IJAREEIE

e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

Volume 11, Issue 3, March 2022

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.282

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 11, Issue 3, March 2022 ||

DOI:10.15662/IJAREEIE.2022.1103007

Modeling and Simulation of Cost-Effective and Reliable Hybrid Renewable Energy System with Nine Level Inverter

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ABSTRACT: The use of non-conventional energy sources to meet today's energy needs has become critical in the face of fossil fuel shortages. The project's major goal is to electrify rural areas and distant areas. A cost-effective and dependable hybrid renewable energy system for remote places has been implemented in this research. The hybrid system combines solar and wind energy systems because they complement each other and are abundant in nature. Depending on the availability of the sources, it can work in standalone or hybrid mode. A redesigned inverter with minimal components is utilized to obtain high quality output ac power that can feed straight to loads in remote places, allowing for more efficient use of solar and wind energy.The hybrid energy system is modelled and simulated using MATLAB/Simulink software. For improved performance, the proposed concept is executed with a nine-level inverter rather than a seven-level inverter.

KEYWORDS: Photo Voltaic Systems,Wind Energy, DC-DC Converters, MATLAB/Simulink.

I. INTRODUCTION

Because of the global energy crisis and environmental pollution, renewable energy sources are becoming increasingly valuable. Due to the low voltage output of renewable energy systems, high step-up dc/dc converters are commonly used in many renewable energy applications, such as fuel cells, wind power, and solar systems. Photovoltaic systems are predicted to play a significant part in future energy production among renewable energy systems.

PHOTOVOLTAIC SYSTEMS:

A) PV CELL:

Photovoltaic cell is the structure square of the PV framework and semiconductor material for example, silicon and germanium are the structure square of PV cell. Silicon is utilized forphotovoltaic cell because of its benefits over germanium.

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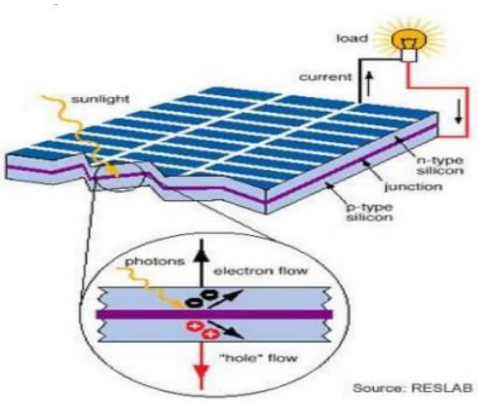
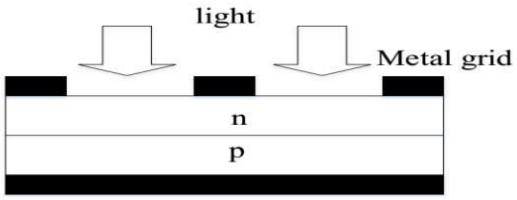


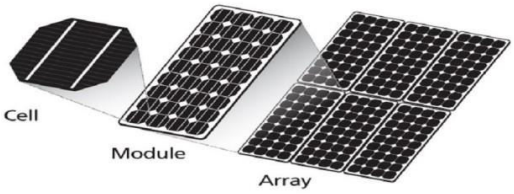
B) PV MODULE:

Because a single PV cell produces a relatively low voltage, multiple PV cells can be connected in serial, parallel, or as a grid (both serial and parallel) to make a PV module. When a greater voltage is required, PV cells are connected in series, and when a high current is required, PV cells are connected in parallel. In most PV modules, 36 or 76 cells are present.



C) PV ARRAY:

A photovoltaic array is simply an interconnection of several PV modules in serial and/or parallel. The power generated by individual modules may not be sufficient to meet the requirement of trading applications, so the modules are secured in a grid form or as an array to gratify the load demand. In an array, the modules are connected like as that of cells connected in a module.



D) WORKING OF PV CELL:

The basic theory involved in working of an individual PV cell is the Photoelectric effect according to which, when a photon particle hits a PV cell, after receiving energy from sunbeam the electrons of the semiconductor get excited and hop to the conduction band from the valence band and become free to move. Movement of electrons create positive and negative terminal and also create potential difference across these two terminals. When an external circuit is connected between these terminals an electric current start flowing through the circuit.

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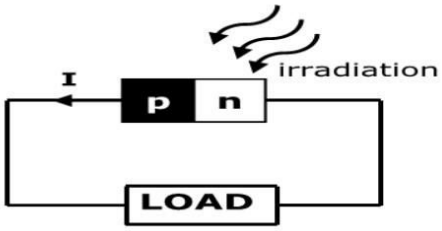
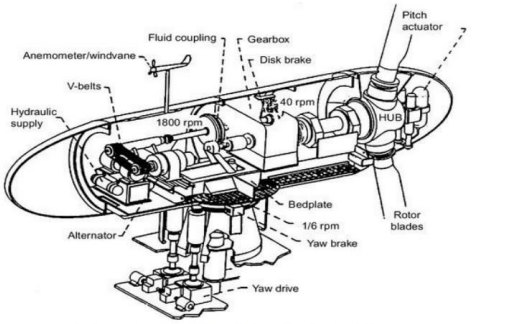
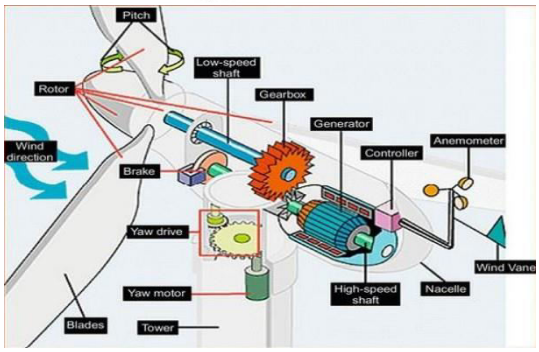


II. WIND ENERGY CONVERSION

A) WIND TURBINE:

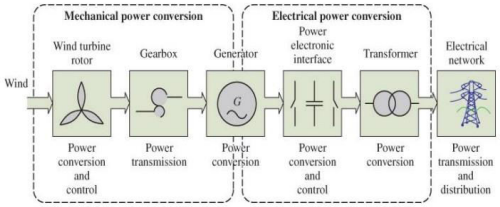
Wind is a form of solar energy and it is available everywhere. Always wind blows from a higher atmospheric pressure region to the lower atmospheric pressure region due to the non-uniform heat by the sun and due to the rotation of the earth.





B) WIND POWER CONVERSION:

The WTS captures wind power by means of aerodynamic blades and converts it to rotating mechanical power in the shaft of the generator. In order to have proper power conversion, the tip speed of the blade should be lower than half that of the sound speed, and thus, the rotational speed will decrease as the diameter of the blade increases.



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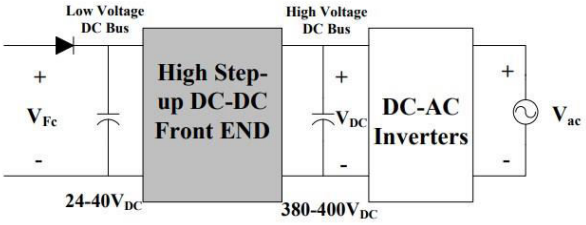
III. DC-DC CONVERTERS

A) NON-ISOLATED CONVERTERS:

The non-isolated converter usually employs an inductor, and there is no dc voltage isolation between the input and the output. The vast majority of applications do not require dc isolation between its input and output voltages. The non-isolated dc-dc converter has a dc path between its input and output.

IV. MULTILEVEL INVERTERS

The term multilevel starts with the three-level inverter introduced by Nabae. By increasing the number of levels in the inverter, the output voltages have more steps generating a staircase waveform, which has a reduced harmonic distortion. However, a high number of levels increases the control complexity and introduces voltage imbalance problems.

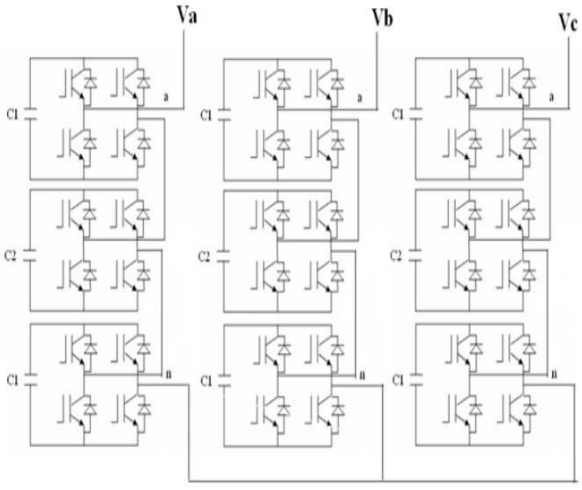


A) H-BRIDGE INVERTERS:

The cascaded H-bridge multilevel Inverter uses separate dc sources (SDCSs). The multilevel inverter using cascaded-inverter with SDCSs synthesizes a desired voltage from several independent sources of dc voltages, which may be obtained from batteries, fuel cells, or solar cells. This configuration recently becomes very popular in ac power supply and adjustable speed drive applications. This new inverter can avoid extra clamping diodes or voltage balancing capacitors. Again, the cascaded multilevel inverters are classified depending the type of DC sources used throughout the input.

V. SEVEN LEVEL CMLI

The converter topology is based on the series connection of single-phase inverters with separate dc sources. Fig. 1.22 shows the power circuit for one phase leg of a three-level , five-level and seven-level cascaded inverter. The resulting phase voltage is synthesized by the addition of the voltages generated by the different cells.



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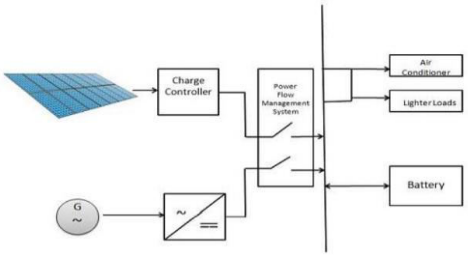
VI. CONTROL STRATEGY FOR POWER FLOW MANAGEMENT

Global Warming is a serious threat faced by the contemporary world. There are two major causes of global warming. They are, burning of fossil fuels and deforestation. Burning of fossil fuels contributes significantly as they are used in many places like transport, industries, power generation, etc., According to [6] Transport section contributes about 13.1% of the total carbon dioxide emissions which is the primary cause of global warming.

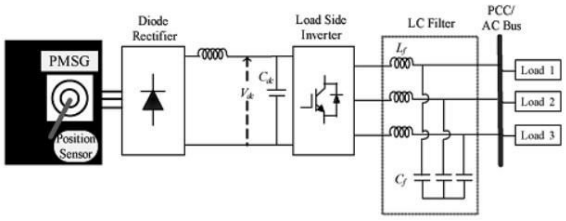
A) SYSTEM OVERVIEW:

This section covers a brief overview of the proposed system to be implemented. The proposed system aims at integrating two sources of energy, the PV energy and fossil fuel energy. The aim of the system is to reduce the power given by the alternator to drive the electrical loads in an air-conditioned bus through the effective incorporation of solar energy.



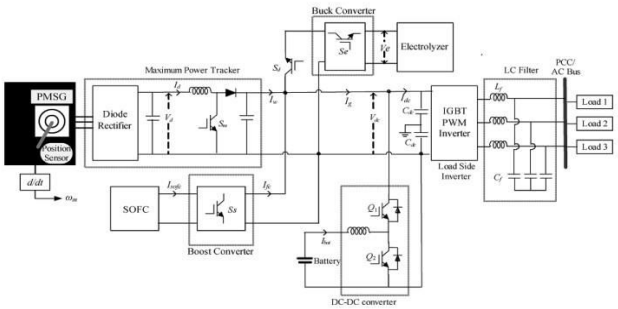
VII. PERMANENT MAGNET SYNCHRONOUS GENERATOR-BASE STANDALONEWIND ENERGY SUPPLY SYSTEM

In wind energy application, variable speed wind turbines are popular mainly because of their capability to capture more power from the wind using the maximum power point tracking (MPPT) algorithm and improved efficiency [12]. Presently, doubly feed induction generators 40 (DFIGs) are widely used as the generator in a variable speed wind turbine system. In case of DFIG, there is a requirement of the gearbox to match the turbine and rotor speed.



A) CONTROL OF DC LINK VOLTAGE:

By providing the neutral system, we can feed to both single-phase as well as three-phase loads. The battery is connected to the dc link through a dc–dc bidirectional buck-boost converter. Using a bidirectional buck-boost converter, the battery voltage can be kept lower as compared to reference dc link voltage and hence fewer batteries need to be connected in series.



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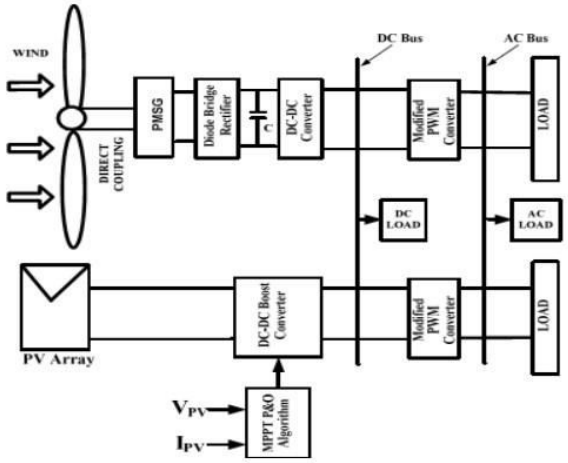
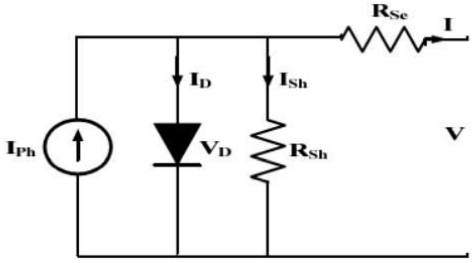
VIII. HYBRID RENEWABLE ENERGY SYSTEM FOR RURAL AREAS

The demand for energy in the past decade is continuously increasing as well as the raw material required to generate the electricity using conventional techniques are depleting, as a result alternate methods to be found to generate electricity. Traditionally centralized power plants are used to generate power.



A) SOLAR ENERGY SYATEM:

The basic blocks of the solar energy system are shown in the hybrid system Fig.3.1. It consists of PV array, DC-DC boost converter stage, and modified DC-AC PWM converter stage with minimum power electronic switches followed by load. The load may be dc or ac load. For the dc load, PV is connected to the load through dc-dc boost converter where as in case of ac load, connected through DC-DC-AC power conversion stage.



B) WIND ENERGY SYSTEM:

The advanced wind turbine designs and tremendous research developments in the field of power electronics made Wind energy as one of the best alternative sources for power generation. And it features like clean, variable, environment friendly, huge availability makes as promising one. Wind energy system (WES) Fig.3.1 consists of the wind turbine, permanent magnet synchronous generator (PMSG), diode bridge rectifier, the modified PWM inverter followed by load.

IX. MODIFIED DC-AC INVERTER

In hybrid power system and standalone renewable energy systems, power electronics technology plays a vital role in the interfacing wind/solar output to loads in remote areas. Good quality of output, minimum stress on switches, maximum efficiency in medium and high-power applications can be obtained by using multi-level inverters. The implemented system uses the modified DC-AC PWM inverter topology shown in Fig.3.3 to generate seven 48 level output voltage.

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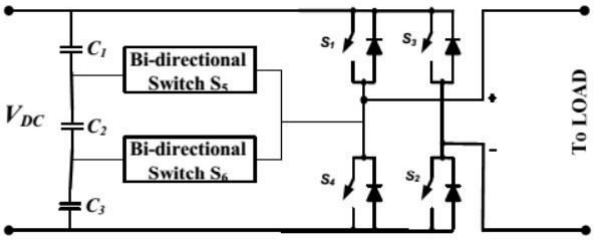

X. MATLLAB

MATLAB (matrix laboratory) is a fourth-generation high-level programming language and interactive environment for numerical computation, visualization and programming. MATLAB is developed by Math Works. It allows matrix manipulations; plotting of functions and data; implementation of algorithms; creation of user interfaces; interfacing with programs written in other languages, including C, C++, Java, and FORTRAN; analyze data; develop algorithms; and create models and applications. It has numerous built-in commands and math functions that help you in mathematical calculations, generating plots, and performing numerical methods.

XI. FEATURES OF MATLAB

Following are the basic features of MATLAB − • It is a high-level language for numerical computation, visualization and application development. • It also provides an interactive environment for iterative exploration, design and problem solving. • It provides vast library of mathematical functions for linear algebra, statistics, Fourier analysis, filtering, optimization, numerical integration and solving ordinary differential equations. • It provides built-in graphics for visualizing data and tools for creating custom plots. • MATLAB's programming interface gives development tools for improving code quality maintainability and maximizing performance. • It provides tools for building applications with custom graphical interfaces. • It provides functions for integrating MATLAB based algorithms with external applications and languages such as C, Java, .NET and Microsoft Excel.

XII. USES OF MATLAB

MATLAB is widely used as a computational tool in science and engineering encompassing the fields of physics, chemistry, math and all engineering streams. It is used in a range of applications including − 50 • Signal Processing and Communications • Image and Video Processing • Control Systems • Test and Measurement • Computational Finance • Computational Biology

XIII. SIMULINK

Simulink is a simulation and model-based design environment for dynamic and embedded systems, integrated with MATLAB. Simulink, also developed by MathWorks, is a data flow graphical programming language tool for modeling, simulating and analyzing multi-domain dynamic systems. It is basically a graphical block diagramming tool with customizable set of block libraries. It allows you to incorporate MATLAB algorithms into models as well as export the simulation results into MATLAB for further analysis. Simulink supports: •System-level design •Simulation •Automatic code generation •Testing and verification of embedded systems.

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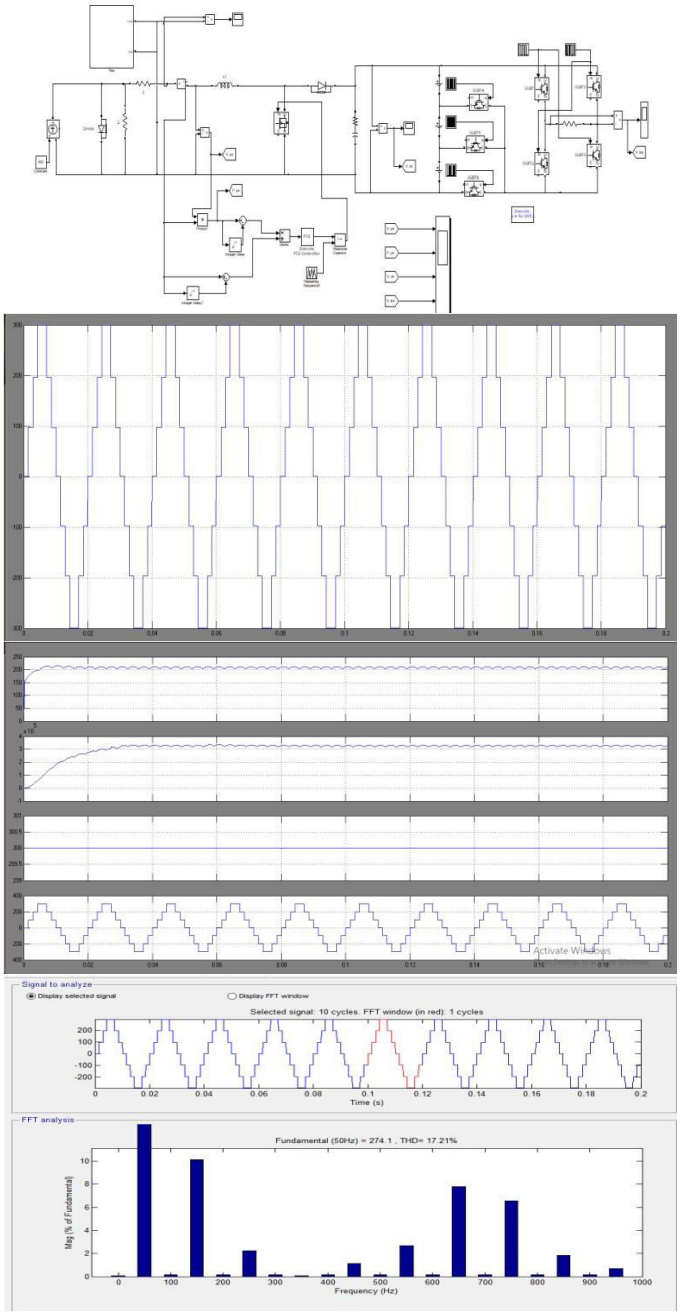
XIV. SIMULINK RESULTS

- **RESULT 1:**



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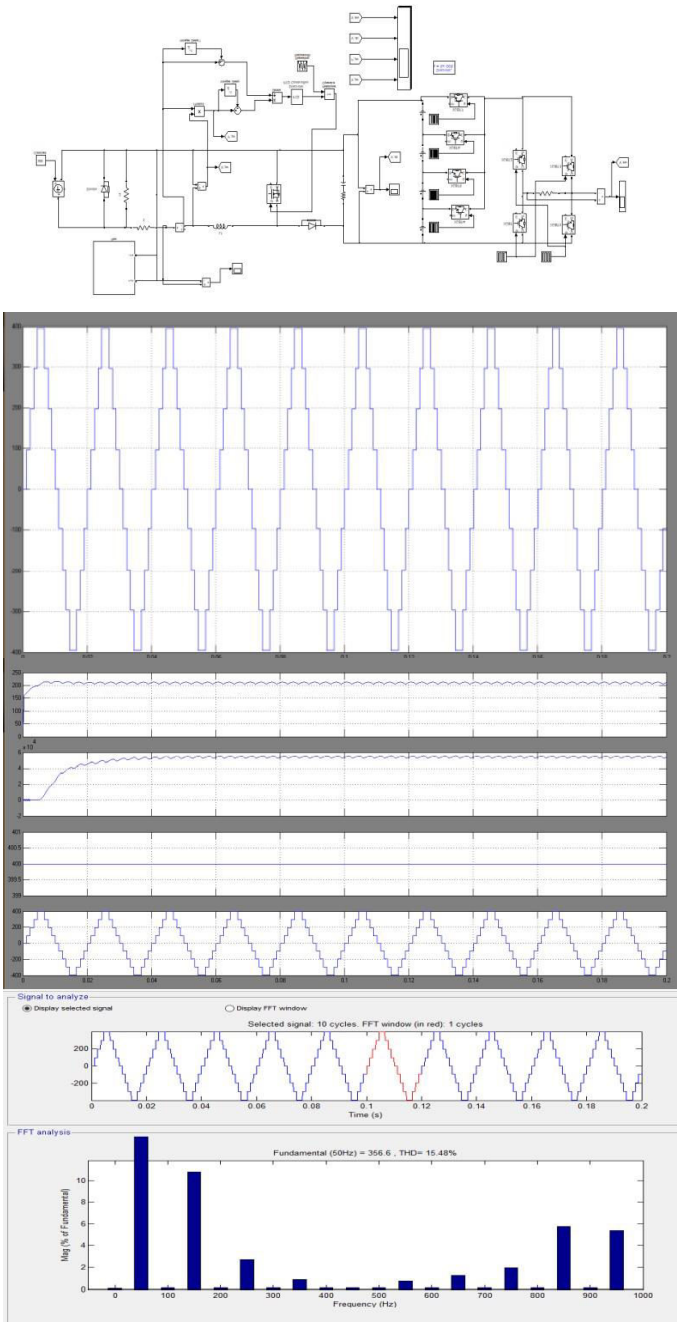
- **RESULT 2:**



XV. CONCLUSION

The implemented hybrid energy system is used to generate and distribute power among the remote areas as the solar energy and wind energy are plenty in nature. Depending on the availability of the solar and wind energy, this system feeds the loads in standalone mode or hybrid mode. The implemented system can be used to feed directly AC as well as DC loads without any grid connection.

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XVI. FUTURE SCOPE

1. The proposed concept in this project is limited for local loads purpose like house hold applications, so further we can implement it to Industrial applications by taking inverter system in three-phase mode. 2. Since it is based on renewable energy sources like PV and Wind, the produced energy not only for normal loads also we can transfer surplus energy to local grids. 3. Based on the requirement of the output power quality the inverter can be chosen, in this we are using seven and nine level inverters, so we can further increase the inverter level to specific requirement.

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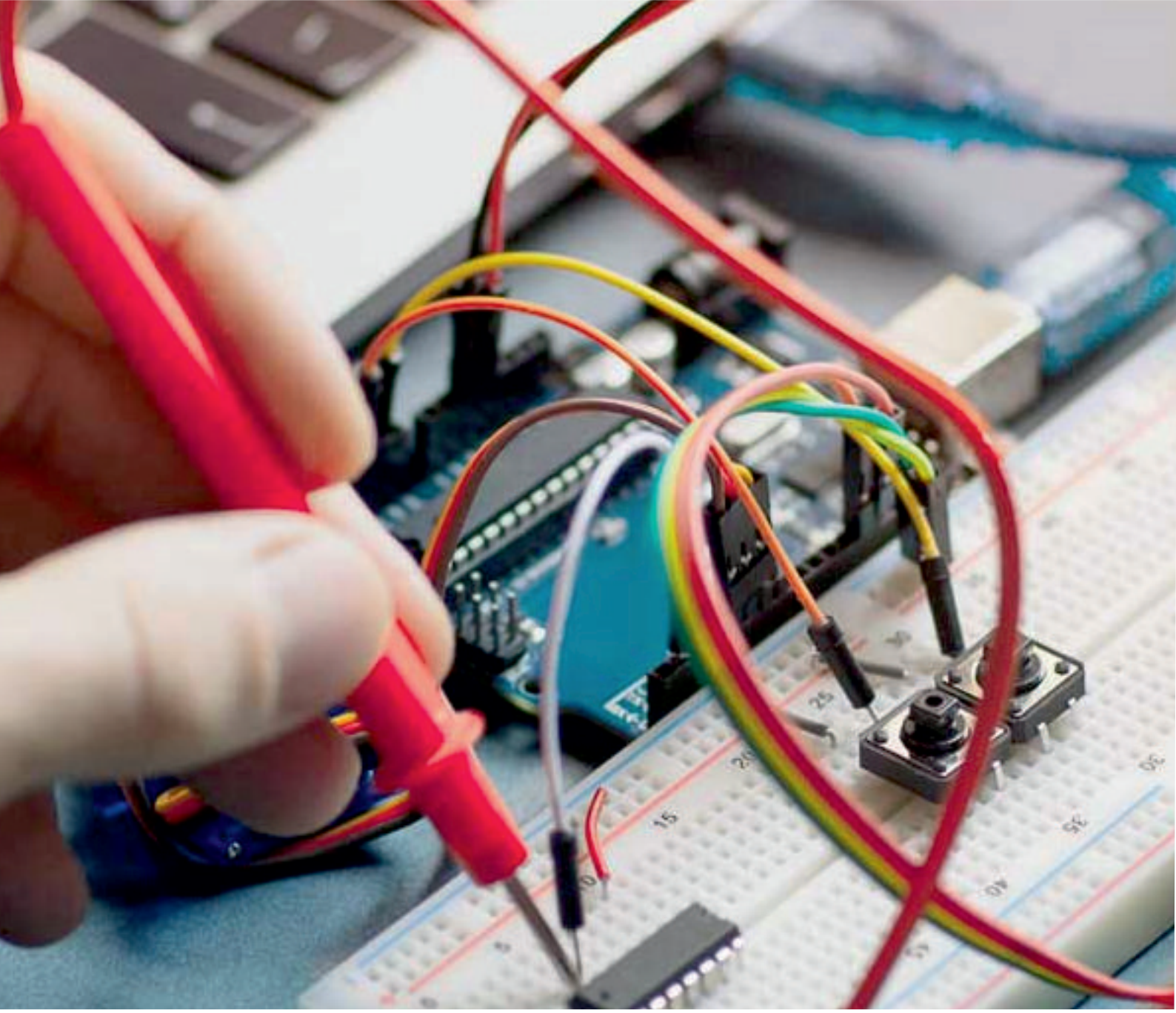

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