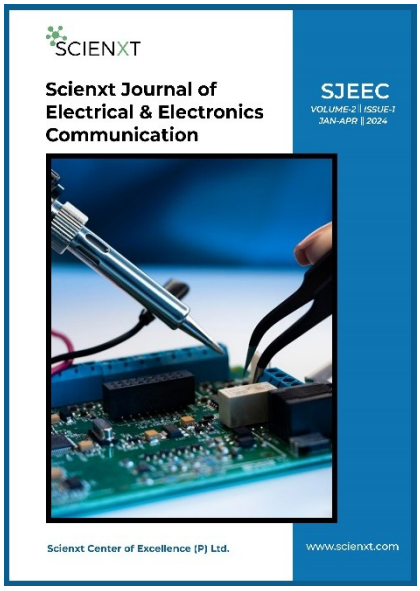

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Grid integration of solar system using various MLI topologies; a review

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Abstract:

There has been expanding need to heighten the support of cleaner types of energy to blend with the existing utility infrastructure, especially wind, small hydro and solar energy. The most popular and widely adopted renewable energy is solar energy which has been utilized for powering utility. The grid connected operation of these green form of energy sources require inverters. Multi-functionality in converters are drawing attention of researchers, since it is the main link of grid tied solar system. A lot of ongoing research has been reported in literature for auxiliary services on power quality improvement through multi-functional grid-tied (MFGT) converters. These converters can perform dual work of interfacing solar system with the grid and also conditions the power at point of common coupling. This paper presents an overview

Keywords:

Solar Panel, Maximum Power Point Tracking, multi-functional grid-tied (MFGT) converters, Power quality issues, Single stage, Dual Stage.

1. Introduction:

Energy crisis and increasing environmental pollution problems has urged the immediate need for “green” and “low-carbon” power generation system. [1, 2]. Photovoltaic (PV) [2-5] is a very popular form of RES which can synthesize electricity without any thermal or electro-mechanical interlink. When a cluster of solar modules are assembled at a place, it results in a solar panel. The energy generated from this integrated module group is referred as solar power. The solar cells are also known as photovoltaic cells or the PV cells. As the name itself suggests, photo means light while voltaic refer to electricity. Solar cells are electrical devices in the solid form that help convert energy from sunlight into electric energy with the help of photovoltaic effect. When a number of solar cells are clustered together, they are called solar modules which together save energy from sunlight. When a cluster of solar modules are assembled at a place, it results in a solar panel.in general, grid-connected PV systems may be developed as of single-stage (S-S) or dual-stage (D-S) units [3]. S-S PV can be designed using a single unit of a grid-tied inverter (dc/ac converter) [4]–[9]. Generally the PV array is directly connected to the dc-bus of the grid-tied inverter in S-S. Contrary, in D-S PV systems, in additional with the dc/ac converter a dc/dc converter is also placed between the PV array and the inverter [10]–[12] as shown in Fig. 1 and 2. For gird tied PV application, as demonstrated in Fig. 2, the two-stage GCIs are mostly used in single-phase utility grid and their capacities are usual small; however, the single-stage GCIs are mainly utilized in three-phase utility and their capacities are relatively bigger. Hence the choice among the both depend upon their usage and voltage level. Also their comparison is not worthy since they are integrated irrespective to component requirement and applications.

Many efforts has done to improve the performance of the system with minimum losses, distortion and as possible as the maximum efficiency by using different topologies of multilevel inverter and with different levels.

In this paper a brief overview on MFGT is presented for grid connected operation of solar system.

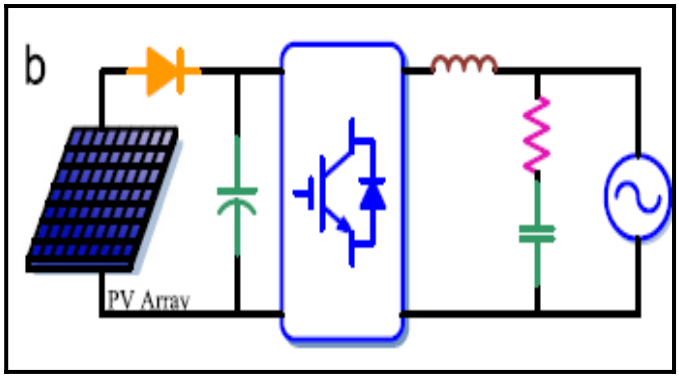

Figure. 1: Grid tied Single-Stage solar system

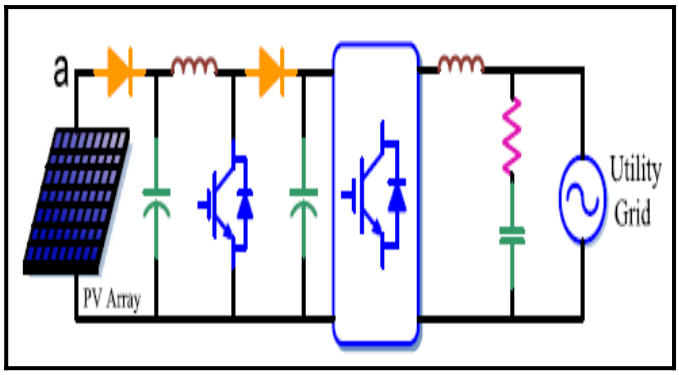

Figure. 2: Grid tied Single-Stage solar system

2. Overview on grid-connected inverters System:

MFGT converters are special Grid Tied Converters (GTCs), hence it is worth to introduce in brief the conventional. GTC are the most needful components for an effective interfacing of renewable resources (RR), like photovoltaic (PV) arrays, wind turbines (WTs). For the state of the art of designing MFCT converters is worth to note that the high efficiency and low cost are two important issues of. [13, 14].

MFGCI topologies in single-phase system usually have small capacities and aim to small-scale RESs application. Available MFGCIs in single-phase are mainly employed for PV application, and attach APF and/or DVR functionalities .A kind of MFGTC configuration using single-phase full-bridge topology is demonstrated in Fig. 3.

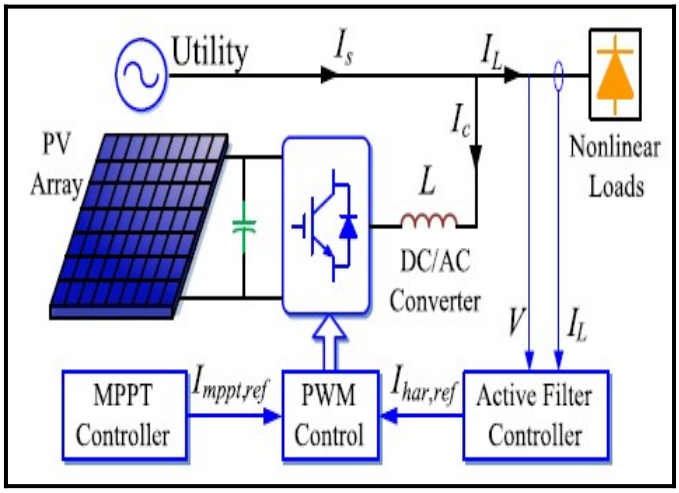

Figure. 3: Typical configuration of a single-phase full-bridge MFGT converter

The single-phase MFGTC suffers some drawbacks:

- The fluctuation of irradiations causes the regulation in voltage hence the stability of the large solar system is questionable.
- The conventional MFGT converters employs very bulky filter components hence the overall inductance of the system will be increased.
- Also, there is no electric isolation, the dc component injects into utility will affect other devices.

For large solar generation system it is worthy to employ three phase system as demonstrated in Fig. 4.

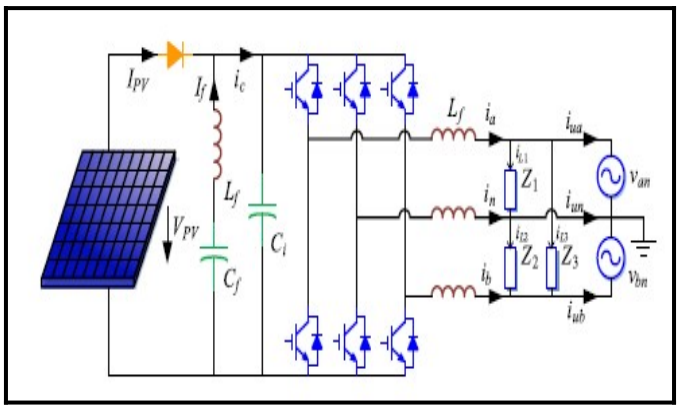

Figure. 4: Typical configuration of a three-phase full-bridge MFGT converter

3. Inverter topologies to design MFGT converters:

The MFGT converters are designed using multi-level inverters (MLIs) with active power filtering capabilities to overcome various power quality issues. The grid connected operation

of solar energy leads to numerous power quality issues which has to be taken care immediately or it will harm the system severely.

Hence it is worthy to design a MFGT converters which can improve performance of the system in terms of power quality.

For integrating RR with the utility system either 2-level or multi-level inverter (MLI) is employed. 2-level inverter has high THD content as compared to MLI in the AC output voltage hence MLIs are preferred. Tremendous research work is available to improve the performance of the system in a way to reduce losses, distortion and to enhance the efficiency by using different topologies of MLIs. In general MLIs are broadly classified as flying capacitor type, neutral point clamped and cascade H-bridge. In the first two types the series of switches shares the common Dc supply while cascaded type required separate DC sources for individual units which is shared according to the generated output voltages. The two most preferred topologies are neutral point clamped (NPC) and cascade H-bridge (CHB) since these topologies can be easily interfaced with RR and gives better performance efficiency as compared to flying capacitors type.. The NPC-MLI find applications in Static VAR compensation, Variable speed motor drives, High voltage DC-AC transmission lines and applications of CHB-MLI are Motor drives, Active filters, Electric vehicle drives, DC power source utilization, Power factor compensators, Back-back frequency link systems and Interfacing with renewable energy resources.

In this section above mentioned topologies are discussed in brief.

Other than the above mentioned conventional topologies there are several topologies also been reported recently in literature which are specifically designed as per the application requirements and are generally combination of any of the two above mentioned topologies with some modification. These topologies are termed as hybrid topologies of MLIs.

3.1. Diode clamped multilevel converter (NPC) topology:

The diode clamped converter provides multiple voltages through connecting the phases to a series capacitors banks as shown in fig. 5. The concept can be increased to number of levels by increasing the number of capacitors. Earlier this methods was only limited to three levels in which two capacitors connected across the dc bus resulting in one additional level that is the neutral point, so the terminology neutral point clamped (NPC) inverter was introduced in the theories[8-15], [18], [20].

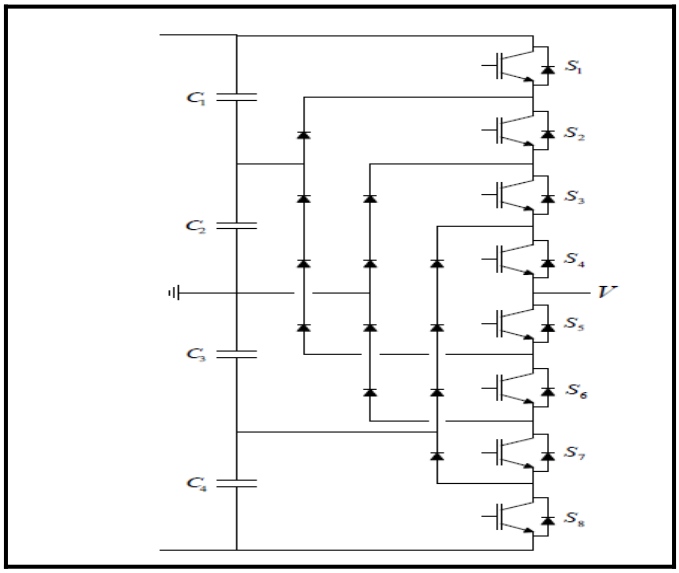

Figure. 5: Single phase of a 5-level diode clamped multilevel inverter

3.2. Flying capacitor (FC) topology:

The flying capacitor involves series connection of capacitor clamped switching devices as shown in fig. 6. This has several advantages when compared to the NPC topology. Like one feature is that added clamping diodes are not needed in this topology. Further, the flying capacitor converter has switching redundancy within the phase which can be used to balance the FC due to this only one dc source is required [8-15].

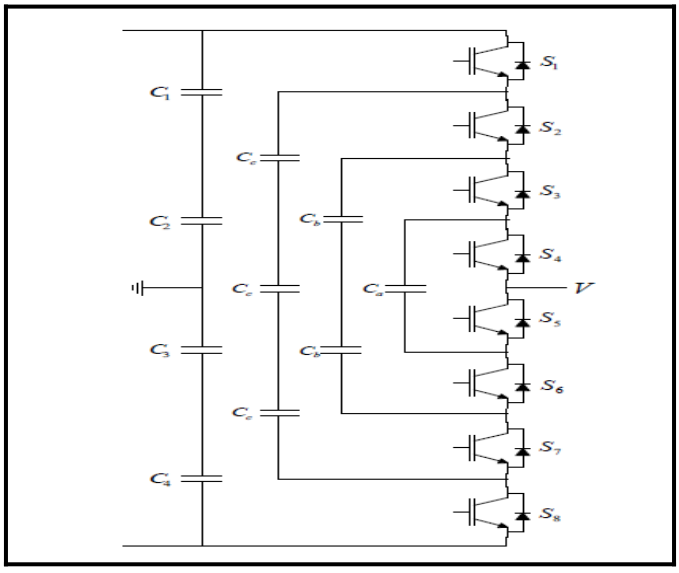

Figure. 6: Single phase of a 5-level Flying capacitor multilevel inverter

3.3. Cascade*H-bridge multilevel converter (CHB-MLI) topology:*

In cascade H-bridge there are several different configurations as well. This topology consists of series power conversion units, the voltage and power level may be conveniently scaled as

shown in Fig.7. A noticeable disadvantage of this CHB topology is large number of isolated voltages are required to supply each cell unit separately [8-15]. In this study focus is on the increasing different levels in converters starting from basic three levels to the nine levels with their simulated results giving a comparison on using two different topologies NCP and CHB type.

All above mentioned

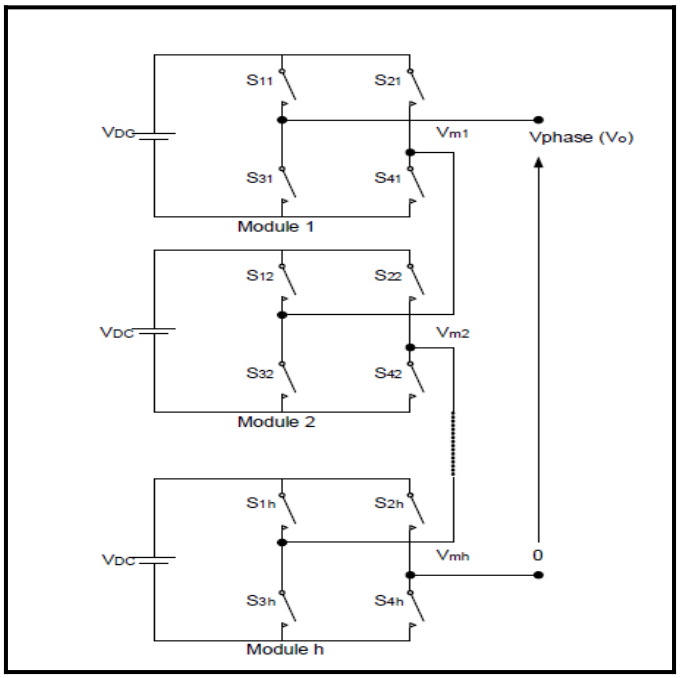

Figure. 7: Single phase of a cascaded H-bridge multilevel inverter

4. Conclusion:

Inverters are the important link between RES and utility grid interface. There are several task that a properly stimulated inverter can perform like power quality improvement, battery back-up etc. this paper presents an overview on such functionalities of inverter and its application in modern power system

To enhance the cost function and reliability of the grid connected RR a new class of converters namely MFGT converters are gaining interest of researchers which not only integrate the RR with the grid but also improves the grid profile in terms of power quality. This paper presents an overview to such topologies.

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