MODELLING AND ANALYSIS OF DFIG BASED HYBRID RENEWABLE ENERGY SOURCES

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ABSTRACT: The intricate modeling, planning, and control approach of the grid-connected photovoltaic (PV)/wind hybrid power organization are examined in this suggested work. The main AC-bus of the hybrid power system combines wind farms and photovoltaic plants to boost system efficiency. Both wind farms and PV stations use the Maximum Power Point Tracking (MPPT) technique to get the most power out of the hybrid power system when the environment changes. Using Matlab/Simulink tools, the modeling and simulation of the hybrid power system has been introduced. The effectiveness of the MPPT technique and fuzzy logic controller control approach for the hybrid power system is evaluated across a range of environmental variables, including variations in wind speed and solar irradiation. The simulation's outcomes demonstrate how well the MPPT technique works to maximize the fuzzy logic controller's output from the hybrid power system when environmental conditions vary. Furthermore, the hybrid power system operates at the unit power factor since the current that is injected into the electrical grid is in phase with the grid voltage. Furthermore, the control method successfully maintains a steady grid voltage despite variations in the external environment and the electricity supplied by the hybrid power system.

KEYWORDS: Maximum Power Point Tracking (MPPT), Fuzzy logic controller, Wind, Solar.

I.INTRODUCTION: Global temperature changes have become a major problem in global warming in recent years. In addition to energy demand, there is also an environmental threat. Nowadays; the critical issue in the entire world is to meet the permanent growth of the energy demand. Moreover, the rapid depletion and the exhaustible nature of the conventional power sources, has necessitated imperative researches for the renewable energy sources as alternative sources of energy. Among the renewable sources of energy, photovoltaic energy and wind energy have attracted great attention and can be considered as the most promising power technologies to produce electricity. The wind energy can be captured using large generators to generate great power capacity. Also, the PV energy has shown great potential as another promising power technology to generate electricity since being clean, global, and free and can be harnessed without emission of pollutants.

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. Therefore, integration of these renewable energy sources as PV/wind hybrid power system can be utilized for overcoming the intermittency and generation more reliable power with higher quality to the electrical grid and rural areas. Over recent years, several literatures have been carried out in the PV/wind hybrid power system, such as Laabidi [1], introduced modeling and control system for PV/wind hybrid power system interconnected with the electrical grid.

Suggested quandary asymmetric inverter with backup battery that employed many countries are concerned to reduce their ozone-damaging emissions and to continue their efforts to improve the energy system. 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 considered to be one of the most important renewable sources available in abundance, free of pollution and free of charge in remote areas where there is still no electricity. [2]-[3]. Solar power extracted from solar photovoltaic (PV) cells delivers low efficiency [4]. Because of these problems, it is important to extract maximum power from solar photovoltaic cells and improve efficiency indifferent weather and temperature conditions.

An MPPT or Maximum Power Point Tracking is an electronic tracking device usually digital DC to DC converter which is connected between solar panels and battery or the utility grid that optimizes 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 tries to use this information not only to control the output Typically, this means that the voltage is reduced while the current is increased and most of the overall output power is maintained. In this research with the MPPT controller, we used P&O algorithm that has a conversion efficiency of 95%. Output gain varies greatly due to partial shading, bad weather condition, temperature effect, battery charging state, and other consideration. In PV/wind hybrid power system. Benadli [3], presented sliding mode control strategy for standalone PV/wind hybrid power system. Recently, the Doubly Fed Induction Generator (DFIG) is the most commonly employed in the PV/wind hybrid power systems. Due to its various advantages such as simple construction, decoupled control of active and reactive power, partially rated converters, and the ability to extract the maximum power from wind turbines [4-6]. Several researches and surveys have been investigated in the integration of PV station and wind farm based-DFIG as hybrid power system [7, 8]. Among them, Rajesh [7], introduced PV and DFIG based wind hybrid power system to provide sustainable power for remote areas. Kumar [8], presented simulation analysis for integration of PV and wind based-DFIG as hybrid power system interconnected with the electrical grid. Recently, some control strategies have been proposed to overcome problems related to the injected power quality and extraction of the maximum power from the hybrid power system under variation of the environmental conditions. Sera [9], investigated perturb and-observe MPPT technique to extract the maximum power from PV systems during variation of the solar irradiance.

II. PROPOSED SYSTEM: This have a observe investigates a detailed dynamic modeling, format and control method of a grid-related PV/wind hybrid strength gadget. The hybrid power device includes PV station of 1MW rating and a wind farm of nine MW rating which might be integrated thru fundamental AC-bus to inject the generated power and enhance the gadget typical overall performance. The MPPT approach is applied for each PV station and wind farm to extract the most electricity from hybrid power system at some point of variant of the environmental conditions. The effectiveness of the MPPT approach and manipulate method for the hybrid energy gadget is evaluated at some point of remarkable environmental situations which includes the versions of sun irradiance and wind pace. The simulation effects have proven the effectiveness of the MPPT technique in extraction the most power from hybrid strength system at some point of version of the environmental conditions. Moreover, the hybrid electricity machine efficaciously operates at harmony electricity element for the motive that injected reactive electricity from hybrid electricity device is equal to 0. Furthermore, the manipulate technique successfully maintains the grid voltage steady irrespective of the variation of environmental conditions and the injected electricity from the hybrid power machine.

The device configuration of the studied PV/wind hybrid electricity machine is depicted in Fig. 1. The hybrid strength tool in conjunction with PV station of 1MW rating and wind farm of nine MW rating placed at one-of-a-kind locations. The PV station and wind farm are blanketed thru principal PCC-bus to inject the generated strength and beautify the machine performance. The PV station includes many PV modules electrically related in parallel-collection mixtures to benefit the favored energy potential. Moreover, the PV station is prepared with the DC/DC increase converter to step up array output voltage, and aggregated DC/AC inverter to transform the generated DC strength to AC power. The incremental conductance MPPT approach is carried out to extract most electricity from PV station underneath model of the sun irradiance. Also, the PV station is interconnected with the PCC-bus through 260 V/25 KV □/Y transformers. On the other hand, the wind farm is taken into consideration to contain one same aggregated DFIG that driven by way of a huge aggregated wind turbine. Furthermore, the wind farm includes the grid side converter (GSC) for maintaining the DC-bus voltage regular and the rotor facet converter (RSC) for extraction the maximum strength from wind generators. Moreover, a changed

MPPT method primarily based on mechanical strength length is finished to seize the maximum energy from wind farm throughout version of the wind pace .In addition; the wind farm is interconnected with the PCC-bus via 575 V/25 KV Δ/Y transformers. The hybrid energy gadget is controlled to perform at crew spirit strength thing, and the injected lively energy is transmitted to the electric grid thru 30 Km transmission lines and 25 KV/one hundred twenty KV Y/Δ transformers.

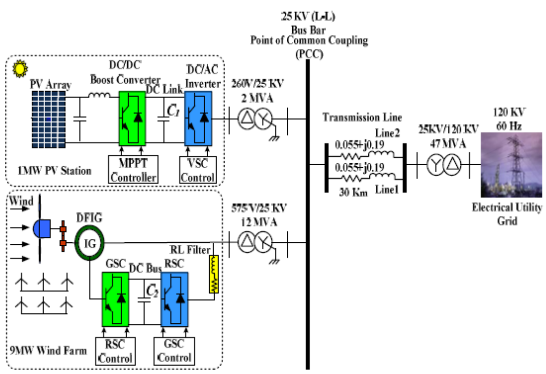


Fig. 2.1. The system configuration of PV/wind hybrid power system.

2.1 PHOTOVOLTAIC CONVERSION SYSTEM

The electrical modeling of a PV device and its characteristics are introduced in this section. In addition, the MPPT and DC/AC inverter controller of incremental conductance are discussed.

A. PV System Model

In order to compose the string to achieve the desired voltage level, the PV station consists of several PV modules connected electrically in sequence. In order to get the necessary power capacity, a large number of PV strings are also parallel-connected to form a PV array. To obtain the maximum power under solar irradiation variation, each PV array is linked to the DC/DC boost converter. The PV arrays are then connected to the main DC/AC inverter in parallel to monitor the injected active power into the electrical grid and achieve the reactive power necessary. There are several advantages to this design, such as constant DC-link voltage, low losses, greater reliability, and cost-effectiveness [10]. Centered on the Shockley diode, the electrical modelling of the PV array was implemented, as shown in Fig. 2.2. The corresponding PV array current-voltage (I-V) ratio can be expressed as follows

$$I = N_p I_{ph} - N_p I_s \left\{ \exp\left[\frac{q\left(\frac{V}{N_s} + \frac{R_s I}{N_p}\right)}{KTA} \right] - 1 \right\} - \left(\frac{\frac{N_p V}{N_s} + R_s I}{R_{sh}} \right) \quad (1)$$

$$I_{ph} = \frac{G}{1000} \cdot \left[I_{sc} + K_i \left(T - T_{ref} \right) \right] \quad (2)$$

$$I_s = I_{rs} \cdot \left(\frac{T}{T_{ref}} \right)^3 \exp\left[\frac{q E_g}{K A} \cdot \left(\frac{1}{T_{ref}} - \frac{1}{T} \right) \right] \quad (3)$$

The electrical qualities of PV exhibit can be reenacted as to the varieties in the ecological conditions, for example, changes in sun based illumination power and temperature. Fig. 2.3 shows the current-voltage (I-V) attributes and the power voltage (P-V) qualities of the PV cluster during varieties of the sun powered irradiance.

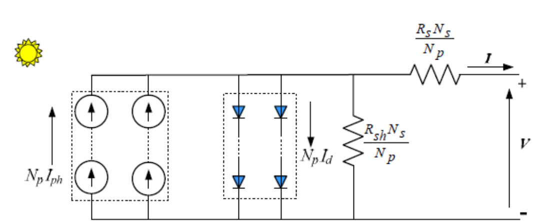
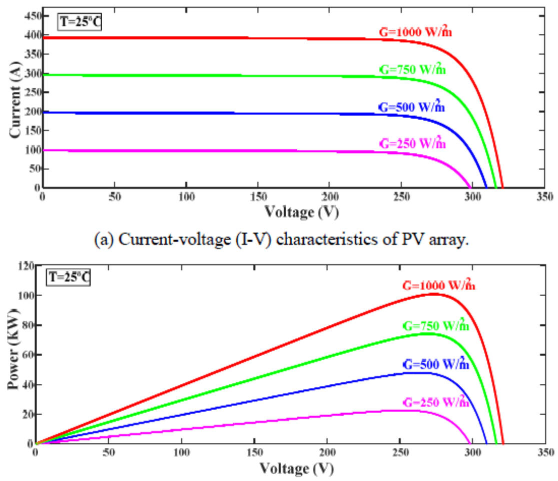


Fig. 2.2. The electrical model of PV array.



(a) Current-voltage (I-V) characteristics of PV array.

(b) Power-voltage (P-V) characteristics of PV array.

Fig. 2.3. Characteristics of PV array under variations of the solar irradiance.

B. Incremental Conductance

MPPT Technique Maximum power point following procedures is fundamental in the photovoltaic transformation frameworks. Since the force of sun oriented light changes with time, the MPPT method is utilized to extricate the greatest yield power from PV cluster under variety of the sun based irradiance. Subsequently, the goal of the MPPT procedure is to direct the lift converter regulator so the PV cluster works at the most extreme force point (MPP). In this paper, the steady conductance MPPT technique is used to catch the most extreme force, because of its effortlessness and favorable position of offering great execution under fast variety of sun oriented irradiance [9]. Fig. 2.4 delineates the relating flowchart of the steady conductance MPPT procedure. Also, the usage of this MPPT method in Matlab/Simulink model is appeared in Fig. 5. The gradual conductance system is subject to the way that the slant of Power-voltage (P-V) bend is equivalent to zero at the MPP. Additionally, the subsidiary of force regarding voltage (dPpv/dVpv) is positive at the left of the MPP and is negative at the privilege of the MPP. The numerical model of steady conductance MPPT strategy can be communicated as follows [9]: The yield power from PV cluster:

$$P_{pv} = V_{pv} * I_{pv} \quad (4)$$

$$\frac{dP_{pv}}{dV_{pv}} = \frac{d}{dV_{pv}}[V_{pv} * I_{pv}] = I_{pv} + V_{pv}\frac{dI_{pv}}{dV_{pv}} \quad (5)$$

$$\frac{dP_{pv}}{dV_{pv}} = 0, \quad \frac{dI_{pv}}{dV_{pv}} = -\frac{I_{pv}}{V_{pv}} \quad \text{at the MPP } \Delta V_n = 0 \quad (6)$$

$$\frac{dI_{pv}}{dV_{pv}} > -\frac{I_{pv}}{V_{pv}} \quad \text{Left of the MPP, increment } V_{pv} \quad (7)$$

$$\frac{dI_{pv}}{dV_{pv}} < -\frac{I_{pv}}{V_{pv}} \quad \text{Right of the MPP, decrement } V_{pv} \quad (8)$$

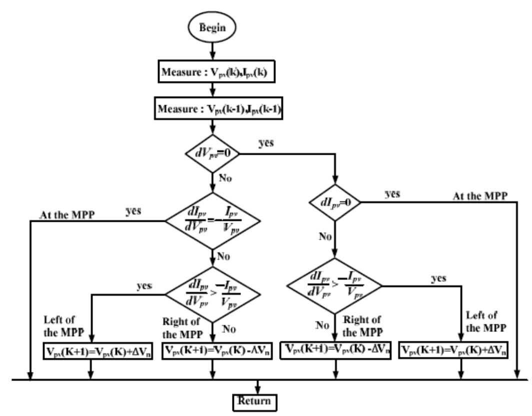


Fig. 2.4. Flowchart of incremental conductance MPPT technique.

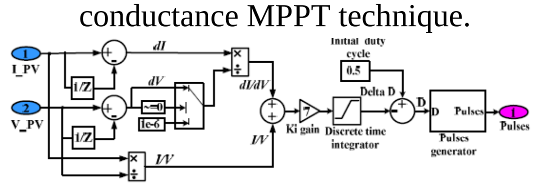


Fig. 5. Matlab/Simulink model of incremental conductance MPPT technique.

C. DC/AC Inverter Controller

The 3-level, 3-phase DC/AC inverter is used in this paper to integrate the PV station with the electric grid. Fig. 6 explains the DC/AC inverter control scheme. The voltage-oriented control strategy is applied to control the voltage of the DC connection, control the active power injected into the electrical grid, and achieve the reactive power needed.

There are many benefits to this control strategy, such as constant DC-Link voltage, fast dynamics and decoupled control power. [11].

$$V_{abc} = V_{abc\_inv} - R_f \cdot I_{abc\_inv} - L_f \cdot \frac{dI_{abc\_inv}}{dt} \quad (9)$$

Transforming (9) into d-q rotating reference frame yields:

$$V_{d\_inv} = V_d + R_f I_d + L_f \frac{dI_d}{dt} - \omega L_f I_q \quad (10)$$

$$V_{q\_inv} = V_q + R_f I_q + L_f \frac{dI_q}{dt} + \omega L_f I_d \quad (11)$$

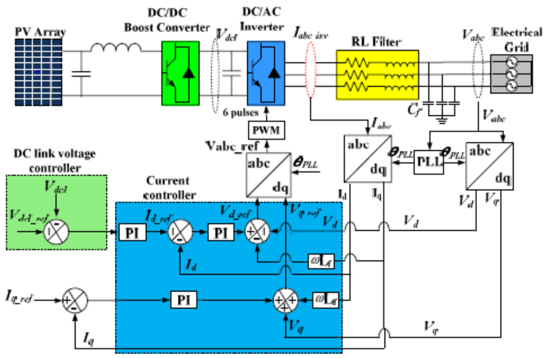


Fig. 2.6. The control scheme for the DC/AC inverter.

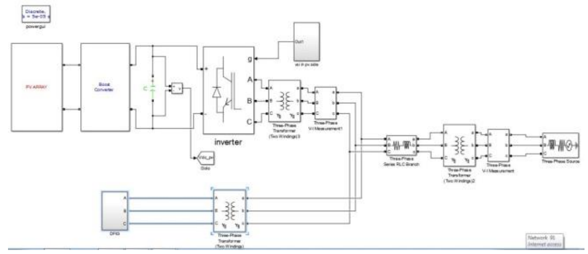
2.2. WIND ENERGY CONVERSION SYSTEM

The mechanical modelling of the wind turbine and its features are discussed in this section. In addition, the RSC controller, the GSC controller and the technique of the MPPT are being investigated.

A. Wind Turbine Model It is possible to model the wind turbines as an aerodynamic input torque that drives the DFIG. Fig. 8 displays the characteristic curve of power for wind turbines at varying wind speeds. The mechanical energy (Pm) derived from the wind turbine can be expressed as follows. [2]:

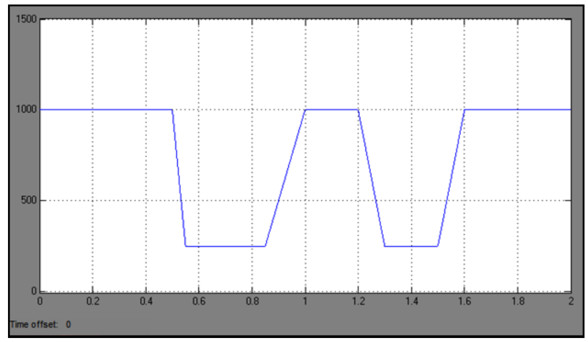
$$P_m = \frac{1}{2} \rho A_t C_p(\lambda, \beta) V_w^3$$

III.SIMULATION RESULTS

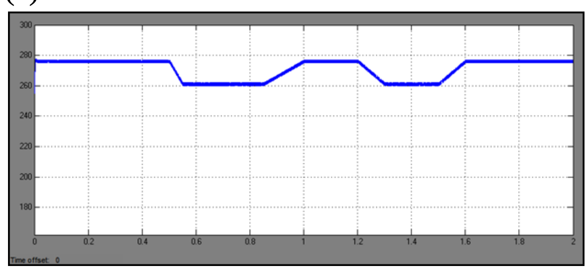


3.1 Proposed simlink diagram

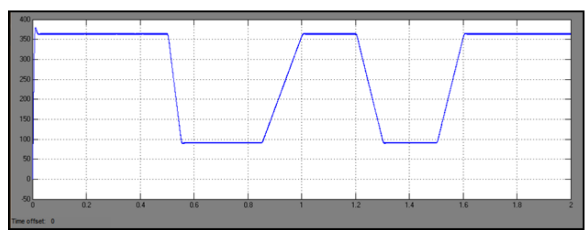
Fig. 3.2. Performance of PV array during the variation of solar irradiance.



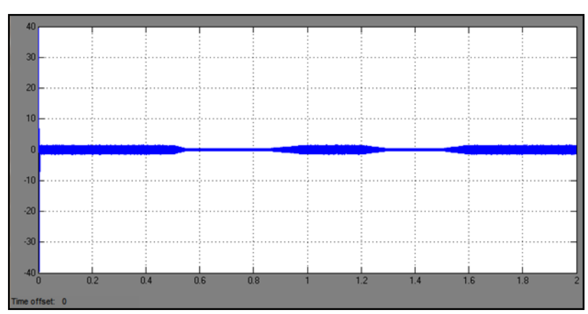
(a) Solar Irradiance.



b) PV array voltage.

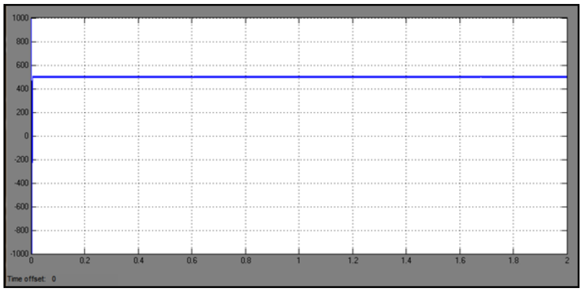


(c) PV array current.

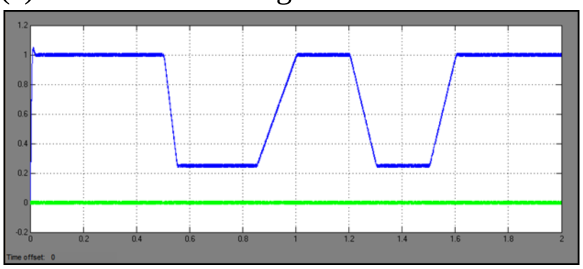


(d) A derivative of power with respect to voltage (dPpv/dVpv).

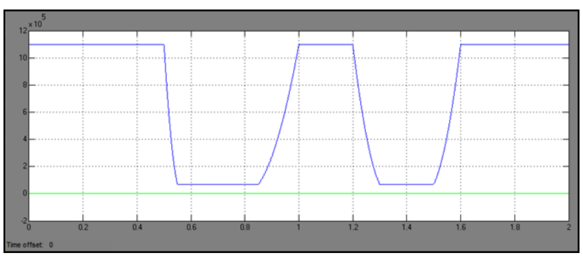
Fig. 3.2. Performance of PV station during variation of the solar irradiance.



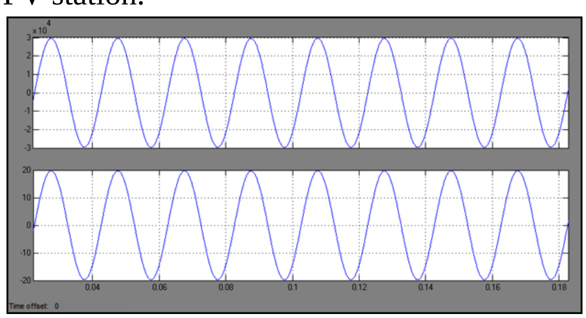
(a) PV DC-link Voltage.



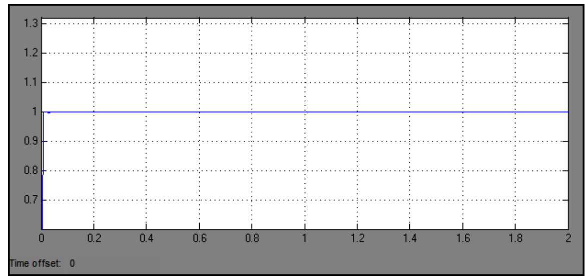
(b) d-q axis components of injected current from PV station.



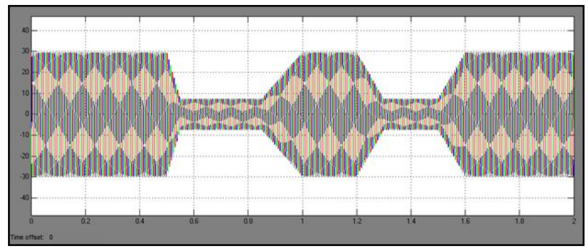
(c) Injected active and reactive power from PV station.



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

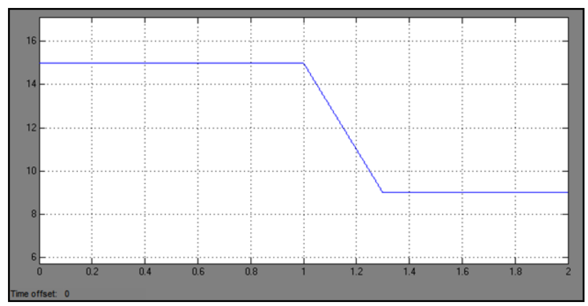


(e) The power factor of the inverter.

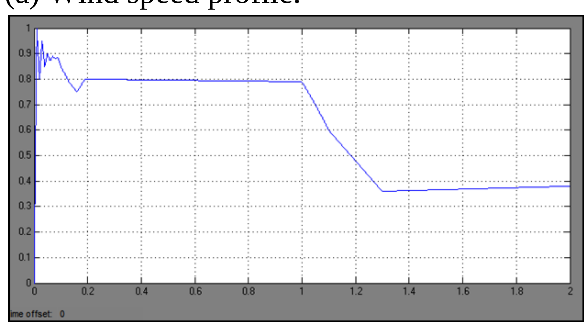


f) Injected current from PV station.

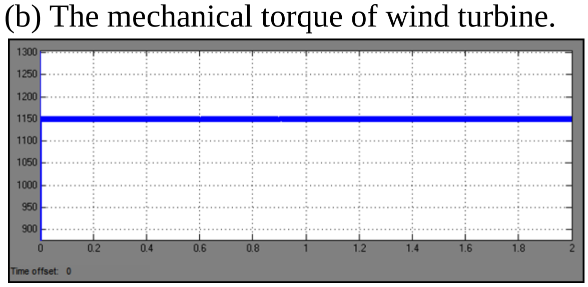
Fig. 3.3. Performance of wind farm during variation of the wind speed.



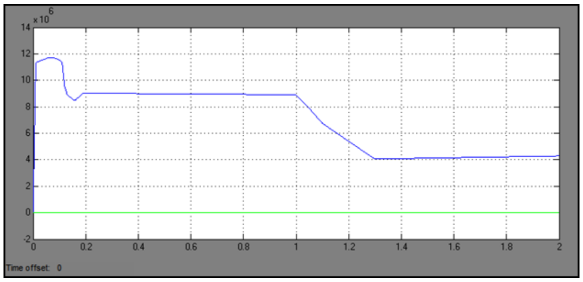
(a) Wind speed profile.



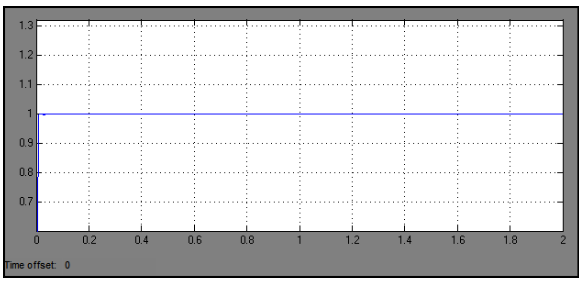
(b) The mechanical torque of wind turbine.



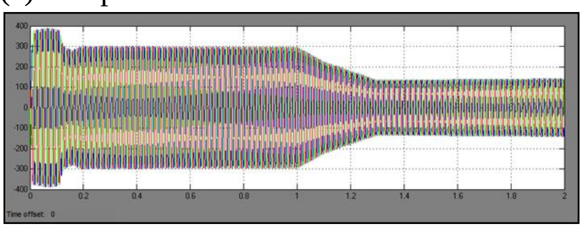
(c) The DC-bus voltage of DFIG.



(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.

.CONCLUSION

This work successfully investigates the design, control strategy, and comprehensive dynamic modeling of a grid-connected PV/wind hybrid power system. In order to inject the generated electricity and increase the system's output through the main AC bus, the hybrid power system is made up of a 1 MW photovoltaic station and a 9 MW wind farm. The PV station uses the incremental conductance MPPT approach to achieve full power during variations in solar irradiation. On the other side, modified MPPT technology that is based on mechanical power computation is used to harvest the most electricity possible from the wind farm during variations in wind velocity. The effectiveness of the MPPT approaches and manipulation method for the hybrid electrical system is assessed under a variety of climatic variables, such as variations in wind speed and solar irradiation. As climatic circumstances change, the simulation's results demonstrate the effectiveness of MPPT approaches in obtaining the hybrid strength device's total electricity. Furthermore, the hybrid electricity machine operates efficiently on the unit power aspect because the injected reactive electricity from it equals zero. Furthermore, the manage approach effectively maintains the steady grid voltage despite changes in the environment and the electricity injected from the hybrid power system.

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