International Journal of Electrical Engineering & Emerging Technology, Vol. 02, No. 02, Dec 2019, pp 18-21

Highway-based, vehicle driven Vertical Axis Wind Turbine with Solar Power System

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[**Received on:** 25-09-2019 **Accepted on**: 01-10-2019 **Published on:** 03-12-2019]

Abstract- The world is moving towards clean energy sources and utilizing such sources which are abundant, efficient, economical and environmental friendly. This research project is based on two clean energy sources i.e. Wind energy and solar energy utilized together. This research is based on wind energy generation system which captures wind energy (Vehicle-induced Turbulence) from vehicles moving on highways along with solar power generation system. It consists of a vertical axis wind turbine (VAWT), a turbine having vertical shaft with blades surrounding it, is installed in the mid-way of highway. When the vehicles move from the both incoming and outgoing sides of highway. they tend to move the turbine. The turbine connected to the generator thus operates it, which produces electrical energy that can be stored in battery banks, light up the highway street lights and signs, provides electricity to small village nearby or can be connected to the grid using inverters to convert the DC output to AC first. To make the system more reliable and provide continual supply, the hybrid system of VAWT-Solar power generation system is designed in this research, proving it is better to utilize VAWT and solar hybrid instead of individual source generation.

Keywords— VAWT, Highway-based, Vehicle-induced Turbulence, Hybrid system.

I. INTRODUCTION

IT is the energy which controls the entire universe and need of everyone. Generating energy is of very importance in today's world. fuel value is unsteady because of the world economic and restricted resource, it is found that producing electricity with standard fuel can result in the setting pollution. So as to beat these problems, renewable energy (solar, wind etc.) is taken into consideration by applying various techniques to provide electrical energy to the consumers.

The renewable energy sources (wind and solar energy) are estimated as unlimited, clean, inexhaustible and environment friendly [2]. Such characteristics of renewable sources have diverted the attention of energy sectors to use renewables on a larger scale but, one of the drawbacks of these sources is their dependency on variable factors like climatic changes and weather However, some of the problems can be compensated by overcoming weakness of one source with the strength of the other and vice versa. Such a concept is termed as Hybrid system.

II. PROBLEM STATEMENT

The conventional sources for power generation are atmospherically damaging. To overcome this, renewable energy resources are being taken more into consideration and have proved to be efficient energy producers.

Instead of so many advantages there is still one major drawback i.e. dependency of supply. Changing in weather and climate, such as wind and sun not available all the time for wind and solar power generation respectively.

III. OBJECTIVES

- To overcome the drawback regarding dependency; both sources (wind and solar) are integrated. Generating electricity from solar panel in the daytime and the wind produced by vehicles' movements; always available at different places, especially highways, that too with sufficient speed and force of wind if the hybrid system is implemented in the middle of highways.
- A VAWT designed that efficiently uses the wind energy generated by the vehicle speed on the highways [1].
- To design and develop the electronic circuitry for the integration of solar PV array with vertical axis wind turbine.
- To propose environmentally friendly hybrid system for highways.

IV. METHODLOGY

The VAWT-Solar hybrid power generation most importantly focuses on assessing implementation of the a chain of vertical axis wind turbine (small-scale) along the mid of highways making hybrid system with solar to improve efficiency [2]

The research was started by designing VAWT prototype, the results were taken individually then integrated with solar

panels. The whole VAWT-Solar hybrid prototype was then tested on Jamshoro road and results were obtained in terms of Voltage, Current and power values.

The block diagram of our designed model of highway based VAWT-Solar hybrid system is given below in Fig. 1

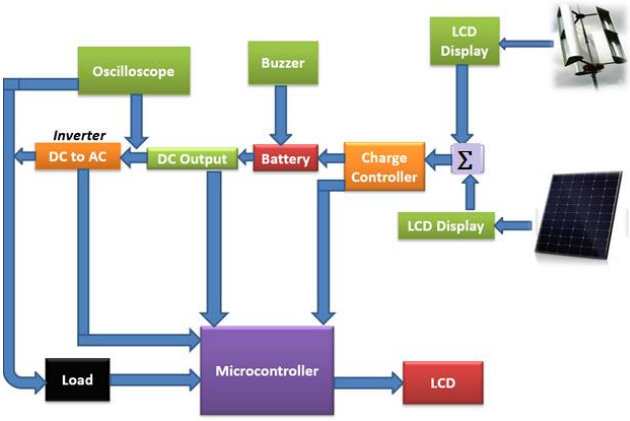

Fig. 1. Block diagram of the designed VAWT-Solar hybrid system

To make this model, in the above block diagram, the components used are mentioned below. For our proposed model the main design parameters of VAWT-Solar hybrid system are shown in Table 1.

TABLE I: Design parameters of the proposed model and their ratings.

Components used	Ratings
Microcontroller	ATMEGA328P
Battery	15V, 7AH
Solar panels Specification of Panel	Rating; 10W, 12V
Vertical axis wind turbine	12V
2 relays	12V
ICs	ULN2003 and 2 IC 7805
Inverter	TTL Logic
Astable multivibrator	CB4047BCN
LCD Module	ADM1602K-NSW-FBS/3.3V
Filter Capacitors	4 in total; 2 for 5V and 2 for 12V
Voltage meters	3 in total; each of 5V
Variable resistors	3 in total; for different purposes
Transformer	10VA

a. Internal diagram for VAWT-Solar hybrid system

The internal diagram for the VAWT-Solar hybrid system is given below in Fig. 2.

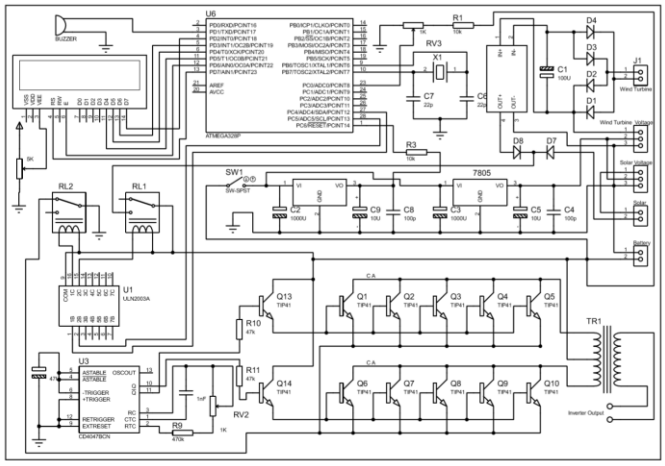

Fig. 1. Internal diagram of the designed VAWT-Solar hybrid system

V. PROTOTYPE RESULTS AND DISCUSSION

The prototype was tested and results were evaluated from 9:00 am to 3:00 pm near the front gate of Electrical Engineering department of Mehran UET, Jamshoro. The system performance was evaluated on 21st August and 27th August 2019.

Solar energy model output

The Solar Power Generation throughout the working time i.e. 9:00 am to 3:00 pm is given below in Table II

TABLE II: Solar Power Generation output

Time	Voltage(V)	Current(A)	Power(W)
9:00am	13.4V	0.15A	2.01W
10:00am	13.67V	0.15A	2.0505W
11:00am	21.2V	0.176A	3.7313W
12:00pm	25V	0.179A	4.475W
13:00pm	30.2V	0.26A	7.852W
14:00pm	34.6V	0.3A	10.38W
15:00pm	34.1V	0.3A	10.23W

Wind Generation model output

The Wind generation output via VAWT throughout the working time i.e. 9:00 am to 3:00 pm is given below in Table III

TABLE III: Wind Generation model Output

Time	Voltage(V)	Current(A)	Power(W)
9:00am	22.7V	0.36A	8.172W
10:00am	19.3V	0.2A	3.866W
11:00am	19.7V	0.26A	5.122W
12:00pm	22.4V	0.399A	8.9376W
13:00pm	27.4V	0.4A	10.96W
14:00pm	27V	0.44A	11.88W
15:00pm	26V	0.394A	10.244W

Hybrid System Model output

The VAWT-solar hybrid output throughout the working time i.e. 9:00am to 3:00 pm is given in Table IV

TABLE IV: Hybrid System Model output

Time	Voltage(V)	Current(A)	Power(W)
9:00am	207V	0.5A	103.5W
10:00am	207.5V	0.5A	103.75W
11:00am	210V	0.6A	126W
12:00pm	215V	0.64A	137.6W
13:00pm	219.2V	0.71A	155.632W
14:00pm	219.3V	0.69A	151.317W
15:00pm	219V	0.68A	148.92W

Output curve

The Comparison of voltages of individual solar power generation model, individual VAWT power generation model and the hybrid system of VAWT-Solar system of same ratings as individual connected together is given in the chart format below. The Solar and VAWT output voltages are dc output while hybrid output is inverted, stepped-up AC voltage.

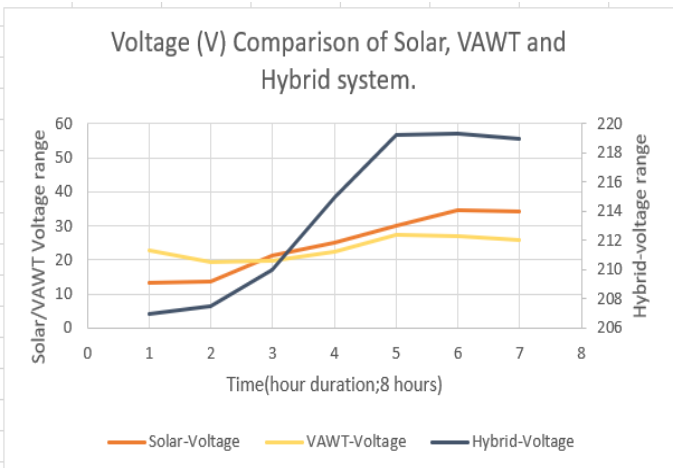

Fig. 2. Voltage Comparison of Solar, VAWT and Hybrid system

The output voltage of the VAWT- Solar hybrid system is near to 220V AC. The graphical results were obtained by using a Digital-Oscilloscope in Fig. 3.

The output voltage was thus reduced to 36V from 220V by resistive voltage divider circuit of 3.3MΩ and 0.75MΩ

The 36.7V voltage was obtained across resistor of value 0.75MΩ.

The Voltage was then further reduced to approximately 8V (peak to peak) which consists of harmonics.

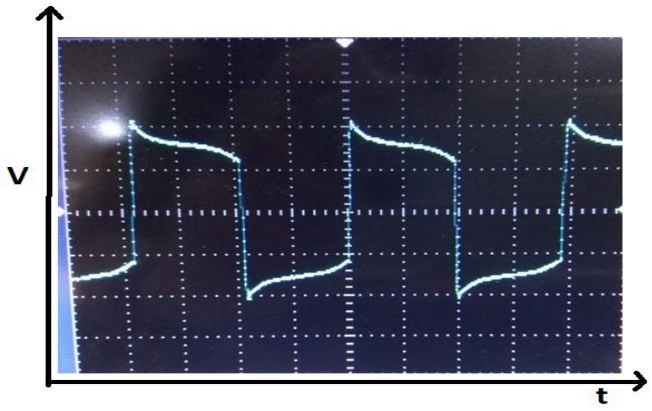

Fig. 3. Graphical results of VAWT-Solar hybrid system

The harmonics in the curves can be reduced by using inductive load instead of resistive only.

Here the time/division is taken as 5ms. Volt/division is 2V. $3V_{pp}$*2V/div=6V if harmonics are reduced and a straight line after one grid block is take as the peak voltage, thus a pure square wave is formed. 8V-6V= 2V; thus 2V harmonics have been calculated.

The Comparison of voltages of individual solar power generation model, individual VAWT power generation model

and the hybrid system of VAWT-Solar system of same ratings as individual connected together is given in the Fig. 4.

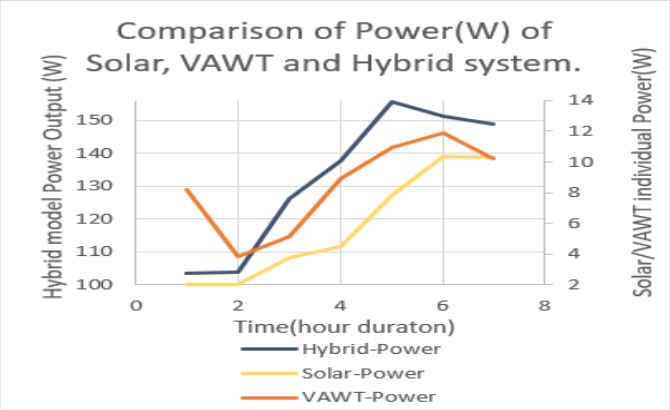

Fig. 4. Power Comparison of Solar, VAWT and hybrid system

VI. SYSTEM DESIGN

Vertical Axis Wind Turbine Construction Parameters and other device ratings are shown in the Table V.

TABLE V: VAWT Constructional parameters

Number of blades = 4
Width of one blade = 2.5 inch
Material of blades = PVC
Frame width = 4x22 inch
Total frame height= 26.5 inch
Main frame material = Mild steel
Frame thickness = 4mm
VAWT overall diameter = 20.5 inch
VAWT overall height = 20 inch
Power Ratings of Devices:
Solar Plate = 10 W,12V
VAWT = 12V
Battery = 15V, 7AH

a. Prototype operation:

The solar panels covert the sunlight energy into electricity during day hours and store it in a DC battery. The power through wind turbine is generated when the hitting wind crosses a certain value called cut-in value. The AC output power obtained from Wind Generator is converted to DC power by means of bridge rectifier (it uses four diodes in a bridge circuit configuration). In conjunction with the rectifier circuit, smoothing capacitors are used. The purpose of smoothing capacitor is to smooth or even fluctuations in the DC signal. Capacitors reduce the amount of ripple voltage and stores this DC power in battery. [4] The energy obtained from wind and solar power generation is stored in the battery. By using the inverter, the battery's DC voltage gets converted to AC and is used by electrical loads. An inverter converts DC to AC. The output recieved from the inverter is fed to a step-up transformer which increases the voltage to 220V AC output. A microcontroller is used which triggers the relay after comparing input of both sources. [5]

VII. ACKNOWLEDGMENT

The research, project and the paper wouldn't be possible to accomplish without the guidance, cooperation and exceptional support of the Supervisor of the research, **Prof. Dr. Abdul Sattar Larik.** His cooperation and expert opinion on the topics turned out to be very valuable and helpful for us every time, therefore heartfelt gratitude to our Supervisor. The Co-supervisor **Prof. Dr. Mukhtiar Ahmed Mahar's** contribution is worth notifying, paying sincere gratitude to the co-supervisor for his key importance in completion of work.

The work was financially supported by MUET RINU (Research Incubation in public Universities) in collaboration with IEC; and recommended for funding by IGNITE – National Technology Fund.

VIII. CONCLUSION

The design parameters were described in first along with their technical specification. The main idea was to design a small-scale vertical axis wind turbine integrated with solar power system. It is noticed from the evaluated results that the vehicles moving on highways can produce enough energy to provide electricity to the streetlights, the output gets enhanced when VAWT is integrated with solar power system and that electricity produced can supply nearby villages or off grid areas.

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