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ENHANCING VOLAGE STABILITY AND IMPROVING POWER QUALITY IN SMART GRID WITH RES FED CASCADED MULTILEVEL INVERTER

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ABSTRACT

Research focuses on renewable energy-based smart grids to meet appropriate energy demands in the world. The smart grid is an autonomous power network that can efficiently transmit electricity. As a result, a multi-level inverter (MLI) that is connected to the smart grid which increases the efficiency of the system. The main objective of system is to inject power generated by the renewable sources such as solar energy, wind energy & fuel cells with multilevel inverter for improving the power quality, lowering Total Harmonic Distortion (THD), increasing the efficiency, and maintaining voltage stability.
Keywords: Solar PV array, Fuel Cell, Multilevel Inverter, Wind energy system.

INTRODUCTION

Renewable energy can be termed as liveliness from unlimited natural resources. There are many sources of natural renewable energy resource like sunlight, water, air, biomass, andgeothermal heat. Over a specified geographical area, the scope and opportunities for renewable energy resources are vast in contrast to other forms of energy like fossil fuels that are limited and concentrated to specific localities. With the rapid development of renewable energy, efficiency, economic benefits are immense and would result in significant energy security, while reducing the environmental effects. This includes positive developments in improved healthcare and reduction in infant mortality rates due to reduced pollution effect and countries would save millions on healthcare. And for reliable source of power, smart grids provide the technologies that improve the any fault detection and self-heal the power network without interrupting the supplied electricity. Smart grid technology can sustain a huge number of fluctuations caused due to weather conditions. Multilevel Inverters (MLIs) are playing a very vital role in the smart grid technology.

So, Power electronics inverters are increasingly more widely used for several applications, such as clean energy, electric power systems, and motor drive systems (renewable). Due to their numerous advantages, such as high-quality output waveforms, less voltage stress on switches, decreased switching losses, and better efficiency, multilevel inverters have also recently attracted a lot of attention. The idea behind multilevel inverters (MLIs) is to convert power utilizing minuscule voltage increases by using many semiconductor switches. These MLIs have been widely employed in high or medium power operations, including variable-speed drives as well as static VAR compensator (SVC) reactive power compensation. MLIs also were applied to low-power operations like solar power systems (PV) and hybrid e-mobiles. The neutral point clamped (NPC), recently developed flying capacitor (FC), and to produce inverted AC from separate DC sources the cascaded H-bridge (CHB), these considered as 3 fundamental topologies of MLI.

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Compared to NPC inverters, this design provides several benefits, including equivalent voltage sharing across semiconductor switches. Such kind of topology, however, necessitates a large quantity of storage capacitors for high voltage steps. The cascaded H-bridge CHB inverters are made up of H-Bridge cells that are coupled in series including an isolated dc supply. That topology is appropriate for high-level operations because of its versatility and ease of handling. Depending upon the values by dc voltage supply VS, the CHB inverters split into 2 major sections: symmetric &asymmetric topologies. The symmetric topology employs equal-valued dc input VS like battery or generator. This characteristic provides high modularity by giving only some levels as in output waveform compared to asymmetric one, which uses various dc VS to provide increases output voltage levels.

PROPOSED BLOCK DIAGRAM

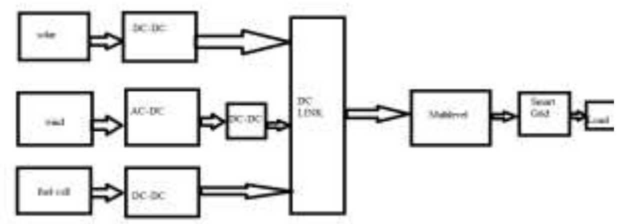

Fig (1): Block Diagram of Multilevel Inverter based Grid connected System

A) Solar Energy:

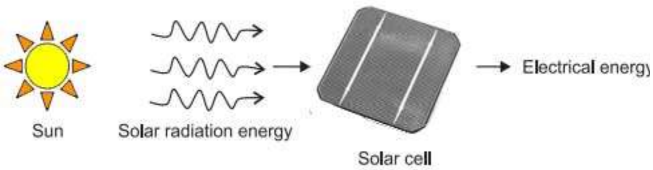

Fig (2): Solar power Generation

Generation of electricity by using solar energy depends upon the photovoltaic effect in some specific materials. There are certain materials that produce electric current when these are exposed to direct sun light. This effect is seen in combination of two thin layers of semiconductor materials. One layer of this combination will have a depleted number of electrons. When sunlight strikes on this layer it absorbs the photons of sunlight ray and consequently the electrons are excited and jump to the other layer. This phenomenon creates a charge difference between the layers and resulting to a tiny potential difference between them. The unit of such combination of two layers of semiconductor materials for producing electric potential difference in sunlight is called solar cell. Silicon is normally used as the semiconductor material for producing such solar cell. For building cell silicon material is cut into very thin wafers. Some of these wafers are doped with impurities. Then the un-doped and doped wafers are then sandwiched together to build solar cell. Metallic strip is then attached to two extreme layers to collect current. Conductive metal strips attached to the cells take the electrical current. One solar cell or photovoltaic cell is not capable of producing desired electricity instead it produces very tiny amount of electricity hence for extracting desired level of electricity desired number of such cells are connected together in both parallel and series to form a solar module or photovoltaic module.

B) Wind Energy:

The terms wind energy or wind power describe the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity. Wind energy is a free**,** renewable resource, so no matter how much is used today, there will still be the same supply in the future. Wind energy is also a source of clean, non-polluting, electricity. Unlike conventional power plants, wind plants emit no air pollutants or greenhouse gases. According to the U.S. Department of Energy, in 1990, California's wind power plants offset the emission of more than 2.5 billion pounds of carbon dioxide, and 15 million pounds of

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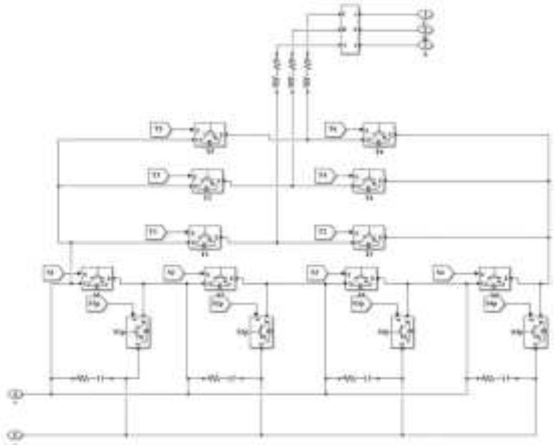
other pollutants that would have otherwise been produced. It would take a forest of 90 million to 175 million trees to provide the same air quality.

C) Fuel Cells:

A fuel cell can be described as an electrochemical cell which, through an electrochemical reaction, generates electrical energy from the fuel. To maintain the reactions that produce electricity, these cells require a continuous input of fuel and an oxidizing agent (generally oxygen). Thus, before the supply of fuel and oxygen is cut off these cells will continuously produce electricity. A fuel cell, which consists of a cathode, an anode, and an electrolyte, is similar to electrochemical cells. The electrolyte makes the motion of the protons possible in these cells.

D)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. The quality of the output voltage is improved as the number of voltage levels increase and reduced the filter size. The cascaded multilevel inverter has employed due to the maximum demand of medium voltage high power inverters. This multilevel inverter topology can extend rated inverter voltage and power by increasing the stepped voltage levels. They can also increase equivalent switching frequency without increase of actual switching frequency, thus reducing ripple component of inverter output voltage and Electromagnetic Interference (EMI) effects. In this concept, to extend the power supply, the review of the total harmonic distortion has to be reduced and improved, for the performance of the system.



Fig(3): 31-Level multilevel Inverter

MODULATION CONTROL TECHNIQUE:

In the controlling strategy for Multilevel Inverter family pulse width modulation (PWM) control is most widely used method. The modulation technique used in this sinusoidal PWM technique. An inverter generates an output of Ac voltage from an input of Dc with the help of switching circuits to reproduce a sine wave by generating one or more square pulses of voltage per half cycle. In sinusoidal pulse width modulation, the modulation signal is always less than the peak of the carrier signal. It is one of the methods to reduce the low frequency harmonics in the inverter waveform. In this method, a reference copy of the desired sinusoidal waveform and the modulating wave is compared to a much higher frequency triangular waveform called the carrier wave.

So, for the above applied SPWM vector concatenation we have the following advantages:

1. It is used to simplify the circuit and to reduce the size.
2. It can track with current and voltage values with less time.
3. It can be applied to any class cascade H-bridge multilevel inverter with current tracking.

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.

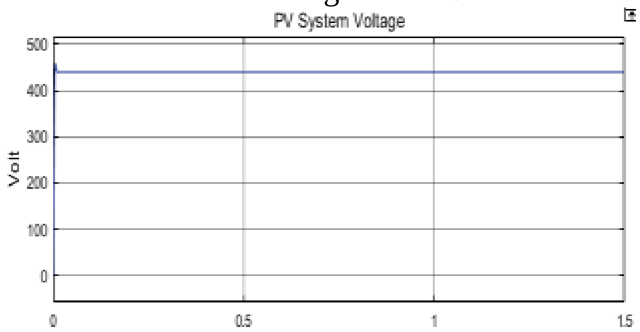


Fig (a): PV System voltage 440v

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.

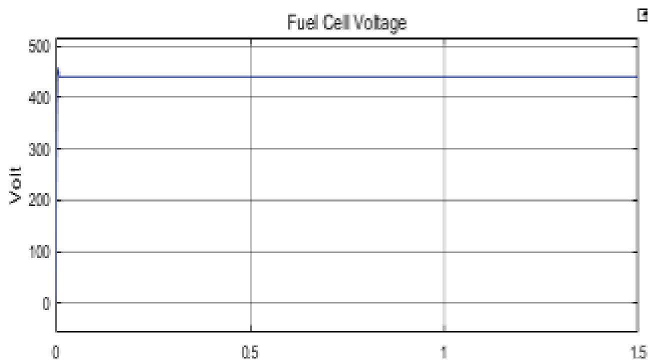


Fig (c): Fuel System voltage 440v

Fig (d) depicts the total Dc 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.

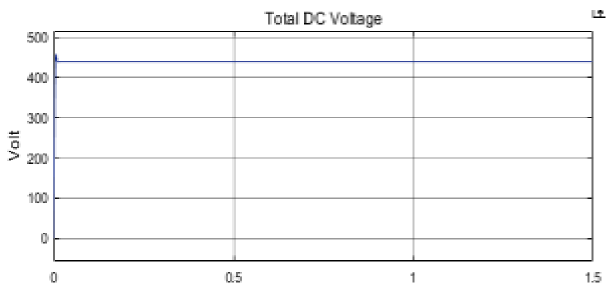


Fig (d): Total DC voltage 440v

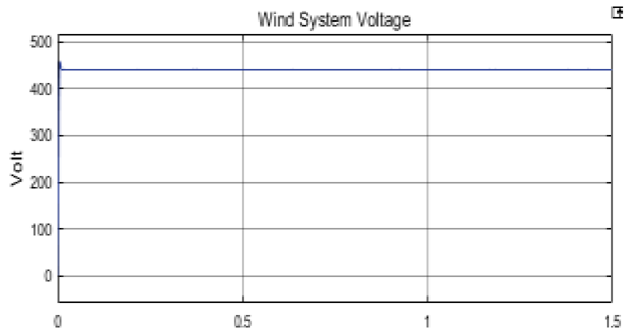


Fig (b): Wind System Voltage 440v

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.

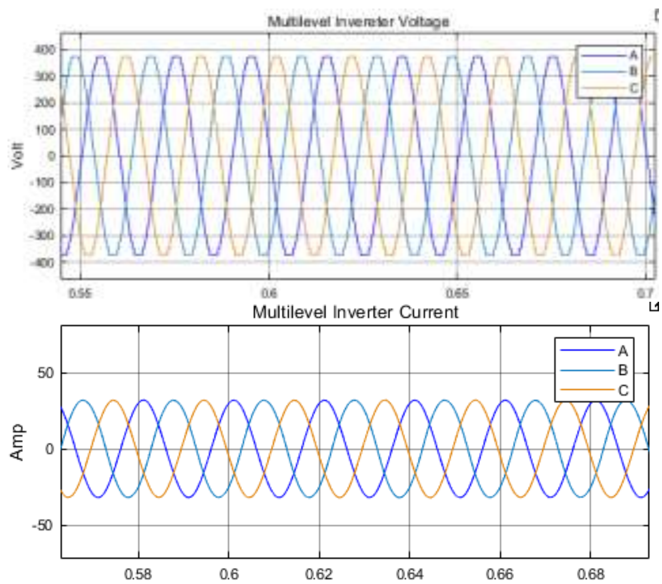


Fig (e) depicts the 31 level DC – AC Multilevel inverter side Voltage and Current the maximum obtained Voltage is 372 V and the maximum obtained current is 33.33 Amp.

Fig (e):31 level Multi-level inverter Voltage 372 V and Current 33.33 Amp

Fig (f) depicts the (i) FFT Analysis and (ii) total harmonic Distortion of 31-level multilevel inverter. The obtained THD is

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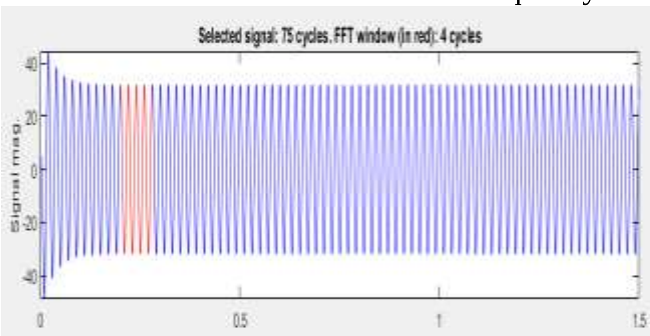
0.71% for the 50Hz frequency.



Fig(f(i)):FFT Analysis

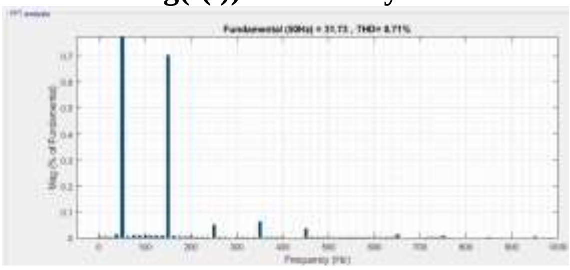


Fig (f(ii)): THD Level of the 31-level MLI is 0.71%

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.

REFERENCES:

[1] Gandini, D.; de Almeida, A.T. Direct current microgrids based on solar power systems and storage optimization, as a tool for cost-effective rural electrification. Renew. Energy 2021, 111, 275–283. [CrossRef].
[2] Hirsch, A.; Parag, Y.; Guerrero, J. Microgrids: A review of technologies, key drives and outstanding issues. Renew. Sustain. Energy Rev. 2020, 90, 402–411. [CrossRef].
[3] Liu, Z.; Su, M.; Sun, Y.; Yuan, W.; Han, H.; Feng, J. Existence and Stability of Equilibrium of DC Microgrid with Constant Power Loads. IEEE Trans. Power Syst. 2018, 33, 6999–7010. [CrossRef].
[4] Cheng, Z.; Li, Z.; Li, S.; Gao, J.; Si, J.; Das, H.S.; Dong, W. A novel cascaded control to improve stability and inertia of parallel buck-boost converters in DC microgrid. Int. J. Electr. Power Energy Syst. 2020, 119, 105950. [CrossRef].
[5] Eid, A. Utility integration of PV-wind-fuel cell hybrid distributed generation systems under variable load demands. Int. J. Electr. Power Energy Syst. 2014.

[6] M.H.Mondol, M. R. Tur, S. P. Biswas, M. K.Hossain,S. Shuvo and E. Hossain, "Compact Three Phase Multilevel Inverter for Low and Medium Power Photovoltaic Systems," in IEEE Access, vol. 8, pp. 60824-60837, 2020, doi:10.1109/ACCESS.2020.2983131.

[7] Celik AN, Acikgoz N. Modelling and experimental verification of the operating current of mono-crystalline photovoltaic modules using four-and five-parameter models. Appl Energy, 2007, 84:1–15.

[8] Khaligh A, Onar OC. Energy harvesting: solar, wind, and ocean energy conversion systems. 1st edn. Boca Raton, FL: Taylor and Francis Group, 2010.

[9] Leedy AW, Guo L, Aganah KA. A constant voltage MPPT method for a solar powered boost converter with DC motor load. In: 2012 Proceedings of IEEE Southeastcon, Orlando, FL, USA, 15–18 March 2012, 1–6.

[10] Chalh A, Hammoumi El A, Motahhir S, et al. trusted simulation using Proteus model for a PV system: test case of an improved HC MPPT algorithm. Energies, 2020, 13:1943.

[11] Saleh AL, Obed AA, Hassoun ZA, et al. Modeling and simulation of a low cost perturb & observe and incremental conductance MPPT techniques in Proteus software based on fyback converter. IOP Conference Series: Materials Science and Engineering, 2020, 881:012152.

[12] Mirhassani SM, Golroodbari SZ, Golroodbari SM, et al. An improved particle swarm optimization based maximum power point tracking strategy with variable sampling time. International Journal of Electrical Power & Energy Systems, 2015, 64:761–770.

[13] Yaqoob SJ, Hussein AR, Saleh AL. Low cost and simple P&O MPP tracker using fyback converter. Solid State Technol, 2020, 63:9676–9689.

[14] Rashid, M. H, 2004. "Power electronics: Circuits, devices and Applications". Third Edition, Prentice Hall.

[15] J. Rodriguez, J. S. Lai, and F. Z. Peng, "Multilevel Inverters: A survey Of topologies, controls and applications," Industrial Electronics, IEEE Trans. Ind. Electronics, Volume 49, no. 4, pp. 724-738, 2002.

[16] Ibrahim Babaei, 2008, "A Cascaded Multilevel Converter Topology with Reduced number of Switches" IEEE Transactions on power electronics, Vol. 23, No. 6.

[17] Bharath. K, R. J. Satputaley, "Single phase Asymmetrical Cascaded Multilevel Inverter Design for Induction Motor," ASAR International Conference, ISBN: 978-81-927147-0-7.

[18] K.RadhaSree,Sivapathi,Vardham. V, and Dr. R. Seyezhai, "Asymmetric Cascaded Multilevel Inverter for Electric Vehicles,"IEEE-ICAESM-2012.

[19] P. Satheesh Kumar, Dr S. P. Natrajan, Dr. Alamelu Nachiappan, Dr.B.Shanti,"Performance Evaluation of Nine Level Modified CHB Multilevel Inverter for Various PWM Strategies," IJMER, Vol. 3.Issue. 5, Sept-Oct. 2013 pp-2758-2766.

[20] International Journal of Engineering Research & Technology (IJERT) Vol. 3 Issue 8, August - 2014