 1, pp. 319–329, Feb.2007.

[12] I. Barbi, R. Gules, R. Redl, and N. O. Sokal, “DC-DC converter: four switches Vpk=Vin /2, capacitive turn-off snubbing, ZV turn-on,” *IEEETrans. Power Electron.*, vol. 19, no. 4, pp. 918–927, Jul. 2004.