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Design and Development of Prototype Highway Lighting with Road Side Wind Energy Harvester

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Abstract: ***In this paper we present an efficient wind turbine structure for specific application. Hybrid wind turbine has been designed and developed for highway side applications. It is a combination of two conventional Vertical Axis Wind Turbines (VAWT). Darrieus and Savonius wind turbines are used as a combine model for Highway Side Wind Turbine (HSWT). A charge controller circuit has also been designed and developed. It provides charge monitor and flow control within the whole circuitry with the help of microcontroller. Battery bank system is used to store charge generated by the HSWT. A prototype model has been developed and analyzed in real physical environment. Finally the paper analyses the operation and feasibility of the proposed HSWT model.***

Keywords: HAWT, HSWT, Hybrid Model, Charge Controller, High Power Generation

1. Introduction

Modern electrical and electronics technology needs electrical energy to work. Every automated system which works on electrical energy is useless without electricity. Current energy scenario shows that there is not an adequate amount of conventional energy for future. As demand of energy increases day by day in exponential order, energy consumption is also increasing. Increased demand and less available supply of energy creates huge energy gap which is increasing rapidly. So it is imperative to generate energy from other sources along with conventional sources.

Wind energy sources are one of the highly available and reliable renewable energy resources. Discontinuous availability of wind energy makes a limitation on its utilization. This limitation can be removed by utilization of the area where wind flow is more [1]. For this problem Highways are the better solutions. Highways are the backbone of any nation for development, it remains busy day night. Wind turbulence created by the vehicles on the road can help us to generate electrical energy [2][3].

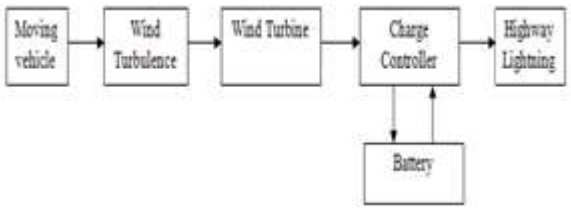

Figure 1: Block Diagram for Proposed Model

2. Modeling of HSWT

For highway side applications, generation of wind turbulence is directly proportional to the speed of vehicle. For utilization of moderate wind speed, a wind turbine is needed that should have high initial torque for initial starting and it should be suitable for high wind speed [4]. For this purpose of two VAWT turbines- Savonius and H type rotor Turbines are combined together. Savonius have advantage of high torque at low wind speed but it is not suitable for high wind speed. It works on drag phenomena hence have less efficiency [5]. Darrieus have advantage of high efficiency at high wind velocity but it is not self starting [6]. It requires high wind for particular time to self-start. Together they overcome disadvantage of each-other and become suitable for highway side applications.

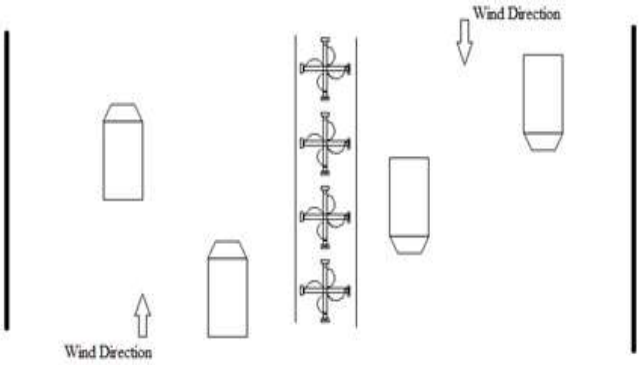

Figure.2 Description of Wind Turbulence Generation

Wind turbine for this specific application is so designed that it can utilize the wind turbulence from every direction. Every time when any vehicle passes on the highway then wind disturbed by that vehicle intends wind turbine to move in the clock wise direction. Traffic on the highway can be defined in three categories as; heavy, moderate and low traffic [7].

Assume that traffic always remain fast at the highways so the average wind turbulence velocity is 7m/s

$$Power = 0.5 * Cp * \rho * A * V3 \quad (1)$$

Wind velocity (V) =7m/s
Area of blade (l x b) = 0.900 m^2
Air density (ρ)=1.23kg/ m^2
Power coefficient (Cp) = 0.4
Substituting all the values in equation (1),

$$P = 0.5 * 0.4 * 1.023 * 0.900 * 7\text{^}3$$

Generated Power = 75.94 watt

3. Charge Controller

Charge controller circuit is the electronic part of this research work. It contains most of the electronic modules of the circuitry. It takes care of the input from generator to the battery and load. This circuit used to monitor and control charge flow across the whole system. It is used to control

battery charging and discharging process along with load connectivity process. An algorithm is defined to control flow mechanism inside the whole circuitry. Algorithm shows the flow chart of the program for microcontroller.

PIC18F452 microcontroller is used in this system. High availability, ease to use programming tool and inbuilt ADC along with in circuit serial programming capability makes it optimum choice to be used. Microchip Programming Lab Integrated Development Environment (MPLAB IDE) is used to create project. C18 complier and mikroProg Suite is used for programming and burning process.

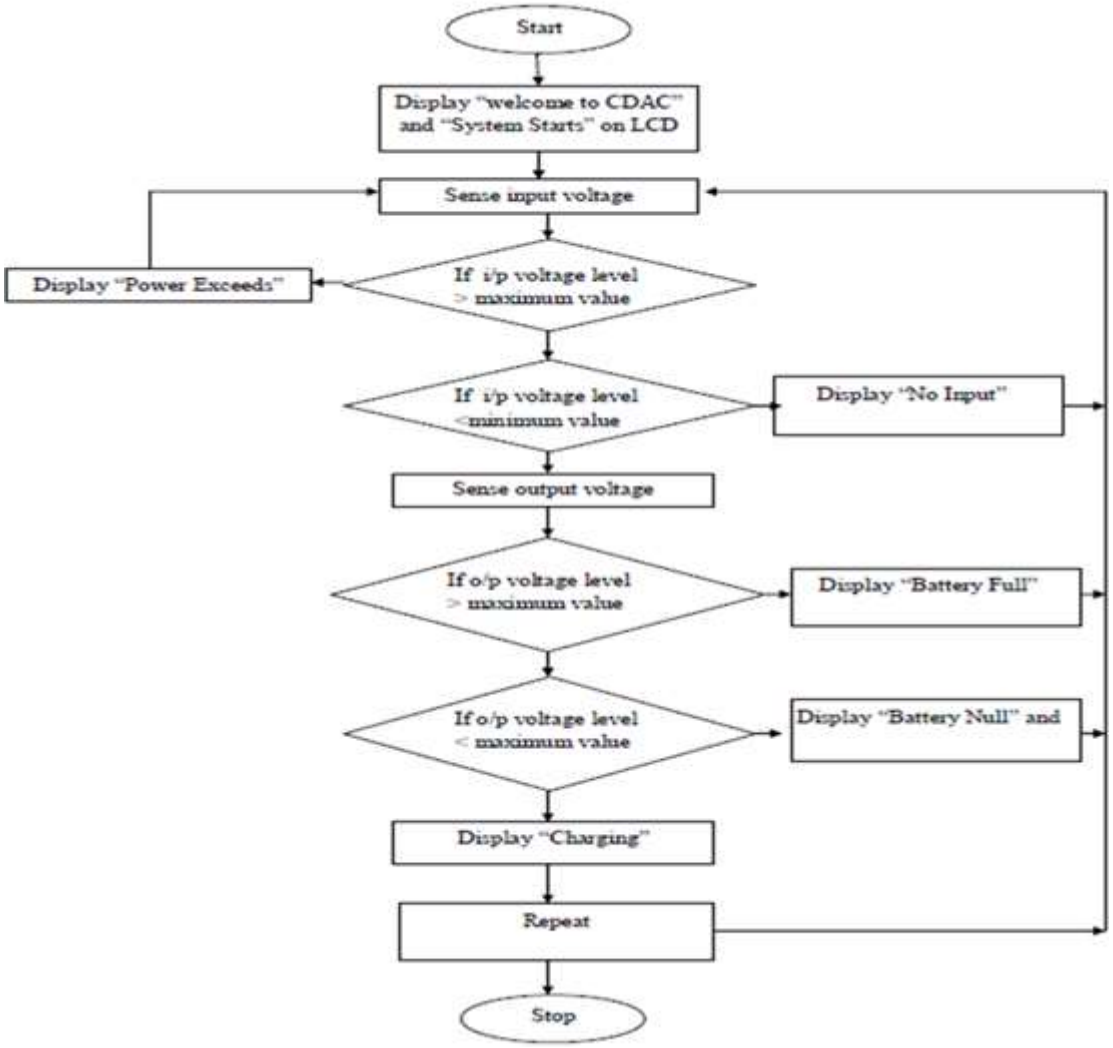

Figure 3: Flow Chart for Controller

Firstly microcontroller sense the generated voltage with the help of voltage sensing circuitry then it checks the voltage level to its predefined value. If generated power is greater than 14.5V then power exceeds condition occurs and microcontroller prevents further circuitry with the help of relay circuit. In same manner, condition for deep charging and discharging is maintained by the controller with sensed output voltage at the battery terminal. LDR circuitry is used to sense the light intensity. When sunlight goes down so that there is insufficient light to drive vehicle then LDR circuit turns the relay on and connect the load to the battery. LDR circuitry is independent of the microcontroller. It consists of and OP-AMP which is working in dual supply mode as a comparator. For generation of dual supply, charge pump inverter circuit is used which gives -5V supply for +5V input supply. Input to the microcontroller and LDR is also supplied by the battery. LCD is used to show program flow of the controller. It represents 'charging', 'deep discharging', 'over charging', 'power exceeds' and 'No input' Condition as per the status of the program flow. LED panel is used to define status of the program. LED cluster have also been develop for the highway lightning prototype.

4. Results and Analysis

Prototype for highway wind turbine has been developed in the laboratory. Darrieus part of the turbine has been made of the Partal wood and Savonius part is designed with 2 mm aluminum sheet. Both the turbines are combined together with the help of L-shape connector and iron frame work. At the top of the turbine 12volts, 300rpm and 1Amp current capability geared DC motor has been connected. So for one volt power generation 25rpm is needed. Shape and structure of turbine at time of highway testing is shown in the figure.4

Figure 4: Highway testing of the prototype

Power generated by the hybrid turbine is greater than individual turbines. It shows that the efficiency of the turbine has been enhanced without increasing the swept area. For feasible system its cost should be less and performance should be high. Cost of the system varies with the location. However the price may be different for different locations and working conditions. The cost for single unit is shown in the Table.2. For sufficient power generation there should be three different model connected in series to provide sufficient DC voltage for charging for the battery sub system.

Table 1: Costing of Final Product

S. No.	*Items*	*Cost*
1	Wind Turbine Blade Assembly	2000/-
2	Charge Controller	1000/-
3	LED Cluster	300/-
4	Wiring and Misc.	200/-
5	Motor and Battery	1500/-
6	PCB Fabrication	3000/-
Total		7000/-

5. Conclusion

Cost effective, green energy source for power generation can help to reduce power requirement. An efficient hybrid wind turbine is designed to be use in road side application for energy generation. This turbine is specially designed for road side applications which generate energy by utilization of natural wind and wind turbulence. A microcontroller operated effective charge controller has been developed. Charge controller charge battery from generated voltage and utilize this energy for later use. The presented system is cost effective, ready to use and user friendly system which used to serve specifically in highway lightning system. It is very useful in the areas which have heavy traffic on road without congestion. With the help of public aids, this system can be used to facilitate many houses and home and will be very handy for implementation.

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Author Profile

Rita Devi has received her B.Tech Degree in Electronics & Communication Engineering from P.T.U. Jalandhar in 2011. Currently she is pursuing her M.Tech thesis from CDAC Mohali. Her field of expertise is Electronics Product Design Technology.

Jaspal Singh graduated with distinction from Thapar University in the year 1991. He has hands-on experience in the entire range of medical instrumentation and systems. He worked in multinational, GE medical systems. He was involved in teaching and training medical equipment technology at various levels. He completed his MBA. He received M. Tech degree in electronic instrumentation from Punjab University. Thereafter he has worked extensively and lead several projects on development of various electronics & embedded system technologies.