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DYNAMIC MODELING, DESIGN AND CONTROL STRATEGY OF A GRID-CONNECTED PHOTOVOLTAIC (PV)/WIND HYBRID POWER SYSTEM.

Dr N.Usha
Professor, Department of EEE
NBKR Institute Of Science & Technology,(Autonomous) Vidyanagar, Tirupati (Dist),A.P

ABSTRACT

The dynamic modelling, design, and control strategy of a grid-connected photovoltaic (PV)/wind hybrid power system are investigated in this paper. The hybrid power system consists of a PV station and a wind farm that are linked via a main AC-bus to improve system performance. Logic controller with fuzzy logic The Maximum Power Point Tracking (MPPT) technique is used on both PV stations and wind farms to extract the most power from hybrid power systems as environmental conditions change. The Matlab/Simulink software was used to model and simulate the hybrid power system. The effectiveness of the MPPT technique and fuzzy logic controller control strategy for the hybrid power system is assessed under a variety of environmental conditions, including variations in solar irradiance and wind speed. The simulation results demonstrate the effectiveness of the MPPT technique in extracting the maximum power from the hybrid power system while the environmental conditions vary. Furthermore, because the injected current to the electrical grid is in phase with the grid voltage, the hybrid power system operates at unity power factor. Furthermore, the control strategy successfully keeps the grid voltage constant despite changes in environmental conditions and the injected power from the hybrid power system.

I.INTRODUCTION

In recent years, global temperature changes have become a major issue in global warming. Aside from energy demand, there is also an environmental risk. The critical issue in the world today is meeting the constant increase in energy demand. Furthermore, the rapid depletion and exhaustibility of conventional energy sources has necessitated urgent research into renewable energy sources as alternative energy sources.

Among renewable energy sources, photovoltaic energy and wind energy have received a lot of attention and can be considered the most promising power technologies for producing electricity. Wind energy can be captured and used to generate large amounts of power using large generators. PV energy has also shown great promise as a promising power technology.However, both the PV energy and wind energy have their own demerits since they are intermittent in nature and immensely dependent on the environmental conditions such as the variations of solar irradiance and wind speed. As a result, integrating these renewable energy sources as a PV/wind hybrid power system can be used to overcome intermittency and generate more reliable, high-quality power for the electrical grid and rural areas. Several literatures have been conducted in the PV/wind hybrid power system in recent years, such as Laabidi [1], who introduced modelling and control system for PV/wind hybrid power system interconnected with the electrical grid. Suggested quinary asymmetric inverter with backup battery that many countries are concerned about reducing ozone-depleting emissions and continuing efforts to improve the energy system. Renewable energy sources will see how these issues are resolved. In 2017, 17 countries produced more than 90% of their electricity from renewable sources [1]. Renewable energy sources see how these problems are solved. In2017, an estimated 17 countries generated more than90% of their electricity from renewable sources [1]. Solar energy is regarded as one of the most important renewable sources, as it is abundant, pollution-free, and free in remote areas where there is still no electricity. [2]-[3]. Solar power derived from photovoltaic (PV) cells has a low efficiency [4]. Because of these issues, it is critical to extract the maximum power from solar photovoltaic cells while also improving efficiency in varying weather and temperature conditions.

An MPPT, or Maximum Power Point Tracking, is a digital DC to DC converter that is connected between solar panels and batteries or the utility grid and optimises the match between the solar array (PV panels) and the battery bank or utility grid. It monitors the PV array for the maximum power point and attempts to use this information not only to control the output but also to optimise the array. Typically, this means that the voltage is reduced while the current is increased, retaining the majority of the overall output power. We used the P&O algorithm with the MPPT controller in this study, which has a conversion efficiency of 95%. Because of partial shading, bad weather, temperature effect, and battery charging state, output gain varies greatly.

In a hybrid PV/wind power system. Benadli presented a sliding mode control strategy for a standalone PV/wind hybrid power system in [3]. Recently, the Doubly Fed Induction Generator (DFIG) has become the most widely used in PV/wind hybrid power systems. Because of its numerous benefits, including simple construction, decoupled control of active and reactive power, partially rated converters, and the ability to extract maximum power from wind turbines [4-6]. Several studies and surveys on the integration of PV stations and wind farm-based-DFIG as hybrid power systems have been conducted [7, 8]. Rajesh [7] was one of them, and he introduced a PV and DFIG-based wind hybrid power system to provide sustainable power to remote areas. Kumar [8] presented a simulation analysis for the hybridization of PV and wind-based DFIG. Recently, some control strategies have been proposed to overcome issues with injected power quality and extracting the maximum power from the hybrid power system under varying environmental conditions. Sera [9] investigated the perturb and observe MPPT technique for extracting maximum power from PV systems as solar irradiance varied.

II.PROPOSED SYSTEM

The purpose of this research is to look into the detailed dynamic modelling, design, and control strategy of a grid-connected PV/wind hybrid power system. The hybrid power system consists of a 1MW PV station and a 9MW wind farm that are linked via a main AC-bus to inject generated power and improve system performance. The MPPT technique is used for both PV stations and wind farms to extract the maximum power from hybrid power systems as environmental conditions change. The effectiveness of the MPPT technique and control strategy for the hybrid power system is assessed under a variety of environmental conditions, including changes in solar irradiance and wind speed. Furthermore, the hybrid power system operates at unity power factor because the injected reactive power from the hybrid power system is equal to zero. Furthermore, the control strategy successfully maintains grid voltage constant despite variations in environmental conditions and hybrid power system injected power.

A.SYSTEM CONFIGURATION

Figure 1 depicts the system configuration of the investigated PV/wind hybrid power system. The hybrid power system consists of a 1MW PV station and a 9MW wind farm located at different locations. The PV station and wind farm are linked via the main PCC-bus to inject generated power and improve system performance. To achieve the desired power capacity, the PV station is made up of many PV modules that are electrically connected in parallel-series combinations. Furthermore, the PV station includes a DC/DC boost converter to increase array output voltage and an aggregated DC/AC inverter to convert generated DC power to AC power. In addition, the PV station is linked to the PCC-bus via a 260 V/25 KV/Y transformer. The wind farm, on the other hand, is thought to contain one equivalent aggregated DFIG that is powered by a large aggregated wind turbine. The wind farm also includes a grid side converter (GSC) to keep the DC-bus voltage constant and a rotor side converter (RSC) to extract the maximum power from the wind turbines. Furthermore, a modified MPPT technique based on mechanical power measurement is used to capture the maximum power from the wind farm as the wind speed varies. Furthermore, the wind farm is linked to the PCC-bus via 575 V/25 KV/Y transformers. The hybrid power system is programmed to operate at a power factor of one, and the injected active power is transmitted to the electrical grid through 30 Km transmission lines and 25 KV/120 KV Y/Δ transformers.

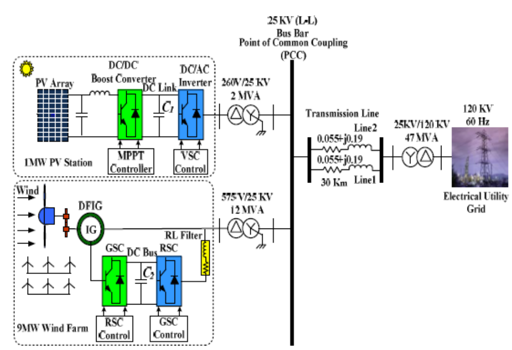


Fig.1. The system configuration of PV/wind hybrid power system.

B. Incremental Conductance

MPPT Procedure In photovoltaic conversion systems, maximum power point tracking strategies are critical. Because the intensity of solar irradiation varies over time, the MPPT technique is used to extract the maximum output power from a PV array when the solar irradiance varies. As a result, the MPPT technique's goal is to regulate the boost converter controller so that the PV array operates at its maximum power point (MPP). Because of its simplicity and advantage of providing good performance under rapid variations in solar irradiance, the incremental conductance MPPT strategy is used to capture the maximum power in this paper [9]. The corresponding flowchart of the incremental conductance MPPT technique is shown in Fig. 4. Figure 5 depicts the implementation of this MPPT technique in a Matlab/Simulink model. The incremental conductance strategy is predicated on the fact that the slope of the power-voltage (P-V) curve at the MPP is equal to zero. Furthermore, the power-voltage derivative (dPpv/dVpv) is positive to the left of the MPP and negative to the right of the MPP. The incremental conductance MPPT technique's mathematical model is as follows [9]: The PV array's output power is as follows:

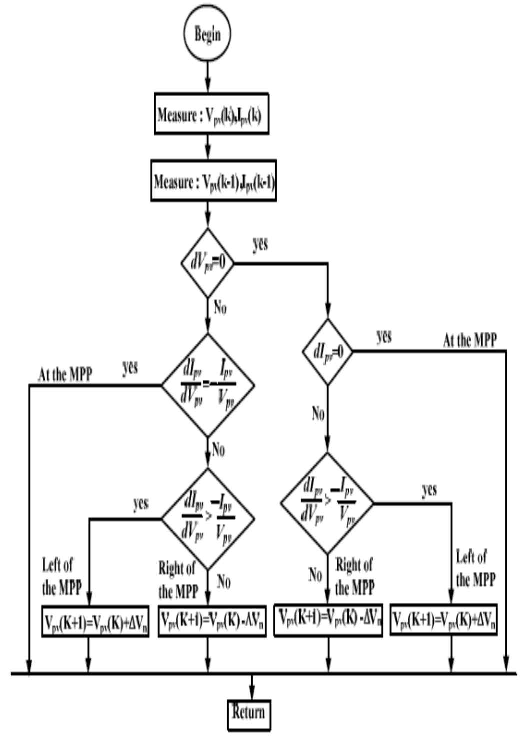


Fig. 2. Flowchart of incremental conductance MPPT technique.

C. DC/AC Inverter Controller

To connect the PV station to the electrical grid, a 3-level, 3-phase DC/AC inverter is used in this paper. The control scheme for a DC/AC inverter is depicted in Figure 6. To regulate the DC link voltage, control the injected active power to the electrical grid, and achieve the required reactive power, a voltage-oriented control strategy is used. This control strategy has several advantages, including constant DC-Link voltage, fast dynamics, and decoupled control. [11].

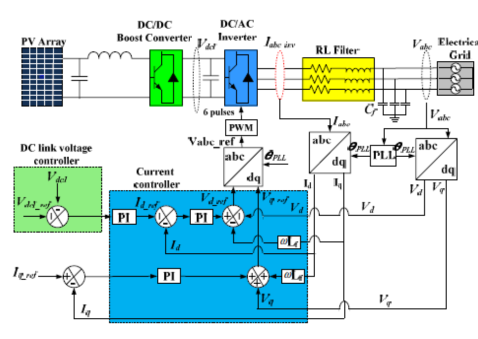


Fig. 3. The control scheme for the DC/AC inverter.

III.SIMULATION RESULTS

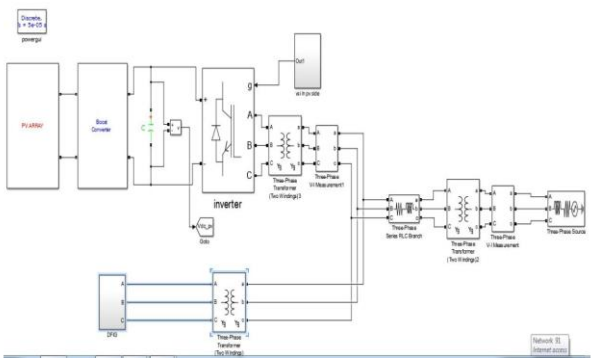
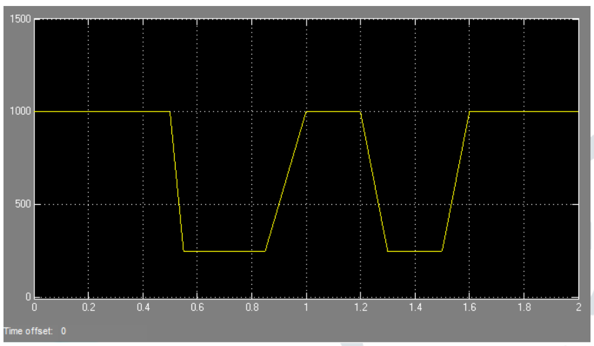
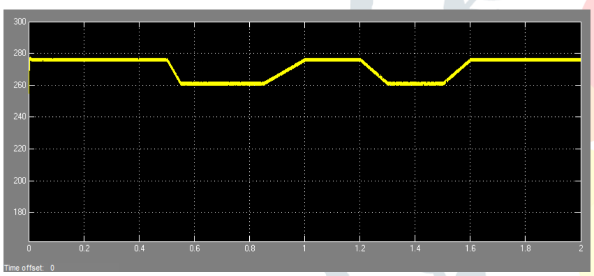


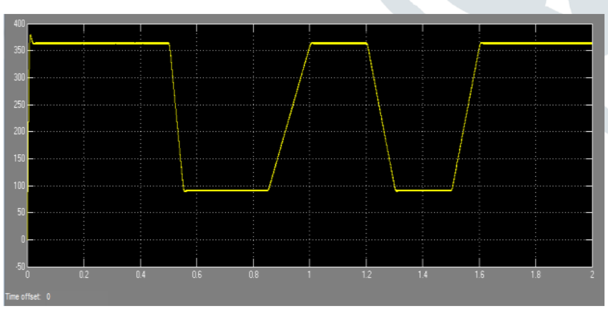
Fig .4. Proposed Simulink diagram



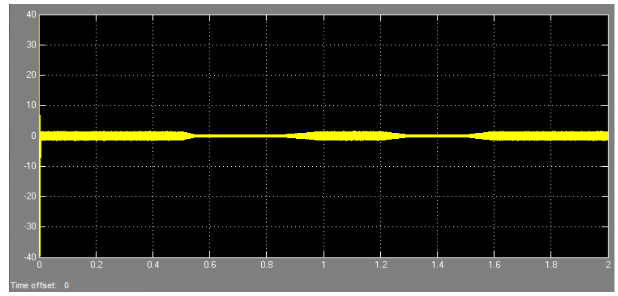
(a) Solar Irradiance.



b) PV array voltage.

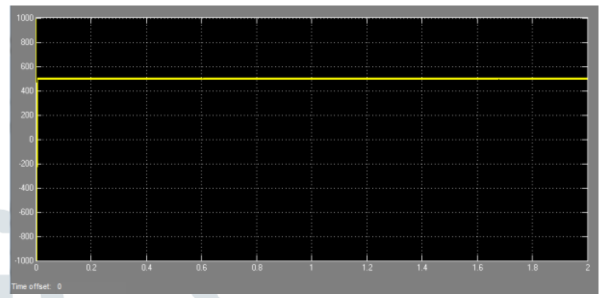


(c) PV array current.

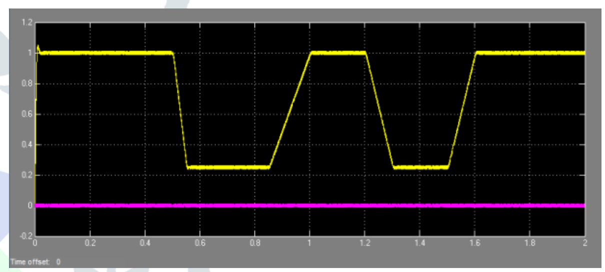


(d) A derivative of power with respect to voltage (dPpv/dVpv).

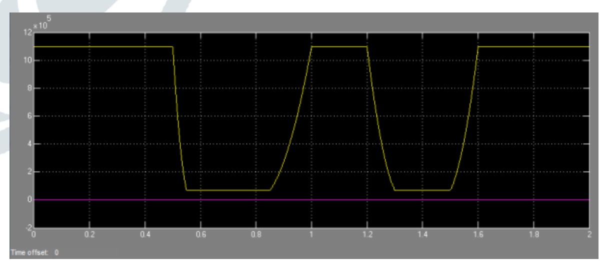
Fig. 5. Performance of PV array during the variation of solar irradiance.



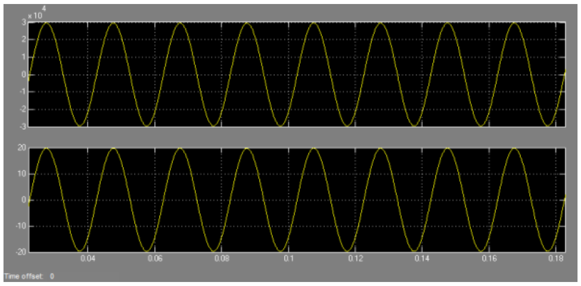
(a) PV DC-link Voltage.



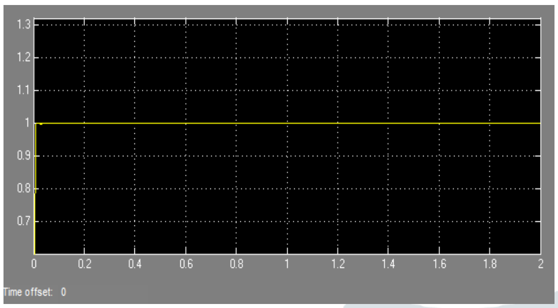
(b) d-q axis components of injected current from PV station.



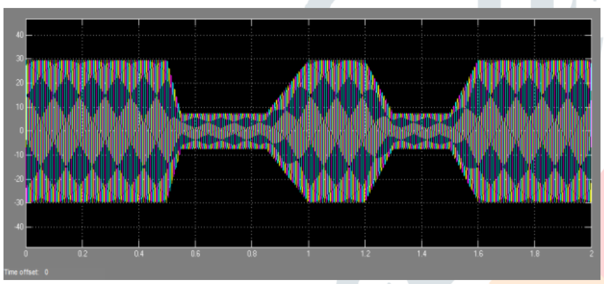
(c) Injected active and reactive power from PV station.



(d) Grid voltage and injected current from PV station.

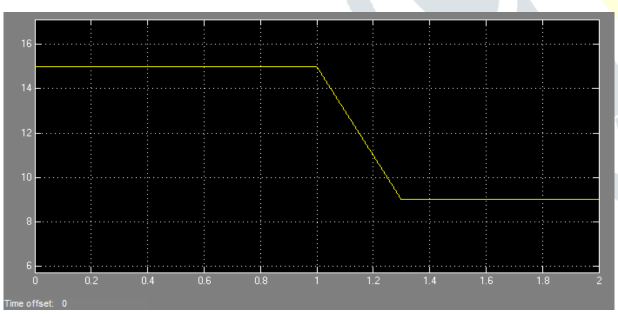


(e) The power factor of the inverter.

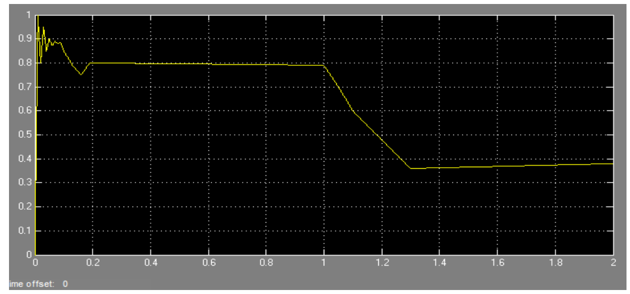


f) Injected current from PV station.

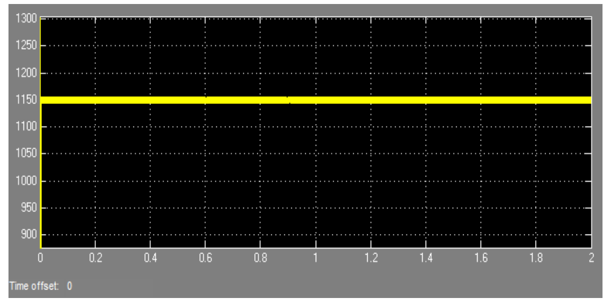
Fig.6. Performance of PV station during variation of the solar irradiance.



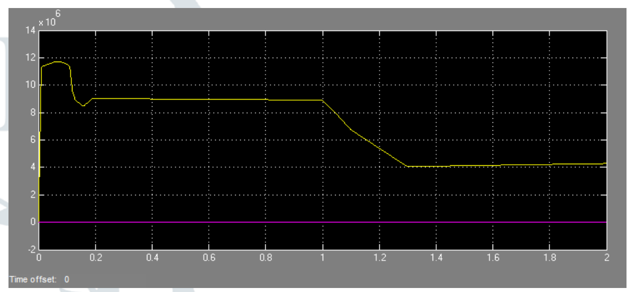
(a) Wind speed profile.



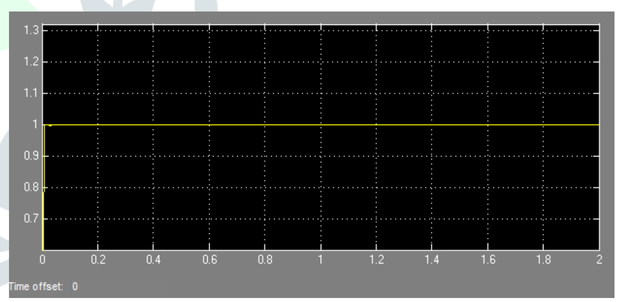
(b) The mechanical torque of wind turbine.



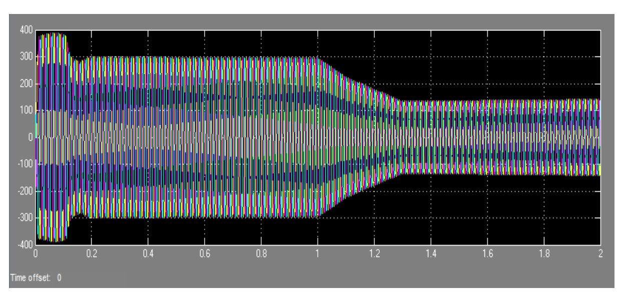
(c) The DC-bus voltage of DFIG.



(d) Injected active and reactive power from the wind farm.

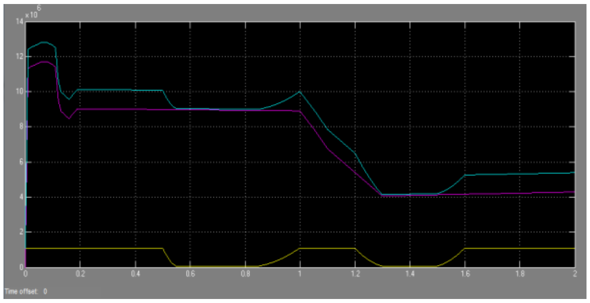


(e) The power factor of the wind farm.

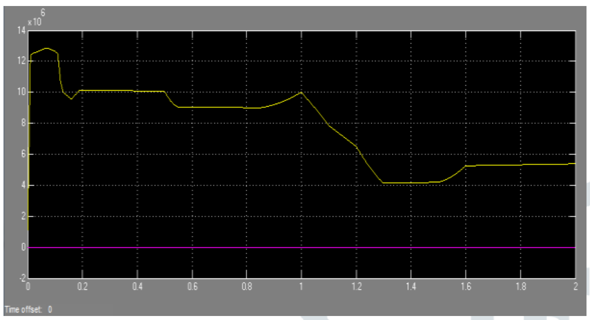


(f) Injected current from the wind farm.

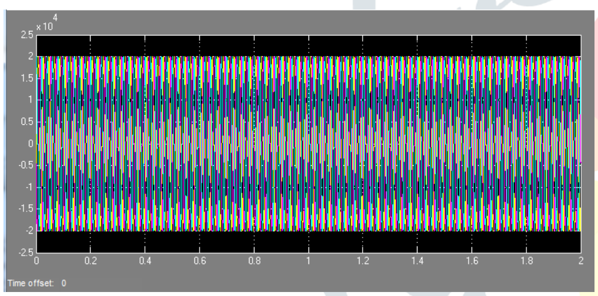
Fig. 7. Performance of wind farm during variation of the wind speed.



(a) Power flow between PV station, wind farm, and hybrid power system.



(b) Injected active and reactive power from the hybrid system.



(c) PCC-bus voltage.

Fig. 8. Performance of hybrid power system at PCC-bus.

IV.CONCLUSION

A detailed dynamic modelling, design, and control strategy for a grid-connected PV/wind hybrid power system has been successfully investigated in this paper. The hybrid power system consists of a 1MW PV station and a 9MW wind farm that are linked via a main AC-bus to inject generated power and improve system performance. For the PV station, the incremental conductance MPPT technique is used to extract the maximum power during variations in solar irradiance. In contrast, a modified MPPT technique based on mechanical power measurement is used to capture the maximum power from a wind farm as the wind speed varies. Various tests are performed to assess the effectiveness of the MPPT techniques and control strategy for the hybrid power system. The simulation results demonstrated the effectiveness of MPPT techniques in extracting the maximum power from hybrid power systems under varying environmental conditions. Furthermore, the hybrid power system operates at unity power factor because the injected reactive power from the hybrid power system is equal to zero. Furthermore, the control strategy successfully maintains grid voltage constant despite variations in environmental conditions and hybrid power system injected power.

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