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RESEARCH ARTICLE OPEN ACCESS

A STUDY ON RENEWABLE ENERGY SOURCES USING MODULAR MULTILEVEL CONVERTER IN FINDING POWER QUALITY

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Abstract:

Power quality is very important aspect in power system. The harmonics in power systems are produced by various electronic devices. Conventional inverters produce more harmonics and distortions in power system which can be reduced by filters with increase in size and cost. The advances in technologies have led the power capacity of the renewable energy system to grow. It can be a problem to integrate the renewable energy sources to the conventional grid in terms of the stability, voltage regulation and power quality issues. The proposed power converter does not need to employ the large interface inductor at input side and the huge electrolytic capacitor at DC lin. it utilizes high-frequency transformers for the galvanic isolation instead of bulky line-frequency transformers. Compared with the existing multilevel converters, one of the most desirable advantages offered by MMC may be its ability to process both active power and reactive power with its terminals directly connected to high-voltage networks. D-STATCOM (Distribution Static Compensator) is a shunt device which is generally used to solve power quality problems in distribution systems. In this concept in future by increasing the levels of Multilevel Inverter we improve the power quality.

Keywords **—Modular Multi-level Converter, Renewable Energy Source, Total Harmonic Distortion (THD).**

1.0 INTRODUCTION:

Due to the possibility of providing energy with less dependence on the fossil fuels, renewable energy sources, in particular solar photovoltaic (PV) conversion have gained increased acceptance and growth in recent times. Significant advantages of pv panels include clean and reliable energy production and suitability for distributed generation. Recently renewable energy power supplied into the utility grid has been paid much attention due to increase in fossil fuel prices, environmental pollution and energy demand boom. Among various renewable energy resources such as solar, wind, tidal, geothermal, biomass etc., the solar photovoltaic system being more attractive and promising green resource because of its abundant availability, safe resource, cost free and eco-friendly. Conventional inverter topologies such as voltage source inverter (VSI) and the current source inverter (CSI) are being utilized to convert solar power generated electrical power into the utility grid. Whereas these topologies require additional DC/DC converter stage resulting in a two stage power conversion and also require interfacing transformer to inject power into the grid. Currently intensive research is going on in MMC and it has high potential for medium power applications. Modular multilevel converters have several advantages over conventional multilevel topologies. Among the all power quality concers is controlling the active and reactive power transferring to or from the grid requires attention. Now days, this attention is possible using power electronics. The distributed energy sources such as wind and solar have been attracting increasing interest in recent years. Recently, distributed generation (DG) has been introduced to the modern power systems in order to avoid generating power and transmitting it over a long distance. Relatively small power generations such as small wind or solar system, would be an approach to penetrate renewable to the power systems.

A. Photovoltaic Systems

A photovoltaic system, converts the light received from the sun into electric energy. In this system, semi conductive materials are used in the construction of solar cells, which transform the self contained energy of photons into electricity, when they are exposed to sun light. The cells are placed in an array that is either fixed or moving to keep tracking the sun in order to generate the maximum power. These systems are environmental friendly without any kind of emission, easy to use, with simple designs and it does not require any other fuel than solar light. On the other hand, they need large spaces and the initial cost is high.

B. Fuel Cells

Fuel cells operation is similar to a battery that is continuously charged with a fuel gas with high hydrogen content; this is the charge of the fuel cell together with air, which supplies the required oxygen for the chemical reaction. The fuel cell utilizes the reaction of hydrogen and oxygen with the aid of an ion conducting electrolyte to produce an induced DC voltage. The DC voltage is converted into AC voltage using inverters and then is delivered to the grid. A fuel cell also produces heat and water along with electricity but it has a high running cost, which is its major disadvantage. The main advantage of a fuel cell is that there are no moving parts, which increase the reliability of this technology and no noise is generated. Moreover, they can be operated with a width spectrum of fossil fuels with higher efficiency than any other generation device. On the other hand, it is necessary to assess the impact of the pollution emissions and ageing of the electrolyte characteristics, as well as its effect in the efficiency and life time of the cell.

2.0 LITERATURE REVIEW:

Sid-Ali Amamra et al (2017) a novel three-phase parallel grid-connected multilevel inverter topology with a novel switching strategy is proposed. This inverter is intended to feed a microgrid from renewable energy sources (RES) to overcome the problem of the polluted sinusoidal output in classical inverters and to reduce component count, particularly for generating a multilevel waveform with a large number of levels. The proposed power converter consists of n two-level (n + 1) phase inverters connected in parallel, where n is the number of RES.

Gorle Kalyani et al (2016) The Power Quality Enhancement is very good in distribution system because of these regions: This is a Voltage Source Multi-level Converter topology mainly used in high voltage and high power applications. It is an AC to DC topology built by a series connection of (cascaded) halfbridge (or other) modules. This converter exhibits some important advantages with respect to 2- level H-bridge or 3- level (Neutral point clamped, flying capacitor etc., power converters.

J. M. Guerrero et al (2015) It was observed that PV inverters under certain circumstances switched off undesirably or exceeded harmonic regulations. As a result there was more focused has been made by researchers on power quality standards at PCC. For that purpose analysis on PV inverters, distributed network, and simulation study was required. Author had analyzed the phenomena of harmonic interference of large populations of these inverters in order to compare the network interaction of numerous inverters topologies and their control strategy.

S. Senthil et al (2014) This mainly concentrates on a new compilation of smart grid technology using multilevel inverter with space vector modulation techniques. In this paper we have connected wind turbine, PV cell, Pico generator set so that the Electrical Energy is generated and it is connected to the Grid using multilevel Topologies. Multilevel converters have been mainly used in medium or high power system applications, such as static reactive power compensation and adjustable-speed drives. In these applications, due to the limitations of the currently available power semiconductor technology, a multilevel concept is usually a unique alternative because it is based on low-frequency switching and provides voltage or current sharing between the power semiconductors.

Bhim Singh et al (2012),"A Review of Single-Phase Improved Power Quality AC–DC Converters", in this journal deals with a comprehensive review of improved power quality converters (IPQCs) configurations, control approaches, design features, selection of components, other related considerations, and their suitability and selection for specific applications.

3.0 RESEARCH METHODOLOGY:

The Modular Multilevel Converter:

Topology of MMC:

A basic structure of a MMC is shown in Figure. MMC is composed of many series-connected sub-modules (SMs) and the primary function of SMs provides many separate DC sources for synthesizing the desired voltage. The number of output voltage levels in MMC is N+1, where N is the number of SMs in per upper or lower arm of a single phase. Seen from the AC side, all SMs of a single phase are connected in series. So its AC output voltage is the sum of all SMs' output. By switching SMs in the upper and lower arm, the voltage Udc is adjusted. In a similar manner, the voltage Ujo (j=a, b, c) can be adjusted to a desired value if Udc is fix. No additional external connection or energy transmission to the SMs is needed, for full 4-quadrant operation of the converter system.

Basic Operating Principle of SM

A suitable and simple realization of the SM is given in Figure 2. The interface of the SM is composed solely of two electrical terminals and one bi-directional fiber-optic interface. Table 1 summarizes the switch states of a cell and their resultant influence on associated capacitor voltages. When the switching device S_m is on and Sc is off, output voltage VO=0; when the switching device S_m is off and Sc is on, voltage V_O=Vd_c. No VO=-Vdc is possible. Output voltage of SM is unipolar. By switching a number of the N SMs in the upper and lower arm, the voltages in each arm can be synthesized. So the voltage Udc and voltages Ujo (j=a, b, c) can be adjusted independently.

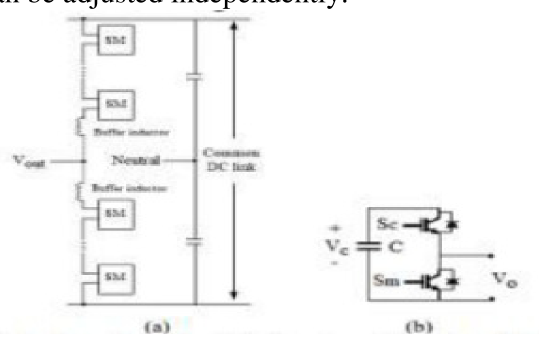

Fig shows a) Configuration of the MMC topology, b) A sub-module (SM)

By properly switching between these two states, proper voltage can be maintained for each SM. Therefore, the total DC side is the sum of all capacitors voltages in one leg. In this topology, the high number of levels reduces the average switching frequency without compromising of power quality.

Selection of SMs and Capacitor Voltage Balancing

The capacitor voltages of the individual SMs must be monitored and kept equal. The voltages of the capacitors are periodically measured with a typical sampling-rate in the millisecond-range. According to their voltage, the capacitors are sorted in descending order by software. The modulation strategy determines the number of SMs that should be on in the upper and lower arms of the MMC (i.e., Sc). Capacitor voltage values and also the direction of the arm currents are used to select Sc of the SMs in the upper (lower) arm and to determine which S per (lower) arm is positive, in order to impress the desired arm voltage, the required SMs with the lowest voltages are switched on. When the current in the upper (lower) arm is negative, in order to impress the desired arm voltage, the demanded number of SMs with the highest voltages is selected. Regardless of the direction of the upper (lower) arm current, if Sc of the SM is off, the corresponding capacitor will be bypassed and its voltage remains unchanged. By this method, continuous balancing of the capacitor voltages is achieved. Additionally, the power losses can be kept low by switching SMs solely, when a change of the output state is requested.

CONTROLLER DESIGN FOR STATCOM

The aim of the designed D-STATCOM inverter is to provide utilities with distributive control of VAR compensation and power factor (PF) on feeder lines. This inverter is able to control the active and reactive power regardless of the input active power required by the DC link. Generally, there are two modes of operation for DSTATCOM inverter when it is connected to the grid: 1) when active power is gained from the wind turbine and it powers the DC link, which is called inverter mode, 2) when no active power is gained from the wind turbine, which is called DSTATCOM mode. The proposed DSTATCOM inverter is able to maintain the PF of the grid at a certain target value whether the DC link capacitors are charged by the current comes from the rectifier or the DC link is open circuited and DC link capacitors are charged by the grid.

Table shows Commonly control states of a sub-modular.

Mode	Sm	SC	iO	VO	Power path	C
1	on	off	> 0	0	S_m	unchanged
2	on	off	< 0	0	D_m	unchanged
3	on	off	> 0	V_{dc}	D_c	charging
4	on	off	> 0	V_{dc}	S_c	discharging

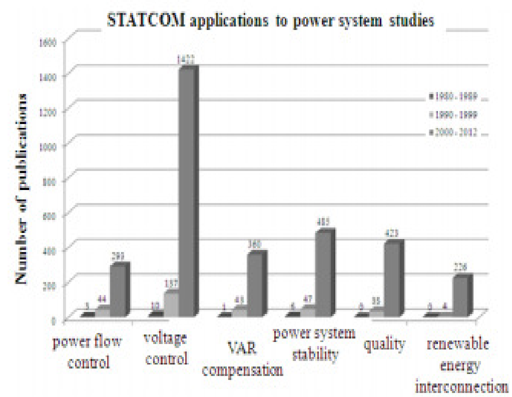

Fig shows STATCOM growth (publications in the IEEE/IEE library)

Here the simulation is carried out by two different cases they are five and seven level D-STATCOM models

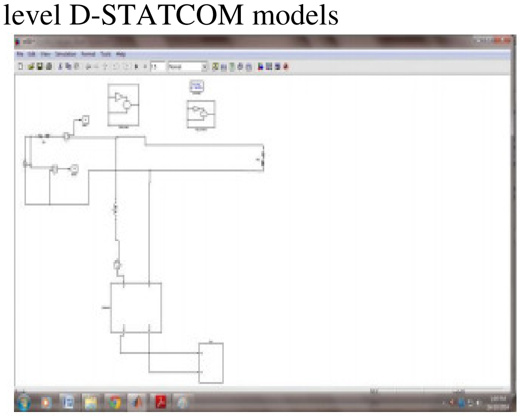

Fig. shows the Matlab/simulink model of proposed converter

4.0 RESULTS:

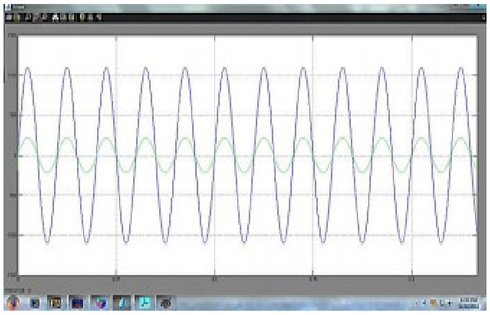

Fig. shows Output voltage of the D-STATCOM for five level inverter

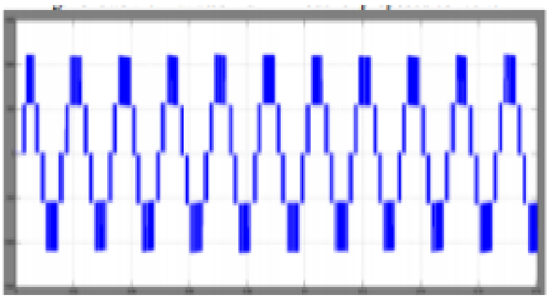

Fig. shows Output voltage of the D-STATCOM for Seven level inverter

5.0 CONCLUSIONS:

The concept of a multilevel D-STATCOM inverter for small- to mid-sized (10-12KW) wind installations is prefered and shows a new way in which distributed renewable sources can be used to provide control and support in distribution systems. The proposed single -phase D-STATCOM inverter using MMC topology can actively regulate the reactive power on individual feeder lines while providing the variable output power of the renewable energy source. The aim is to utilities with distributive control of VAR compensation and power factor correction on feeder lines. The proposed D-STATCOM inverter performs in two modes: 1) inverter mode, in which there is a variable active power from the wind turbine, 2) DSTATCOM mode, in which the DC link is open circuit and no active power is gained from the renewable energy source. Finally by increasing the levels, power quality is also improved so in the next generation this concept can be implemented at higher levels to improve the Power Quality.

REFERENCES:

1. Sid-Ali Amamra; Kamal Meghriche; Abderrezzak Cherifi; Bruno Francois, (2017), "Multilevel Inverter Topology for Renewable Energy Grid Integration", IEEE Transactions on Industrial Electronics, ISSN: 1557-9948, Volume: 64, Issue: 11, PP: 8855 – 8866
2. Gorle Kalyani, SH Suresh Kumar Budi, (2016), "Power Quality Enhancement using Distributed Generation Modular Multilevel Inverter with Active Power Control", International journal of innovative technologies, ISSN: 2321-8665, Vol.04, Issue.19, Pages: 3798-3802.
3. J. M. Guerrero, L. G. de Vicuna, J. Matas, M. Castilla, and J. Miret (2015.) "A wireless controller to enhance dynamic performance of parallel inverters in distributed generation systems," IEEE Trans. Power Electron., vol. 19, no. 5, pp. 1205–1213.
4. S. Senthil, K. Ravi (2014), "A new compilation of renewable energy sources using multilevel inverter with space vector modulation techniques", International Conference on Green Computing Communication and Electrical Engineering (ICGCCEE), ISBN: 978-1-4799-4982-3, 10.1109/ICGCCEE.2014.6922318
5. Bhim Singh, Brij N. Singh, Ambrish Chandra, Kamal AlHaddad, Ashish Pandey, and Dwarka P. Kothari, (2012), "A Review of Single-Phase Improved Power Quality AC–DC Converters", IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 50, NO. 5.