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A New Multilevel Renewable Energy System Neuro-Fuzzy Controller

K Sridhar[1] and M Suresh Naidu[2]
Department of Electrical and Electronics Engineering, BIET Engineering College, Hyderabad
[1]Corresponding Author: sridhareee@gmail.com

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Abstract*: Development and use of single phase-type multilevel inverters have grown more in the last several years. A new topology-based seven-level inverter that uses less power electronics and links to the utility grid is proposed in this research. This proposed multilevel inverter works at basic frequency with only eight power electronics switches. We consider this inverter to be a photovoltaic system because it creates seven modes of output from the input. Because only a few circuit switches are required, the overall cost, complexity and losses from switching are very little. The inverter is responsible for changing the signal from negative to positive, giving us both positive and negative cycles and the DC/DC converter takes that signal and changes it into three positive voltages. Enhancing the output waveform is possible by adding a filter circuit to the output main of the multilevel inverter. To address this, a neuro-fuzzy controller strategy for the seven-level inverter was introduced in this paper. The simulation results are shown in the MATLAB Simulink toolbox.*

Keywords*: Renewable energy sources, Solar panels, THD, Multi-level inverters, ANFIS*

I. Introduction

Uninterrupted grid electricity is unavailable in many rural regions. Both hydro and thermal power plants provide the majority of the grid's electricity. In light of the rapidly declining cost of conservative energy sources, solar and wind energy provide a superior alternative resource that is also pollution-free. The resources of renewable energy are profitable and will not negatively impact the environment. The study discusses a seven-level inverter based on single phase photovoltaics [2].

PV power generating is a new modern trend because of its many benefits, which include low-cost, environmentally friendly power generation. It's possible that a multilevel inverter will provide an output voltage and current waveform that is nearly sinusoidal, which will reduce harmonic distortion and enhance power quality [1]. The harmonic may decrease as the level rises, but the number of switches required for converter conduction may rise. As the number of switches increases, switching stress may develop, which can result in switching losses.

The switches are improved according to the concept of multilevel inverters such as the clamping circuit with diode-based inverter [3], the flying capacitor-based inverter [4] and the cascaded-based inverter [1]. More diodes must be used to get the desired number of levels in a diode-clamped inverter. Since the flying capacitor inverter stores charge in a large number of capacitors, the cost for switches increases.

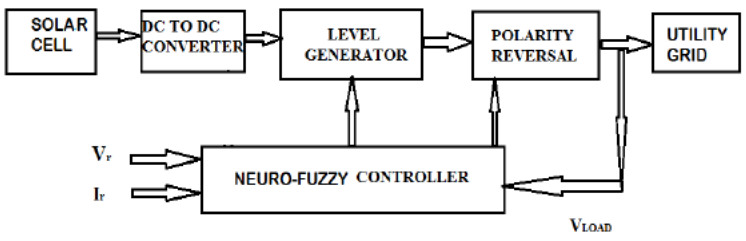

Fig 1: Block Diagram of Neuro-Fuzzy Controller

It is expected that a modified multilevel inverter offering seven levels will be developed to exceed the performance of traditional systems [1]. The neuro-fuzzy controlled photovoltaic energy generation system consists of a 7-Level inverter, a capacitor selection circuit and a dc/dc boost converter. With this technique, you need only three switches instead of seven to achieve seven output levels. The system only requires up to six power switching devices and in high frequency mode, just one will be active at a time. A boost converter is responsible for increasing the solar panel's dc output and MPPT stands for the technique that misleads its switches.

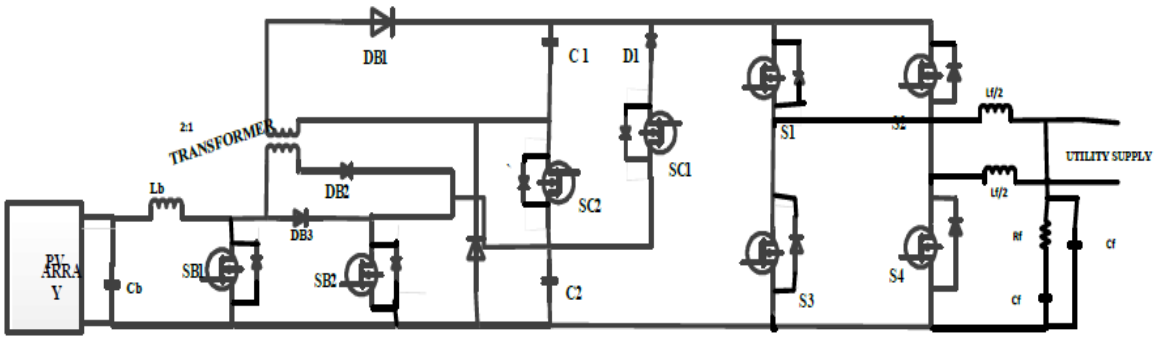

Fig 2: Proposed Circuit Configurations

II. DC-DC Converter Boost on Photovoltaic Cell

A boost converter is necessary to increase a solar system's output because solar radiation is so variable and limited. A boost converter primarily converts direct current (dc) at a lower voltage into dc at a higher voltage. Figure 3 shows solar array systems connected to a dc-to-dc boost converter. With this system, varying irradiance levels have no effect on the output voltage or current. Using a transformer to raise voltage in order to create the desired output voltage levels is a crucial aspect of this subject. The transformer and boost converter will be used to charge the two capacitors.

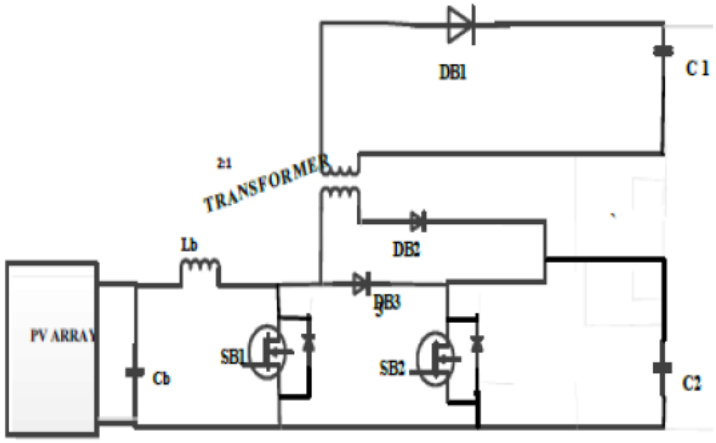

Fig 3: Photovoltaic System Along with Boost Converter

III. Seven Level Inverter

To transform the generated DC electricity into AC power for usage in appliances, an inverter is installed in the system. The suggested multilayer inverter, depicted in Figure 4, is made up of a single multilevel inverter that generates voltage and current at seven different levels. This inverter will offer polarity reversal for the negative power flow, forming both positive and negative cycles. The sinusoidal waveform is maintained and the harmonic content is decreased by the filter inductor at the load side. All of the switches in the boost converter and one multi-level inverter receive PWM signals.

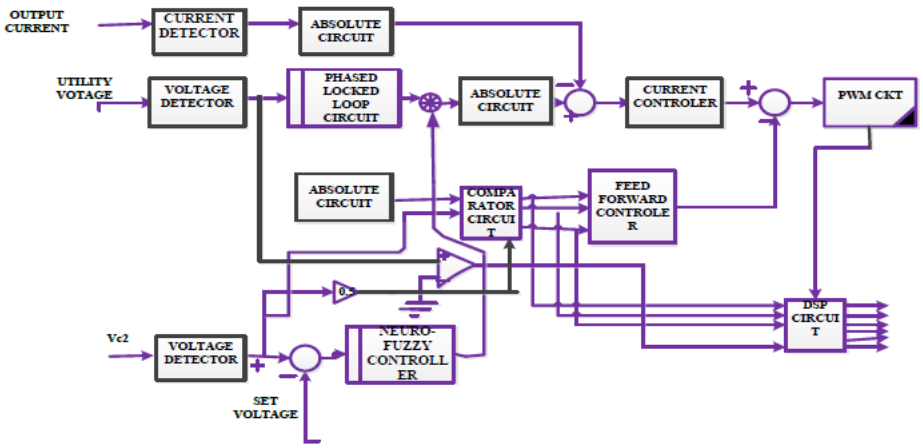

Fig 4: Closed Loop for Multi-Level Inverter

IV. Control Block Diagram

The seven-level and the boost converter inverters are intended to be controlled by this suggested control diagram. These seven-level inverters transform low-level DC electricity into high-level AC power and supply it to the utility grid system. Capacitors C1 and C2 are utilized in this option to raise the voltage levels. The solar power generating system provides the dc-to-dc converter, and the maximum power point tracking system helps to increase the solar power plant's voltage. Figure 5 displays these control diagrams.

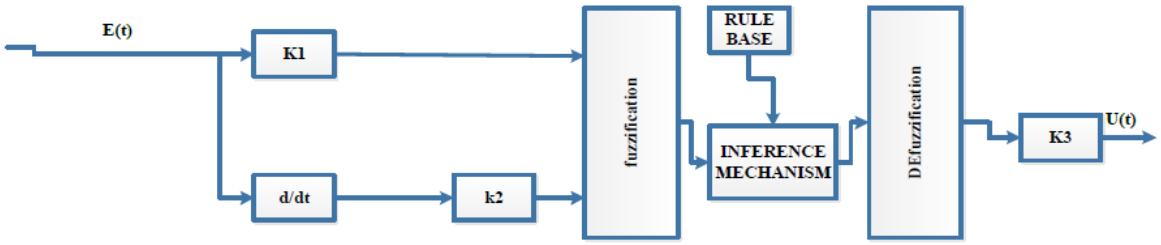

Fig 5: Configuration of Fuzzy Inference System

V. Simulation Results

A controller configuration using fuzzy control was designed to prove the effectiveness of the proposed solar design. In the figure, the solar system produces a voltage of 45.6V and a dc-to-dc converter brings this up to approximately 55V. The same voltage is increased again to approximately 180V by using a dual switch-controlled dc-dc boost converter. The increased voltage is controlled by the use of charged capacitors C1 and C2 in the seven-level converter system.

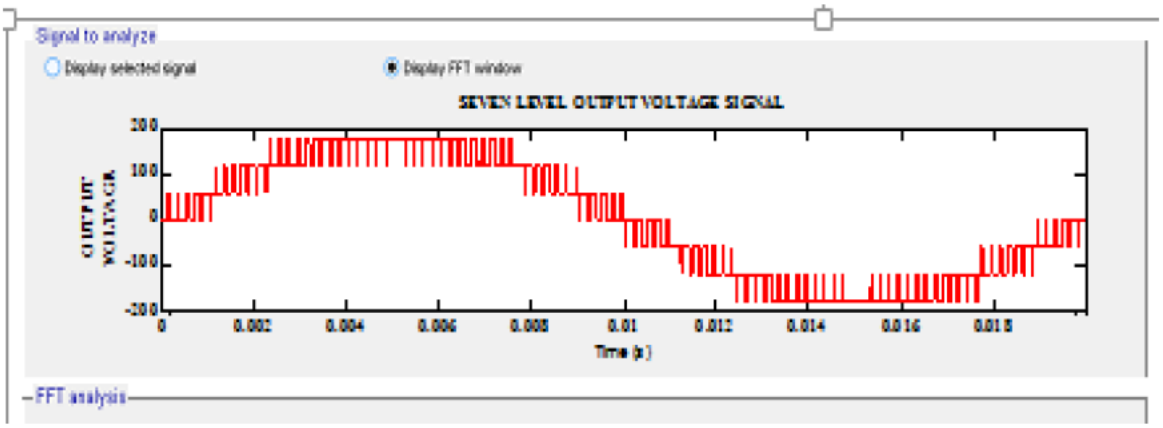

Fig 6: Seven Level Output Voltage

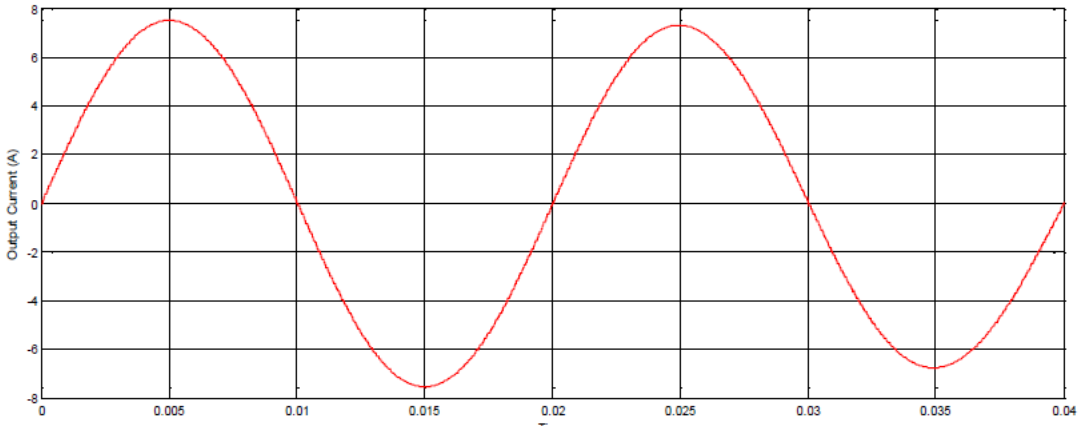

Fig 7: Output Current

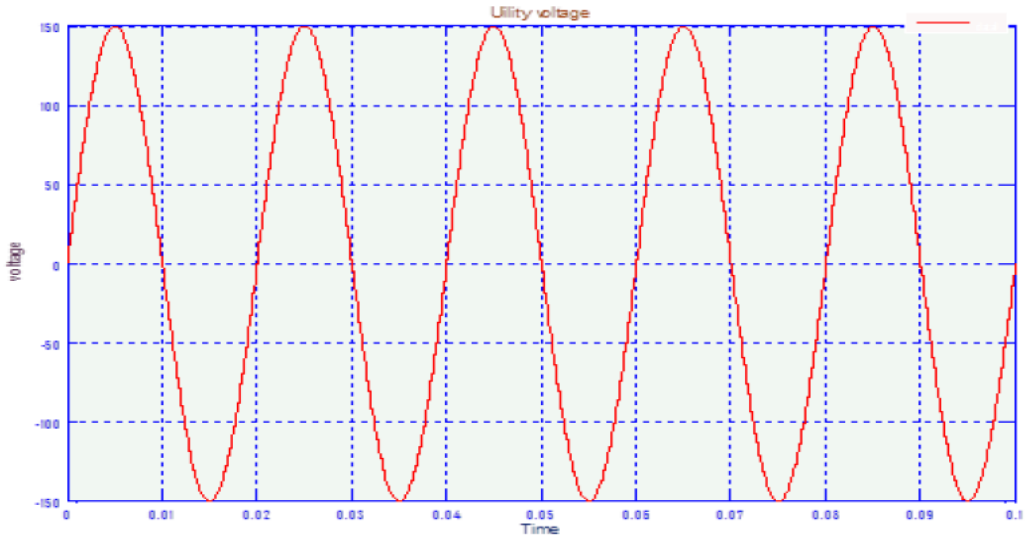

Fig 8: Utility Grid Voltage

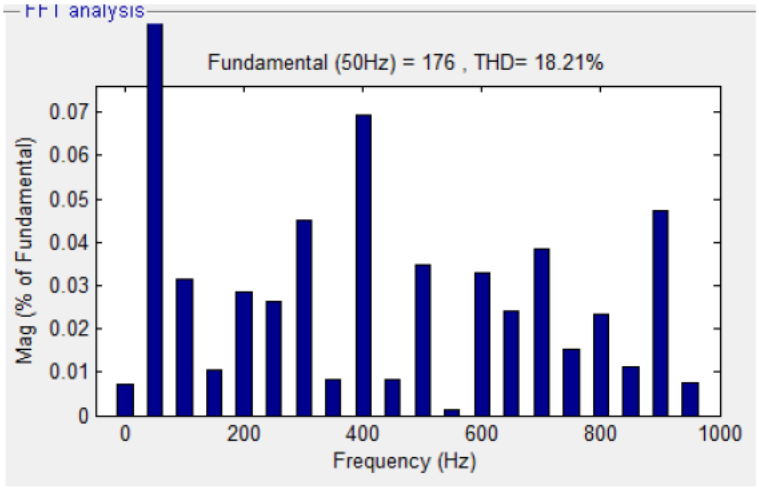

Fig 9: THD for Output Voltage

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