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Review on Power Quality Improvements in Grid-Connected PV System Using Hybrid Technology with MMC

Reena Tiwari[1] and Dr. Shweta Chourasia[2]

M.Tech Student, Department of Electrical and Electronics Engineering[1]

Associate Professor Department of Electrical and Electronics Engineering[2]

Bhopal Institute of Science and Technology, Bhopal, Madhya Pradesh, India

Abstract: *In recent trends, photo-voltaic (PV) is mostly build upon competitive technological development of power quality (PQ) issues. In this article, a hybrid control strategy is implemented with multi-level inverter (MLI) to improve PQ features. As a result, the combination of these controllers with suitable level of MLI could improve the PQ features in a significant way the demand for electricity is raising in the country with an increase in population. To meet the peak load demands renewable energy sources like solar and wind can be used along with conventional sources. Compared to wind power generation the installation cost and the production cost are less in the Photo-Voltaic (PV) energy generation. But due to the widespread use of nonlinear electronic equipment's, the power quality issues are more in grid connected PV systems Solar PV is now, after hydro and wind power, the third most important renewable energy source in terms of globally installed capacity. More than 100 countries use solar PV. Installations may be ground-mounted (and sometimes integrated with farming and grazing) or built into the roof or walls of a building (either building integrated with photovoltaics or simply rooftop).*

Keywords: Fuzzy Logic Controller, Total Harmonic Distortion, Multi-level inverter (MLI), Maximum Power Point Tracking, Power quality (PQ), Hybrid control, Electrical micro grids (MGs).

I. INTRODUCTION

Nowadays, Technologies in RES have got more opportunities for promoting PV for generating electric power. At present, the counting of renewable source of energy and its sizes are extending to growing rapidly, correspondingly with the influence of power system the electrical grids are steadily developing because of its stable technical confrontation it would have to meet; the involvement of distributive generation, renewable source of energy, power flow with bidirectional, etc. Photovoltaic's (PV) is a method of generating electrical power by converting sunlight into direct current electricity using semiconducting materials that exhibit the photovoltaic effect. A photovoltaic system employs solar panels composed of a number of solar cells to supply usable solar power. Power generation from solar PV has long been seen as a clean sustainable energy technology which draws upon the planets most plentiful and widely distributed renewable energy source – the sun. The direct conversion of sunlight to electricity occurs without any moving parts or environmental emissions during operation. Due to increased automation, now we all have become heavily dependent on electrical energy. Surely, we all have to look for the alternate sources of energy as the fossil fuels are diminishing with the time and sometimes conventional energy sources are not capable to meet the peak load requirement. Due to limitations of fossil fuels and environmental issues, it is necessary to pay attention towards non-conventional energy sources. Many research efforts have been made and still going on in the field of nonconventional energy sources. Renewable energy source in solar form is the most imperative sustainable energy source as it is the endless source of energy. In this paper solar PV module has been modeled using MATLAB with MPPT controller and VSC Controller with constant and variable irradiation level and reference cited therein Several Investigations on MPPT methods and their comparison have been carried out with grid integration also In this paper, an attempt has been made to achieve MPPT using P&O algorithm, DC bus voltage control.

II. THE REVOLUTION IN VSC TECHNOLOGY

The Insulated Gate Bipolar Transistor (IGBT) was introduced as the main building block of the HVDC converter valves in the late 1990s. In contrast with thyristors, the IGBT is capable of "turning-off" whenever it is required to do so, independently of the AC voltage of the system. This seemingly small difference has completely revolutionized the world of HVDC, announcing the start of a new era in HVDC technology Furthermore, the IGBT required a complete change in the way that HVDC stations were designed and controlled, as the implementation of a Voltage Source Converter (VSC) HVDC station was now possible. As the devices are "self-commutating" they do not need a strong AC grid offering the possibility of black-start capability. Moreover, VSCs may switch at higher frequencies (1-2 kHz).

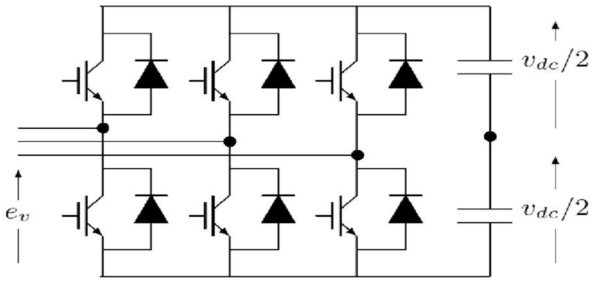

Fig. 1. A 2- Level VSC Topology

This implies lower space requirements compared to LCCs, as smaller filters are now required to mitigate significantly smaller high-frequency harmonic in addition, the VSC has the inherent capability to control active and reactive power adding an important degree of flexibility in power systems.

III. OBJECTIVE

The aim of this proposed research work is to design an effective methodology for the power electronic device with the consideration of PQ improvement. The objectives of this research are listed below.

- To satisfy the load demand of the grid, an efficient control strategy should be developed with PV source. Optimization algorithm is utilized for providing the adequate switching pulse to the multi-level inverter to provide essential power to micro grid.
- The PQ of the device is improved to create an effective power electronic device for the end users. By providing the adequate power to the grid side, there is certainly no probability of PQ problems.
- To maintain the constant voltage magnitude under system disturbances, the control strategy is used in the desired system to avoid PQ problems.

IV. LITERATURE REVIEW

He, K. Zhang, J. Xiong and S. Fan In typical multilevel converter (MMC), the cooperation between switching activities and fluctuating capacitor voltages of the sub modules brings about second-and other even-order harmonics in the circling streams.

M. Zhang, L. Huang, W. Yao and Z. Lu, An improved, circling, current control procedure by applying an automated module dismal controller is discussed for harmonic transfer of a carrier arrange move beat width-change (CPS-PWM)-based specific multilevel converter (MMC) in this work.

Wu, X. Xu, Y. Liu and D. Xu, This work presents The major frequency segment in the arm current of a modular multilevel converter is a need for the operation of the converter, similar to the association and bypassing of the sub modules. Unavoidably, this will bring about rotating segments in the capacitor voltages.

Fan, K. Zhang, J. Xiong and Y. Xue, Measured multilevel converter winds up recognizably a champion among the most promising high power converters in light of their specific structure design, dispersed dc capacitors, upgraded power quality, and the same dc voltage sources required. Nevertheless, capacitor voltage modifying remains one important test.

Y. Cho and J. S. Lai This exploration researches a module redundant control conspire for bridgeless power factor calculate redress (PFC) converters to alleviate input current and flow distortions under consistent conduction mode and irregular conduction mode working conditions.

K. Ilves, A. Antonopoulos, S. Norrga and H. P. Nee The key recurrence part in the arm streams of a measured multilevel converter is a need for the operation of the converter, similar to the association and bypassing of the sub modules. Unavoidably, this will bring about rotating parts in the capacitor voltages

Calais M, Agelidis VG The design and control issues associated with the development of a 1.8 kW prototype single-phase grid-connected photovoltaic system incorporating a multilevel cascaded inverter are discussed in this paper.

V. THE BASIC CONTROL DIAGRAMS

The closed loop current control system for VSC can be simply represented by Figure 2. iA (iB, ic) is measured for instantaneous output AC current of VSC; iAc (iBc, icc) is reference phase current. The functions of current controllers are to force the phase currents follow the references and generate the gate states SA (SB, Sc), which can decrease the current error $\varepsilon_A(\varepsilon_B\varepsilon_C)$. Thus, current controller actually has two functions: error compensation (reducing$\varepsilon_A, \varepsilon_B\varepsilon_C$) and modulation (generating gate states).

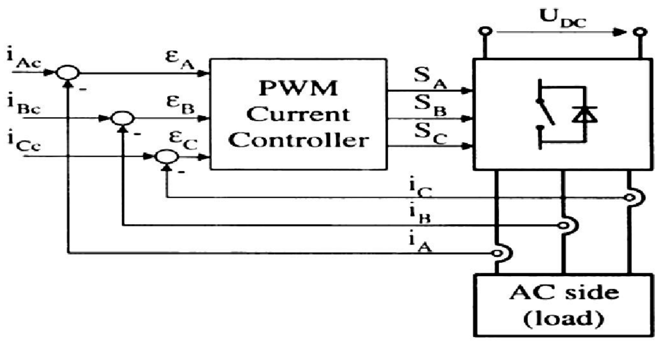

Fig. 2. Current Control System for VSC.

According to the current control systems can be ordered into two fundamental gatherings, linear and nonlinear controllers. By and large, straight controllers isolate the error compensation and voltage adjustment parts; the modulation part uses conventional voltage modulators. While nonlinear controllers do not need modulation part as linear current control algorithms includes: PI stationary and synchronous control, resonant control, state feedback control and deadbeat control. While model predictive control and hysteresis control belongs to non-linear control. and in neural networks and fuzzy logic controllers are classified into nonlinear current control even though they have modulation part, may because the inherent nonlinearity of the control algorithm.

VI. PROPOSED MODELS

The proposed model for the power controller system modular multilevel converter there are number of subsystems are used as demonstrated in figure are subsystem, subsysyem1 subsystem2 and so on subsystem 11 cascaded subsystems are act as level for modular converter connected with number of inductor coils are L, L1 and so forth up

to L5 and a series RLC three phase load is connected with the proposed model in figure 4.1 where A, B, C are three phases of the power supply.

Figure 4.2 illustrated case A of proposed work having PI controller with fuzzy logic control controller function of the fuzzy logic controller has already discussed. a fuzzy controller is a powerful tool used in a Matlab Simulink.

Fuzzy control has emerged one of the most active and fruitful areas of research especially in industrial processes which do not rely upon the conventional methods because of lack of quantitative data regarding the input and output relations. Fuzzy control is based on fuzzy logic, a logical system which is much closer to human thinking and natural language than traditional logical systems Fuzzy logic controller (FLC) based on fuzzy logic provides a means of converting a linguistic control strategy based on expert knowledge into an automatic control strategy.

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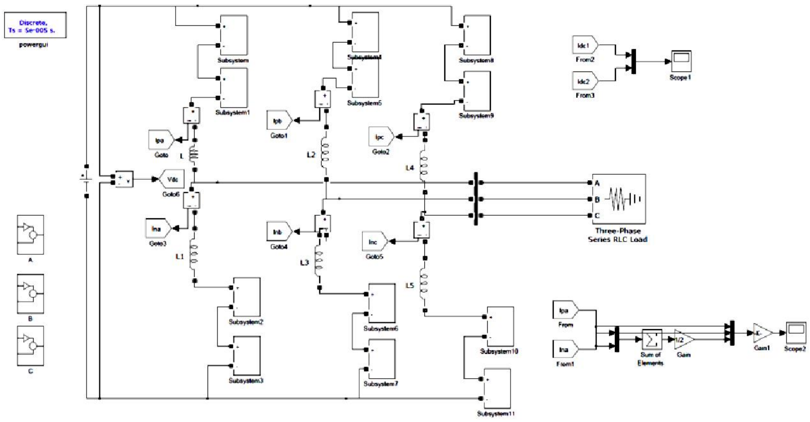

Fig. 3 Proposed Models

VII. MODULAR MULTILEVEL CONVERTER

Voltage sourced converters can build up a three-phase AC voltage via a DC-voltage. It uses semiconductors such as IBGTs with turn-off capabilities in order to control the DC-voltage into a sinusoidal behavior, The most common types are two or three level technologies, with two and three voltage levels respectively. The IGBT switching scheme ensures a sinusoidal average output, the voltage steps are steep, thus creating an extensive filtering need, the multilevel converter output in figure 4(c) shows how small increments build a sinusoidal output without similar filtering needs.

MMC is a multilevel converter topology introduced by A. Legnica and R. Marquardt Presents some of the advantageous features of an MMC Modular Realization a converter built up by modules can easily be scaled to different voltage- and power levels multilevel waveform the converter can be expanded to any number of voltage steps. A high number of voltage steps reduce the harmonic distortions. High availability the use of well-known components together with the possibility for redundancy minimizes the downtime.

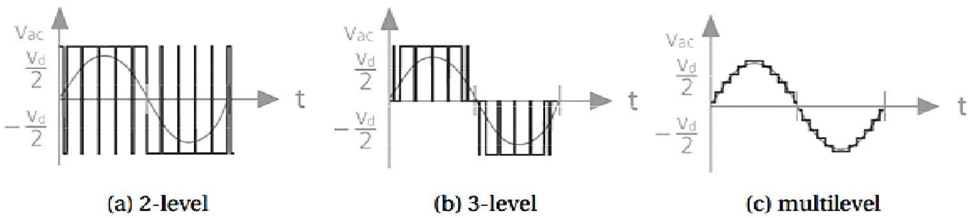

Fig . 4 VSC Output Voltages.

Failure management the converter can continue to operate, even though some of components experience failure.

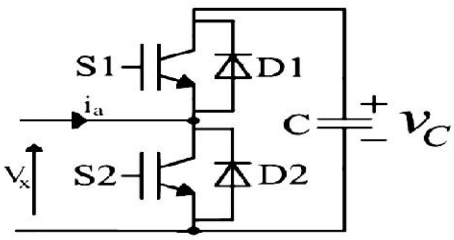

Fig. 5 The half-bridge sub module

The half-bridge sub module in figure 5 has several control states, dependent of the different switching states and the direction of the current through the sub module. In Table.1 shows the different control states. When IGBT S1 is switched on and S2 is switched off, the voltage, v_c of the capacitor, C, is applied to the sub module terminals. A positive current, i_s, will charge the capacitor, while a negative i_a will discharge the capacitor. When S1 is turned off and S2 is turned on, the capacitor, C, is bypassed, making sure the terminal voltage, Vx is zero.

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Table.1 Sub modules states

State	S1	S2	i_a	V_x	$\frac{dVc}{dt}$
1	on	off	>0	v_c	>0
2	on	off	<0	v_c	<0
3	off	on	>0	0	0
4	off	on	<0	0	0

MLIs have been extensively employed to improve the PQ of the PV systems. However, the need for large number of components, higher standing voltage, and high harmonic content in the output of a conventional MLI greatly affects the system efficiency. Here, in this research, a hybrid control strategy (for example; hybrid neural network with whale optimization algorithm, hybrid shuffled frog leap Algorithm with ant lion optimizer, or glow-worm swarm optimization with rule based techniques) is considered, with suitable level of inverter (5 level, 15 level, or 27 level with less number of switches) to reduce the PQ issues present in the system. The hybrid control strategy will be applied to determine the optimum switching angles for the MLI which will reduce the complexity of the calculations. The PQ problems are occurred, when the source cannot send the essential power to the grid. So, the proposed method is exploited to provide the proper switching pulse to the multi-level converter. The switching pulse from the optimization algorithm is mainly based on the load demand of the grid. Then the multi-level converter provides the required power to the grid for eliminating the PQ problems.

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