Advanced Uncontrolled Power for Rural Access

Andrew Mathew Domnic Francis[1], Askar Ali Kismath[2], Ganesh Kumar Durai[3], Karthikeyan V.[4], Maniiarasan P.[5]

[1,2,3,] *Pre final year, Nehru institute of Engineering & Technology, Coimbatore, Tamilnadu,*
[4,5]*Nehru institute of Engineering & Technology, Coimbatore, Tamilnadu*

Abstract: Power cut is one of the major problems faced in India. Renewable energy is the best idea to overcome the power cut and other power related issues. Out of all available renewable energy sources Wind and Solar energy are the best form of renewable energy which is most suitable for rural electrification. The above said renewable energy which will never run out, pollution free and sustainable. Hence the proposed system combines solar energy and wind energy for high power generation. By implementing this system consumers in rural areas will have uninterrupted access to electricity. Keeping the above said in mind, the proposed project combines solar and wind power plant together as a hybrid power plant in which the blades of wind turbine are placed inside the duct and the solar unit is aided with Maximum Power Point Tracking (MPPT) which will produce maximum output by operating them at an optimum point.

Keywords: Renewable energy, Hybrid power, Pollution Free, Sustainable, Maximum Power Point Tracking (MPPT).

1. INTRODUCTION

The power related issues can be sorted out by migrating to renewable energy sources. Out of available energy sources, usually wind power and solar power based electricity are being considered and tried out for remote area electrification. This is because the wind power and the solar power are found to be available in bulk and more convenient to install. The proposed project intends to implement the hybrid power plant for rural electrification by fulfilling the following objectives

- To design a wind turbine in such a way that it produces optimum output even at low wind speed
- To obtain optimum output from the solar panel by tracking the maximum power point (MPP) of a Photo Voltaic (PV) array
- To couple the output of both PV unit and wind unit with help of hybrid charge controller and to obtain a constant output
- The design is expected to ensure efficiency, economic operation and ease of transportation
- The design is especially intended for rural electrification so as to light two CFL bulbs(15 watts each) and two fans(24 watts each) by generating power of 80 Watts

2. METHODOLOGY

EXISTING SYSTEM. Normally wind turbines and solar panels are coupled together for the construction of the hybrid power plant. It is a well known fact that wind fluctuates during different seasons of the year. Drawback in the existing system is that the criteria for both solar unit and wind unit to produce maximum power does not coincide for a particular season[5]. (i.e.) the speed of the wind is neither high nor constant at all places throughout the year and the intensity of sunlight reaching the earth also changes with climate which causes the hybrid plant to work inefficiently.

PROPOSED SYSTEM. To overcome the above said drawback, a specially designed system which couples the output of wind turbine unit and solar unit using hybrid charge controller is proposed. The wind turbine unit is designed in such a way that it will generate electricity even at low wind speed. It is based on the Bernoulli's principle[4]. According to Bernoulli's principle, when the air flow through the duct the velocity is decreased and the pressure is increased which makes the blades to rotate even at low wind speed. In addition to this arrangement, the solar panel aided with MPPT is merged to obtain optimum power. The MPPT is not the device but actually a technique (or) algorithm used to auto track the solar panel. It does auto tracking by continuously tracking the maximum power point (MPPT)[1] of the system. **The MPP depends on irradiance conditions and the panel's temperature.**

3. BLOCK DIAGRAM

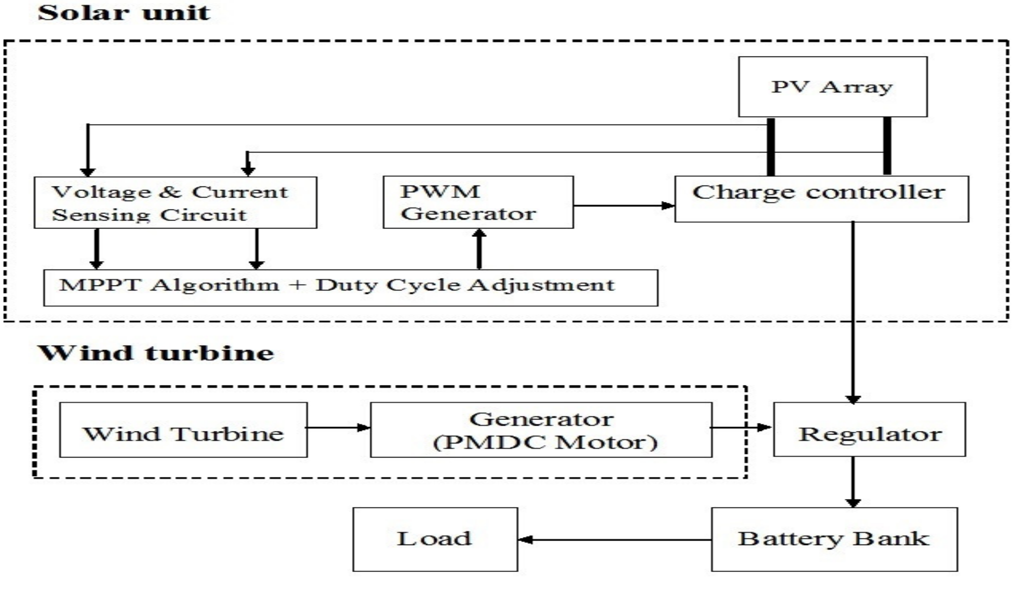

Fig.1.Overall block diagram of the hybrid system.

The components are explained below,

SOLAR PANEL. A solar panel is a set of solar pv modules electrically connected and mounted on a supporting structure. The solar module can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. The output of solar panel is given as input to the MPPT block[2].

CURRENT SENSOR. In order for the MPPT controller to measure the current provided by the solar panel, a single resistor (Rsense) is placed in series between the solar panel and the DC-DC converter. The voltage across Rsense is fed into an current sensor whose output voltage is then fed into an ADC driver circuit (op-amp in a voltage follower configuration that feeds into a low-pass filter) before being delivered to the MPPT controller. By choosing the value of Rsense as 51 mΩ, the maximum voltage drop across Rsense, is small enough, even in a worst-case scenario, to be considered negligible.The allowable voltage range for each ADC channel of the MPPT controller is 0-3 Vdc. Therefore, the output voltage of the current sensor which serves as an equivalent voltage representation of the solar panel's current should not exceed 3 Vdc. Based on the chosen value of Rsense as 51 mΩ, the maximum voltage, Vout sent to the ADC driver circuit is ~2.73 Vdc.

VOLTAGE SENSOR. In order to measure the voltage provided by the solar panel, two resistors, R1 and R2, are employed in parallel with the solar panel to act as a voltage divider. By choosing the values of R1 and R2 as 1.07 MΩ and 165 kΩ, respectively, the maximum amount of current diverted from the load, I2, is small enough, even in a worst-case scenario, to be considered negligible. The allowable voltage range for each channel of the MPPT controller is 0-3 Vdc. Based on the chosen value of R2 as 165 kΩ, the maximum voltage V(R2,max), sent to ADC driver circuit is ~2.81 Vdc.

DC-DC CONVERTER. A DC-DC converter is an electronic circuit which converts a source of direct current from one voltage level to another. Electronic switch-mode DC-DC converters operate by storing the input energy temporarily and then releasing that energy to the output at a different voltage and current. Just like a transformer, they essentially change the input energy into a different impedance level. So whatever the output voltage level, the output power all comes from the input; there's no energy manufactured inside the converter. It is this principle that makes a DC-DC Converter essential for MPPT[8]. The converter presents an electrical load to the solar panel that varies the output voltage of the converter varies. This load variation in turn causes a change in the operating point of the panel. Thus by intelligently controlling the operation of the DC-DC converter, the power output of the panel can be intelligently controlled and made to output the maximum possible.

The DC-DC power converter used in the system is a Micro 24 Vout, 100 W converter. The input voltage range of the converter is 9-36 Vdc. Because the voltage provided by the solar panel can drop below the converter's 9 Vdc minimum and thus cause the converter to shut down, our MPPT system is only operational when the voltage provided by the solar panel is greater than or equal to 9 Vdc. The output voltage of the converter can be varied between 10% and 110% of its nominal 24 Vdc output (i.e. 2.4-26.4 Vdc) .The converter has the capability of functioning in isolated or non-isolated mode depending on whether the grounds of the converter (-IN and -OUT) are separate or connected together, respectively.

MPPT CONTROLLER. The microcontroller provides the control in the system. The choice of microcontroller for the system dictates much of the cost, performance, and flexibility of the entire system. The single-chip C2000 family of microcontrollers is targeted toward real-time control applications which requires high performance integrated peripherals.

MPPT TECHNIQUE. The proposed MPPT technique uses Perturb & Observe (P&O) algorithm[3]. The comparison chart of the output of open loop solar unit and the P&O algorithm can be understood with help of flow chart is in the figure shown below,

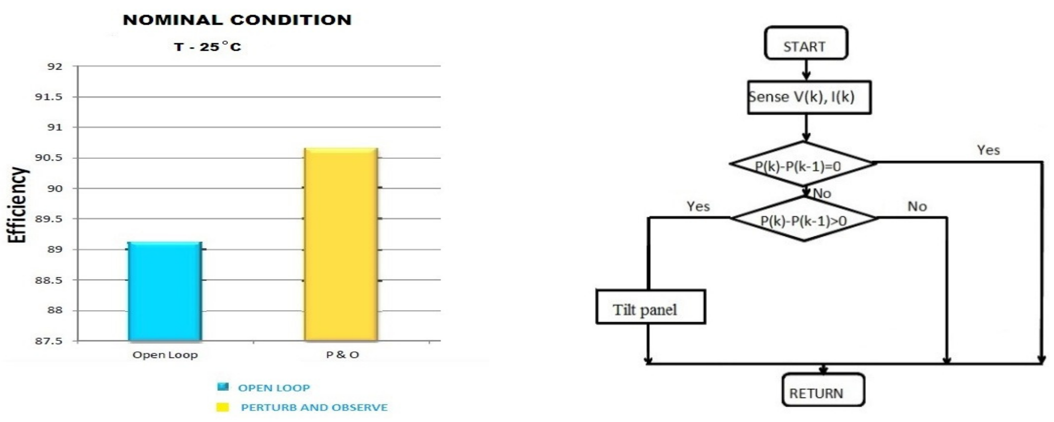

Fig.2. Flow chat and algorithm for MPPT Technique

Based on the change in power, the operating voltage of the PV array is perturbed in a given direction and if the power drawn from the PV array increases, this means that the operating point has moved toward the MPP therefore, the operating voltage must be further perturbed in the same direction. Otherwise, the power drawn from the PV array decreases, the operating point has moved away from the MPP and therefore, the direction of the operating voltage perturbation must be reversed.

4. CALCULATION OF WIND TURBINE

SPEED IN GEAR BOX.

$N1/N2 = D2/D1$

Where N1=Input speed to the gearbox in rpm

N2=Output speed from the gearbox

D2=Diameter of the generator gear 60mm

D1=Diameter of the main gear 195mm

$N2= (D2/D1) * N1$

DESIGN OF BALL BEARING.

Bearing no.6202

Outer diameter of Bearing (D) =35mm

Thickness of Bearing (B) =12mm

Inner diameter of the bearing (d) = 15mm

Maximum speed = 14,000 rpm

Mean diameter (d_m) = (D+ d)/2 => (35+15)/2=25

IDEAL WIND POWER CALCULATIONS.

Wind power (P) is calculated by the following general equation (the proof for which will be derived in the following equation)

$P=Cp * ½ \ell*A*V^3$

Where Cp is the power coefficient

ℓ is the density of the oncoming air

A is the swept area of the rotor

$A= (\pi.d^2)/4$

V is the velocity of the wind

The actual power is further reduced by two more inefficiencies, due to the gear box losses and the generator efficiency.

SIMULATION SETUP. Matlab version 7.10 is used as simulation software. Hybrid system is modeled using simulink and is shown in fig 1.3. The output of wind turbine and solar panel are applied for voltage and current measurement respectively. The voltage is measured by directly connecting the voltage sensor in series. The current is measured across the resistor which is in series with the output of wind turbine and solar panel respectively. The measured analog current and voltage value is converted into the digital form with the use of Analog to Digital Convertor (ADC). The power is calculated by multiplying the digital voltage value and current respectively.

This power value can be viewed using a display. The MPPT algorithm is applied based on the continuous monitoring of power.

5. SIMULATION

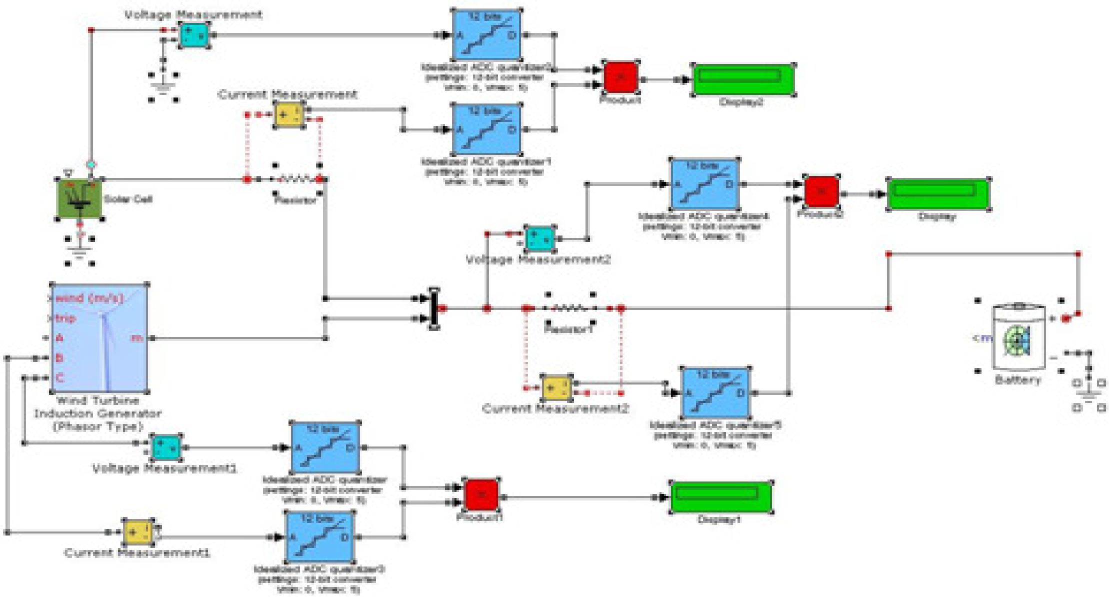

Fig.3. Overall block diagram of hybrid power plan

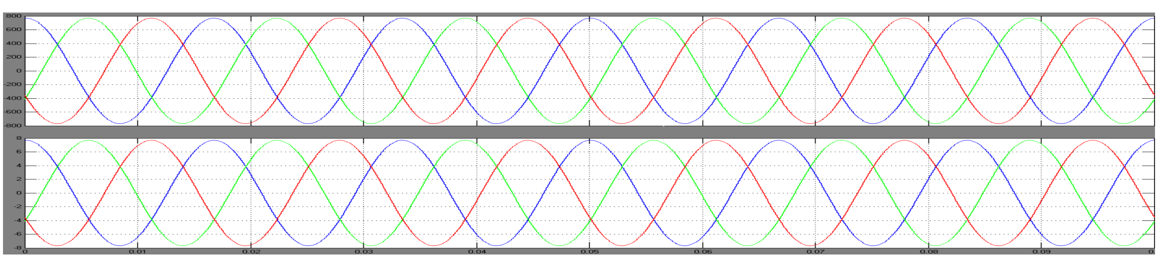

Fig.4. Hybrid power plant output in grid.

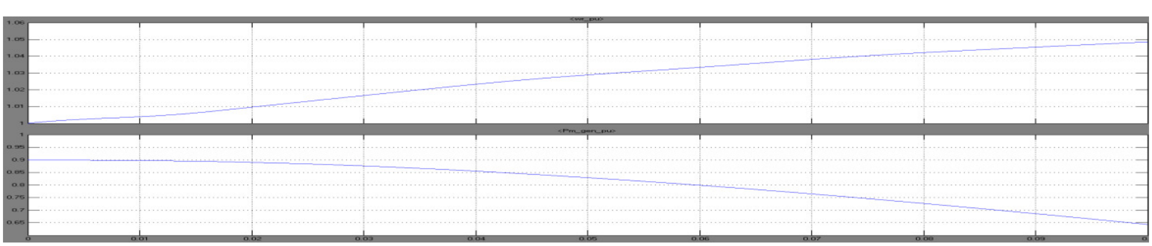

Fig.5. Wind turbine output

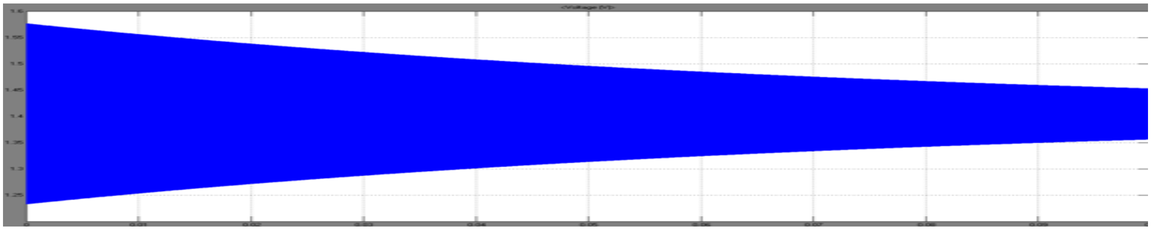

Fig.6. Hybrid power plant output in battery.

6. CONCLUSION

The convergence method for the wind turbine is simulated using Nozzle simulator. From the simulation it is known that the exit pressure is increased and it is greater than the inlet pressure. The hybrid power system is simulated using MATLAB version 7.10. The simulation results show that the hybrid power system is capable of generating 440V,50Hz,5A and 2200W. Hence, from the simulation results, it is known that the hybrid power system is suitable for residential load. With the aid of simulation results, the hardware can be implemented.

REFERENCES

[1] C. Liu, B. Wu and R. Cheung, (2004), ‘ Advanced Algorithm For MPPT Control Of Photovoltaic Systems’,Canadian Solar Buildings Conference Montreal.

[2] Robert C.N. Pilawa-Podgurski, Nathan A. Pallo, Walker R. Chan, David J. Perreault, Ivan L. Celanovic,(2010), ‘Low-Power Maximum Power Point Tracker with Digital Control for Thermo photovoltaic Generators’, 978-1-4244-4783-1/10.

[3] Nicola Femia, Giovanni Petrone, Giovanni Spagnuolo,(2005), ‘Optimization of Perturb and Observe Maximum Power Point Tracking Method’, IEEE Transactions On Power Electronics, Vol.No.20, pp.No.4.

[4] Quanyuan Jiang and Haijiao Wang,(2013),’Two-Time-Scale Coordination Control for a Battery Energy Storage System to Mitigate Wind Power Fluctuations’, IEEE transactions on energy conversion,Vol.No.28,pp.No.1

[5] S. Georges, F. H. Slaoui “Case Study of Hybrid Wind-Solar Power Systems for Street Lighting “- 21st International Conferences on Systems Engineering-2011.

[6] Tao CHEN1 Jin Ming YANG1” Research on Energy Management for Wind/PV Hybrid Power System” School of Electric Power, South China University of Technology, Guangdong key laboratory of Clean energy technology, 510640 Guangzhou China - 2009 ; 3rd International Conference on Power Electronics Systems and Applications.

[7] “How to build a WIND TURBINE “Axial flux alternator windmill plans 8 foot and 4 foot diameter machines ©Hugh Piggott -May 2003.

[8] S. Ramya, T. Manokaran “Analysis and Design of Multi Input Dc–Dc Converter for Integrated Wind PV Cell Renewable Energy Generated System”- International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-1, Issue-5, November 2012.

[9] S. Ramkumar, V. Sumathi M.E “Implementation of Reduced Switch Modular Inverter for Hybrid of Solar Photovoltaic and Wind Energy System” - International Journal of Scientific and Research Publications, Volume 3, Issue 2, February 2013 1 ISSN 2250-3153.