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Volage Stability Enhacement & Total Harmonic Distortion Reduction by Utilizing a 31-Level Multi Level Inverter

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ABSTRACT

The project aims to enhance voltage-stability and improve power quality in smart grids by using renewable energy sources (RES) and a 31-level inverter. The 31-level inverter uses cascaded H-bridge topology, which allows for high-voltage, high-power applications with reduced harmonic distortion. The proposed system consists of a RES-based power generation system, a 31-level inverter, and a voltage control strategy. The RES system consists of a solar photovoltaic (PV) array and a wind turbine, which generate power and feed it into the 31-level inverter. The inverter is controlled by a voltage control strategy that ensures stable voltage and reduces harmonic distortion. Simulation results show that the proposed system improves power quality and enhances voltage-stability in the smart grid. The 31-level inverter reduces total harmonic distortion to less than 5%, which is well within the limits set by international standards. The simulation results can be evaluated by using Matlab/Simulink Software.

Keywords: Solar PV array, Fuel Cell, Multilevel Inverter, Wind energy system.

INTRODUCTION:

Nowadays, most distributed generation units (DGs) and renewable energy sources (RESs), including photovoltaic (PV) systems and fuel cells (FCs), directly generate DC output power, unlike other sources such as wind turbines. Moreover, no converter is needed to combine these sources with the energy storage system (ESS). On the other hand, many customers are powered by energy equipment with an AC-to-DC converter and presently use new devices and electronic loads that use DC energy. Furthermore, the DC-based environment is an easy way to efficiently provide power to these loads.

The PV module or array has been one of the most-used in recent decades because it has a minimum installation cost and requires a minimum operation area. The PV panel or arrays should be operated to deliver the required power to the load or grid. The integration of renewable energy sources (RES) such as solar and wind power into the power grid has become increasingly important as society moves towards a cleaner and more sustainable energy future. However, the intermittent nature of these RES can cause voltage stability issues and poor power quality, which can have negative impacts on the performance and reliability of the grid.

To address these issues, this project proposes the use of a 31-level inverter in a smart grid system that is fed by RES. The 31-level inverter is a multilevel inverter that can produce a high-quality sinusoidal waveform with low harmonic distortion, making it well-suited for use in smart grids with RES. The project aims to enhance voltage stability and improve power quality in the smart grid by controlling the output of the 31-level inverter. The control strategy will be based on a spwm algorithm that can accurately predict the power output of the RES and adjust the output of the inverter accordingly to maintain voltage stability and improve power quality. The proposed system will be implemented and tested in a laboratory environment using a real-time digital simulator. The performance of the system will be evaluated under various operating conditions, including different levels of RES penetration, to assess its effectiveness in enhancing voltage stability and improving power quality in the smart grid. Overall, this project has the potential to make a significant contribution to the development of smarter and more reliable power grids that are better able to accommodate the integration of renewable energy sources.

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Smart Grid is based on Digital Technology that is used to supply electricity to consumers via Two-Way Digital Communication. This system allows for monitoring, analysis, control and communication within the supply chain to help improve efficiency, reduce the energy consumption and cost and maximise the transparency and reliability of the energy supply chain. The flow of electricity from utility to consumer becomes a two-way conversation, saving consumers money, energy, delivering more transparency in terms of end-user use, and reducing carbon emissions.

A smart grid distribution system, whose objective is to develop a power grid more efficient and reliable, improving safety and quality of supply in accordance with the requirements of the digital age.

PROPOSED SYSTEM:

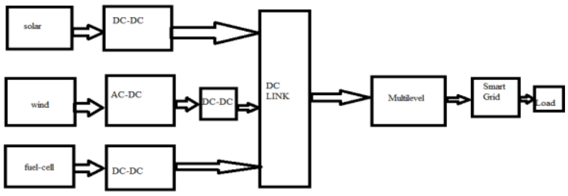

Fig1: Proposed Block Diagram

The proposed system has consists of multilevel inveter which is connected with the renewable energy sources such as solar energy, wind energy and fuel cell and is supplied to the smart grid. Sinusoidal pulse width modulation technique is being used for the implementation of the proposed system.

MODULATION STRATEGY:

Multilevel inverter has to synthesize a staircase waveform by using the modulation technique to have a controlled output voltage. There is variety of modulation techniques available. Basically the control technique can be classified as the pulse width modulation which is considered as the most efficient method. In this system, Sinusoidal pulse width modulation technique is used.

In this PWM technique, the sinusoidal AC voltagereference is compared with the high-frequency triangular carrier wave in real time to determine switching states for each pole in the inverter.

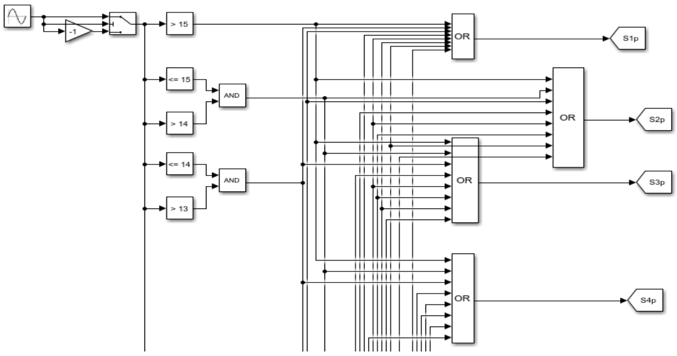

Fig2: Simulation control circuit of 31-level cascaded multilevel inverter

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SIMULATION MODEL OF 31-LEVEL MULTILEVEL INVERTER:

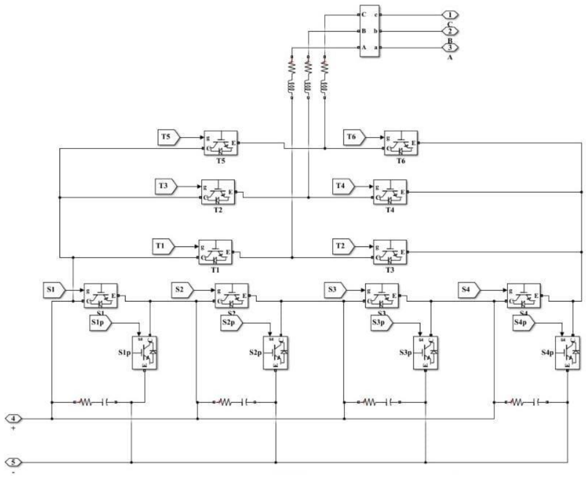

Fig 3:31-level multilevel inverter

The circuit diagram proposed 31-level multilevel Inverter is shown in Fig :(3)The circuit works on the series connection of switching power devices creates serious problems occur during unequal power distribution in the load. As alternatives to effectively solve the above problems, different circuit topologies of multilevel inverter and converter have been modelled and employed. The output voltage of the multilevel inverter has many levels produced from DC voltage source. This multilevel inverter topology can extend rated inverter voltage and power by increasing the stepped voltage levels.

SIMULATION RESULTS:

By the control of sinusoidal pulse width modulation for the 31-level multilevel inverter different output voltages are obtained respectively. Fig (a) depicts the PV system output voltage (x-axis is taken as time (in sec) and y-axis is taken as voltage (in v)), and the obtained maximum voltage is 440v.

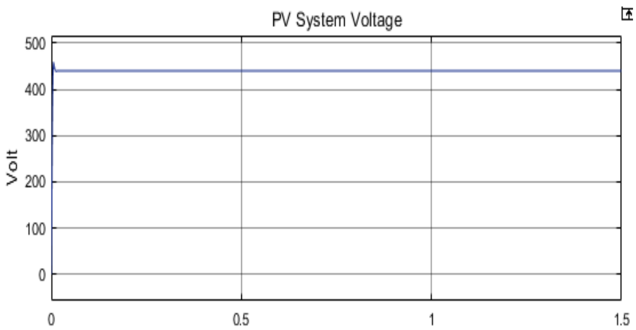

Fig (a): PV System voltage 440v

Fig (b) depicts the wind system output voltage (x-axis is taken as time (in sec) and y-axis is taken as voltage (in v)), and the obtained maximum voltage is 440v.

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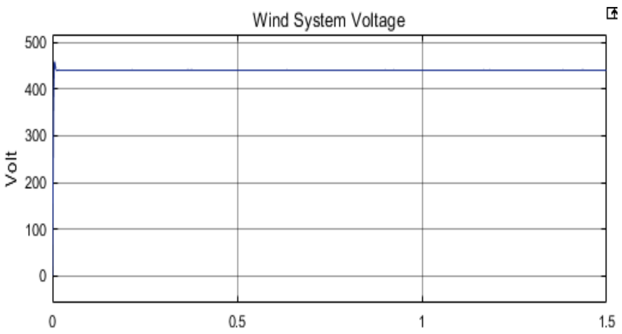
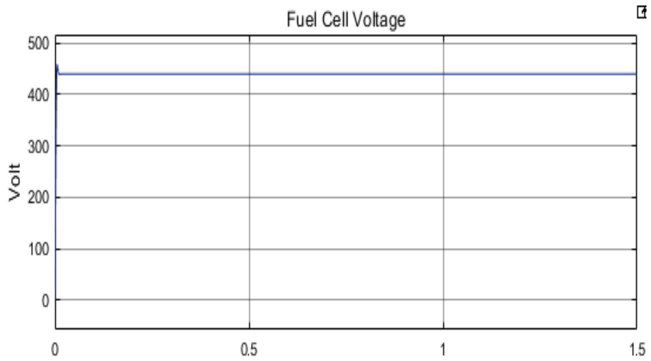


Fig (b): Wind System Voltage 440v

Fig (c) depicts the Fuel system output voltage (x-axis is taken as time (in sec) and y-axis is taken as voltage (in v)), and the obtained maximum voltage is 440v.



Fig(c): Fuel System voltage 440v

Fig (d) depicts the 31 level DC – AC Multilevel inverter side Voltage and Current the maximum obtained Voltage is 372 V and the maximum obtained current is 33.33 Amp

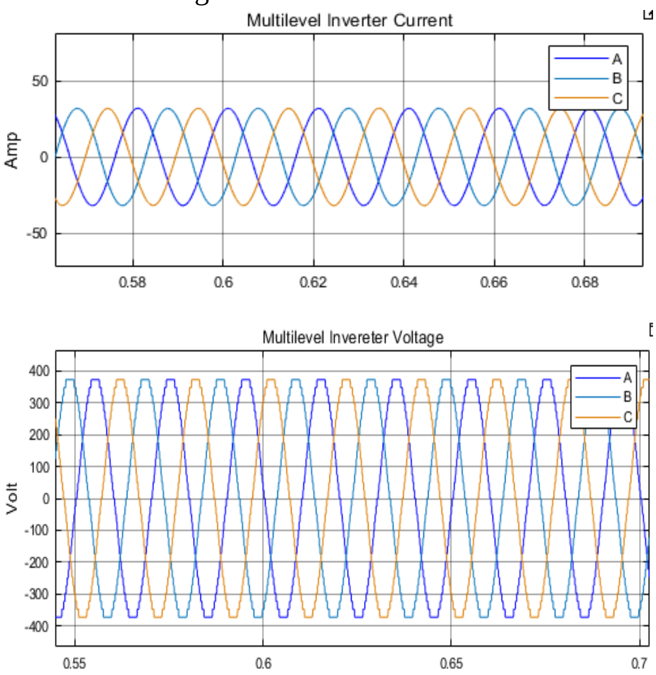


Fig (d): 31-level multilevel inverter

Fig (f) depicts the total harmonic Distortion of 31-level multilevel inverter. The obtained THD is 0.71% for the 50Hz frequency

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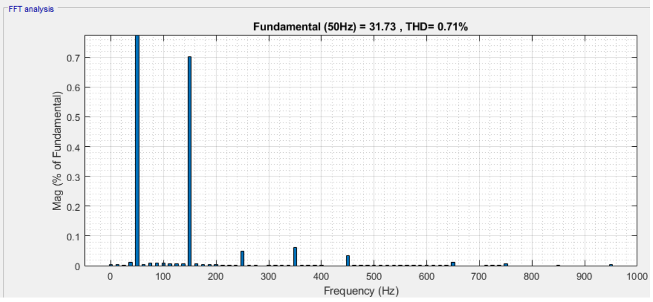

Fig (f): THD of 31-level multilevel inverter

CONCLUSION:

In conclusion, the use of renewable energy sources (RES) in smart grids can greatly enhance voltage-stability and improve power quality. This project specifically focused on the implementation of a 31-level inverter to facilitate the integration of RES into the grid. Simulation results show that the proposed system improves power quality and enhances voltage-stability in the smart grid. The 31-level inverter reduces total harmonic distortion to less than 5%, which is well within the limits set by international standards. The proposed system also enhances the overall performance of the smart grid by increasing its efficiency, reducing its carbon footprint, and promoting the use of renewable energy sources.Overall, the results of this project show that the use of RES and advanced inverter technologies can greatly benefit smart grid systems,

Improving power quality and contributing to a more sustainable energy future.

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