Power Quality Improvement in Three Phase Grid Connected PV System using Fuzzy Logic

Rishi Tiwari[1], Prof. Ranvijay Singh Senger[2]

[1]*Mtech Research Scholar,* [2]*Research Guide*

Department of Electrical Engineering, LNCT Bhopal

Abstract - Solar cells converts solar energy into electrical energy, these photovoltaic cells are basically electronic devices. Photo voltaic cells do not have the ability of storage capacity; however conservation can be performed utilizing batteries. The serious harmonic issue in Power electronic switching devices related to power system caused by nonlinear loads. Because of their inherent property of drawing harmonic current and reactive power from AC supply. They cause voltage unbalance and neutral currents issue in power system. With the distortion of current and voltage waveform because of essence of harmonic impact the power system equipment that are associated to maintain steady and reliable power flow in the power system. In proposed examination work implemented a control scheme in MATLAB SIMULINK which consists of four components: PI controller, moving average filter, fuzzy logic controller and repetitive controller. It is applied to MMC equipped with fuzzy controlled logic, which controls the harmonics by suppressing them up to a significant level. The proposed model is designed for three phase applications and the simulation results clearly define the effectiveness of the control mechanism. This project basically shows the comparison between previous reference method and proposed method which is helpful to reduce the distortion in power.

Keywords - MMC, Fuzzy Logic, Harmonic Suppression, Three phase, Repetitive Control, SIMULINK.

I. INTRODUCTION

Power quality is becoming a major issue in modern day power equipment because of the high usage of power electronic devices. The pollution in the equipment is mainly due to the nonlinear characteristics of the devices. They cause various problems like voltage distortion, current distortion, low power factor, interference in the nearby communication networks etc. in the form of harmonics. These harmonics are responsible for over-heating of equipment, noise or vibrations and may even cause damage. Due to the various problems caused due to the power quality issues, there is an urgent need for improving the power quality thereby reducing losses.

The demand for the electrical energy increasing every day, and the availability of fossil fuel sources declining day by day, this made us to think about alternative energy source solar energy. A lot of research is being going on this area, but still the effective utilization of solar energy is not happening. This thing motivates me to work on extract maximum power from the solar cell, and to connect the solar cell effectively to the grid, and to contribute my way of thoughts towards the power quality improvement of the system, when a solar cell is connected to the grid.

Photovoltaic (PV) cells converts' most abundant and freely available solar energy into electrical energy without causing any harm to the environment, where as in the case of thermal plants produces harmful gasses into the atmosphere

PV cells produce electricity without having any mechanical rotating part, thereby the losses with this type of generation are very less. The voltage generated by these solar cells is analogous to that of battery. The voltage and current ratings of the solar cell can be increased by connecting positive and negative leads of cell in series and parallel combination.

The commercial available circuit of the solar cell with the grid is shown as below. The circuit contains collection of PV cells known as PV module connected to dc grid. The dc available power is converted into ac power using inverter circuit. The available ac power will be fed to the loads available in its surroundings.

Solar cell can be modelled as current source (Iph) in parallel with Diode (D), Shunt resistance (Rsh) and series resistance (Rse).Current and voltage profile of the solar cell depends on Atmosphere temperature (T), and irradiance (S). The output power of Photo voltaic cell is given by P=V*I. The current produced by the PV cell is equal to the current produced by the current source minus the diode and shunt resistance current.

Harmonic pollution is mostly common in low voltage side due to wide use of nonlinear loads (UPS, SMPS, Rectifier etc.), which is undesirable as it cause serious voltage fluctuation and voltage dip in power system. So it required to eliminate undesirable current and voltage harmonics and to compensate the reactive power to improve the performance and operation of the power system. The use of traditional passive filter in removing harmonics is not that much effective because their static action and no real time action or dynamic action is taken for the removal of harmonics. But the shunt active power filter on the other hand gives promising results when compared with conventional active and passive filters.

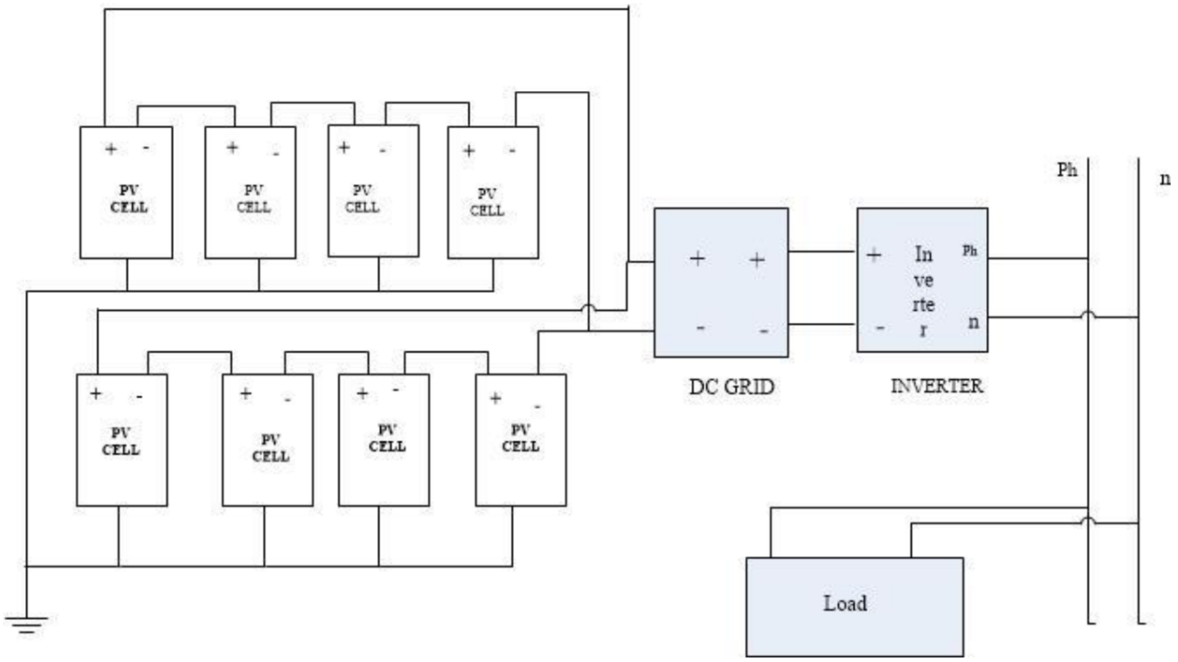


Fig. 1.1 Commercially available connection of the solar cell.

II. PROPOSED MODEL

In this examination power quality improvement in three phase grid connected PV system using fuzzy logic has proposed and a Simulink model has been implemented results are examined based on simulation of proposed model.

Brief Description of Simulink Blocks

Power GUI

The Powergui block is compulsory for simulation of any Simulink model, since it gives the information for the type of signal used. It is used to allow discretization of signals, store the equivalent Simulink circuit in the form of the state-space equations of the model, providing phasor solution, variable SIMULINK solver etc.

Scope

The scope blocks of real-time category come in 3 types: Target, File and Host. The block dialog box changes depending on the setting for parameter. The block dialog box by default, displays the parameters for Target scopes.

Fuzzy Logic Controller

To implement the fuzzy inference system (FIS) as described initially, we use fuzzy logic controller.

PI Controller

Proportional Integral contains the control functionality of PI output power equals to the sum of proportion and integration coefficients. The higher the proportion coefficient, the less the output power at the same control error. The higher the integration coefficient, the slower the accumulated integration coefficient. PI control provides zero control error and is insensitive to interference of the measurement channel.

Subsystem

The subsystem block represents a specific set of blocks contained in a specified library of blocks. The block's context menu lets you choose which block the subsystem represents.

Derivative

This block takes the derivative of its input by computing the differential du/dt, the change in input value is represented by du and the change in time is represented by dt, since the previous simulation time step. The initial output for the block is zero and it takes one input and generates one output.

PWM Generator

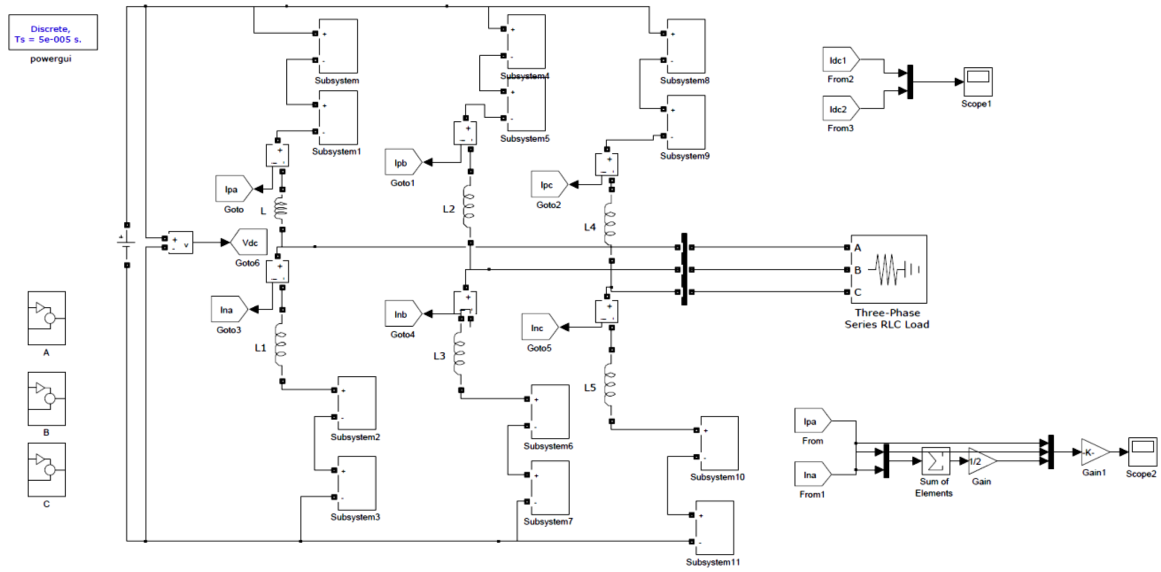
This block generates pulses for carrier based PWM; self commutated IGBT, FET or MOSFET bridges. In "generator mode" option, depending on the quantity of bridge arms selected, the block can be used either for 1-phase or 3-phase PWM control.

Repetitive Control

Repetitive control (RC) is another method that is widely used to control power converters, An RCS contains an internal model of a periodic signal with a period of L. Regarding the periodicity of harmonic distortions, repetitive-control-based methods provide better results than conventional ones because they suppress harmonic distortions simultaneously.

The control signal is often generated by a controller that is explicitly described by a transfer-function with appropriate coefficients. If there are a number of frequencies contained in the exogenous signal, the repetitive control system will contain all periodic modes, and the number of these is proportional to the period and inversely proportional to the sampling in¬terval. It can result in a very high order control system, especially under fast sampling, which could then lead to numerical sensitivity, noise amplification, sensitivity to modeling errors and other undesirable problems in a practical application.

Fig. 2.1 Proposed Model



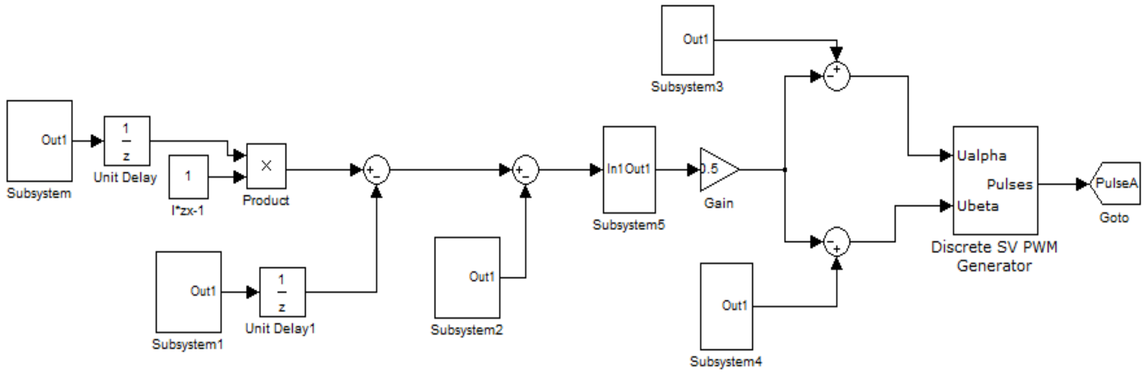


Fig. 2.2 Case A: PI Controller with Proposed Fuzzy Logic Controller

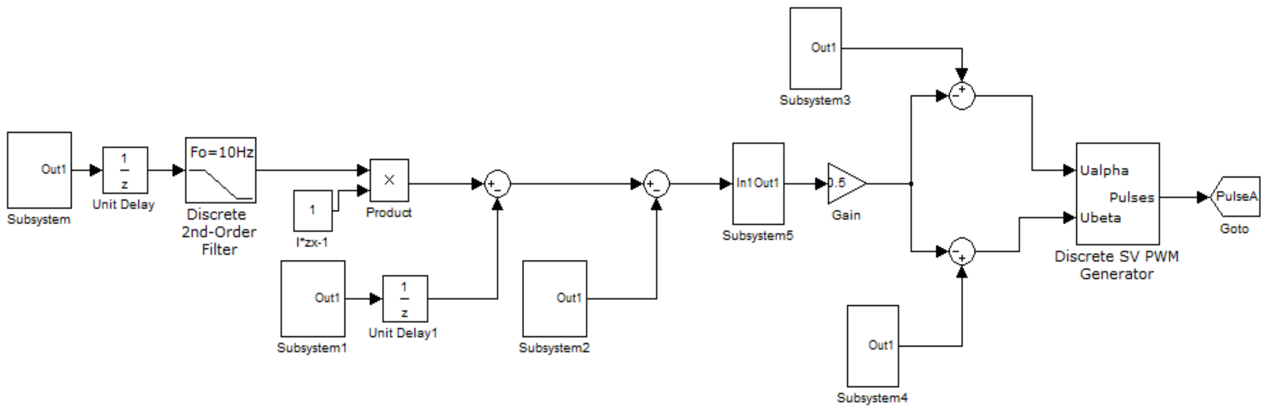


Fig. 2.3 Case B: PI Controller, Moving Average Filter with Proposed Fuzzy Logic Controller

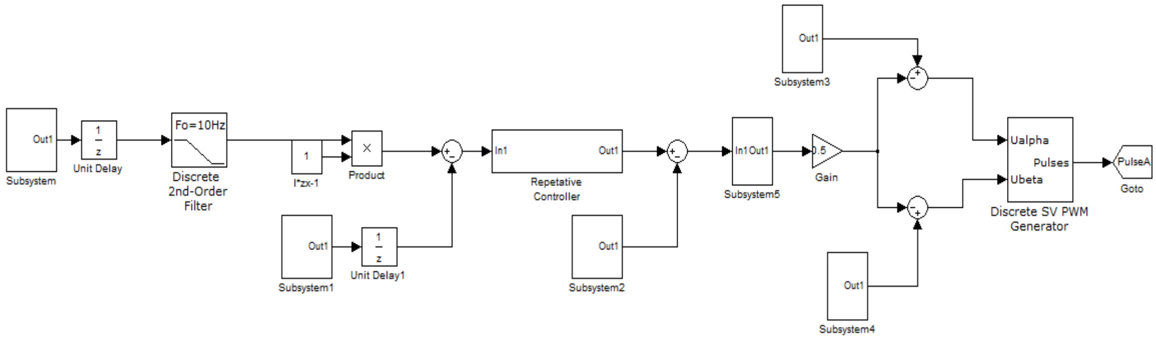


Fig. 2.4 Case C: PI Controller, Moving Average Filter Followed By Repetitive Controller with Proposed Fuzzy Logic Controller

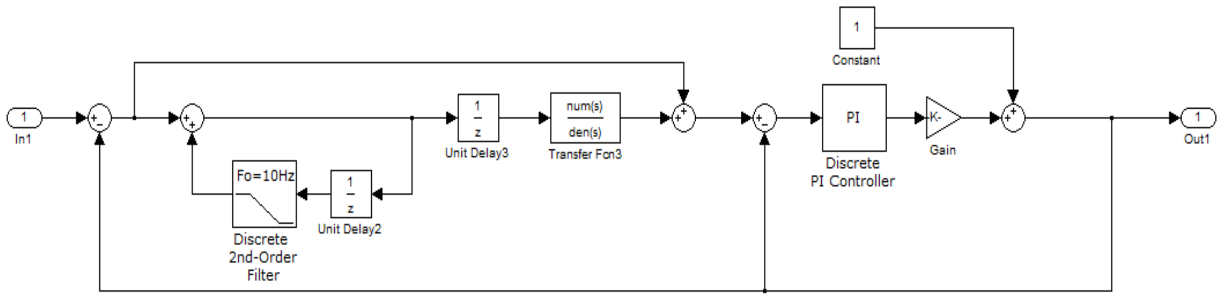


Fig. 2.5 Repetitive Controller

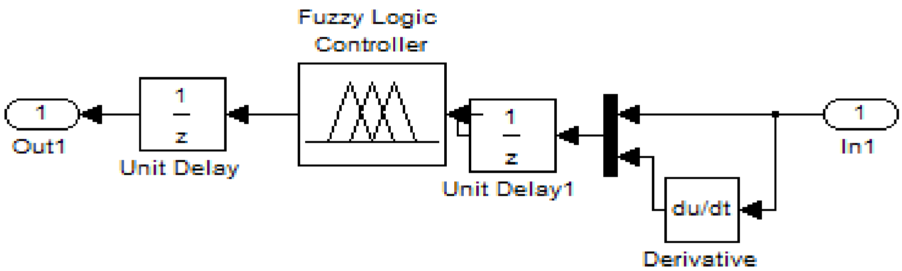


Fig. 5.6 Fuzzy Logic Controller

III. SIMULATION OUTCOMES

This section gives the simulation results in MATLAB about the work that has been done. It gives the results about the photovoltaic cell characteristics, and the dependence of the results on the atmosphere conditions like temperature and irradiation. It describes about the results relating to linear and nonlinear loads after applying reactive power compensation to the inverter and gives the results about the total harmonic results level.

The comparative analysis between proposed system using PI controller repetitive controller and fuzzy logic controller system with power filter. The simulation outcomes of proposed system are visualized on MATLAB scope and examined based on various test experiment.

As shown in Fig. 3.1 simulation waveforms of case A: PI controller with proposed fuzzy logic controller.

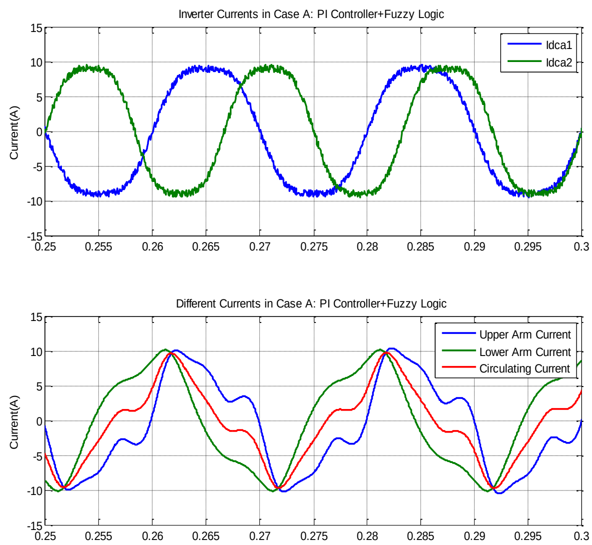


Fig. 3.1 Simulation Waveforms of Case A: PI Controller with Proposed Fuzzy Logic Controller.

In Fig. 3.1 two inverter current waweform idca1 and idca2 are taken in case A PI cotroller and fuzzy logic controller and its curreponding characteristics for different current uper arm lower arm and circulating currents are shown.

Simulation waveform of Case B: PI controller, moving average filter with proposed fuzzy logic controller are shown in Fig 3.2. For inverter current in case C: Pi ctronller MAF and fuzzy logic controller.

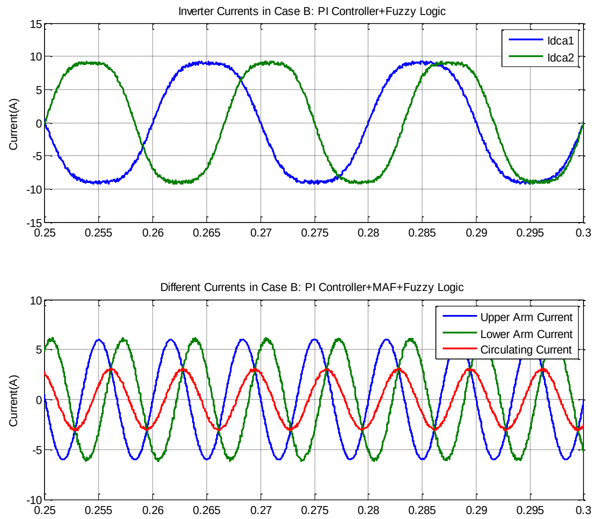


Fig. 3.2 Simulation Waveforms of Case B: PI Controller, Moving Average Filter with Proposed Fuzzy Logic controller.

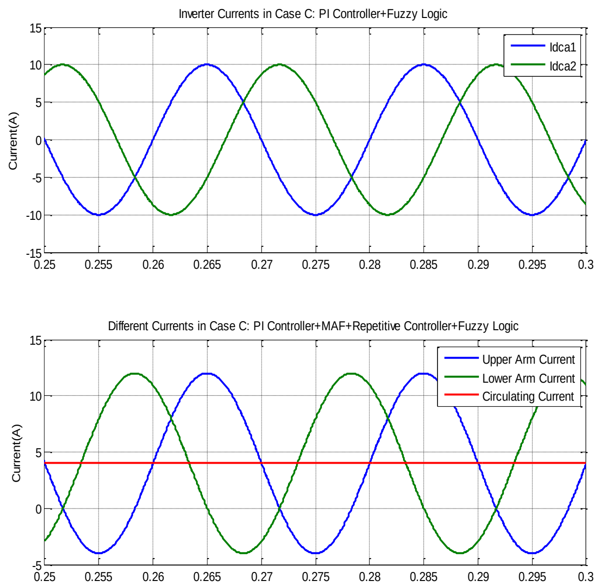


Fig. 3.3 Simulation Waveforms of Case C: PI Controller, Moving Average Filter followed by Repetitive Controller with Proposed Fuzzy Logic Controller.

Simulation waveform of case C: PI controller with moving average filter followed by repetitive controller has shown in Fig. 3.3 where inverter current n case C is taken and its corresponding different current in case B: PI controller and MAF along with fuzzy logic have shown for upper arm current lower arm current and circulating current .

IV. CONCLUSION AND FUTURE SCOPE

In this examination a power quality improvement in three phase grid connected PV system has been proposed using fuzzy logic and repetitive controller RC. With the application of the proposed repetitive controller, the circulating current waveform which was previously having different higher order frequency components or harmonics due to which its magnitude was higher has now been suppressed. This examination work gives the simulation of Photovoltaic cell with various methods like direct simulation; MATLAB tool box and the results are compared for these methods. Due to the harmonics suppression of this scheme, the reduced magnitude of the circulating currents will result into overall reduction in losses. The fuzzy logic which is itself a very flexible technique, simulates all the parameters and their constraints in an efficient way and helps the simulation process to be carried out in a much simpler manner. The proposed scheme can be utilized with advanced controllers in which some of them are still in research phase for the purpose of harmonics suppression. The characteristics of photovoltaic cells can be improved using different topologies; reactive power theory can be extended to the nonlinear loads also. Fuzzy logic controller schemes can be applied for the power quality improvement. Also in future it is a scope to find a better way than proposed control method to eliminate harmonics in power utility system with maintaining reliability and stability of the system by using PWM based current controller.

REFERENCES

[1] L. He, K. Zhang, J. Xiong and S. Fan, "A Repetitive Control Scheme for Harmonic Suppression of Circulating Current in Modular Multilevel Converters," in IEEE Transactions on Power Electronics, vol. 30, no. 1, pp. 471-481, Jan. 2015.).

[2] M. Zhang, L. Huang, W. Yao and Z. Lu, "Circulating Harmonic Current Elimination of a CPS-PWM-Based Modular Multilevel Converter With a Plug-In Repetitive Controller," in IEEE Transactions on Power Electronics, vol. 29, no. 4, pp. 2083-2097, April 2014.

[3] Q. Song, W. Liu, X. Li, H. Rao, S. Xu and L. Li, "A Steady-State Analysis Method for a Modular Multilevel Converter," in IEEE Transactions on Power Electronics, vol. 28, no. 8, pp. 3702-3713, Aug. 2013.

[4] Y. Cho and J. S. Lai, "Digital Plug-In Repetitive Controller for Single-Phase Bridgeless PFC Converters," in IEEE Transactions on Power Electronics, vol. 28, no. 1, pp. 165-175, Jan. 2013.

[5] K. Ilves, A. Antonopoulos, S. Norrga and H. P. Nee, "Steady-State Analysis of Interaction Between Harmonic Components of Arm and Line Quantities of Modular Multilevel Converters," in IEEE Transactions on Power Electronics, vol. 27, no. 1, pp. 57-68, Jan. 2012.

[6] K. Ilves, A. Antonopoulos, L. Harnefors, S. Norrga and H. P. Nee, "Circulating current control in modular multilevel converters with fundamental switching frequency," Proceedings of The 7th International Power Electronics and Motion Control Conference, Harbin, 2012, pp. 249-256.

[7] S. Kouro, M. Malinowski, K. Gopakumar, J. Pou, L. G. Franquelo, B. Wu, J. Rodriguez, M. A. Perez, and J. I. Leon, "Recent advances and industrial applications of multilevel converters," IEEE Trans. Ind. Electron., vol. 57, no. 8, pp. 2553-2580, Aug. 2010.

[8] A. Lesnicar and R. Marquardt, "An innovative modular multilevel converter topology suitable for a wide power range," in Proc. IEEE Power Tech Conf., 2003, pp. 1-3.

[9] M. Glinkaand R. Marquardt, "AnewAC/AC multilevel converterfamily," IEEE Trans. Ind. Electron., vol. 52, no. 3, pp. 662-669, Jun. 2005.

[10] H. Akagi, "Classification, terminology, and application of the modular multilevel cascade converter (MMCC)," IEEE Trans. Power Electron., vol. 26, no. 11, pp. 3119-3130, Nov. 2011.

[11] A. Antonopoulos, L. Angquist, and H.-P. Nee, "On dynamics and voltage control of the modular multilevel converter," in Proc. Eur. Conf. Power Electron. Appl., Barcelona, Spain, Sep. 8-10, 2009, pp. 1-10.

[12] L. Angquist, A. Antonopoulos, D. Siemaszko, K. Ilves, M. Vasiladiotis, and H.Nee, "Inner control of modular multilevel converters—An approach using open-loop estimation of stored energy," in Proc. Int. Power Eng. Conf., Sapporo, Japan, Jun. 21-24, 2010, pp. 1579-1585.

[13] Q. Tu, Z. Xu, and L. Xu, "Reduced switching-frequency modulation and circulating current suppression for modular multilevel PWM Converters," IEEE Trans. PowerDel., vol. 26, no. 3, pp. 2009-2017, Jul. 2011.

[14] X. She and A. Huang, "Circulating current control of double-star choppercell modular multilevel converter for HVDC system," in Proc. Annu. Conf. IEEE Ind. Electron. Society, ETS Montreal, QC, Canada, Oct. 25-28, 2012, pp. 1234-1239.