A Photovoltaic Systems Based Large Scale Grid Model of Active and Reactive Power Control of Using Cascaded Modular Multilevel Inverters

Rajani Bhimte[1], Dr. Yogesh Pahariya[2], Prof. E. Vijay Kumar[3]

[1]Mtech Scholar, [2]Principal, [3]Research Guide

Department of Electrical Engineering, RKDFIST, Bhopal

Abstract - The rising demand of green energy across the world has given popularity to Grid connected PV system. Now a day's there are various topologies of Multilevel Inverters are developing day by day. Using these multilevel inverters can enable to interface the PV systems with Grid easily and effectively. But there are lots of issues occur while using PV systems like power flow control and output voltage disturbances due to irregular output voltages produces by PV systems. With the fast growth of distributed generators, including the PV, the quality of their produced power needs to be further improved in order to not adversely affect the hosting network's performance. This can be achieved through utilizing appropriate inverter structures, inverter control schemes, and/or better bridge systems. In this work to improve power quality a photovoltaic systems based large scale grid model has been proposed with active and reactive power control utilizing of cascaded modular multilevel inverters.

Keywords - Photovoltaic system, PV-array, Power control, Cascaded Modular Multilevel Inverters (CMMI), large scale grid.

I. INTRODUCTION

PV systems can be interfaced to the grid through single-phase or three-phase connections. The single-phase inverters, which connect the smaller PV arrays to the grid, sufferer from a double-frequency pulsation in DC-link voltage, which decreases the power efficiency of the PV array. Depending on the operational and functional requirements of the system, the specific components required such as a DC-DC power converter, a DC-AC power inverter, battery bank along with its controller, supplementary energy sources and the specified electrical load or appliances. A standalone PV system is shown in Figure 1.1,

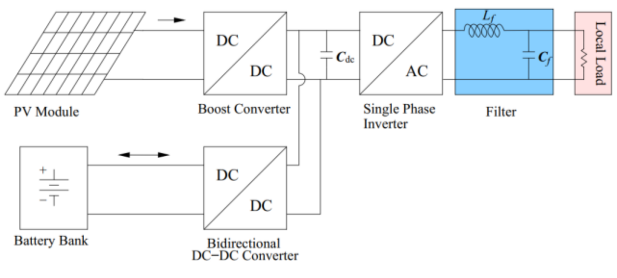

Figure 1.1 Battery connected standalone PV system.

along with battery backup, all the interfacing components like DC-DC converter and DC-AC inverter, and local load. PV systems are mainly design to give the electric supply to load and load can be AC type or DC type. Supply for load or appliances can be needed in day time or evening time or both time. PV system can supply only in day time and for supply required during night hours, it requires batteries, where power can be stored and utilized.

Voltage source inverter control method regulates phase angle of the grid mainly through receiving voltage signals from the dc side of the inverter which is called the outer loop to control the grid voltage while it regulates voltage reference from ac side load voltage to control inverter output current which is called inner loop. In PV systems, the control task is normally performed in synchronous dq frame synchronized with the grid voltage, which results in decoupled real and reactive power control through the decoupled d- and q-axis current control-loops. During the normal operation of a PV system, the d-axis current control-loop is utilized for the DC-link voltage regulation which results in maximum power production (operation of PV array at MPP voltage). In the case of over frequency in the network, however, the power setpoint is calculated depending on the network frequency and is applied to the current control scheme, which results in the operation of a PV array with an operating voltage different than the MPP(Maximum Power Point) voltage. On the other hand, the reactive power setpoint for PV systems in normal operating condition is set to zero or an small value to deliver unity power factor at the network connection point. However, in case of required dynamic or static voltage support, the reactive power setpoint is calculated accordingly, depending on the network voltage

II. SYSTEM MODEL

Grid connected PV generation system is mainly composed of the PV array, the inverter device with the function of maximum power tracking and the control system.

The control tasks of a grid connected inverter can be divided in two parts: (1) The input side primarily tasked with extracting the maximum power from the pv modules. (2) Grid side controller tasked with control of active and reactive power, ensuring high quality of injected power and maintaining synchronization with the grid.

Traditionally the control strategy applied to the grid-side converter consists mainly of two cascaded loops. Usually, there is a fast internal current loop, which regulates the grid cur- rent, and an external voltage loop, which controls the dc-link voltage. The current loop is responsible for power quality issues and current protection; thus, harmonic compensation and dynamics are the important properties of the current controller. The dc-link voltage controller is designed for balancing the power flow in the system. Usually, the design of this controller aims for system stability having slow dynamics.

A photovoltaic array is a linked assembly of PV modules. Most PV array use an inverter to convert the dc power produced by the modules into alternating current. The modules in a PV array are connected in series to obtain the desired the voltage, the individual string are then connected in parallel to allow the system to produce more current.

A solar or PV inverter converts variable direct current (DC) output of the photovoltaic solar panel into a utility frequency alternating current that can be fed into a commercial electrical grid or it is used by the local or off grid electrical network. It is a critical component in the photovoltaic system allowing the use of ordinary commercial appliances. Solar inverters have special functions adapted for use with the photovoltaic arrays including maximum power point tracking and anti islanding protection.

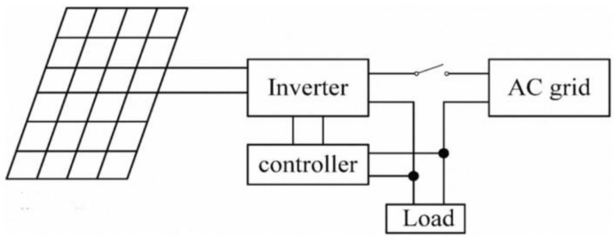

Figure 2.1 Schematic of grid connected power generation structure.

Inverter can control the switch state of shut and conduct, thus the system may form two different working ways which are parallel operation and independently operation. When the system is working in parallel operation way, the inverter belongs to the current mode Equivalent circuit of the inverter in parallel operating operating mode is shown in figure 2.2 below.

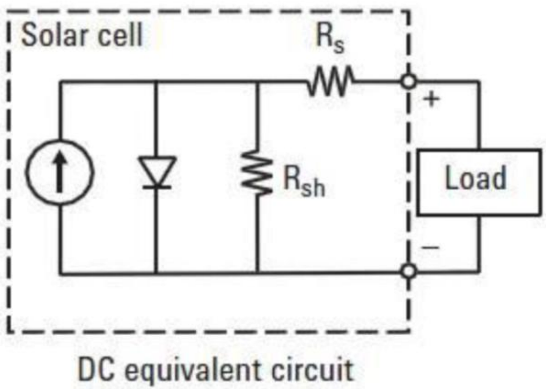

Figure 2.2 DC Equivalent Circuits.

III. PROPOSED METHODOLOGY

The proposed photovoltaic systems based large scale system model of Active and reactive power control system depends on utilizing cascaded modular multilevel inverters. Figure 3.1 Schematic of a multi-stage Modular Multi-level Converter. Also, figure 3.3 demonstrates the model of proposed cascaded modular multi level control system. Contrasted with traditional VSC innovation, Modular Multilevel topology rather offers points of interest, for example, higher voltage levels, modlar development, longer maintenance interims and enhanced reliability. A multilevel approach ensures a lessening of yield harmonics because of sinusoidal yield voltages: along these grid filters end up negligible, prompting system cost and many-sided quality diminishment. Like in numerous other building fields, modular and distribution systems are turning into the proposed topology to accomplish present day project necessities: this arrangement guarantee a more solid operation, encourages diagnosis, maintenance and reconfigurations of control system. Especially in fail safe situations, modular configuration allows control system to isolate the problem, drive the process in safe state easily, and in many cases allows one to reach an almost normal operation even if in faulty conditions. the concept of a modular converter topology has the intrinsic capability to improve the reliability, as a fault module can be bypassed allowing the operation of the whole circuit without affecting significantly the performance.

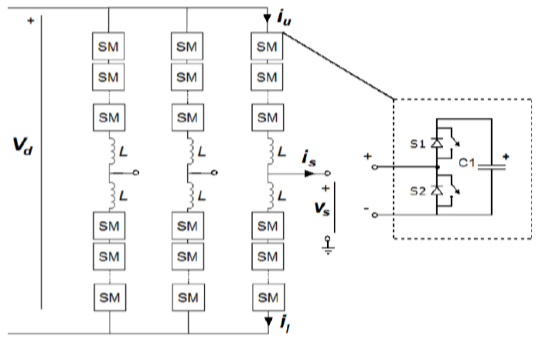

Figure 3.1 Schematic of a three-phase Modular Multi-level Converter.

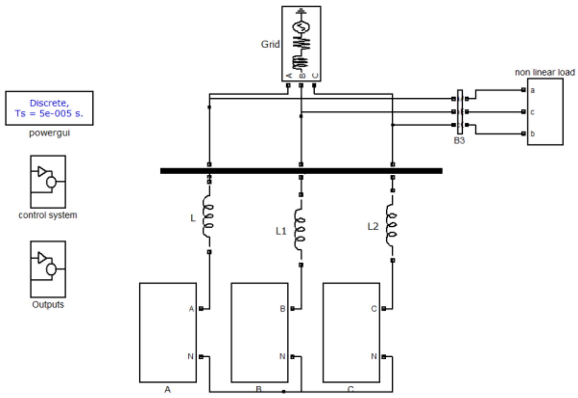

Fig.3.2 Proposed Grid Connected PV System.

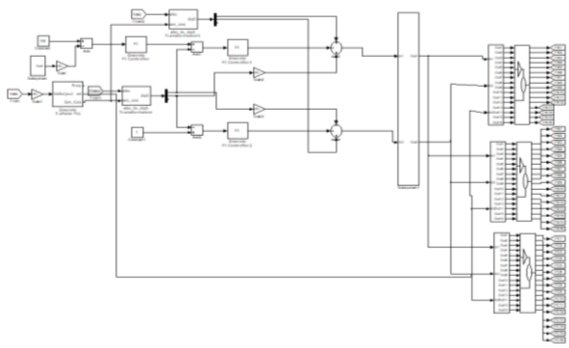

Fig.3.3 Proposed Cascaded Modular Multi Level Control System.

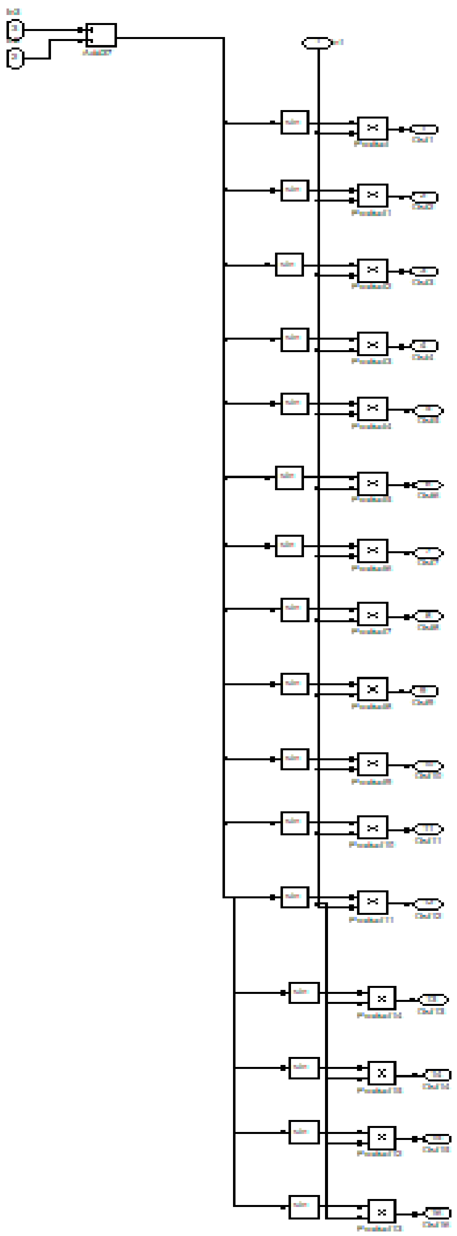

Fig.3.3 Proposed Multi Level PWM

The common structure of a MMC is appeared in Fig. 3.1, and the arrangement of a Sub-Module (SM) is given in Fig. 3.1 Every SM is a straightforward chopper cell made out of two IGBT switches (S1 and S2), two hostile to parallel diodes and a capacitor C. Each stage leg of the converter has two arms, every one constituted by a number N of SMs. In each arm there is likewise a little inductor to adjust for the voltage contrast amongst upper and lower arms delivered when a SM is changed in or out. In a MMC the quantity of ventures of the yield voltage is identified with the quantity of series associated SMs. With a specific end goal to indicate how the voltage levels are created, in the accompanying. A proposed pulse width modulation has been given in figure 3.3 is having a multi level modulation scheme for producing alternate levels, as a rule there are a few conceivable switching designs that can be chosen with a specific end goal to keep the capacitor voltages adjusted. In MMC of Fig. 3.3, the switching succession is controlled so that at every moment just N SMs (i.e. half of the 2N SMs of a stage leg) are in the on-state.

IV. SIMULATION RESULTS

Implementation and simulation of proposed system has done on Matlab Simulink. The simulation outcome of proposed work has given in figure 4.1, figure 4.2 and figure 4.3. From the analysis of simulation result it is clear that proposed work has better control as compared past existing work. Fig.4.1 shows the waveform of Dynamic Response (Real and Reactive Power) of the proposed System having voltage sag. Fig.4.2 shows waveform of the traditionally the control strategy applied to the grid-side converter consists mainly of two cascaded loops. Usually, there is a fast internal current loop, which regulates the grid current, and an external voltage loop, which controls the dc-link voltage. The current loop is responsible for power quality issues and current protection; thus, harmonic compensation and dynamics are the important properties of the current controller. The dc-link voltage controller is designed for balancing the power flow in the system. Usually, the design of this controller aims for system stability having slow dynamics Dynamic Response (Real and Reactive Power) of the System when Subject to Frequency Variations of Proposed System. Fig.4.3 shows the waveform of Dynamic Response (Real and Reactive Power) of the System due to Different Speed Controller parameters of Proposed System.

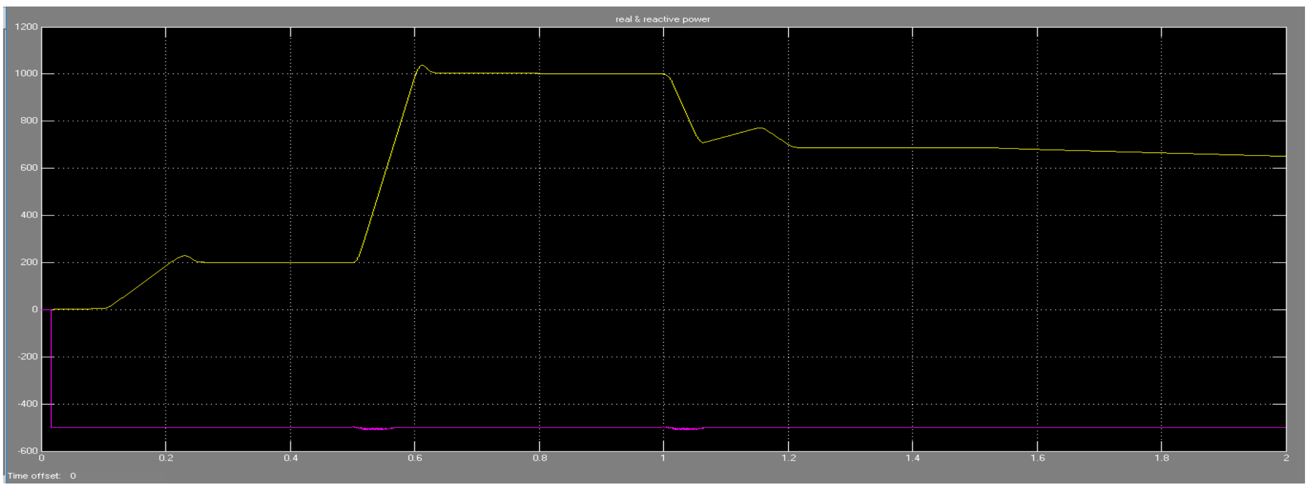

Fig.4.1 Dynamic Response (Real and Reactive Power) of the System when Subject to 90% Voltage Sag of Proposed System.

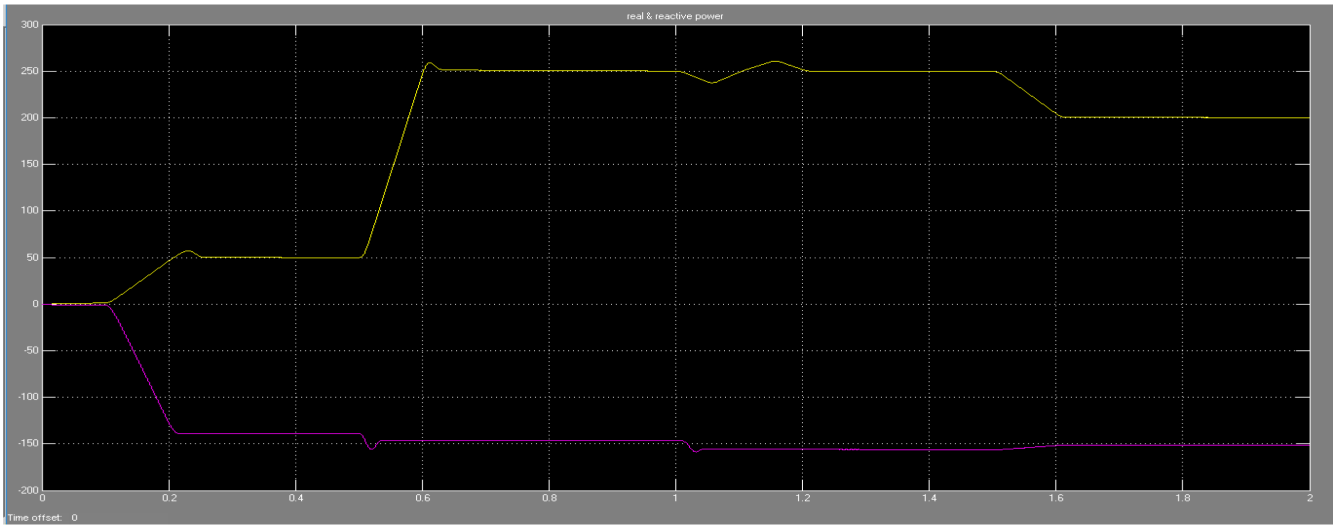

Fig.4.2 Dynamic Response (Real and Reactive Power) of the System when Subject to Frequency Variations of Proposed System.

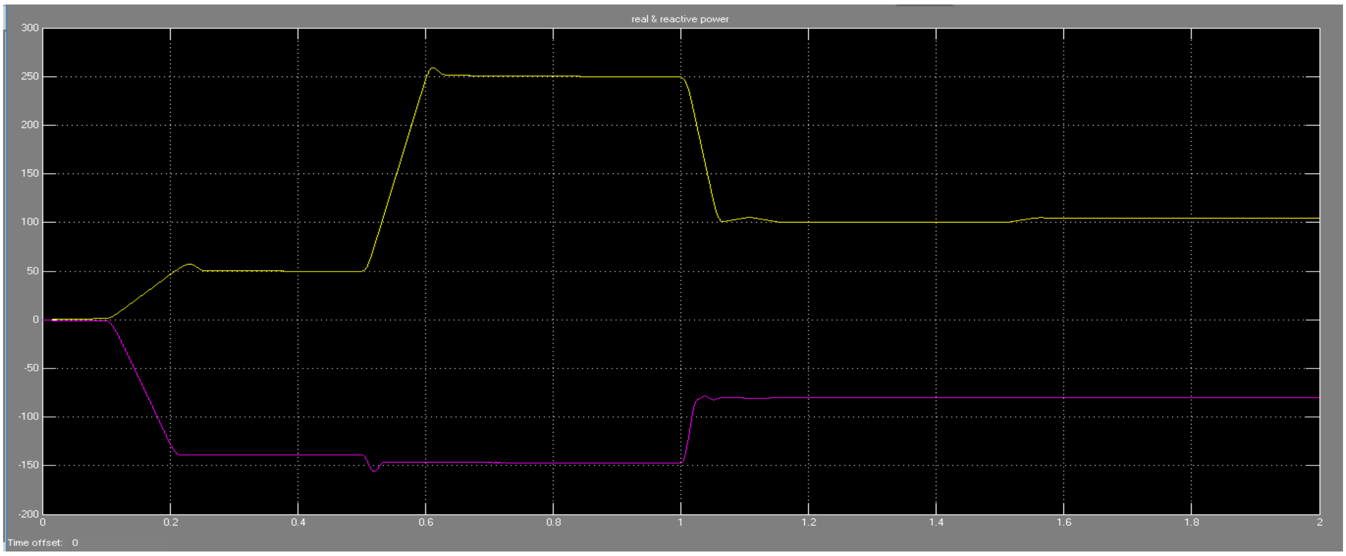

Fig.4.3 Dynamic Response (Real and Reactive Power) of the System due to Different Speed Controller parameters of Proposed System.

V. CONCLUSION AND FUTURE SCOPES

Solar energy has turned into a promising, prominent and elective source as a result of its favourable circumstances, for example, pollution free, sustainability and zero maintenance cost. The CMMI offers several interesting characteristics. Its modularity makes it highly scalable and enables it to meet conceptually any voltage level requirement. The high number of voltage levels yield superior performance, reducing or even eliminating the need for ac side filters. The performance of proposed system is evaluated on Matlab Simulink simulator. The cascaded modular multilevel inverters have been used to control active and reactive power. From the analysis of outcome waveform it is clear that proposed control strategy has better dynamic response compared to existing previous work. In future experimental set up will be developed to validate the effectiveness of the proposed controllers system and extended by connecting with the utility grid to exchange the power from PV source to grid and vice-versa.

REFERENCES

[1] X. Liang and J. He, "Load Model for Medium Voltage Cascaded H-Bridge Multi-Level Inverter Drive Systems," in IEEE Power and Energy Technology Systems Journal, vol. 3, no. 1, pp. 13-23, March 2016.

[2] A.K. Ranjan, D. V. Bhaskar and N. Parida, "Analysis and simulation of cascaded H-bridge multi level inverter using level-shift PWM technique," 2015 International Conference on Circuits, Power and Computing Technologies [ICCPCT-2015], Nagercoil, 2015, pp. 1-5.

[3] P. D. H. Darmawardana, T. D. Kahingala, K. M. C. G. Karunarathna, L. B. S. N. Kularatne and J. P. Karunadasa, "Nine level cascaded H Bridge Inverter (For High Performing UPS Applications)," 2015 Moratuwa Engineering Research Conference (MERCon), Moratuwa, 2015, pp. 76-81.

[4] S. Boobalan and R. Dhanasekaran, "Hybrid topology of asymmetric cascaded multilevel inverter with renewable energy sources," 2014 IEEE International Conference on Advanced Communications, Control and Computing Technologies, Ramanathapuram, 2014, pp. 1046-1051.

[5] N. L. H. Bang, N. V. Nho, N. K. T. Tam and N. M. Dung, "Simulation and experiment of hybrid modulation strategy with common-mode voltage reduction for seven-level hybrid cascaded inverter," 2014 International Conference and Utility Exhibition on Green Energy for Sustainable Development (ICUE), Pattaya, 2014, pp. 1-7.

[6] R. Deepak, V. S. Kasturi, L. Sarkar, Y. R. Manjunatha and B. R. Lakshmikantha, "Novel multilevel inverter with reduced number of switches and batteries," 2013 International conference on Circuits, Controls and Communications (CCUBE), Bengaluru, 2013, pp. 1-5.

[7] S. K. Chattopadhyay and C. Chakraborty, "Multilevel inverters with level doubling network: A new topological variation," IECON 2013 - 39th Annual Conference of the IEEE Industrial Electronics Society, Vienna, 2013, pp. 6263-6268.

[8] IEEE Task Force on Load Representation for Dynamic Performance, ‘‘Load representation for dynamic performance analysis [of power systems],’’ IEEE Trans. Power Syst., vol. 8, no. 2, pp. 472–482, May 1993.

[9] IEEE Task Force on Load Representation for Dynamic Performance, ‘‘Standard load models for power flow and dynamic performance simula- tion,’’ IEEE Trans. Power Syst., vol. 10, no. 3, pp. 1302–1313, Aug. 1995.

[10] A. Merdassi, L. Gerbaud, and S. Bacha, ‘‘A new automatic average mod- elling tool for power electronics systems,’’ in Proc. IEEE Power Electron. Specialists Conf. (PESC), Jun. 2008, pp. 3425–3431.

[11] J. Sun and H. Grotstollen, ‘‘Averaged modelling of switching power converters: Reformulation and theoretical basis,’’ in Proc. IEEE 23rd Annu. Power Electron. Specialists Conf. (PESC), vol. 2. Jun./Jul. 1992, pp. 1165–1172.

[12] S. Cuk and R. D. Middlebrook, ‘‘A general unified approach to modelling switching-converter power stages,’’ in Proc. IEEE Annu. Power Electron. Specialists Conf. (PESC), Jun. 1976, pp. 18–31.

[13] A. Griffo, J. B. Wang, and D. Howe, ‘‘State-space average modelling of 18-pulse diode rectifier,’’ in Proc. 3rd Int. Conf. Sci. Comput. Comput. Eng. (IC-SCCE), Jul. 2008, pp. 1–8.

[14] T. A. Meynard, M. Fadel, and N. Aouda, ‘‘Modeling of multilevel convert- ers,’’ IEEE Trans. Ind. Electron., vol. 44, no. 3, pp. 356–364, Jun. 1997.

[15] A. Uan-Zo-li, R. P. Burgos, F. Lacaux, F. Wang, and D. Boroyevich, ‘‘Assessment of multipulse converter average models for stability studies using a quasistationary small-signal technique,’’ in Proc. 4th Int. Power Electron. Motor Control Conf., vol. 3. Aug. 2004, pp. 1654–1658.

[16] S. Rosado, R. Burgos, F. Wang, and D. Boroyevich, ‘‘Large- and small- signal evaluation of average models for multi-pulse diode rectifiers,’’ in Proc. IEEE Workshops Comput. Power Electron. (COMPEL), Jul. 2006, pp. 89–94.