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Research Article

PV system based grid-connected system

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Abstract

Due to the increasing crisis of power supply distributed generations are encouraged for supplying power in the remote locations or in the consumer side itself. The major component for getting the supply to connect in the grid is the inverter. For grid connected system, the inverters must produce voltage in the required sinusoidal voltage waveform of magnitude, phase sequence and frequency same as the grid values. In real time by using non-renewable energy resources, the voltage magnitude produced is less, so many renewable energy resources are combined together to produce required output of higher voltage. But the high voltage requires more insulation which are not economical. Thus a Five level cascaded multilevel inverter has a structure of separate dc sources which will be produced using the PV system. Therefore it reduces the insulation cost but at the same time, getting the magnitude and shape of the voltage waveform from the inverter is quite difficult because huge amount of semiconductor switches are used and also isolated voltage sources may not be readily available all the time. Hence the harmonic content in the inverter output waveform is very high. As a result a Passive filter has to be designed to reduce these harmonics.

Keywords: Inverter; Maximum Power Point Tracker; Photovoltaic; Grid.

Introduction

An electric grid refers to the network consisting of synchronized power producers and power consumers. It is connected by the transmission and the distribution networks. Grid usually refers to the transmission system for electricity. A grid usually serves to transmit voltage at high voltage levels and to interconnect transmission lines that transmit electricity over longer distance (Araujo at al., 2010). The amount of the energy from renewable energy sources that is delivered to supply network has significantly risen. PV based Grid-connected system are nowadays recognized for their contribution to environment friendly power generation. A main aim of these systems is to increase the energy injected to the grid by decreasing the harmonics, and by providing high reliability.

The usage of renewable energy resources like solar energy and wind energy are encouraged nowadays due to the depletion in the non-renewable energy resources. Usually, a harmonic problem can be probably particular disturbance, which is produced by the presence of non-linear components in the electrical system that leads to a significant modification of wave shapes in terms of sinusoidal components at a frequency which is different from the fundamental frequency (Tolbert and Peng, 2000). So it becomes necessary to decrease the harmonics in the grid connected system. This paper first explains the types of the multilevel inverter system. Next the brief overview on multilevel inverter and lastly an overview and comparison of existing single phase cascaded multilevel inverter with and without a filter in it and finally the conclusion.

Materials and methods

Multilevel inverters produce higher power output. They are operated through multiple switches instead of one. To convert a DC signal into an AC signal fast switching of DC signal is required so that multiple levels are obtained. This produces a staircase wave that is quite close to a sine wave.

Diode clamped multilevel inverters

The Diode Clamped Multilevel Inverter mainly makes use of the diodes and provides the multiple voltage levels through the various phases to the capacitor banks which are in series connection. A diode transfers a limited amount of voltage in order to reduce the stress on other electrical devices as shown in Figure 1. The maximum output voltage is half of the input DC voltage. It is the main disadvantage of this kind of multilevel inverter (Daher et al., 2008). This problem can be solved by increasing the switches, diodes, capacitors.

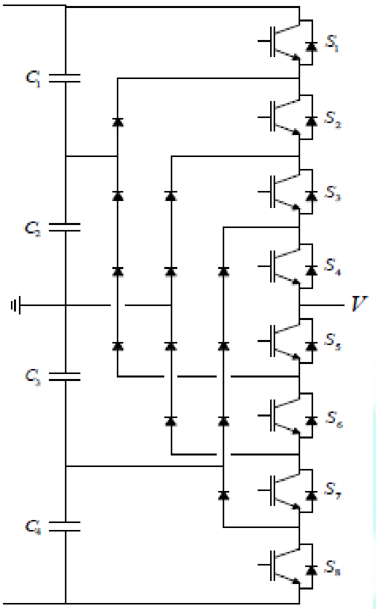

Figure 1. Diode clamped multilevel

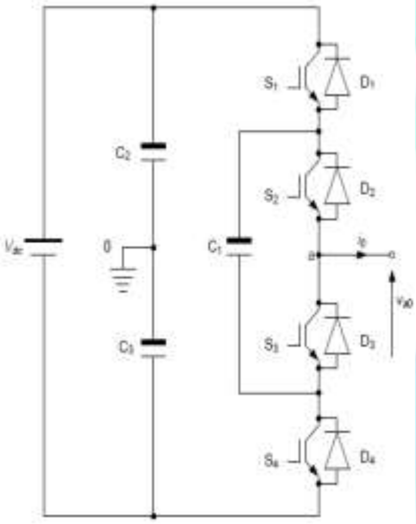

Figure 2. Flying capacitor multilevel inverter

***Flying capacitor multilevel* inverters**

This kind of an inverter mainly uses is capacitors as shown in the Figure 2. It is designed in a series fashion of capacitor clamped switching cells.

The capacitors can transfer only the certain limited amount of voltage to electrical devices. In flying capacitor multilevel inverter switching states are like in the diode clamped inverter discussed in the previous section.

Cascaded h-bridges multilevel inverter

The basic concept of cascaded H-bridge multilevel inverter is based on adding H-bridge inverters in a series manner to get a sinusoidal voltage output waveform (Walker and Sernia, 2004). The output voltage is defined as the addition of the voltages that is generated by individual cell. The cascaded multilevel inverter diagram is shown in Figure 3. The number of output voltage stages are 2n+1, where n is the number of cells. One of the main benefits of this type of multilevel inverter is that it needs comparatively less number of components with the other two previous types (Myrzik and Calais, 2003). The price and weight of the inverter are less than those of the previous two inverters. The block diagram of Grid connected PV System is shown in Figure 4. The harmonics in the output of the five level inverter is found for the efficient connecting it to the grid.

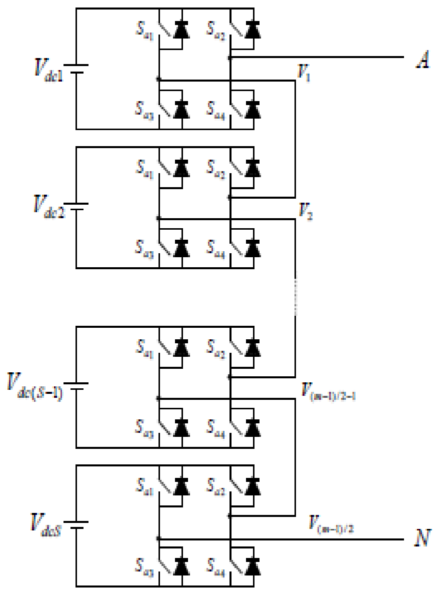

Figure 3. Cascaded multilevel inverter

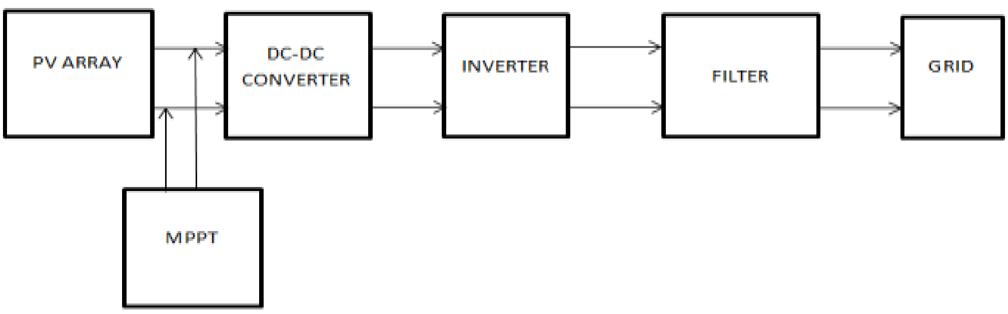

Figure 4. Block diagram of grid connected PV system

PV system

Photovoltaic (PV) system is the greener source of power and the most effective source of energy in recent times. Therefore PV has become an important source of power for a wide range of applications. Improvements in power conversion ratio as well as reducing the cost have helped create this development. Even with more efficiency and reduced cost, the goal remains to increase the power from the PV system under various lighting conditions (Liu et al., 2011). The power obtained from the PV system of one or more photovoltaic cells is mainly dependent on some of the factors like the irradiance, the temperature, and the current drawn from the cells (Calais and Agelidis, 1998).

Maximum Power Point Tracking (MPPT) is used to extract the maximum value of voltage and current from these systems (Kjaer et al., 2005). Such applications as connecting the DG to the grid, lighting application, standalone applications, powering an electric motor benefit from MPPT. Maximum Power Point Tracking, is usually referred to as MPPT, is an electronic system that works on the Photovoltaic (PV) system in a regulated manner so that it allows the modules to produce the maximum power they are capable of (Carrasco et al., 2006). Each solar cell has a point where the current (I) and voltage (V) output from the cell causes the maximum power output of the cell. The MPPT algorithm contains many techniques like Perturb and Observe and Incremental Conductance (Meinhardt and Cramer, 2000).

The Perturb and Observe method can cause deviation in output power produced about the maximum power point even under steady state. The incremental conductance method is better over Perturb and Observe (P&O) method that it can determine the maximum power point without oscillating around this predetermined value. It can execute maximum power point tracking under varying irradiation conditions with higher efficiency than the Perturb and Observe method (Calais et al., 2002). So the incremental conductance is commonly preferred method.

Incremental conductance

The incremental conductance algorithm was established based on the fact that the slope of the curve power vs. voltage (current) of the PV is zero at the particular power point, negative (positive) on the right of it and positive (negative) on the left (Meinhardt and Cramer, 2000). By comparing the rise of the power vs. the rise of the voltage or current between two consecutives samples, the change in the MPP voltage can be determined. The advantages of incremental conductance algorithm include direct control of extracted power from the PV and good tracking efficiency. The response is high and good control for the extracted power.

Results and discussions

Filters come under the category of analog circuits which execute signal processing functions, extensively to eliminate unnecessary frequency components like harmonics from the signal, to enhance wanted ones (Das, 2003).

The simulation of five level cascade inverter is done and the output is analysed. The FFT analysis is performed in order to find the THD in the system. From the analysis, it can be seen that the harmonics obtained from the voltage and the current output waveform has a THD level of 20.39% and 17.29% as shown in Figure 5 and Figure 6. To reduce the harmonics the output wave form a passive filter is introduced into the system (Schimpf and Norum, 20081). The passive filter is a combination of L and C. The value of L and C are designed in such a way that the harmonics in the system is reduced for efficient operation of the system. Again the FFT analysis is done to find the harmonics in the inverter with filter. It is found that the harmonics in the voltage and the current waveform is 4.83% and 4.74% as shown in Figure 7 and Figure 8.

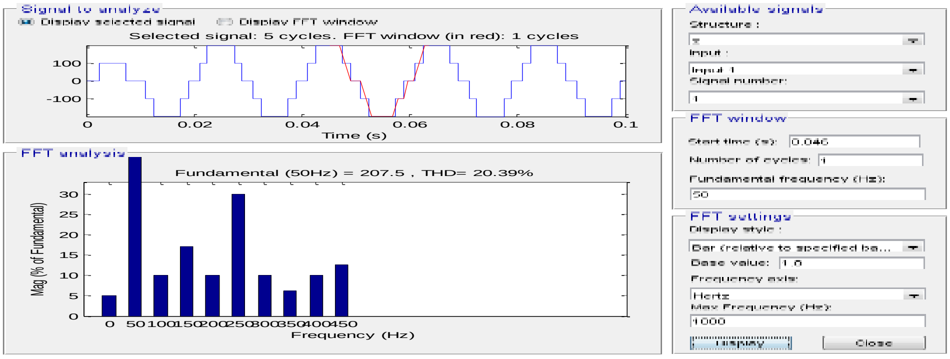

Figure 5. FFT analysis of the voltage waveform without filter

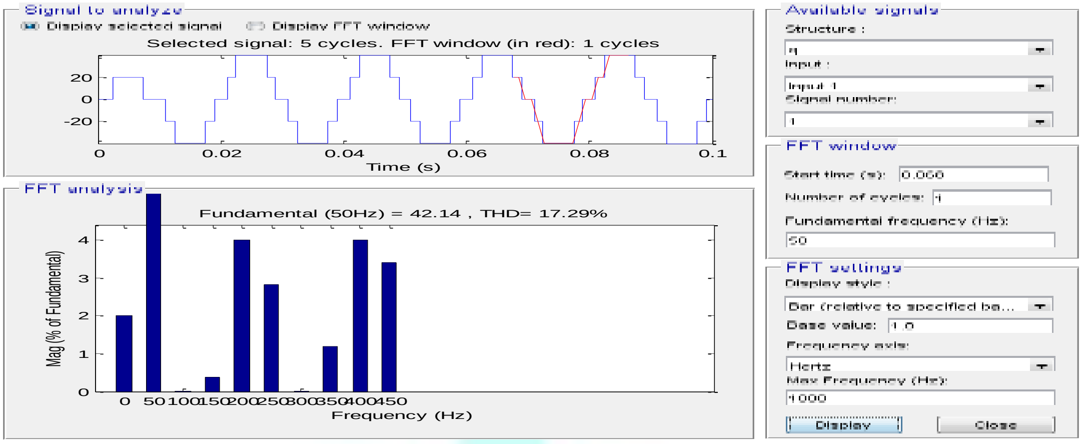

Figure 6. FFT analysis of the current waveform without filter

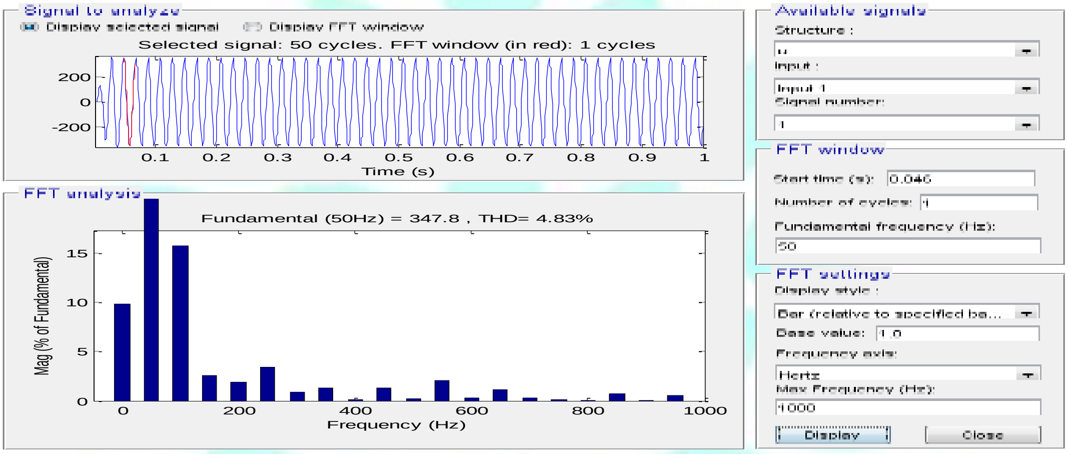

Figure 7. FFT analysis of voltage waveform with filter

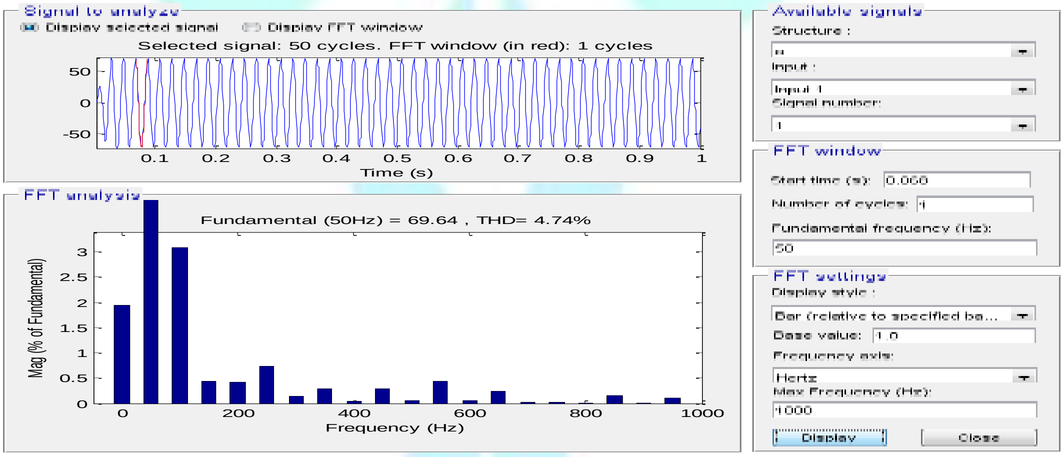

Figure 8. FFT analysis of current waveform with filter

Table 1. Comparison of results obtained from the inverter with and without filter

THD value	Without Filter, %	With Filter, %
Voltage	20.39	4.83
Current	17.29	4.74

From the results, it was found that the harmonics in the system is considerably reduced due to the introduction of passive filter into the circuit compared to the result obtained without the filter (Bloemink and Green, 2011) and with the introduction of filter in the circuit. The voltage harmonics and current harmonics values are significantly reduced, and the results are compared as shown in Table 1.

Conclusions

The Multilevel Inverters are beneficial as the number of switches in inverter increases but this increases the harmonic distortion. The distortion in the output is reduced by the proper design of the filter for the inverter. Distortion in AC output voltage and current decreases the performance of the system therefore in grid connected systems, it is important to maintain the voltage. A filter is required between an inverter and grid, imposing a current-like performance for decreasing the harmonics in the output current waveform. So a LC filter is having good performance to mitigate the harmonics present in the output of the inverter.

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