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International Journal for Modern Trends in Science and Technology, 9(02): 273-277, 2023

ISSN: 2455-3778 online
DOI: https://doi.org/10.46501/IJMTST0903042
Available online at: http://www.ijmtst.com/vol9issue03.html

Design and implementation of a Multilevel Inverter for Wind Energy

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To Cite this Article
B. Anand Swaroop, G. Ramya, G. Joseph Thambi, V. Bhaskar Rao, M. Dinesh and K. Jagadeesh. Design and implementation of a Multilevel Inverter for Wind Energy. International Journal for Modern Trends in Science and Technology 2023, 9(03), pp. 273-277. https://doi.org/10.46501/IJMTST0903042

Article Info
Received: 28 February 2023; Accepted: 23 March 2023; Published: 27 March 2023.

ABSTRACT

In this paper a new three phase wind energy based multilevel inverter is presented. The proposed inverter is placed between the wind turbine and the grid, and is able to regulate active and reactive power transferred to the grid. This Wind Energy is equipped with inverter in order to reduce the harmonics of the local feeder lines. Using the proposed inverter for small-to medium-size wind applications will eliminate the use of the capacitor banks as well as FACTS devices as it reduce harmonics of the distribution lines. The goal of the paper is to introduce different ways to increase the penetration of the renewable energy systems into the distribution systems. This will encourage the utilities and customers to act not only as a consumer, but also as a supplier of energy. Moreover, using the new types of converters with compensation capabilities will significantly reduce the total cost of the renewable energy applications. The function of the proposed inverter is to transfer active power to the grid of the local power lines regardless of the incoming active power from the wind turbine.

KEY WORDS: Multilevel Inverter, Harmonics, Pulse Width Modulation.

1.INTRODUCTION:

The role of power electronics in distribution system has greatly increased recently. The power electronics devices are usually used to convert the non-conventional forms of energy to the suitable energy for grid, in terms of voltage and frequency, in permanent magnet (PM) wind applications, a back-to-back converter is normally utilized to connect the generator to the grid. A rectifier converts the output power of the wind of the wind turbine to a DC power. The DC power is then converted to the desired AC power for power lines using an inverter and a transformer. With a recent development in wind energy, utilizing smarter wind energy inverters (WEIs) has become an important issue. There are a lot of single-phase lines in United States, which power small-to-medium-size wind turbine. Increasing the number of small-to-medium wind turbines will make several troubles for local utilities such as harmonics or power factor is generally desirable in a power system to decrease power losses and improve voltage regulation at the load. It is often desirable to adjust the PF of a system to near 1.0. When reactive elements supply or absorb reactive power near the load, the apparent power is reduced. In other words, the current drawn by the load is reduced, which decreases the power losses.

Therefore, the voltage regulation is improved if the reactive power compensation is performed near large loads. The proposed inverter will be used to regulate the reactive power of the local distribution lines and can be placed between the wind turbine and the grid, same as a regular WEI without any additional cost. The function of the proposed inverter is not only to convert DC power coming from DC link to a suitable AC power for the main grid, but also to reduce the harmonics of local grid by injecting enough reactive power to the grid. In the proposed control strategy, the concepts of the inverter possess compensating capability with no additional cost. The active power is controlled by adjusting the power angle, which is angle between the voltages of the inverter and the grid, and reactive power is regulated by the modulation index 'm'.

There are large number of publications on integration of renewable energy systems into powers system. A list of complete publications for grid integration of wind and solar energy was presented. New commercial wind energy converters are introduced without any detailed information regarding the efficiency or the topology used for the converters. A complete list of the most important multilevel inverters was reviewed. Also, different modulation methods such as sinusoidal pulse width modulation (PWM), selective harmonic elimination, optimized harmonic stepped waveform technique, and space vector modulation were discussed and compared. Among all Multilevel topologies the cascaded H-bridge multilevel converter is very well-known for several reasons.

The main reason is that it is simple to obtain a higher number of levels. The modular multilevel converter (MMC) was introduced in 2000s. this project mostly looks at the main circuit components. Also, it compares two different types of MMC, including H-bridge and full bridge sub modules. The proposed inverter is placed between the renewable energy source and the main grid.

2. LITERATURE SURVEY

The objectives of the inverter considered in this thesis is to convert DC power coming from DC link to a suitable AC power to the main grid, and also to regulate the PF of the local grid at a target PF by injecting reactive power to the grid. In this control strategy, the concepts of the inverter. The active power will be controlled by varying the power angle 'δ', i.e., angle between inverter voltage, the grid voltage and reactive power is regulated by the modulation index 'm'. The list of the most important multilevel inverter was reviewed and different modulation techniques such as sinusoidal pulse width modulation, selective harmonic elimination and space vector modulation were studied

3. MULTILEVEL INVERTER

A multi-level inverter is a method of generating high-voltage waveforms from low voltage components. It creates the output voltage with multiple DC voltages as inputs. Many voltage levels are combined to produce a smoother waveform. Inverters are often used to provide power to electronics in the case of no power available where as a multilevel inverter is a more powerful inverter, where it does the same thing as an inverter except provides energy in higher-power consumption.

Multilevel inverters are improved alternative devices to regular two-level inverters, to decrease dv/dt and di/dt ratios while providing an increased number of output levels in current and voltage waveforms.

Multilevel inverters are mainly three types.

1. Diode clamped multilevel inverters
2. Flying capacitors multilevel inverters
3. Cascaded H-bridge multilevel inverters

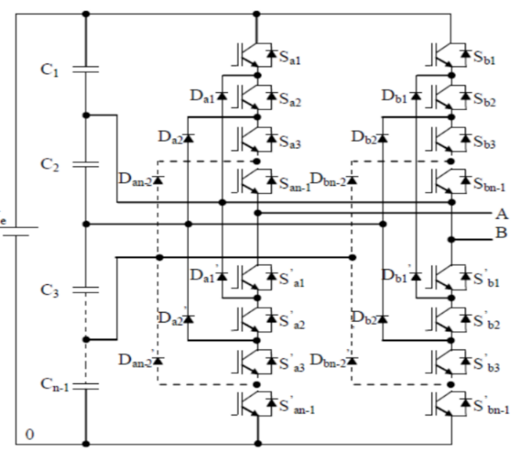

Fig-1: Diode Clamped Multilevel Inverter

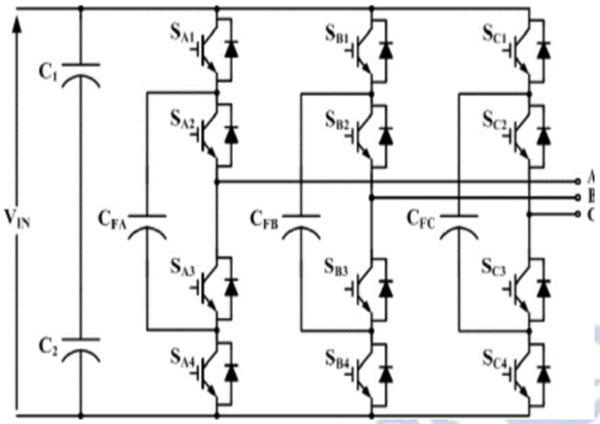

Fig-2: Flying Capacitors Multilevel Inverter

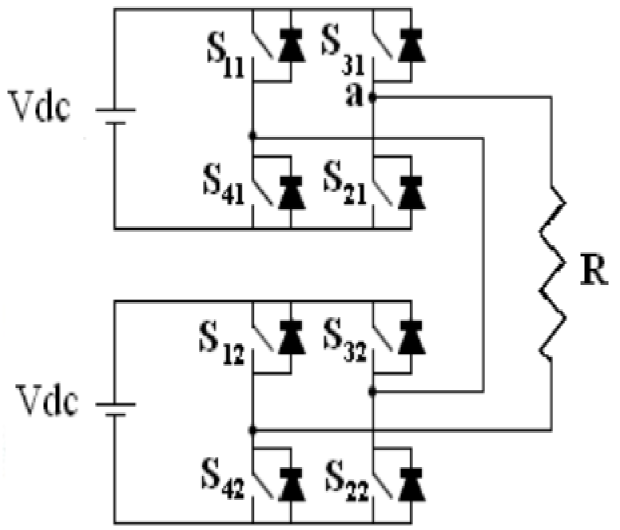

Fig-3: Cascaded H bridge Multilevel Inverter

Features of Multilevel inverter.

1. A low rate of change in voltage and very low distortion have been generated.
2. It naturally rectifies the large voltage transients.
3. They can generate a very low distorted input current and can be operated with a very low switching frequency.

The Multilevel inverter produce common mode voltage and it reducing the stress of the motor and the motor will not damage. Multilevel inverters can draw input current with low distortion. Multilevel inverter can operate at both fundamental switching frequencies, that are higher switching frequency and lower switching frequency. The main drawback of multilevel inverter is their complex circuit, hence a great number of power devices that must be commutated in a precisely determined sequence and also a greater number of passive components and hence un need of a complex control circuitry.

4. SIMULATION STUDY

The proposed control scheme is simulated using SIMULINK in power system block set. The block diagram of the different level of inverter is simulated and is shown in the Figure 4, 5and the corresponding outputs are shown in the Figures.

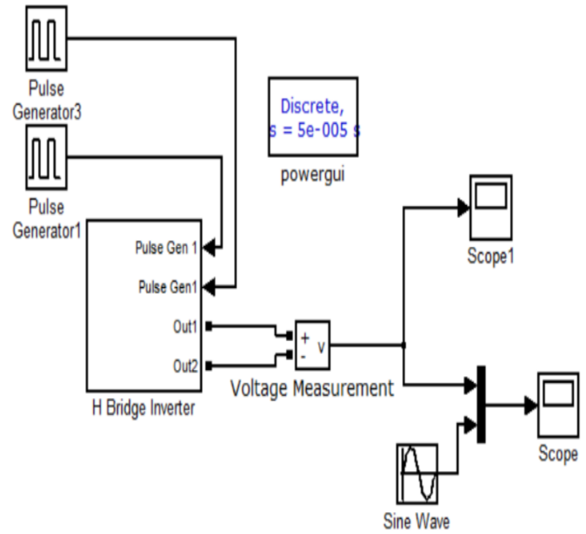

Figure 4: Simulation diagram of 3 Level Inverter

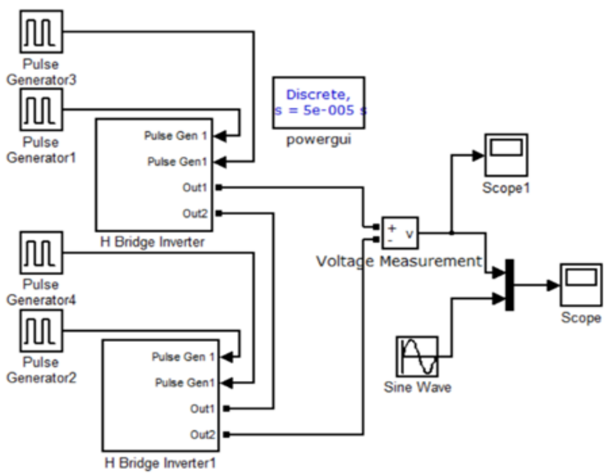

Figure 5: Simulation diagram of 5 Level Inverter

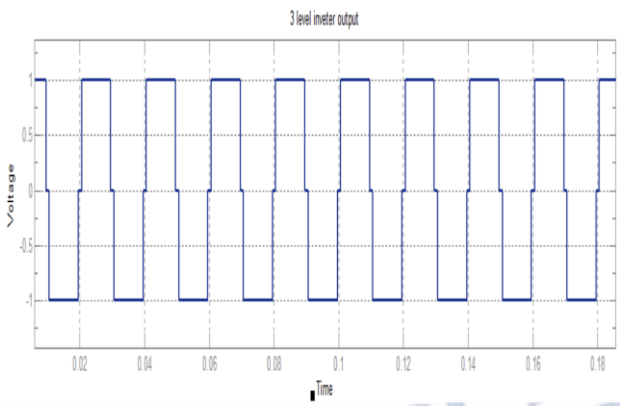

Figure 6: Output of 3 Level Inverter

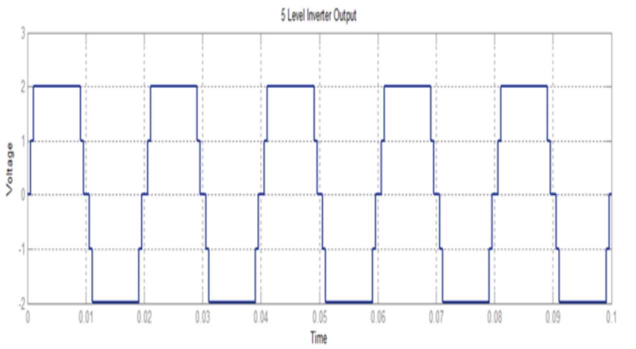

Figure 7: Output of 5 Level Inverter

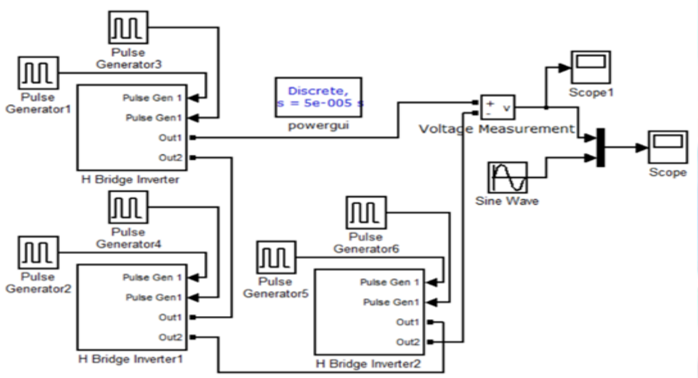

Figure 8: Simulation diagram of 7 Level Inverter

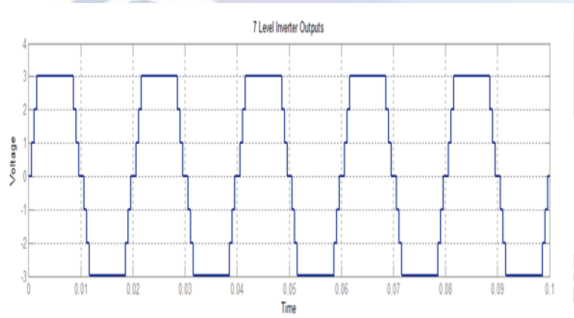

Figure 9: Output of 7 Level Inverter

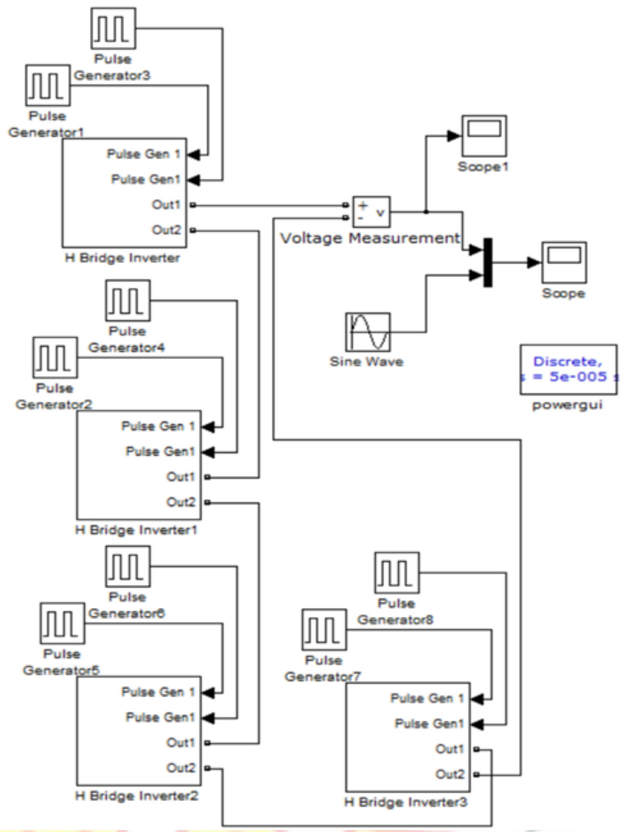

Figure 10: Simulation diagram of 9 Level Inverter

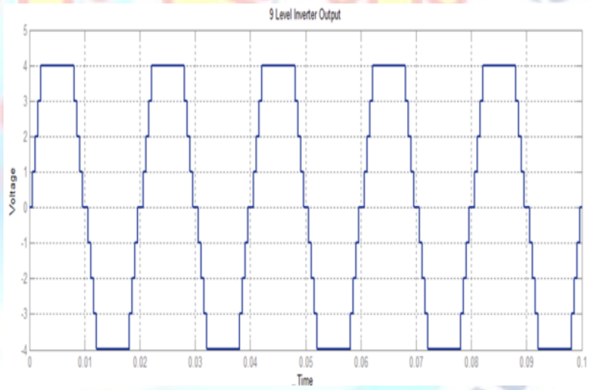

Figure 11: Output of 9 Level Inverter

The proposed Multilevel inverter is connected to the wind energy system using Simulink is shown in the Figure 12 and the corresponding outputs are shown in the Figure 13.

Wind energy system included with turbine & electrical generator. The responsibility of wind energy design has to arrest mechanical power in the air speed & has to alter it in to electrical power. It indulges an ideal IGBT, GTO, or MOSFET and anti parallel diode. The IGBT/Diode block is a simplified mode of an IGBT (or GTO or MOSFET)/Diode pair in which forward voltages of the forced-commutated device and diode are ignored.The Pulse Generator generates square wave pulses at regular intervals.

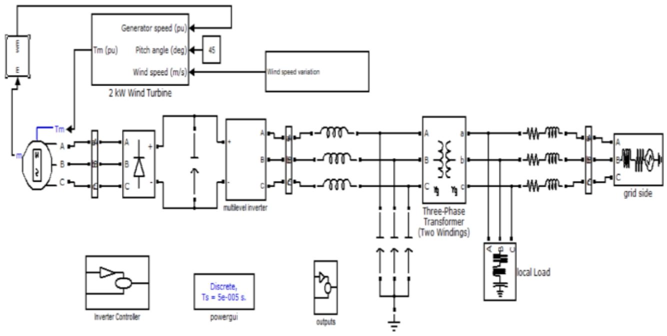

Figure 12: The proposed 11 Level Inverter connected to Wind Energy

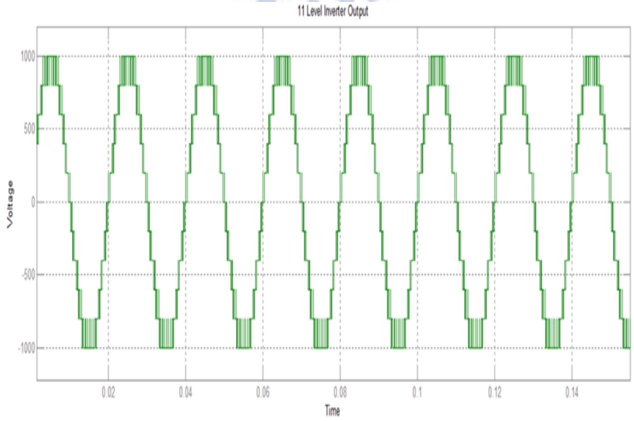

Figure 13: The output wave from of 11-level inverter connected to wind energy

5. CONCLUSION

In this paper modular multilevel inverter with compensation capability for small and medium sized wind turbines are presented. Replacing the existing renewable energy inverters eliminates requirement of separate FACTS devices to control and support in distribution system. The simulation results of 11 level inverter are implemented in MATLAB/Simulink. Results showed good performance of the projected control strategy.**Conflict of interest statement**

Authors declare that they do not have any conflict of interest.

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