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Solar Power Based Single Phase Seven Level Invertor

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Abstract: In low power renewable systems, a single-phase inverter is usually adopted. This project deals with a Seven-Level inverter topology that follows this trend. A review of the state of the art of the Seven-Level topologies and a theoretical power loss comparison with the proposed solution is realized. The proposed inverter architecture is based on a full-bridge topology with two additional power switches and two diodes connected to the midpoint of the dc link. Since the two added levels are obtained by the discharge of the two capacitors of the dc link, the balancing of the midpoint voltage is obtained with a specific pulse width modulation (PWM) strategy. Simulation and experimental results show the effectiveness of the solution.

Keywords: Switch Reduction, 7 Level Inverter, Total Harmonic Distortion, H-bridge multilevel inverter.

I. INTRODUCTION

The developments in power electronics and semiconductor technology have triggered the improvements in power electronic systems. So, different circuit configurations, namely multilevel inverters have become popular and considerable interested by researcher are given to them. The output voltage waveforms in multilevel inverters can be generated at low switching frequencies with low distortion and high frequency. For a medium voltage grid, it is troublesome to connect only one power semiconductor switches directly. As a result, a multilevel power converter structure has been introduced as an alternative in high power and medium voltage situations such as laminates, mills, conveyors, pumps, fans, blowers, compressors, and so on. The concept of multilevel inverters has been introduced since 1975.In cascade multilevel inverter, separate DC-sourced full bridge cells were placed in series to synthesize a staircase AC output voltage. The term multilevel began with the three level converters. Subsequently, several multilevel converter topologies have been developed. The advancements in the field of power electronics and microelectronics made it possible to reduce the magnitude of harmonics with multilevel inverters, in which the number of levels of the inverters is increased rather than increasing the size of the filters. The performance of multilevel inverters enhances as the number of levels of the inverter increases.

In this paper, we are using a new topology of 7-Level inverter for producing output with reduced number of switches. The main objective of this paper is to design an efficient multilevel inverter with reduced switching using Matlab/Simulink. The proposed system introduces the series H-bridge design with three unequal DC sources. The higher number of output voltage levels has the ability to synthesize waveforms with a better harmonic spectrum. This will improve the efficiency of the system and reduce the harmonics present in the system. These designs can create higher power quality for a given number of semiconductor devices than the fundamental topologies alone due to a multiplying effect of the number of levels. The FFT spectrums for the outputs are presented to study the reduction in the harmonics.

II. PREVIOUS RESEARCH

Numerous related research works are already existed in literature which based on multilevel inverter circuit of the system. Some of them are reviewed here.

Vincent Robergeet al. [9] implemented Genetic algorithm based multilevel inverters to improve the high power inverters due to their high-voltage operation, high efficiency, low switching losses, and low electromagnetic interference. A parallel implementation of the GA on graphical processing units is proposed in order to accelerate the computation of the optimal switching angles for multilevel inverters with varying DC sources. GA is used to ignore solving the equation associated with higher order harmonics. A reduction in the eliminated harmonics results in an increase in the degrees of freedom. As a result, the lower order harmonics are eliminated in more operating points. A 9-level inverter is chosen as a case study. The genetic algorithm (GA) for optimization purposes is used.

PedramSotoodehet al. [10] presented the capability of a new single-phase wind energy inverter with the flexible AC transmission system. The proposed inverter is able to regulate active and reactive power transferred to the grid and which is placed between the wind turbine and the grid.

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The power factor can be controlled by using this inverter because of this inverter is equipped with distribution static synchronous compensator. The main objective of this his paper is to introduce new ways to increase the growth of renewable energy systems into the distribution systems. This will encourage the utilities and customers to use interactive supply of energy. Moreover, by using these types of converters will significantly reduce the total cost of the renewable energy application. In this paper, the modular multilevel converter is used as the desired topology to meet all the requirements of a single-phase system such as compatibility with IEEE standards, total harmonic distortion (THD), efficiency, and total cost of the system. This paper was implemented using 11- level inverter then the simulations have been done in MATLAB/Simulink.

Neelesh Kumar et al. [11] proposed three phase multilevel inverter with a small number of switching devices. Large electrical drivesand utility application require advanced power electronicsconverter to meet the high power demands. As a result, multilevelpower converter structure has been introduced as an alternativein high power and medium voltage situations. A multilevelconverter not only achieves high power rating but also improvesthe performance of the whole system in terms of harmonics. Inthis paper the proposed inverter can output more numbers ofvoltage levels with reduced number of switches as compared tocascade H-bridge inverter, which results in reduction ofinstallation cost and have simplicity of control system. Finally,the simulation and experimental results validate the concept ofthis new topology.
Zhong Du et al. [13] implemented cascaded H-bridge multilevel inverter using only a single DC power source and capacitors. Generally, the Standard cascaded multilevel inverters require n DC sources for 2n + 1 level. Without requiring transformers, the scheme proposed here allows the use of a single DC power source with the remaining n-1 DC sources being capacitors, which is referred to as hybrid cascaded H-bridge multilevel inverter (HCMLI) in this paper. The proposed inverter can simultaneously maintain the DC voltage level of the capacitors and choose a fundamental frequency switching pattern to produce a nearly sinusoidal output. HCMLI using only a single DC source for each phase is promising for high-power motor drive applications as it significantly decreases the number of required DC power supplies, provides high-quality output power due to its high number of output levels, and results in high conversion efficiency and low thermal stress as it uses a fundamental frequency switching scheme. This paper was implemented for 7-level HCMLI with fundamental frequency switching control and how its modulation index range can be extended using triple harmonic compensation.

D. Kalyanakumar et al. [14]investigated Hybrid 7-Level H–bridge Inverter was used in a Distribution Static Compensator (DSTATCOM) in the Power System industry, so that the proposed system benefits of low harmonic distortion with reduced number of switches to achieve the output over the conventional cascaded 7-level inverter and reduced switching losses. The proposed system is used to obtain the improved power factor, compensate the reactive power and suppress the total harmonic distortion (THD) drawn from a Non-Liner Diode Rectifier Load (NLDRL) of DSTATCOM, by using Sub-Harmonics Pulse Width Modulation (SHPWM) technique is used as a control for the switches of HSL H – bridge Inverter. The proposed hybrid seven levels H – bridge implemented using MatLab/Simulink simulation software for shunt compensation of a 4.5 KV distribution system.

III. PROPOSED APPROACH

The proposed structure of the H-Bridge 7 Level inverter is shown in Figure 1. This proposed inverter consists of an H Bridge circuit with 12 switching devices, three unequal sources and PWM generation circuit. The unequal DC voltage sources of dc3=25, dc2=75, and dc1=225 is connected with H-Bridge circuit to provide the required output voltage for 13-Level.Only one H-bridge is connected with three cells to acquire both positive and negative polarities.

The cascaded H-bridges multilevel inverter introduces the idea of using separate dc sources to produce an ac voltage waveform. Each H-bridge inverter is connected to its own dc source Vdc. By cascading the ac outputs of each H bridge inverter, ac voltage waveform is produced. By closing the appropriate switches, each H-bridge inverter can produce five different voltages.

PWM generation circuit in the above inverter contains the subsystem of 7 Level H-Bridge inverter shown in figure-2.

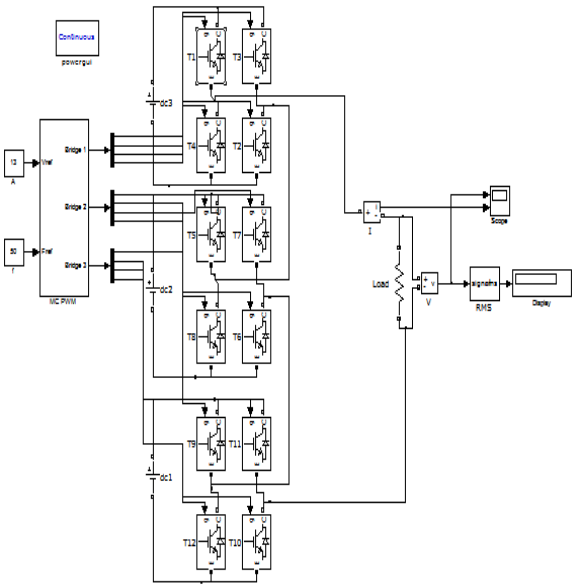

Figure 1: Simulation circuit diagram of proposed H-Bridge 7 level inverter system.

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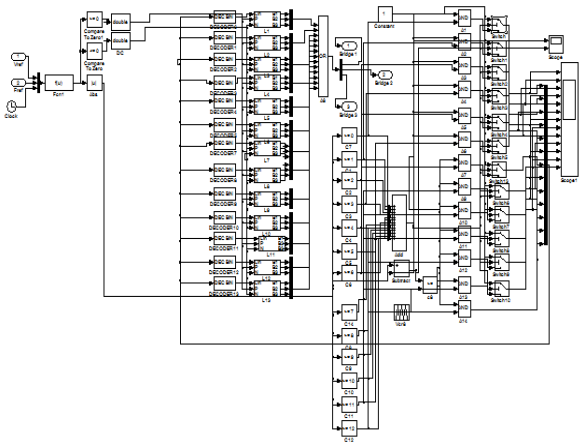

Figure 2: Subsystem Circuit: PWM generation circuit.

IV. MATHEMATICAL MODEL

By turning on controlled switches, T1, T5, T9 (remaining turn off) the output voltage +1Vdc (first level) is produced across the load. Similarly, turning on switches, T1, T2, T5, T6, T9, T10 (remaining turn off) +2Vdc (second level) output is produced across the load. Similarly, further levels can be achieved by further operation. The S number of DC sources or stages and the associated number output level can be calculated by using the equation as follows,

$$N_{level} = 2S+1 \qquad (1)$$

For an example, if S=3, the output wave form will have seven levels (±3Vdc, ±2Vdc, ±1Vdc and 0). Similarly, voltage on each stage can be calculated by using the equation as given,

$$A_i = 1\ V_{dc}(1,2,3) \qquad (2)$$

V. SIMULATION RESULTS AND DISCUSSIONS

In this thesis, new single phase 7 Level H-Bridge inverterwill be focused. Multilevel, i.e., positive, negative, and zero level waveform are synthesized using such an inverter. In the thesis, the total harmonic distortion (THD) methods are used to indicate the quantity of harmonic contents in the output waveforms. To reduce the THD in the output voltage, the lowest s-1 harmonics in each phase voltage need to be eliminated, where s is the number of the full-bridge inverter per phase.

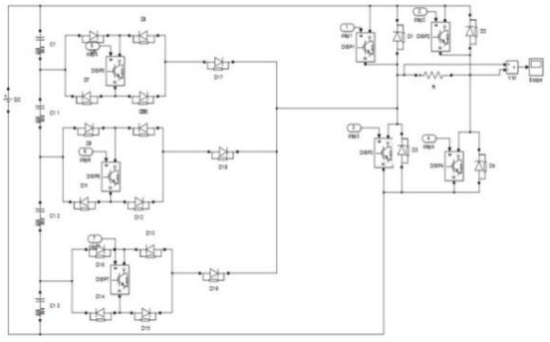

Figure 3: Simulation circuit diagram of Existing system

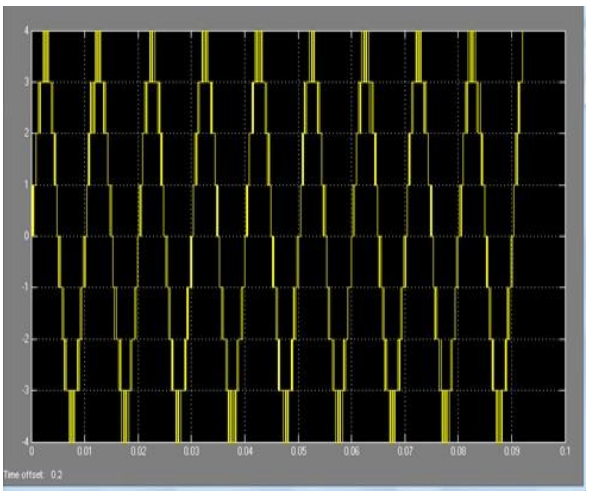

Figure 4: Simulation results of existing system related with voltage and time: 7-Level

In this existing system related with the voltage and time. The range of voltage is ±4V will be applied and with respect to time displayed in the existing system. The 0.09 millisecond of timing will be applied.

The Figure 5 shown below is the Simulink model of the new 13–Level Hbridge Multilevel inverter using power system block sets. The following parameter values are used for simulation: DC inputs of dc3=25, dc2=75, and dc1=225 (for each H bridge with separate sources) at f=50Hz.

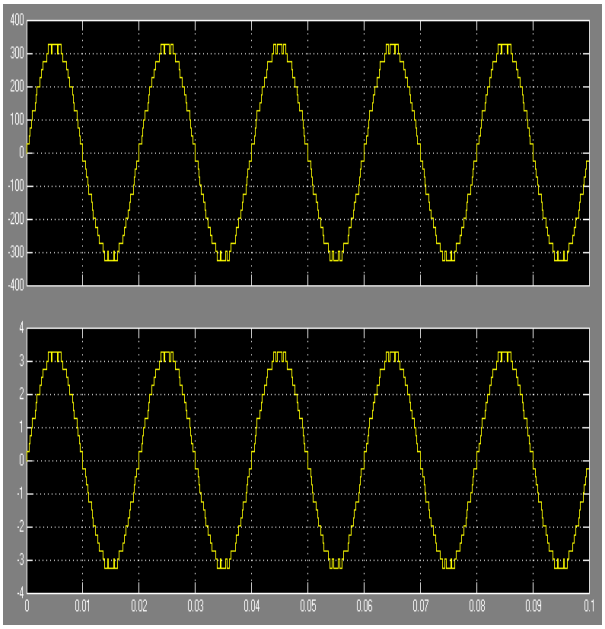

Figure 5: Simulation results of proposed system 7-Level inverter for V and I

In this proposed system of a simulation result is the output voltage, output current and step level will be displayed with respect to time. The maximum step level of 7 Level displayed. And the voltage level and current level for

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various steps displayed. The output voltage per steps with the time will be displayed. The range of voltage is up to ±300V and current value is option ±3A can be delivered. The PWM generation output voltage of the proposed system is followed by,

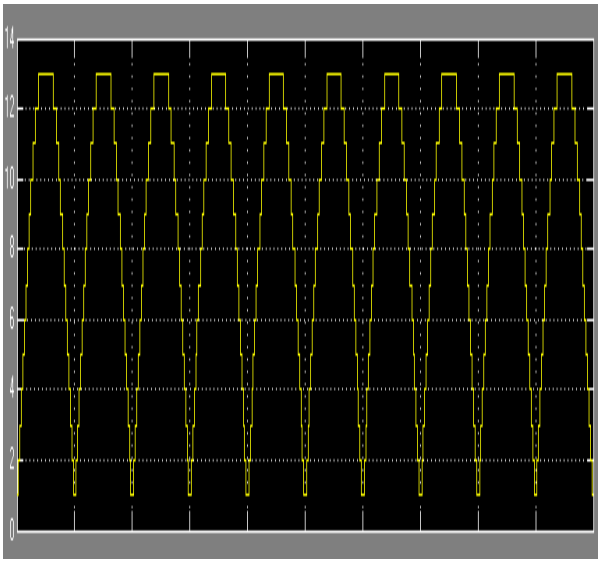

Figure 6: Simulation results for PWM of proposed system

The harmonic spectrum of output voltage and current is shown below. The reduction of THD is used to evaluate the performance of the multilevel inverter.

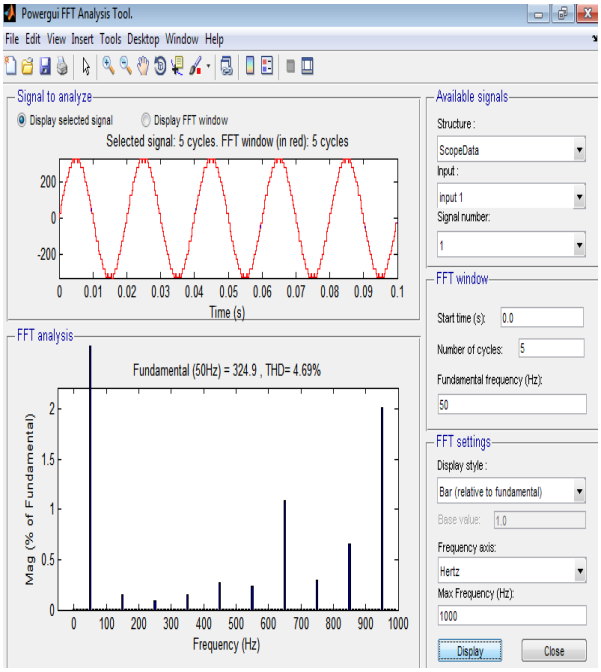

Figure 7: Harmonic spectrum of output voltage

Simulations are done for various values of modulation index and the corresponding THD% are observe during FFT block and listed in Table2.

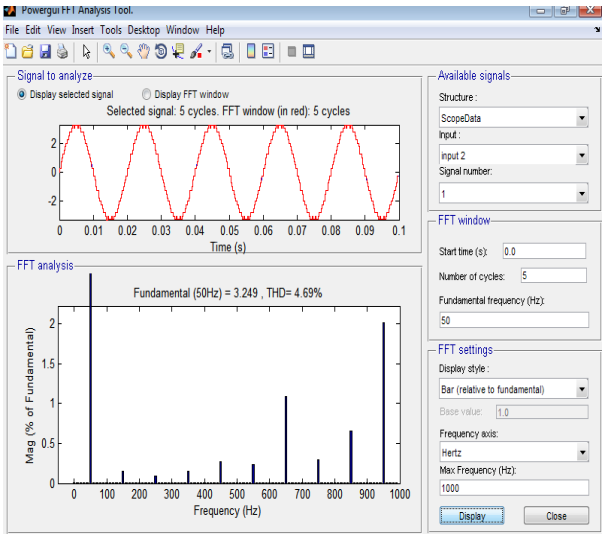

Figure 8: Harmonic spectrum of output current

Parameters	Proposed method using 7 Level s
THD	4.69%
Output current	± 3A
Output voltage	±5V
Frequency	50Hz
Number of switches	12

V. CONCLUSION

Prototype of the 7-level single-phase multilevel inverter consists of H-bridge inverters that it uses separate DC power sources. The control signals for power electronic switches are by using pulse width modulation technique. In this paper both simulation results and hardware prototype model results are correlated. Harmonic analysis carried out using Mat Lab 8.0 version software .It is proved that proposed work of Single phase 7 Level multilevel inverter output voltage total harmonic distortion is reduced and improves the efficiency of system compare with previous topologies of single phase five level multilevel cascade inverter. It is also proved that low total harmonic distortion in proposed technique.

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