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A Review on Voltage Source Inverters Used in The Power Enhancement of Microgrids

Nithya Subramani
M.Tech Scholar
Department of Electrical & Electronics Engineering
Rabindranath Tagore University
Bhopal (MP), India.
Subramaninithy22@gmail.com.

Prof. Achie Malviya
Assistant Professor
Department of Electrical & Electronics Engineering,
Rabindranath Tagore University
Bhopal (MP), India.

***Abstract* – Three key issues that the traditional power system is currently facing are the progressive depletion of fossil fuels, poor energy efficiency, as well as environmental contamination. These issues can be solved by using renewable energy resources (RERs), but several technical and governmental concerns must be resolved before these green generation techniques can be properly integrated into distribution systems. Thus, the voltage source inverters often used boost power quality in microgrids and then also lessen concerns associated to microgrid stability were examined inside this paper.**

Keywords – Distributed Generation system, microgrids, controllers, VSI, RERs.

I. INTRODUCTION

As energy demand rises today, distributed generation (DG) power systems—particularly those that use fuel cells, solar panels, and wind energy—as well as the associated power conversion systems provide enormous benefits. Along with a rise in energy consumption, there have also been more issues with power distribution, such as grid instabilities, poor power factor, and power outages [1]. Moreover, because of its greater flexibility balancing and generally stable stability, DG power systems are thought to be a reasonable answer for such issues. Additionally, their use can enhance the maintenance of distribution networks as well as minimize carbon emission. Due to their critical role in conversion of DC voltage and current, which are often generated by a variety of DG purposes, into AC before even being expelled into the grid or absorbed by the load, VSIs are heavily required for both commercial and industrial uses.Three significant issues that the conventional power system is currently facing are the gradual depletion of fossil resources, poor energy efficiency, and environmental contamination [1-3]. Additionally, particularly in emerging nations, the rising price of expansion is a challenge for the present generation of centralized power plants [4]. These issues can be solved by using renewable energy resources (RERs), but several technical and governmental concerns must be resolved before such green generation technologies can be properly integrated into distribution networks. One of the most effective alternatives to the abovementioned technical and ecological issues is the usage of RERs inside microgrids. A microgrid is described as a collection of distributed generation (DG) units, loads, power electronics, and ESS (energy storage systems) that act as one unit under control [5,6]. In Fig. 1, the typical microgrid's structure is shown. It has the ability to function both independently and in concert with the main grid [7]. To increase energy efficiency, boost power quality and system resilience, lower transmission losses, lower consumer costs, and efficiently allow the use of RER

Figure 1Microgrid Framework

To increase energy efficiency, boost power quality and system resilience, lower transmission losses, lower consumer costs, and efficiently allow the use of RER microgridsare now being constructed.

Among the most important grid integration strategies for renewable energy sources (RES) is the use of VSCs. Thus, as more RES are being used, there are more VSCs that are linked to the grid. Additionally, the grid-connected VSCs may be utilized as active rectifiers as well as power quality conditioners, such as Active Power Filters and Static Synchronous Compensators (STATCOM) (APF). Pulse width modulation (PWM) techniques are frequently employed to sustain the switching of the power semiconductor components of grid-connected Voltage source inverter. Such power semiconductor devices' switching in VSCs results in switching ripple harmonics, which could also seriously impair utility power quality.

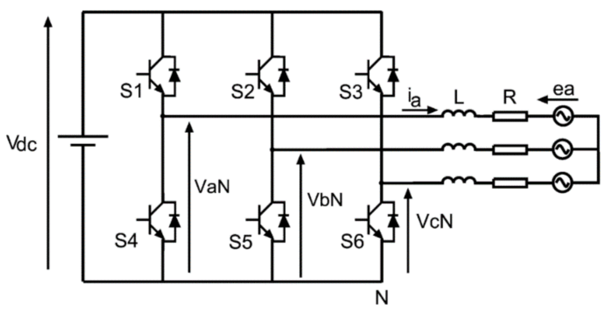

Figure 23-phase Voltage Source Inverters

Because of their outstanding efficiency, dependability, and affordable price with fewer passive filters, voltage source inverters are employed in a wide range of applications [5–6]. Harmonics in voltage as well as current are a prevalent problem in power electronics-based converters and inverters. The modulation method employed largely determines the harmonics in the inverter output. While the DC input voltage is constant in the three-phase voltage source inverter configuration shown in Figure 2, the inverter gain can be adjusted to provide a changeable output voltage. Approaches for pulse width modulation (PWM) can be employed to accomplish this. The objectives of PWM approaches are to provide a wide modulation range, low switching losses, low overall harmonic distortion, easy installation, and low computation time [7]. PWM approaches come in a variety of forms [8,9] and can be divided into Continuous PWM as well as Discontinuous PWM. Examples of continuous PWM comprise third harmonic injection PWM, conventional space vector PWM, and traditional sinusoidal PWM.

II. LITERATURE REVIEW

(Estévez-Bén et al., 2020) [5] Due to the increasing demand for more renewable energy use and the employment of inverters as an intermediary among these innovations and the grid, the research represents the state-of-the-art in this field. The report also offers a comparison of the primary transformerless PV system MLI voltage-source architectures. The primary problems as well as the benefits and drawbacks of each plan are discussed. Also included are recent developments in these techniques used in grid-connected systems. A comparison table depending on static voltage, switching frequency, output levels, the control method employed, efficiency, as well as leakage current is then displayed.

(Bahrami et al., 2020) [6] In order to highlight the benefits of this architecture in this study, a thorough review of seven-level topologies has been conducted. The flying capacitors of this architecture can be balanced at the correct values using a control approach utilizing Model Predictive Control (MPC), as well as the output currents can be controlled without the use of PWM blocks or PI controllers, which is a benefit of MPC in power electronics applications. Experimental findings have been performed under various settings to evaluate the effectiveness of the seven-level topology and the efficacy of the created control approach, which shows the viability of the seven-level topology and the produced control methodology.

(Marzouki et al., 2015) [13] includes a study of the power circuit and the operating principle as well as a number of commercial processes depending on this configuration. Additionally, it offers a list of useful references, which makes the paper particularly beneficial for future researcher in the subject of power electronics.

(Gawande &Ramteke, 2014) [11] gives a thorough analysis and comparison of many current control (CC) methods for MLI, with a focus on different hysteresis current controller approaches. A ramp-comparator controller as well as a predictive controller to achieve constant switching frequency are given together with its quantitative comparison because the hysteresis CC technique presents a problem of changing switching frequency. The functioning of hysteresis current control PWM with constant switching frequency has also been accomplished using a variety of techniques. This paper follows several recommendations to select a specific technique appropriate for use at a given power level, switching frequency, and dynamic response.

(Miveh et al., 2015) [7] In recent times, multi-functional VSIs have drawn more attention due to their useful auxiliary services for enhancing power quality in independent microgrids. Such

VSIs can meet the established power quality as well as stability standards as well as implement an appropriate control strategy in autonomous mode. When comparing to several devices with distinct functionalities, these functionalities are combined into a single device, considerably increasing the cost-effectiveness of microgrids while lowering the investment and bulk. This work provides a thorough evaluation of control methods for power quality improvement inautonomous microgrids employing multi-functional VSIs.

(Sinha & Jana, 2020) [8] proposes several current as well as power-sharing control algorithms for VSI that are linked in parallel and share an AC bus. For parallel-connected voltage source inverters, a thorough categorization and study of wired and wireless (droop) controllers has been conducted. Additionally, the most recent developments and advancements in conventional droop controllers are shown. Ultimately, a comparison of the several wired and wireless controllers is made, outlining their benefits and drawbacks.

III. MULTI-FUNCTIONAL VSIS IN AUTONOMOUS MICROGRIDS FOR STABILITY DEVELOPMENT

Independent microgrid monitoring as well as control are more difficult than grid-connected microgrid maintenance and controls. Additionally, islanding operation has far less physical inertia than that of the grid-connected mode. As a result, concerns with power quality as well as stability might arise from the addition or removal of local loads, disruptions, and minor interruptions like output power variations in DERs. Particularly, the system stability would diminish and the frequency and voltage quality would suffer. Multi-functional VSIs, meanwhile, can enhance dynamic stability as well as power quality through the advancement of power electronics [6].

The feedback controller, continuous load switching, as well as the power limit of micro sources all apply to small signal stability in a microgrid [9]. Furthermore, the major part of the issues with voltage as well as frequency stability in a microgrid are caused by reactive power restrictions, load dynamics, as well as tap changers.

Table 1 Comparison of Various Voltage Control Approaches' Effectiveness In Automatic Mode

Voltage control structure	**Type of controller**	**Advantages**	**Disadvantages**
Digital control strategies	Sliding-mode controller	If properly engineered, the instantaneous inverter output voltage can be directly controlled with excellent dynamic performance that prevents peaking and buzzing and has an appropriate THD.	Complicated, sensitivity to parameter changes and loading circumstances, steady-state faults, and discrete technical challenges.
	Repetitive controller	Outstanding capacity to remove periodic disruptions and guarantee zero steady-state error at all harmonic frequencies	Slow dynamics, inaccurate tracking, a high memory demand, and subpar response to non-periodic disruptions.
	Hysteresis controller	Their implementation is straightforward and reliable, without requiring sophisticated CPUs or circuitry,	The frequency of switching variables alongside variations in parametric loads and operational parameters is this controller's main flaw..
PI control	SRFPI controller	individual control of both active and reactive elements with zero steady-state error.	It may not guarantee good functioning for imbalanced systems. They are not the best ways to increase compensation. harmonic

			disturbances and it has a complex structure

Although many different management strategies have been developed and launched to govern the power quality of autonomous microgrids, it is challenging to achieve all of the aforementioned power quality requirements at once. The explanation for this is that any control technique can accommodate a particular requirement. In this regard, Table I provides a comparative analysis of previously employed voltage control strategies for power quality enhancement in islanding operation.

IV. CONCLUSION

Because of their outstanding efficiency, durability, and affordable price with fewer passive filters, VSI are utilized in a wide range of purposes. Harmonics in voltage and current are a prevalent problem in power electronics-based converters and inverters. Recently decades have seen an increase in interest in multi-functional VSIs due to their useful auxiliary services for improving power quality.

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