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Grid Connected Multilevel Inverter for Renewable Energy Applications

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Abstract

Electrical energy generation from renewable energy sources such as sun, wind etc., are widely adopted due to the increase in electricity consumption. The integration of renewable energy sources with the grid plays an important role in energy utilization. It is difficult to utilize electricity from renewable energy sources directly for the injection of power into the grid. Hence the system needs power electronic converters as an interface between renewable energy sources and grid/load. This paper discusses about the integration of three phase six level voltage source inverter into the grid. Three phase 2000 VA inverter is designed by using three**,** single phase eight switch six level inverters (in quarter cycle) and each single phase inverter uses three DC voltage sources which can be derived from renewable energy sources such as solar, wind and fuel cell. The pure sinusoidal 415V three phase voltage is obtained from inverter to inject the power into grid and to the three phase resistive load. The proposed three phase Multi Level Inverter (MLI) is compared with the conventional three phase inverter and the observed THD of the conventional MLI is 31%. THD of the proposed MLI output voltage is analyzed which is 0.13% and found to be very less compared to six and 12 pulse conventional converter topologies. The simulation on the proposed inverter topology is done in MATLAB/Simulink and the results are verified.

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Keywords: Grid Integration,Multilevel three phase inverter, THD,Renewable energy sources;.

1. Introduction

Nowadays the power obtained from solar and wind energy are connected to the grid for better utilization of renewable energy sources. The power extraction from renewable energy sources cannot be directly utilized by the loads or the grid. The power electronic interface such as DC-DC converters and DC-AC inverters especially MLIs

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are used as an interface between them. The grid can be fed by pure sinusoidal wave or voltage/current with lesser harmonics. Grid frequency should match with the frequency of the signal which is being injected [1]. To obtain lesser harmonics sinusoidal three phase voltage and current, MLI configuration with LC filter is incorporated. Conventional MLIs started with three level outputs such as 0V - Vdc – 0V. Later there were more number of configurations on inverter topology has come out. Since the inverter generates multi stepped wave output, the harmonic profile can also be improved. Further the advantages of MLI's are higher efficiency, reduced dV/dt stresses on the load, lower electromagnetic interference (EMI). DC input voltage sources the MLI's can be derived from renewable energy sources such as Photo Voltaic array with DC to DC converter, Induction generator/Synchronous generator fed wind turbine with rectifier configuration and fuel cell with DC-DC converter [2]. To improve the harmonic profile of the voltage and current waveform for grid integration there are so many techniques adopted waveform such as hysteresis current control, Multi level H bridge cascaded inverter etc.,[3][4].The proposed work focuses on the formulation of grid tied three phase 6 level eight switch inverter (per phase)[5][6] and is formed by three single phase inverters with three DC sources and eight switches [5].Grid integration techniques are discussed in the many number of papers [9-12]. The proposed inverter is connected for powering the 2000W resistive load and to inject power to the grid. For the grid integration three phase inverter output voltage is stepped up by the three phase transformer to bring the voltage to 415V Line. To reduce the harmonics in the output voltage, proper value of three phase transformer leakage inductance is selected [13]. THD of the output waveform is analyzed with the use of MATLAB simulink/FFT block. The proposed new three phase inverter topology generates less harmonic three phase voltage waveform compared to conventional six pulse and twelve pulse inverter topology. The THD of the six pulse converter is 31% and twelve pulse is around 12% [4] and the proposed topology produces THD of 0.13%. Six pulse and 12 pulse converter need LC filter for obtaining the pure sine waveform. But the proposed MLI can be directly connected to the grid and load.

2. Block Diagram of Grid Tied Inverter

The proposed configuration represents the grid connection of three, single phase inverters which are connected in star.The DC sources can be obtained from renewable energy sources such PV/wind and fuel cell which is not focused in this work. The following levels can be obtained 0, Vdc, 2Vdc, 3Vdc, 4Vdc and 5Vdc in quarter cycle of the output waveform. Vdc is selected as 30V and therefore the peak amplitude of a inverter output is 150V.The gate pulse for the switch S1 is formed by using two ramp signals of 180° out of phase with other. The each ramp signal is compared with the different DC levels. Output of them is summed up to produce the pulse for switch S1 and the complement of the pulse of S1 is the pulse of switch S1′. Similarly all the other switches pulses were generated. Switching states of the switches in the single phase inverter is shown in the table:1. The gate pulses are generated based on this switching state shown in Table 1. S1′, S2′, S3′, S4′ pulses are compliment of S1, S2, S3, S4 respectively.

Table 1 : Switching states.

Vphase	S_1	S_2	S_3	S_4
+5 V_{dc}	1	0	1	0
+4 V_{dc}	0	0	1	0
+3 V_{dc}	1	0	1	1
+2 V_{dc}	0	0	1	1
+ V_{dc}	1	0	0	0
0	0	0	0	0

3. System Description

The overall system is analyzed as two cases
Case 1: Three phases Multi level inverter connected to the 415V, 2000 W three phase resistive load.
Case 2: Multi level inverter connected to the 50 W three phase resistive load and to 415V three phase grid