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Analyzing the Bridge Inverter Performance of Hybrid Solar and Wind System in MATLAB SIMULINK

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ABSTRACT
Solar and wind energy systems can operate in a standalone or grid-connected mode, but due to the stochastic nature of solar and wind energy, their efficiency is lower. This disadvantage of being unpredictable and uncontrollable is overcome by hybridized renewable energy sources with grid connected. A hybrid renewable energy system (HRES) is a system that combines renewable and conventional sources of energy, as well as two or more renewable energy sources that can operate independently or as part of a grid. Using the MATLAB/SIMULINK environment, the research focused on constructing a solar renewable power supporting the notion by several H bridge converters. The basic notion of a multilayer converter is to do power conversion by synthesis a stairway output voltages using a series of power semiconductor switches with numerous lower voltage dc sources.

Keywords: RES, Hybrid PV and wind energy systems, Grid-Connected systems, CHB Inverter, HWSECS.

I. Introduction

Hybrid solar PV and wind production systems are becoming increasingly appealing, especially for stand-alone applications. Combining the two renewable energy sources of solar and wind can improve reliability and make their hybrid model more cost-effective to operate because the weaknesses of one system can be compensated for by the strengths of the other. Integrating hybrids solar and wind power devices into the network can assist improve the overall economics and dependability of renewable energy production to meet demand. Likewise, combining hybrid wind and solar power in a stand-alone system can lower the amount of energy storage required to provide continuous electricity [1].

Solar and wind energy systems can operate in a standalone or grid-connected mode, but due to the stochastic nature of solar and wind energy, their efficiency is lower. This disadvantage of being unpredictable and uncontrollable is overcome by hybridized renewable energy sources with grid connected. A hybrid renewable energy system (HRES) is a system that combines renewable and conventional sources of energy, as well as two or more renewable energy sources that can operate independently or as part of a grid. The HRES, which combines solar and wind power as essential resources, has two modes of operation: Both sequential and concurrent events are possible. The solar and wind energy systems produce energy simultaneously in simultaneous mode, whereas they produce electricity sequentially in sequential mode [2]. The main characteristics of HRES are that it combines two or more renewable power production technologies to make the best use of their operating principles and achieve higher efficiency than a solitary power supply could provide.

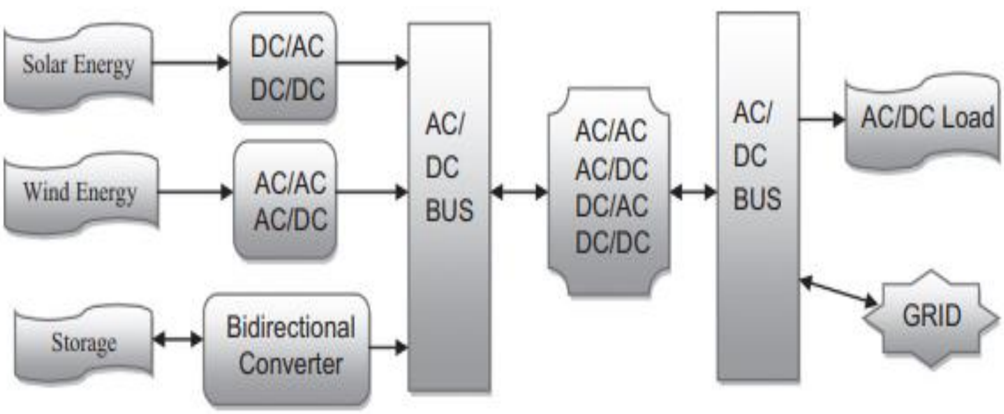

Figure 1 Basic component of solar–wind hybrid renewable energy system [2]

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Many scholars focused on hybrid renewable energy software architecture, simulations, and optimization [4]. Due to the rapid depletion of fossil fuels, there is an urgent need is for alternative energies to meet the ever-increasing energy requirements. Another compelling reason to minimize our reliance on fossil fuels is the mounting threat of global warming.

Power generation technologies that are environmentally friendly will play a significant part in future electrical supply. Power generation from renewable energy such as wind, PV (photovoltaic), MH (micro hydro), biomass, oceans waves, geothermal, and tides are among the renewable energy technologies. The advantages of the aforesaid power systems, such as security of supply, lower carbon emissions, enhanced power quantity, reliability, and employment opportunities for local people, are the main reasons for their adoption. Because renewable energy sources are inherently intermittent, hybrid arrangements of two or even more power generation systems, as well as storage, can help to improve system performance. In order to meet an area's demand, a hybrid renewable energy system (HRES) combines two or more energy resources with such a conventional energy (diesel or petrol generator) and storing [5].

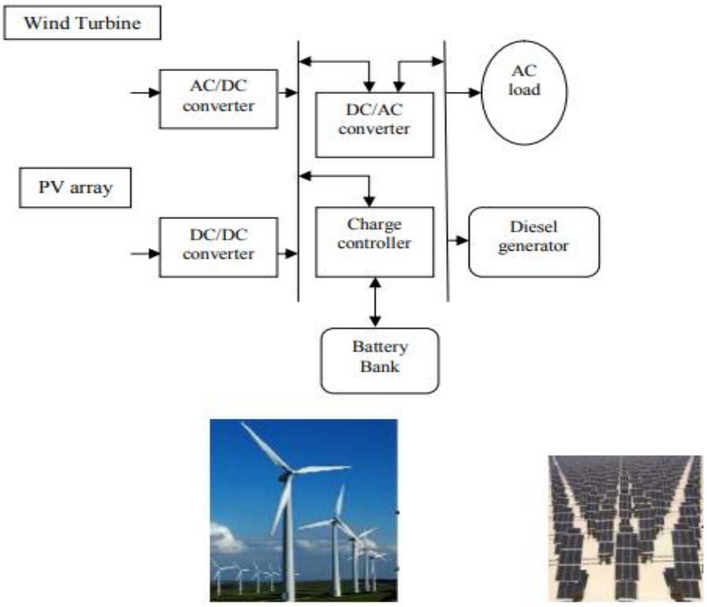

Figure 2 PV/wind/battery/diesel generator HRES [5]

The incorporation of renewable energy sources that are weather-dependent can have an impact on the utility system's stability, quality, and reliability. As a result, the grid codes (GCs) and other standards of many nations have imposed and updated various rules, requirements, and regulations affecting the operation and connectivity of these RESsGC comprises a number of technical standards that explain crucial rules and constraints related to generation units and their integration into the power grid in order to ensure the energy program's stable and suitable operation [6].

II. LITERATURE REVIEW

(S. S. Kumar & Kumar, 2021) [7] The 3-phase CMI-based hybrids network control system is simulated and controlled using the WPS algorithms and WPS-RNN modelling in this manner. The comprehensive modeling and dynamical performances of all modules based on controllers are described. The controller's module may also be sent out based on the regimentation of linking voltages dc and energy injected. As a result, the established control topology is based on the limit as gain and the dc link voltage strict discipline due to current elements as harmonics. The signals controller is optimized, and the PI controller of gain parameters is tweaked, thanks to the established approach. General analysis such as modulated signal, DC link voltage, and PV current are studied.

(Prakash et al., 2021) [8] To reduce THD, this study used a 31-level MLI with a reduced number of switches topologies. The SLDB controller has fine-tuned this inverter's functionality, resulting in error-free output power. The complete project was created in the MATLAB/Simulink environment, and measurements of inverters current and voltage, network current and voltage, and THD, power loss, and efficiency were made. THD, power loss, and efficiencies were analyzed and compared to many existing approaches, including the asymmetrical seven-level inverters, 3LI + TLI, and 13-level cascaded MLI. The proposed model has a THD of 0.1 percent, an efficiency of 99.2 percent, and a power loss of 0.005 (pu), which is better than previous efforts.

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(Humayun et al., 2021) [9] An evaluation of a cascaded five-level SFC-MLI-based STATCOM is presented in this research. When comparing to the CHB architecture, the suggested SFC idea has various advantages. The cascaded SFC topologies has been found to have a reduced number of semiconductor as well as a higher efficiency due to decreased energy losses. The reactive power transfer between the grid and STATCOM is regulated by the suggested control algorithms. In addition, the reactive power delivered by each modules is kept constant. The analysis reveals that, in addition to offering sufficient control, voltages imbalances owing to uneven power loses are prevented, and DC-voltages are maintained constant. The charging balanced control of many DC capacitors is prioritized by the control algorithm, which has no limit on the number of cascading. Experimental results for several test cases are used to verify the effectiveness of the proposed control method. The suggested cascaded SFC-MLI is a suitable approach for STATCOM, according to the practical and theoretical analyses.

(Baier et al., 2021) [10] Because of their excellent reliability and good voltage quality at their output terminals, cascaded H-bridge multilevel (CHB-ML) inverters are an appealing solution for delivering electricity to ac grids. Low switching frequency are required in these CHB-ML inverters to achieve efficient process. The finite-control set model predictive control (FCS-MPC) method is a simple way to regulate this sort of converters, although standard FCS-MPC algorithms have a steady-state inaccuracy when used at low sampling rates and/or when the predictions model's parameters differ from those of the actual system. A energy CHB-ML inverter with an upgraded FCS-MPC scheme is proposed in this work.When a change in the controlling references occurs, the suggested technique eliminates steady-state error in an MPC working at low sampling rates and preserves correct functioning. The practicality of the approach is demonstrated by experimental findings from an energy CHB-ML inverter with three units (seven levels).

(*Grid Connected PV System Using Multilevel Inverter*, 2021) [12].A 1 -φ nine-level PWM inverter for grid connected PV system has been simulated. The aforesaid MLI structure is modulated and controlled using a generalized innovative hybrid double references Phase Shifted PWM approach. In a PV system synced to the power system, a one-nine-level inverter was used. A standard boost converter was used to boost the DC link voltage across every inverters modules to a needed value from the appropriate number of solar PV arrays. The MPPT method was used to generate the converter's a. The P&O technique has been used to extract as much solar energy as possible. The solar energy will be fed into a single stage electric grid via the system. The aforementioned MLI's output frequency and reference voltage have been controlled to track the network frequency and voltage in order to keep UPF constant. A PI current driven algorithm was utilized to track the grid's above controller parameters. The PI controlled variables have been chosen so that the enhance the system power is sinusoidal and UPF, with a better dynamical responsiveness under constantly changing weather conditions.

(Chamarthi et al., 2021) [13] The leakage current suppression of the 3- CHB inverter topology for the PV-fed grid-connected scheme was discussed and validated in this article through simulation and experiment study. It was discovered that the conventional CHB inverter had been unable to efficaciously suppress the current flowing. The suggested 3-CHBMLI topology (see Fig. 2.1), on the other hand, greatly reduced leakage through its created modulation method. The reduced leakage current was likewise found to be well within the requirement (VDE0126-01-01). Moreover, the proposed methodology was found to be simple and straightforward to execute. As a result, the proposed methodology proved ideal for three-phase, energy transformerless inverter application.

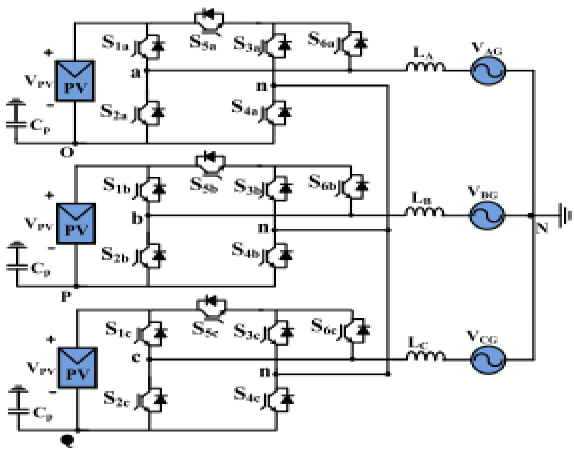

Figure 3 Proposed PV fed 3-φ transformer-less CHB inverter [13].

(Gupta, 2022) [14] The role of D-STATCOM and UPQC controllers in the functioning of a three proposed cascaded H-bridge NLMLI configuration was explored in this study. Two transformers linked in a cascading offer galvanic isolation in this case. Four example studies are conducted to further explain the PQ problems under faulty conditions. At R and RL loads, the impact of the presence of a DC voltage source is investigated. Harmonic patterns at different PCCs are investigated. Case studies I and II demonstrate that targeted harmonies of order 5th, 7th, 11th, and 13th are neutralized. Furthermore, when a DC voltage supply is substituted with two hardware validated SPV arrays of 100 kW each, the impact of an SLG defect is investigated at the load side.The high levels of DC offset and harmonic shown by the FFT interface are adequate to produce voltage and current imbalanced. During the faulty period, a control strategy is employed to govern the flow of actual and power supply. During in the faulty period, the power serves as the primary means of achieving the reactionary power requirement.

III. METHODOLOGY

Our goal is to create a model for a hybrids system that uses both solar and wind power. Mathematical models were used to match the performance of hybrid solar and wind systems while reducing technical requirements and lowering energy costs. Load, average radiation from the sun, winds resources, and temperatures are the key system inputs. MATLAB software is used to design the system. Iteration for size was done to use an optimization method, and output results were produced. The size and several techniques for the functioning of the hybrid model are simulated using existing weather data. To generate the needed voltage and current, the PV system can be connected in series and parallel. Temperatures and solar irradiation are the primary determinants of solar energy output, which includes voltage and current. To achieve the necessary outputs, the wind energy networks are linked in parallel. They're never linked in a logical order. In most cases, the output of the system is formed by combining paralleled string of two different wind turbine kinds in one systems.

Figure 4 shows a block schematic of the system model for energy HWSECS in conjunction with MLI. Through their respective boost converters-based MPPT, the WECS and SECS are linked to isolated dc-links of the proposed 5-level CHBMLI. The dc voltages 'Vwind' and 'VPV' come from the rectified voltage level of the PMSG and the PV array, respectfully. The boost converter can harvest maximal power from wind turbines and PV array individual by using the P&O MPPT algorithms on the semiconductor switches. The control technique will keep the dc-link voltages (VDC1 and VDC2) balance.

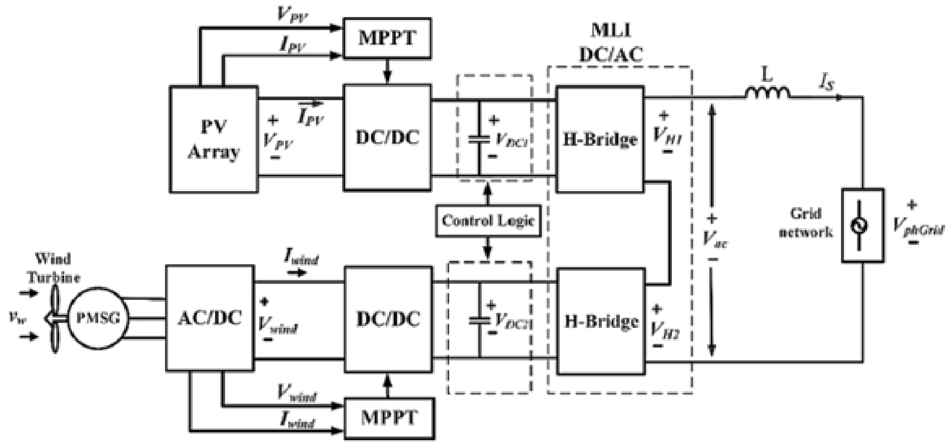

Figure 3 Grid connected HWSECS in conjunction with MLI

Grid connected CHBMLI topology

The CHBMLI is connected to the two isolated power by two HBC modules with independent wind and solar devices under variable solar irradiance and wind speed. Because the suggested CHBMLI uses two HBC modules per phase, the converter output ac side voltage output has five values. As the number of HBC module grows, the converters voltage output rise in level, reducing devices stresses in the HBC. This eliminates the need for filters on the ac side, allowing the quantity of RES to be increased. The maximum power advised by the WECS and SECS MPPTs is varied depending on available environmental circumstances.

The switch functional for each legs of an HBC has been constructed using simple curve fitting for converters factors affecting performance. The switching devices are programmed to prevent switching devices in an HBC leg from being

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turned on at any time. By choosing the right switching function, you can get the desired converter output phase voltage. For identically isolation RES or dc sources, Table 2 displays the switching states and accompanying voltage levels. The variability of the generalised leg transfer function in each HBC is specified as:if the upper switch in the first leg is ON then 'Spj' is taken as +1 and if the lower switch in first leg is ON the 'Spj' is taken as -1. Similarly, for the second leg if the upper switch is ON then 'Snj' is taken as -1 and for the lower switch is ON the 'Snj' is taken as +1.

Figure 4 shows the HWSECS switching model, which is obtained from table 2 above. Because of the hybrid system paradigm, the voltage output for both HBC in a phase may change. The algebraic sum of the voltages produced on the AC side of each HBC is the converter output phase voltage.

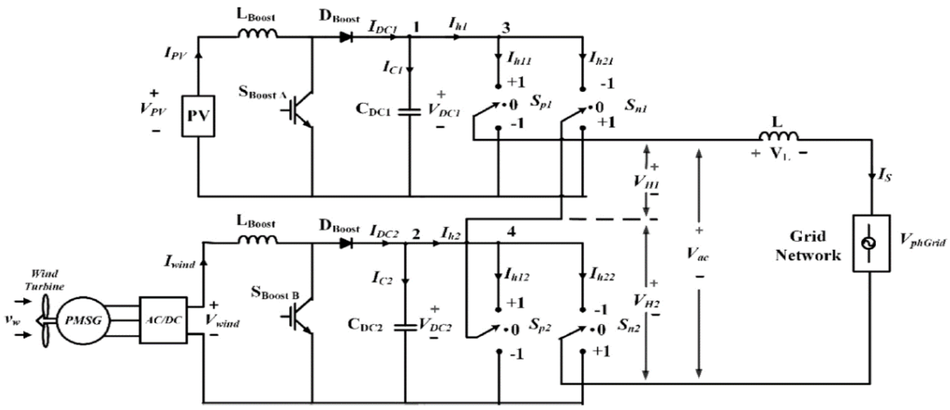

Figure 4 Switching Model of HWSECS

In grid connected CHBMLI, symmetry three phases are used. A generalized fourth order polynomial formulation for 3 phase converters ac sides output voltage (Vac) in terms of transfer function 'Sy' and capacitors voltage (VDC1 &VDC2) may be constructed using Newton's forwards interpolated algorithm as follows:

$$V_{ac} = \begin{cases} V_{DC1} + V_{Dc2} if S_y = 1 \\ V_{DC1} if S_y = 1/2 \\ 0\ S_y = 0 \\ -V_{DC1} if S_y = 1 \\ -V_{DC1} - V_{Dc2} if S_y = -1 \end{cases}$$

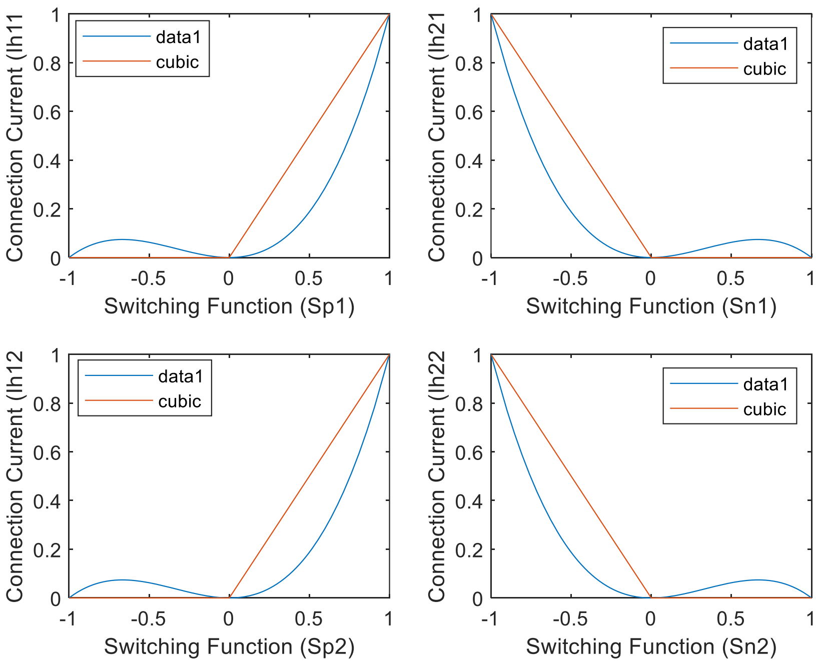

Figure 5 Connection current at H bridge

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IV. RESULT ANALYSIS

Simulation Result of Wind Energy Systems

Output waveforms of wind power systems shown in figure 11. The x-axis indicates the time and the y- axis is the voltage and current.

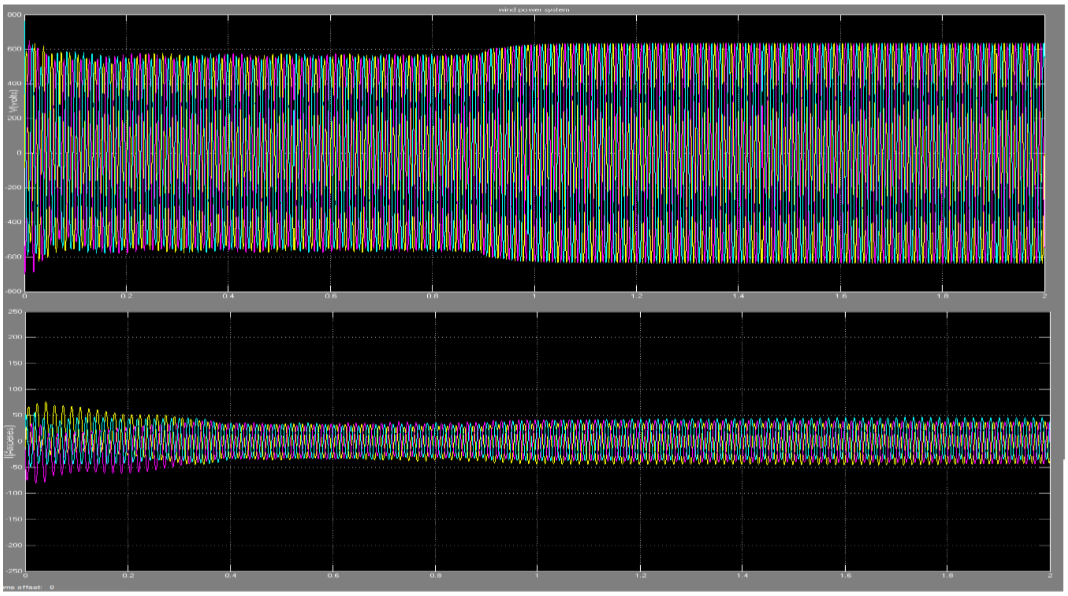

Figure 6 Output Voltage and Current of Wind Power System

Simulation Result of Hybrid Energy System

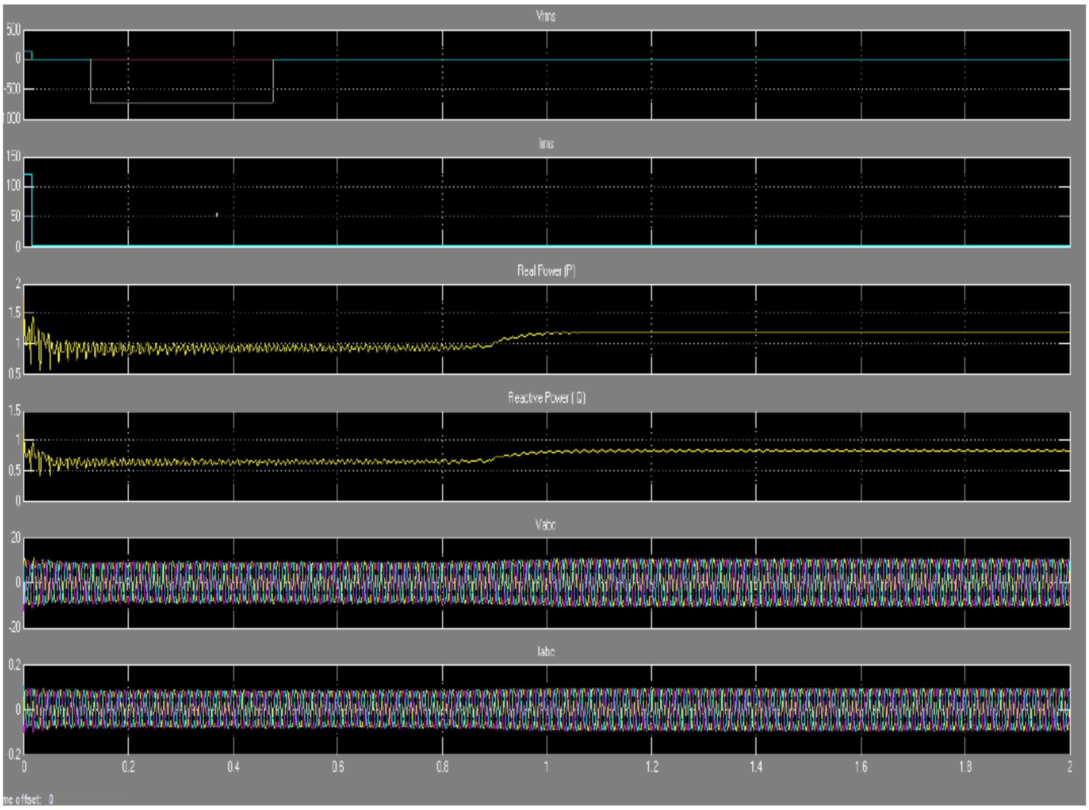

Figure 5: Output of Hybrid Energy System

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The output from of the combination wind and solar power systems is depicted in Figure 5 above. The hybrids program's outputs will be a combination of solar and wind energy. The outputs of the hybrids model's first two graphs are the DC equivalent output waveform of Vrms and Irms. The extra power of the hybrid renewable energy system. Energy distributions are represented in the center two graphs. The bottom plots show the hybrid energy program's sinusoidal voltage or current output. The supply from the hybrid model is also fed to the load, with the remaining electricity going to the grid.
On developing a hybrid model to powering the network with wind and solar power. The wind-generated energy is connected in parallel and shared with the Photovoltaic system. Because sources are dependent on changing climatic circumstances, there is a variation in generating from solar and wind power. As a result, even when the systems are linked in parallel to the grid, there's really likely to be a disparity in power measurement.

V. CONCLUSION

Natural processes constantly replenish renewable energy sources, often known as non-conventional energy sources. Hybrid methods are the best option for producing renewable energy. Hybridizing solar and wind energy sources is a practical way to generate electricity. A dual voltage source converter with split capacitors systems and solar energy is proposed here, with a converter topology that uses a controller for inverter operation.

Using the MATLAB/SIMULINK environment, the research focused on constructing a solar renewable power supporting the notion by several H bridge converters.The basic notion of a multilayer converter is to do power conversion by synthesis a stairway output voltages using a series of power semiconductor switches with numerous lower voltage dc sources. The power switches' commutation combines these many dc sources to create a high voltage output; however, the rated voltage of the semiconductor switches is solely determined by the ratings of the dc voltages to that they are attached.

- A multilayer converter has various advantages over a traditional two-level converter that uses pulse width modulation at high switching frequencies (PWM). The following are some of the appealing qualities of a multilayer converter.
- It also reduces the need for capacitors and diodes in the circuit. In a system developed with renewable power, it enhances outputs voltage or current waveforms.
- As a consequence of this research, it can be concluded that when developing an inverter control strategy, the proposed controller can provide superior outcomes in terms of voltage and power. This control can be employed in electric drivetrains, giving it a more reliable means of controlling.

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