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Real Time Implementation of Wind Electric Generator with Photo Voltaic Panels

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ABSTRACT

This paper deals about the design of hybrid test rig of standalone wind electric generator and photo voltaic panels supported by a prototype model. The wind generation system consists of a wind turbine coupled with permanent magnet synchronous generator. It also constitutes 20W solar panel to enhance complementary function between wind and solar energy supply. This is carried out by the inclusion of the microcontroller ATMEL 89S52. According to the power generated, it has been used to run both ac and dc load. Time varying parameters from the output of the microcontroller can be viewed through using visual basics. The simulation of the complete system has also been done in Simulink platform using Sim Power Systems toolbox in MATLAB. The simulated results have been validated with hardware implementation of the hybrid test bed.

Keywords: Microcontroller ATMEL, solar panel, wind electric generation, visual basic

1. INTRODUCTION

Mass depletion of fossil fuels and high degree of usage of fossil fuels for power production affects the environment badly. Ever increasing pollution level can be reduced enormously by the introduction of power production by utilizing renewable energy sources like solar and wind sources[1,2]. The kinetic energy of wind is converted into mechanical energy to rotate the turbine blades so as to rotate the rotor of generator which is coupled with the shaft of the turbine. The rotor of the machine cuts the magnetic field produced by the stator, thus generating electricity. Photo voltaic technology has been used to trap sun energy by which each solar cell is capable of generating photo electric current by absorbing the intensity of sunlight.

2. SYSTEM OVERVIEW

The main block diagram shown in Figure 1.1 details the complete system with the two main blocks namely the windmill and solar panel. According to the availability of sources, either wind or solar output has been given as the input to the microcontroller. The relay operation depends on the microcontroller output. After the relay is ON the battery gets charged. A current sensor is used to sense the current and is given to ADC. The obtained current value is compared with the threshold value. If the output voltage reaches above 9V, then both AC and DC load will be operated. If the battery charge is more, the relay connects the inverter to run the ac load. The interfacing of microcontroller and PC been done using universal asynchronous receiver transmitter(UART).The various parameters like battery voltage, the output voltage from sun and the voltage got from wind are seen in Visual Basic environment.

The simulation of the same system has been done in Simulink/MATLAB. For simulation, PMSG of the rated capacity at no load condition has been chosen as a wind electric generator and a 20 W solar panel has been used for solar system. According to the available power obtained either wind power or solar power, the corresponding voltage gets boosted using interleaf boost converter. The boosted dc voltage is converted into AC by inverter and used to run the AC load.

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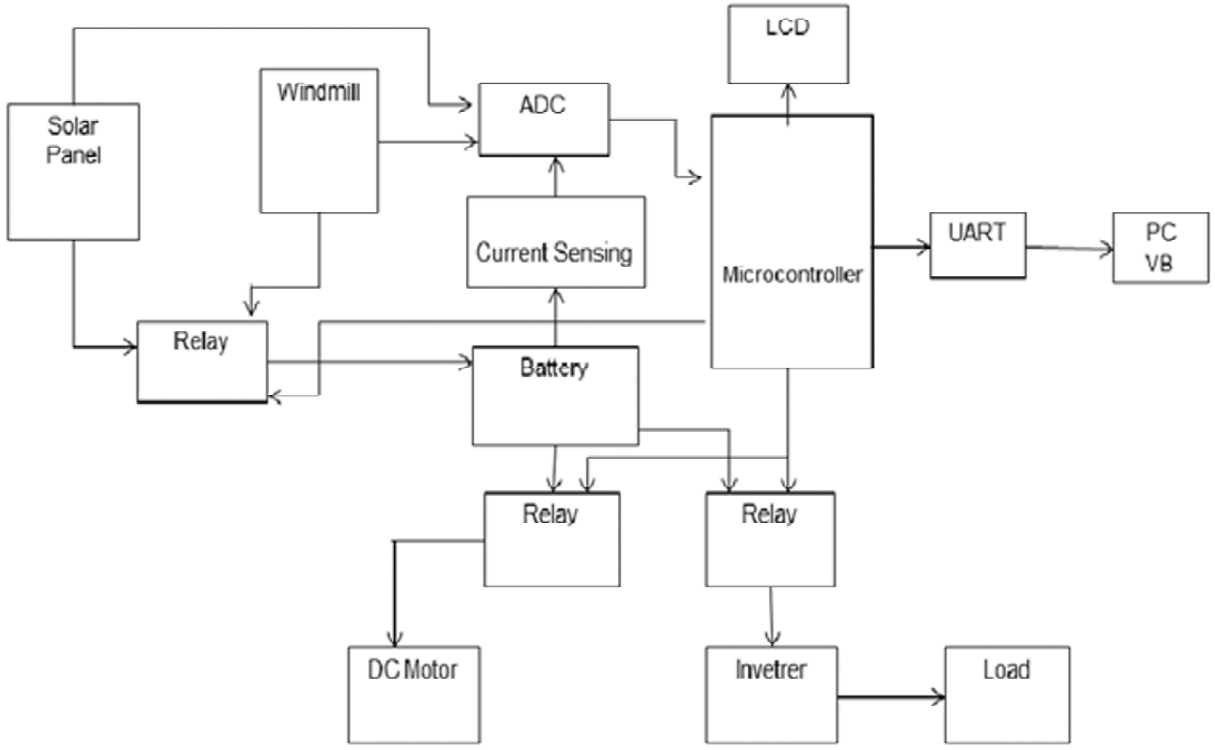

Figure 1: Block diagram of proposed system

3. SYSTEM DESIGN

3.1. Hardware used

The hybrid test prototype model constitutes a solar panel, wind power generation unit and a battery with AC and DC load. The description of all the hardware items used in this project has been given below in detail.

3.1.1. Solar panel

Solar panel refers either a photovoltaic module or a set of photovoltaic (PV) modules electrically connected and mounted on a supporting structure or a solar hot water panel. Solar panels is used as a component of a larger photovoltaic system to generate and supply electricity. Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 320 watts.

Here a 20 watt solar panel PV is used for experimental setup. The open circuit voltage that can be generated by this panel is 18 volts.

3.1.2. Wind electric generator

Generally, the wind electric generator may be a synchronous or induction machine that has been used in a three bladed wind turbine. The absence of gear box in PMSG based wind turbine eventually reduces the overall cost and weight of the nacelle in total [3, 4]. Here a permanent magnet based machine has been used to produce power from the wind. It can produce up to 5V volts according to the wind speed.

3.1.3. ADC

Analog to digital converter converts the analog signal to digital signal which is compatible to the microcontroller. ADC0809 used in this prototype is a low power, single supply, monolithic CMOS with 8 channel multiplexer compatible with microcontroller. The conversion speed is around 100us.

The design of the ADC0809 has been optimized by incorporating the most desirable aspects of several A/D conversion techniques. It offers high speed, high accuracy, minimal temperature dependence, excellent long-term accuracy and repeatability, and consumes minimal power and can be easily interfaced to any microcontroller.

3.1.4. Microcontroller AT89S52

The microcontroller AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable flash memory. The device is manufactured using Atmel's high-density non-volatile memory technology and the on-chip flash allows the program memory to be reprogrammed in system or by a conventional non-volatile memory programmers. The AT89S52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The operating frequency is 11.592Hz.

Figure 1.3 shows the circuit of ATMEL89S52.It consists of forty pins with four ports namely port 0, port 1, port 2, port 3. It has 32 input and output pins and 8 pins for special functions eg. ALE, EA, GND, PSEN, RST, SFR, VCC, XTAL and it has an inbuilt timer and counter.

The microcontroller Atmel 89S52 plays very important role in deciding the operation of the whole system. It takes the digital input and compares and performs the specific operation to switch relays.

3.1.5. Relay

It is an electronic switch with normally open and normally close condition. It is used to perform complementary function.ULN type relay has been used. It has several inbuilt transistors and diodes to perform switching action. Three relays are used, Microcontroller compares and performs a complementary

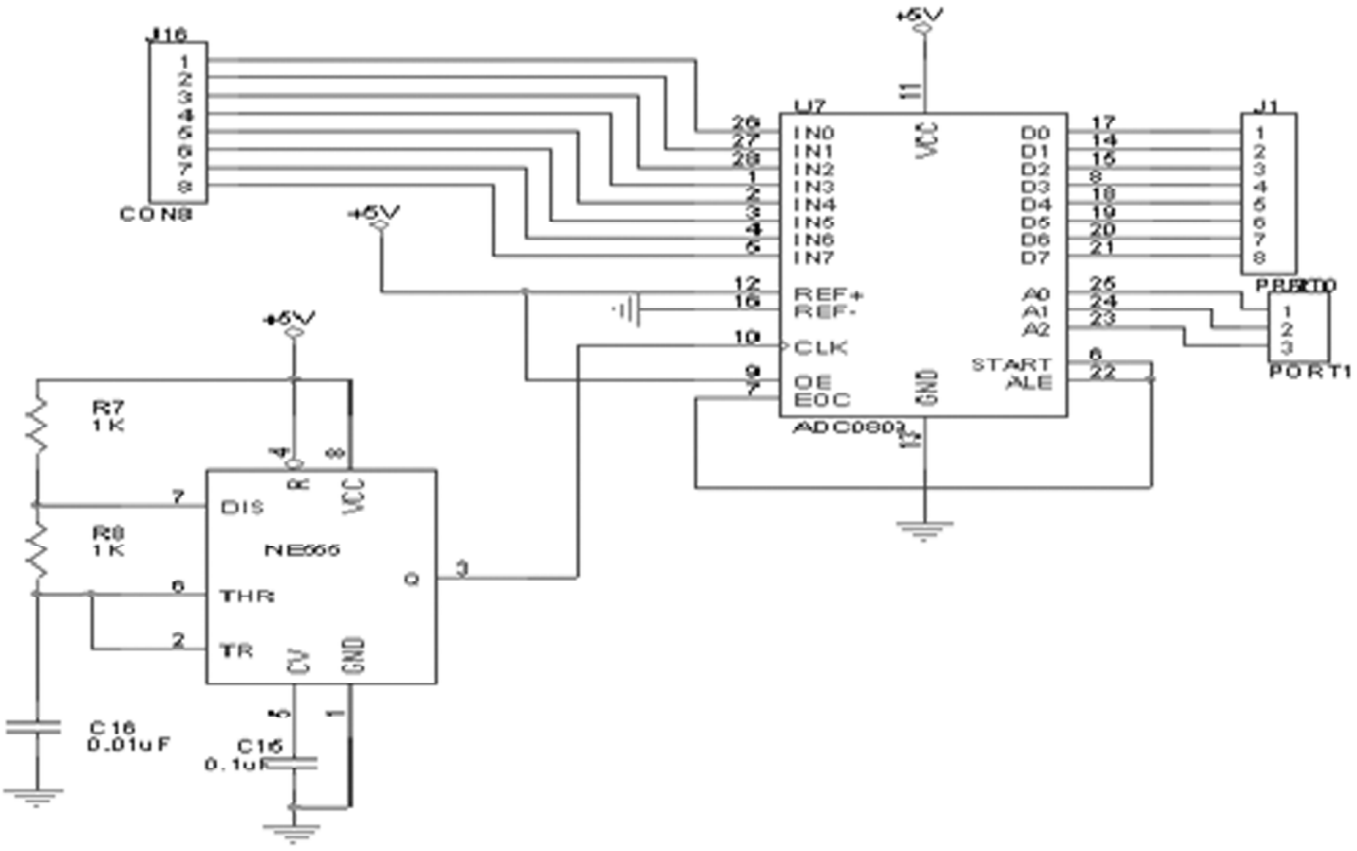

Figure 2:

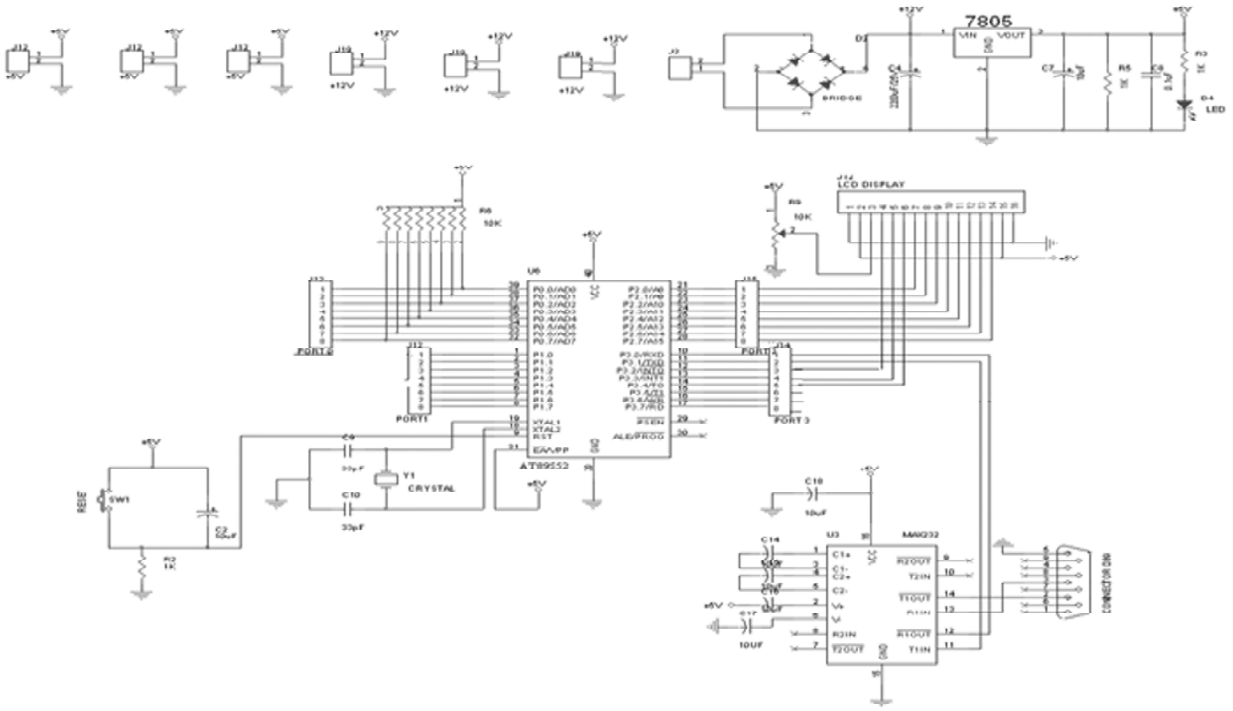

Figure 3: Circuit diagram of AT89S52

operation using relay 1. i.e. if the available power is high from wind, relay1 is used to switch to wind as a predominant source and the respective LED glows. Based on threshold value, relay 2 switches dc load. The third relay has been used to switch inverter to run AC load.

3.1.6. Battery

Battery is to store energy when the generated power goes above certain limit. The battery here used is a monolithic, high performance, lead ion of 12V.

3.1.7. UART

A universal asynchronous receiver/transmitter is a key component of serial communication system. It takes bytes of data and transmits individual bits in a sequential fashion. A UART is usually an individual *r* part of an) integrated circuit used for serial communications over a computer or peripheral device serial port.

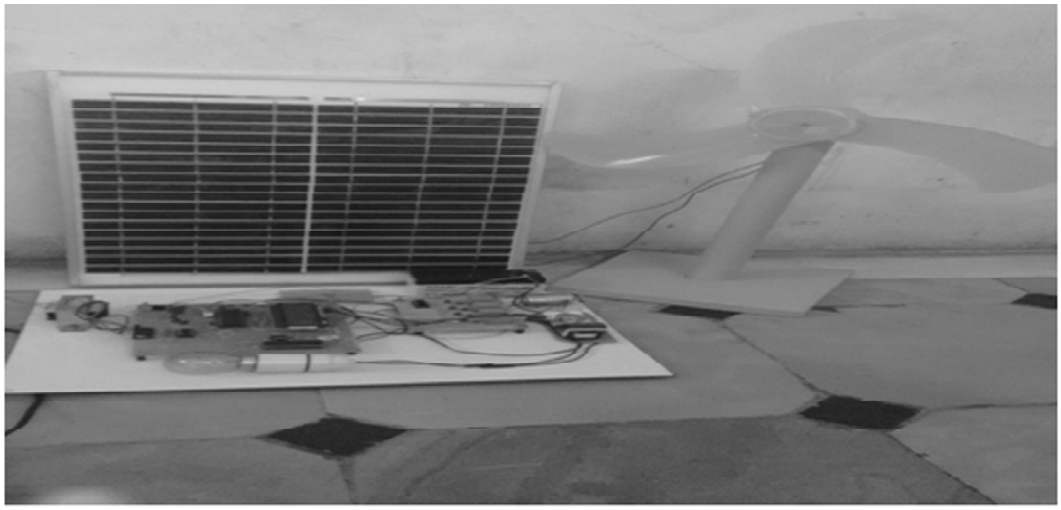

Figure 4:

Here the UART is used to interface the PC with microcontroller and the output parameters have been seen using Visual Basic. LCD is used to display the output parameters simultaneously. The battery got charged using solar or wind energy continuously.

The experimental results have been given in Table 1.1 as below.

Table 1
Experimental results

Parameters	*Solar source*	*Wind source*
Maximum power, Pmax	20 watts	1.5 watts
Short circuit current,Isc	1.12amperes	-NA-
Open circuit voltage,Voc	22.0 volts	-NA-
Output voltage	17.8 volts	12 V

4. SYSTEM SIMULATION

The simulation of the system has been done with the help of Sim Power Systems tool box in Simulink/ MATLAB and results have been validated. MATLAB is software that is used to simulate the non-linear systems and predict the time-varying parameters of a particular system. In this the simulation of integrated hybrid system constituting wind generation unit and photo voltaic system has been done. The power that is generated from the PV panel depends upon the current and voltage values given in equation 1.1

$$I = I_{sc} - I_0\left[e^{\frac{qV_d}{\beta kT}} - 1\right] \tag{1}$$

where

I_o – diode's reverse saturation current

q – electron charge (1.602x10-23C)

Vd – Voltage across the diode (V)

K – Boltzmann's constant (1.381*10-23 J/K)

T – junction temperature in Kelvin (ºK)

V_d – voltage across the PV cell

I – output current

Since mathematical model is used to calculate the response of the wind energy conversion and to determine the maximum power operating point, simulation is useful [5, 6]. The electromagnetic torque developed in permanent magnet synchronous generator is controlled by inspecting the armature current continuously, since it is proportional to the armature current. The complete simulation diagram has been depicted in Figure 5. The various subsystems includes the wind generation unit block and solar system block. PMSG has been taken as wind electric generator and made to run on no-load during simulation. The wind turbine block needs three inputs out of which the generator speed comes from the bus selector output of the machine, the pitch angle from the pitch angle controller and the last the wind speed. The wind speed has been taken as 12 m/s. The pitch angle is maintained zero in order to obtain maximum allowable power from the wind.

The shaft torque obtained must be used to gear up the turbine and the mechanical torque obtained is used to rotate the shaft of rotor of the generator [7]. Likewise shaft torque is utilized to run the generator

rotor. A part of the converted electrical energy is given to a three phase series RLC load. The remaining ac voltage gets converted into corresponding dc voltage by means of universal bridge circuit.

Subsystem of solar system constitutes two in puts,the in solation from sun energy and the short circuit current or the photo current produced due to in solation in each solar cell. The output current is given to the controlled current source, gets multiplied and the voltage drop across the resistor is considered as open circuit voltage. Again this output voltage is boosted by a boost MOSFET converter. The boosted dc voltage is then converted into ac using an IGBT inverter. The gating pulse for each MOSFET comes from the pulse generator. Pulse width modulator generates the carrier signal which is compared with the generated output voltage and gives the corresponding voltage. Both the generated current and voltage can be viewed through the scope.

The following figures from Figure 6 to 13 depict the several outputs got from the wind generating unit and the solar panel.

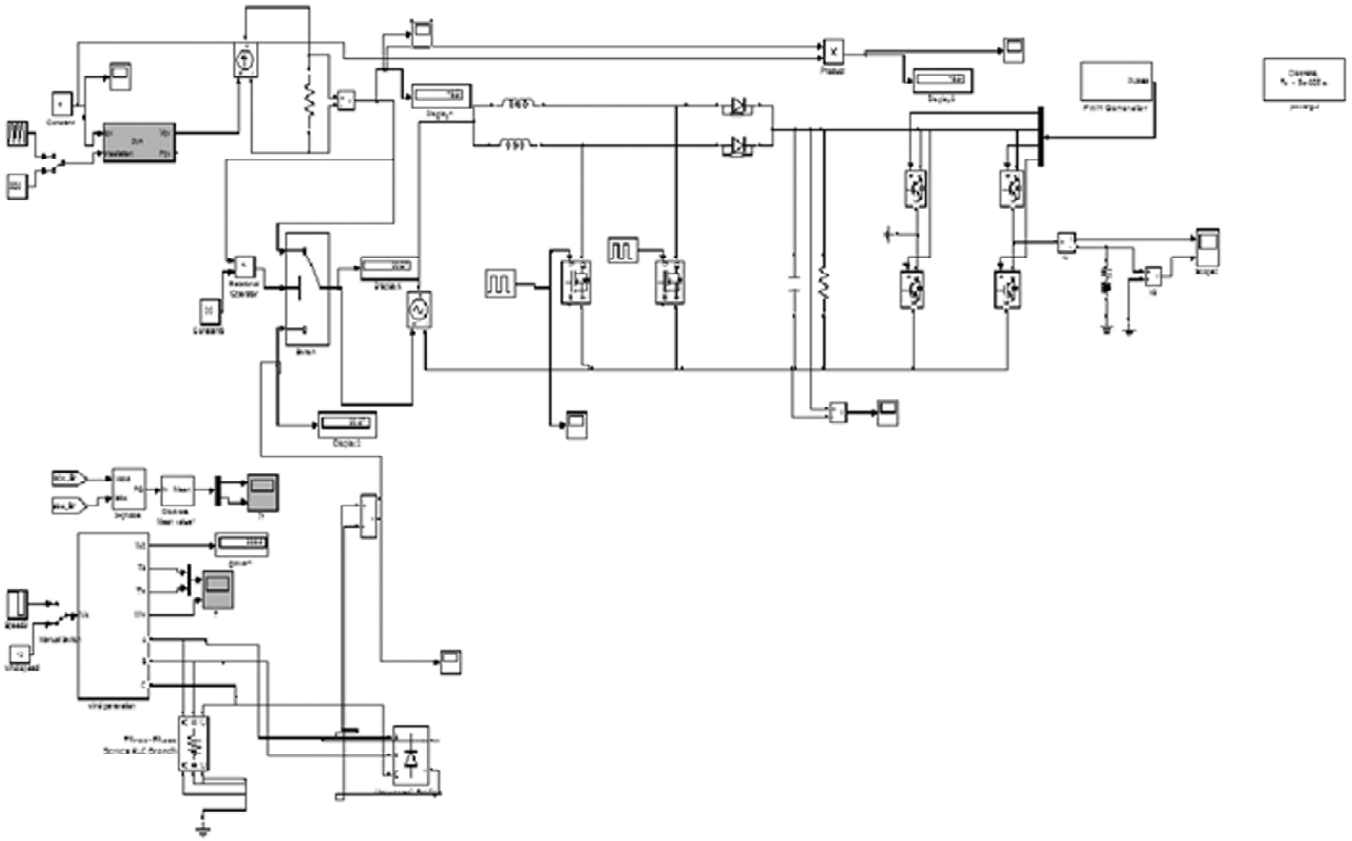

Figure 5: Simulation of proposed hybrid system in Simulink

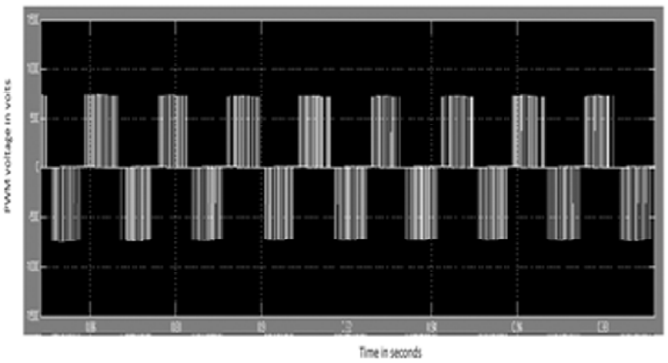

Figure 6: AC output voltage/solar source

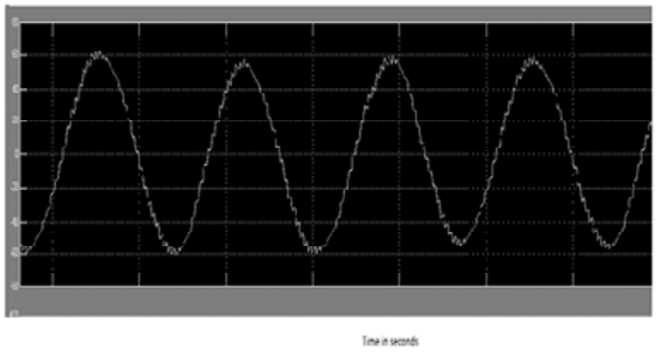

Figure 7: AC output current/solar source

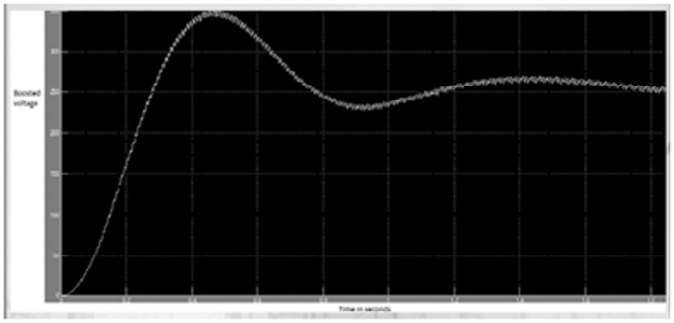

Figure 8: DC output current/solar source

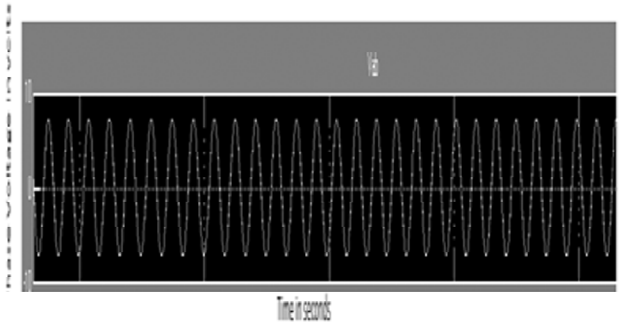

Figure 9: Phase voltage Vab/wind source

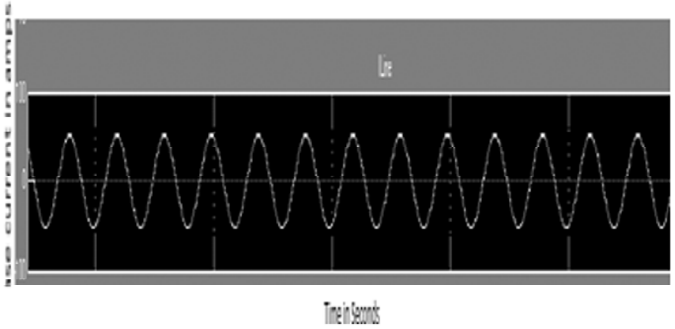

Figure 10: Line current Iabc/wind source

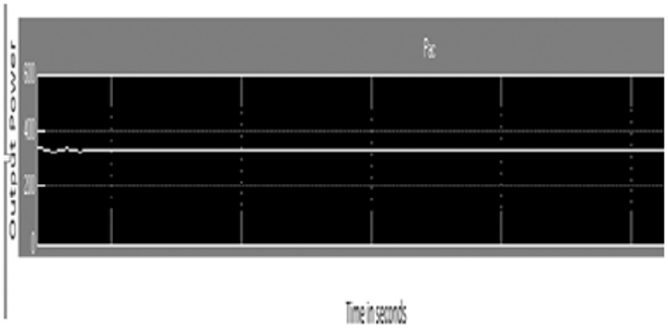

Figure 11: Maximum power Pmax/wind source

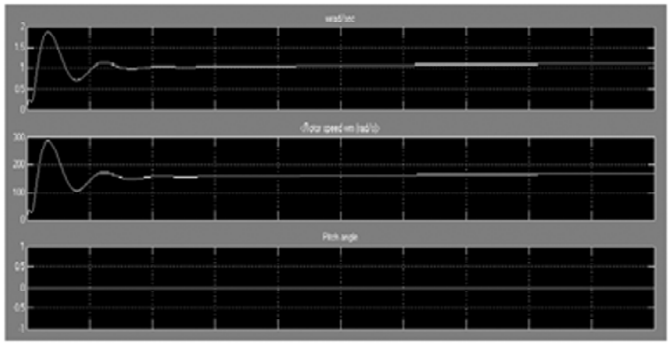

Figure 12: Various parameters of the generator/wind

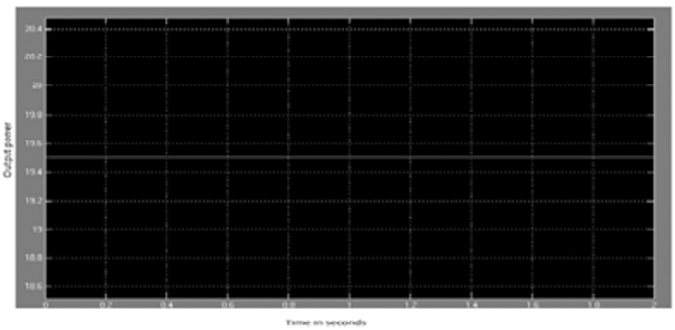

Figure 13: Open circuit voltage of the PV cell

5. CONCLUSION

The hybrid integrated test model shows better performance [8, 9] than being operated as single source. It is also noticed from the experimental results that the output voltage generated by the solar panel is close to its rated value given in the specifications sheet. This prototype model intends in deriving high power unit to meet heavy loads. It is worthwhile because the power generated is free from pollution ensuring clean, green future….

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