International Journal of Engineering Applied Science and Management
ISSN (Online): 2582-6948
Vol. 2 Issue 6, March 2021

NPC Inverter for Power Quality Resources in Grid System: A Review

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Abstract: *This paper presents a multi-objective control scheme based on the dynamic model of three-level, neutral-point-clamped voltage source inverter for integration of distributed generation (DG) resources based on renewable energy resources to the distribution grid. The proposed model has been derived from the abc/αβ and αβ/dq transformation of the AC system variables. The proposed control technique generates the compensation current references and by setting appropriate references of DG control loop, the DG link not only provides active and reactive currents in fundamental frequency, but also it can supply nonlinear load harmonic currents with a fast dynamic response and mathematical analysis have achieved a reduced total harmonic distortion, increased power factor, inject maximum power of renewable energy resources via a multilevel converter as an interface to the AC grid. It also compensated the active and reactive powers of linear and nonlinear loads. The analyses and simulation results show the high performance of proposed control scheme in the integration of renewable energy resources to the AC grid.*

Keywords: *Inverter, Renewable energy resources, AC grid, Distributed generation, Power quality.*

1. Introduction

Multilevel Inverter has the later years been looked upon as a good choice for medium- and high-voltage applications. It was first presented in before the introduction of multilevel inverter the traditional solution has been to connect semiconductors in series to with stand the high voltages. This requires fast switching to[1] avoid unequal voltage sharing between the devices, which could lead to a breakdown. Multilevel inverters have the advantage of clamping the voltages, which prevents the need of fast switching. MLC also have a smoother output voltage than traditional three-level inverters. As different sources like power input, wind turbines are increasing in power ratings, multilevel inverters can be well suited in such applications. The most popular multilevel inverter and the one that will be studied in this report is the neutral point clamped three-level inverter. One of the challenges with the NPC three-level inverter is the increased complexity in the control of it. A lot of research have been done on this inverter topology and a numerous of control have been presented in the literature. Still there is a focus of how to solve the voltage fluctuation between the two capacitors and most of the research to day is to improve the DC-bus balance. The focus in this master thesis will be to continue the work from DC-bus balancing, in over modulation, development in sim model are the most central topics. There will also be a comparison of asymmetrical and symmetrical modulation. DC-bus balancing was studied in detail in the previous project and in this master The reason for studying the currents is to see if exist any difference which could increase the stresses on the capacitors and conductors. One of the goals of the thesis was to verify that SIMULINK.

2. Related Work

Modeling and Control of Multi-Level Inverter for Three-Phase Grid-Connected Photovoltaic, In this paper deals with the multilevel converters control strategy for photovoltaic system integrated in distribution grids. The proposed control scheme ensures the injection of the generated power in the distribution grid with fast dynamic response, while providing an additional active power filtering capability providing the required harmonic and reactive currents to be considered. The control scheme is validated by means of simulations with a cascade converter which interfaces to a distribution grid. Also, for DC link voltage control, it is needed that stabilizes the voltage at the inverter input to insure a continuous flow of energy exchange between the grid and the PV system. Also, a LC filter is necessary to filter the output current and voltage from the harmonics and to protect the grid from their destructive effect.

Tracking of MPP for three-level neutral point clamped qZ-source off-grid inverter in solar applications, In this paper analyzes the most popular maximum power point tracking algorithms for an off-grid photovoltaic system based on three-level neutral-point-clamped quasi-z-source inverter topology to transfer the maximum power to the loads or storage systems. Classical methods, such as dP/dV feedback, perturb and observe method and incremental conductance, have been adapted for this novel topology and tested by simulation in Sim PowerSystem from Matlab/Simulink. All of them use the shoot-through duty cycle as a control variable in dynamic conditions of irradiance to generate the reference shoot-through duty cycle in the modulation technique. In the studied case the power converter is feeding a pure resistive load in all the methods compared. Finally, the dP/dV method has been implemented in the control system of an experimental prototype and verified in a real photovoltaic system.

VSC-Based HVDC Power Transmission Systems An Overview, In this paper ever increasing progress of high-voltage high power fully controlled semiconductor technology continues to have a significant impact on the development of advanced power electronic apparatus used to support optimized operations and efficient Management of electrical grids, which, in many cases, are fully or partially deregulated networks. Developments advance both the HVdc power transmission and the flexible ac transmission system technologies. In this paper, an overview of the recent advances in the area of voltage-source converter (VSC) HVdc technology is provided. Selected key multilevel converter topologies are presented. Control and modeling methods are discussed. A list of VSC-based HVdc installations worldwide is included. It is confirmed that the continuous development of power electronics presents cost-effective opportunities for the utilities to exploit, and HVdc remains a key technology. In particular, VSC-HVdc can address not only conventional network issues such as bulk power transmission, asynchronous network interconnections, back-to-back ac system linking, and voltage/stability support to mention a few, but also niche markets such as the integration of large-scale renewable energy sources with the grid and most recently large onshore/offshore wind farms.

Grid Integration of Renewable Energy Source Using Single-Phase Bidirectional Multilevel Inverter DG Applications, In this paper power electronics and emergence of new multilevel converter topologies, it is possible to work at voltage levels beyond the classic semiconductor limits, so multi-level inverters have been widely used for high-power high-voltage DG applications. Due to higher number of sources, lower EMI, lower % THD in output voltage and less stress on insulation, they are widely used. This work is focused on integration and operation of a single-phase bidirectional multilevel inverter with two buck/boost maximum power point trackers (MPPTs) for distributed generation applications. In a DG system, a bidirectional 5-level multilevel inverter is required to control the power flow between dc bus and ac grid, and to regulate the dc bus to a certain range of voltages. A droop regulation mechanism according to the inverter inductor current levels to reduce capacitor size, balance power flow, and accommodate load variation is proposed. Since the photovoltaic (PV) array voltage can vary from 0 to 600 V, especially with thin-film PV panels, the MPPT topology is formed with buck and boost converters to operate at the dc-bus voltage around 380 V, reducing the voltage stress of its followed multilevel inverter.

Modeling, simulation and control of three-phase three level multilevel inverter for grid connected photovoltaic system, In this paper presents a control for a three phase three-level neutral point clamped inverter (NPC) for grid connected photovoltaic (PV) system. The maximum power point tracking (MPPT) is capable of extracting maximum power from the photovoltaic (PV) array connected to each DC link voltage level. The MPPT algorithm is solved by Perturb &Observe method. The MPPT system is integrated with the DC-link controller so that a DC–DC converter is not needed and the output shows accurate and fast response. Synchronous Reference Frame (dq) Control Strategy is used for grid-connected PV system so that PI controllers are used to control easily DC-link voltage, active and reactive currents.

Modeling and Simulation of Five-level Five-phase Voltage Source Inverter for Photovoltaic Systems, In this paper presents a space vector pulse width modulation (SVPWM) control for a five-level five-phase cascaded H-bridge multilevel inverter (CHMLI) for photovoltaic (PV) systems. The maximum power point tracking (MPPT) is solved by fuzzy logic controller (FLC) and it is capable of extracting maximum power from PV array connected to each DC link voltage level. The fuzzy MPPT is integrated with the inverter so that a DC-DC converter is not needed and the output shows accurate and fast response. This is done to achieve high dynamic performance with low total harmonic distortion (THD). The simulation results are compared with sinusoidal pulse width modulation (SPWM) controlled CHMLI and diode clamped multilevel inverter (DCMLI) in terms of THD. Wind and solar hybrid system can be designed with the help of these global weather patterns, for any location all over the world. Deciding on the best feasible solution will need to be done, on a site-to-site basis. Some sites can be best serviced by mains or grid power, others by generators, and some by Various hybrid energy systems have been installed in many countries over the last decade, resulting in the development of systems that can compete with conventional, fuel based remote area power supplies [2] in many applications. Research has focused on the performance analysis of demonstration systems and High-voltage dc cables between the PV modules and the inverter, power losses due to a centralized MPPT, mismatch losses between the PV modules, losses in the string diodes, and a nonflexible design where the benefits of mass production could not be reached. The grid-con The present technology consists of the string inverters and the ac module . The string inverter, version of the centralized inverter, where a single string of PV modules is connected to the inverter [7]. The input voltage may be high enough to avoid voltage amplification. This requires roughly 16 PV modules in series for European systems. The total open-circuit voltage for 16 PV modules may reach as much as 720 V, which calls for a 1000-V MOSFET/IGBT in order to allow for a 75% voltage de-rating of the semiconductors. The normal operation voltage is, however, as low as 450 510 V. The possibility of using fewer PV modules in series also exists, if a dc–dc converter or line-frequency transformer is used for voltage amplification. There are no losses associated with string diodes and separate MPPTs can be applied to each string. This increases the overall efficiency compared to the centralized inverter, and reduces the price, due to mass production. [6] The ac module depicted in(d) is the integration of the inverter and PV module into one electrical device It removes the mismatch losses between PV modules since there is only one PV module, as well as supports optimal adjustment between the PV module and the inverter and, hence, the individual MPPT. It includes the possibility of an easy enlarging of the system, due to the modular structure. The opportunity to become a “plugand- play” device, which can be used by persons without any knowledge of electrical installations, is also an inherent feature. On the other hand, the necessary high voltage-amplification may reduce the overall efficiency and increase the price per watt, because of more complex circuit topologies. On the other hand, the ac module is intended to be mass produced, which leads to low manufacturing cost and low retail prices. The present solutions use self-commutated dc–ac inverters, by means of IGBTs or MOSFETs, involving high power quality in compliance with the standards.

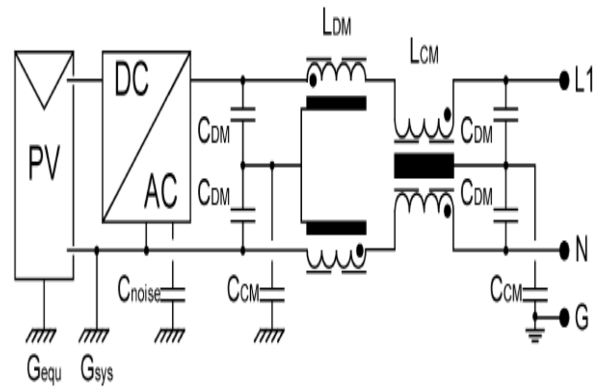

Fig.1.Transformerless high-input-voltage PV inverter with single-phase common-mode

Recent developments in power electronics technology have spurred interest in the use of renewable energy sources as distributed generation (DG) generators. The key component in DG generators is a grid-connected inverter that serves as an effective interface between the renewable energy source and the utility grid. The multifunctional inverter (MFI) is special type of grid-connected inverter that has elicited much attention in recent years. MFIs not only generate power for DGs but also provide increased functionality through improved power quality and voltage and reactive power support; thus, the capability of the auxiliary service for the utility grid is improved. This paper presents a comprehensive review of the various MFI system configurations for single-phase (two-wire) and three-phase (three- or four-wire) systems and control strategies for the compensation of different power quality problems In recent years, the installation of more distributed generators (DG) in power distribution networks has elicited increased attention. A number of reasons can explain this trend. Such reasons include environmental concerns, electricity business restructuring, and the rapid development of small-scale power generation technologies and other micro-grid related devices and systems. In practice, DG units can be constructed with various renewable energy sources However; the real power output from these energy resources is essentially unstable. Given the increasing number of RESs and DG installations, new control strategies must be developed for the proper operation and management of new power grids embedded with DG units to maintain or improve system quality and reliability. Power electronics and smart technologies play an important role in DG operations, in which the effective integration of RES into the power grid is the major objective. A comprehensive review of AC and DC micro-grid systems with RES-based DG units, energy storage devices, and loads available in recent literature was presented in A fuel cell system-based power generation system which was presented in Several typical PV-based DG systems were designed in and a DG system based on a wind power generator was presented in Utility is of concern because of the high penetration level of intermittent RES in distribution systems. This situation may cause a hazard to the network in terms of power quality (PQ), voltage regulation, and stability. [5] The electric PQ guidelines and standard limits can be found in The negative effects of poor PQ were well investigated in and The relation between DG and PQ is ambiguous. Many authors have stressed the positive effects of DG on PQ problems. In the sources of PQ problems in DG systems were analyzed; this study has contributed significantly to this new research field. In , the resonance phenomenon in a PV plant was discussed to define the unwanted trip off of grid-tied inverters, a phenomenon that shows the significance and necessity significance of PQ enhancement in DG systems. In the field of exhaustive PQ evaluation, presented several useful suggestions to form a quantitative exhaustive indicator, including various PQ indicators. Exhaustive evaluation can provide a decision on the existing PQ, which A new type of multilevel inverter is introduced which is created by cascading two three-phase three-level inverters using the load connection, but requires only one dc voltage source. This new inverter can operate as a seven-level inverter and naturally splits the power conversion into a higher-voltage lower-frequency inverter and a lower-voltage higher-frequency inverter. This type of system presents particular advantages to[10] Naval ship propulsion systems which rely on high power quality, survivable drives. New control methods are described involving both joint and separate control of the individual three-level inverters. Simulation results demonstrate the effectiveness of both controls. A laboratory set-up at the Naval Surface. Warfare Center power electronics laboratory was used to validate the proposed joint-inverter control. Due to the effect of compounding levels in the cascaded inverter, a high number of levels are available resulting in a voltage.

3. Conclusions

This paper presents a three-phase cascade inverter for grid connected photovoltaic systems. The proposed control strategy shows benefits for robust control against harmonic distortions in Photovoltaic system applications. The good performances of proposed strategy in both steady state and transient operation have been verified through In order to convert the solar energy efficiently; the maximum power point of the PV array should be tracked to ensure the PV array provides most power to both grid and the load. When solar irradiance or temperature fluctuates, PV generation will change as a result. The controller must act to maintain the DC bus voltage constant as possible and improve the stability of the whole system. Power quality improvement devices in a custom power distribution grid. In addition, some were presented and they show theoretical viability of the proposed model, as well as the control strategy.

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