HYBRID ALGORITHM FOR MPPT OF WIND ENERGY CONVERSION SYSTEMS

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The maximum power can be brought by the conversion system of wind energy when the impedance of load is the same with the impedance of source under a specified speed level of wind. The Maximum Power Point Tracking (MPPT) would become more difficult as the wind speed and load are changing vigorously. However, in the present work, a Wind-Generator (WG) Maximum Power Point Tracking (MPPT) system is available having a high capability buck-type dc/dc converter and a controlling unit operating the MPPT task. The benefits of the MPPT process include accessibility of Wind Generator in a best possible way to bring out quality power. WG functions at a different speed levels as the amount of the wind speed is essential. It contains another trait of possessing higher dependability lower difficulty and less automatic pressure of the WG.

There are two common methods for the Maximum Power Point Tracking (MPPT).One is perturbation and observation (PAO) Method and second one is Incremental Conductance Method. In PAO method, the positive change in power is observed irrespective of the correct flow direction with functional cycling of the converter in the power generating unit of the conversion system of wind energy. The PAO method is slow in directing the highest power functional point and may follow the (MPOP) Maximum Power Operating Point wrongly on the basis of speed altering distinctive or load conditions. The negative Present Conductance and Incremental Conductance values are to be distinguished. The functional cycling can be increased or may be decreased only if the Incremental Conductance is superior to the available value of the conductance. With this method there is no possibility to sense the difference in the environmental conditions, because at steady state its tendency to vary the system condition is very poor. To get rid of these drawbacks of above methods a hybrid algorithm is employed for directing the maximum power. In this method, on power variation, the duty cycle is accustomed in relation to these changes in rectifier output voltage.

Keywords: MPPT, MPOP, WECS, VSCF, CSCF,

I.INTRODUCTION

Renovate and clean energy is drawing more attention throughout the world just to fulfill the power demand as there are some drawbacks regarding conventional style of energy producing resources and lot of anxiety about atmosphere. Above all modernized energy sources, it is considered that wind energy and solar based energy are dependable basis of energy. However, when contrast with fossil fuel and nuclear power production in present days, Wind power is getting a lot of priority as it provides safe ecological conditions, and secure renovate source of power and cost- effective.

From a few hundred kilowatts to a number of megawatts a Wind Energy Conversion System (WECS) will differ in its size. The selection of the generator and converter system is generally decided by the size of WECS. However up to 2MW, Asynchronous generators can be normally employed in systems, further than that magnet synchronous machine are also given priority. A grid The WECS connected grid can produce energy at a steady electrical level of frequency which is decided by the grid. Generally in medium power level of grid related systems, Squirrel cage rotor induction generators can be employed The induction generator works at near synchronous level of speed and pulls out the magnetic power from the mains when it is linked with the stable frequency level of network, which brings the results of Constant Speed Constant Frequency (CSCF) operation of generator. However, capturing of power due to variations in the speed level of wind can be significantly enhanced if there is a possibility in various levels of shaft speed.

Grid-related wind rotor machine is the only solution in VSCF such as Variable Speed Constant Frequency. The stator is straightly linked to three phase grid in double fed induction generator, and the rotor is provided by two back-to-back converters of PWM as revealed in Figure1. Such arrangement provides flexible functions both at speed levels of sub synchronous and super synchronous.

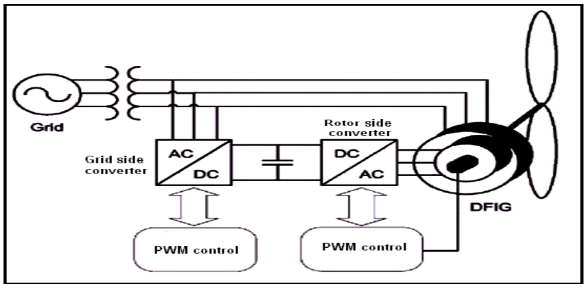


Figure 1: Conversion System of Wind Energy

II. HIGHEST POWER POINT TRACKING MODEL.

A. Highest Power Point Tracking

When the load resistance is being linked the power output varies with it. The resistance level of the load changes constantly along with the speed level of wind which is also not stable. So the system cannot exist by itself in the area of highest operating region of power, which is more desired. In order to functioning of the system the in the (MPOP) Maximum Power Operating Point, the difficulty may be increased. In the MPOP the technique through that a system is organized or prepared is regarded as MPPT i ,e. Maximum Power Point Tracking

Fundamentally, a Maximum Power Point Tracker can be said as a converter which is linked in between the load and the WECS source. The functioning cycle which can constantly be altered and worked out at a value as the highest power is tracked from the source. By the theorem related to transferring of maximum power, a source will set free its highest power when the resistance level of source become equivalent with the load impedance. The function of the converter is managed in a way that the efficient level of resistance can be seen by the source of Wind Energy Conversion System has to be the same with the inner level of resistance. Therefore highest power is distributed. Just to extract the highest wind power, an examination has been given to recognize the feasible dislocation of the functional point in the two functioning sector of wind turbine. **Figure 4**. represents the peculiar curve of wind energy variation as per the operating voltage and it shows two operating zones: the first one is located to the right hand side of the MPP where $dp/d\Omega < 0$ and the second to the left hand side of the MPP where $dp/d\Omega > 0$. For searching the highest wind power functioning point and tracking this point, so as to reduce the error between the operating power and the maximum power, in case of any change related to wind speed, the regulating of the buck converter troubles occasionally by the functioning point of the wind turbine. By obtaining the voltage output and PMSG current, the control uses this information just for increasing or reducing the duty cycle of the buck-boost converter for changing the functional point of the wind turbine. After the perturbation, there is a dislocation of the functioning point from (k-1) to (k). Four cases of perturbation from operating point are distinguished.

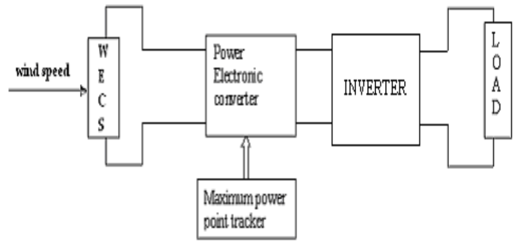


Figure: 2. Block Diagram for Maximum Power Point Tracking

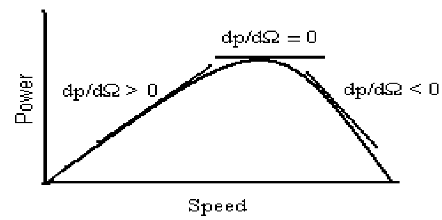


Figure: 3. Probable Displacement of the Operating Point

If $P(k)>P(k-1)$ and $\Omega(k)>\Omega(k-1)$,the power increases after perturbation. This indicates that the MPOP reach is oriented to the good direction. So, the search of the MPOP continues in the same direction and reaches the operating point (k+1) by increasing the duty cycle by ΔD. If $P(k)<P(k-1)$ and $\Omega(k) < \Omega(k-1)$, the power decreases after perturbation. This indicates that the MPOP search is oriented to the bad direction. The MPOP search direction must be changed and the duty cycle is increased by two ΔD to reach the operating point (k+1). If $P(k)>P(k-1)$ and $\Omega(k)< \Omega(k-1)$, the power increases after perturbation. It shows the MPOP search is oriented to the good direction. Then, the MPOP search direction must be maintained and the duty cycling is decreased by one ΔD to reach the (k+1) Functional Point If $P(k)<P(k-1)$ and $\Omega(k)> \Omega(k-1)$, the power is decreased. It shows the MPOP search is oriented to bad direction. The MPOP search direction should be altered and the functioning cycle is to be increased by two ΔD to reach the functioning point (k+1).Therefore search rules of the various cases of operation are summarized in the table1.

Table1. Operation Modes of Buck Converter

ΔD_i	$\Delta D > 0$		$\Delta D < 0$	
ΔP	> 0	< 0	> 0	< 0
$\Delta P/\Delta D$	> 0	< 0	< 0	> 0
region	I	II	II	I
$\Delta\Omega$	-	–	+	+
$\Delta\alpha_{i+1}$	+	-	-	+

B. Condition for Maximum Power Operating Point: The wind energy conversion system in MPPT process depends on straightly with the adjustment of the converter duty cycle dc/dc as per the outcomes of the difference of following WG-output-power measurements. Although the speed level of the wind differs extremely with time, the energy employed by the WG also changes comparatively gradually, since the slow reaction of the dynamic interconnected wind-turbine/generator system. Thus, the difficulty of exploiting the output of WG power utilizing the duty cycle converter as a controller various changes are to be efficiently resolved with the Method of Steepest Ascent as per the control law shown below.

$$D_k = D_{k-1} + C_1 . \frac{\Delta P_{k-1}}{\Delta D_{k-1}} \quad (1)$$

Where D_k and D_{k-1} considered as the values of duty-cycle at k and k - 1 iterations correspondingly ($0 < D_k < 1$); $\Delta P_{k-1}/\Delta D_{k-1}$ is the WG power gradient at step k - 1; and C_1 is the step change.

In order to ensure that this method results in meeting point to the Wind Generator extreme power point at any wind-speed level, it is enough to show that the duty P(D), connecting the WG power P and the converter of dc/dc duty cycle D, consists of one highest point concurring with the WG MPPs. This is clear that at the points of extreme power production

$$\frac{dP}{d\Omega} = 0 \quad (2)$$

Where Ω is the WG rotor speed. Applying the chain based rule, the above said formula will be written as:

$$\frac{dP}{d\Omega} = \frac{dP}{dD} . \frac{dD}{dV_{WG}} . \frac{dV_{WG}}{d\Omega_e} \frac{d\Omega_e}{d\Omega} = 0 \quad (3)$$

Where V_{WG} is the output level of rectifier voltage and Ω_e signifies generator-phase-level of voltage at angular speed.

The input level of voltage is connected to the output level of (battery) voltage only if its buck-type dc/dc converter and the duty cycle are as follows:

$$D = \frac{V_0}{V_{WG}} \quad (4)$$

$$\frac{dD}{dV_{WG}} = -\frac{1}{V_{WG}^2} V_O \neq 0 \quad (5)$$

Where V_0 stands for voltage level of battery. The speed of wind-turbine rotor is linked to the speed of generator as follows: $\Omega_e = p.\Omega$

(6) $\frac{d\Omega_e}{d\Omega} = p > 0$

(7)

Where **p** represents the number of generator pole pairs. The output voltage of rectifier V_{WG} is relative to the generator phase level of voltage V_{ph}. As seen in Fig. 4, it is determined that

$$\frac{dV_{ph}}{d\Omega_e} > 0 \quad (8)$$

$$\frac{dV_{WG}}{d\Omega_e} > 0 \quad (9)$$

Considering above, it holds that

$$\frac{dP}{d\Omega} = 0 \Leftrightarrow \frac{dP}{dD} = 0 \quad (10)$$

Thus, the functioning P (D) consists of one highest point, concurring with the WG MPOP, and by adjusting the dc converter duty-cycle as per the controlling law guarantees a meeting point to the WG MPOP based on speed level of wind condition. The power maximization process is indicated in Figure 4. Because the alterations of duty-cycle follow up the tracking of dP/dD, the value of duty-cycle can be enhanced at a great speed level of side of the WG quality bringing the outcomes in reduction of WG-rotor-speed levels and power will be increased, till the MPOP is spread.

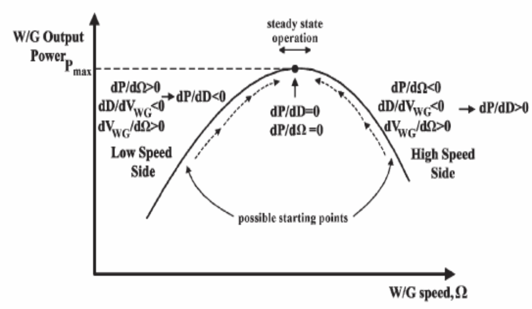


Figure 4.MPP tracking process.

Similarly when the beginning point is in the low-speed side, following the track of dP/dD results in duty-cycle reduction and the subsequent convergence at the MPOP, as the speed level of WG rotor is going to be gradually increased.

III.PERTURBATION AND OBSERVATION METHOD

In this process the duty cycle of the converter is continuously varied for each and every switching period. The direction of variation of duty cycling can be decided in the manner as mentioned below. The productivity power of WECS is continuously monitored and compared with the previous value of measured power. If the present power is greater than the earlier one, the variation of duty cycle is continued in the same direction otherwise in the reverse direction.

The troublesome and monitoring algorithm is revealed graphically in the Figure 5. First, voltage regarding its values and current are measured. The power value is found as multiplication of current and voltage. This present power is compared with the previous one. If both are equal, then no change in duty cycle is needed. i.e., the system is already operating in extreme power functional region. Next, if present power is more than the earlier power, then it is the indication that the present variation of duty cycle approaches to extreme power functioning region. So the duty cycle for the next iteration is done as same as the previous one. i.e., the step value given to the following duty cycle is the same step value with the same direction as the present one.

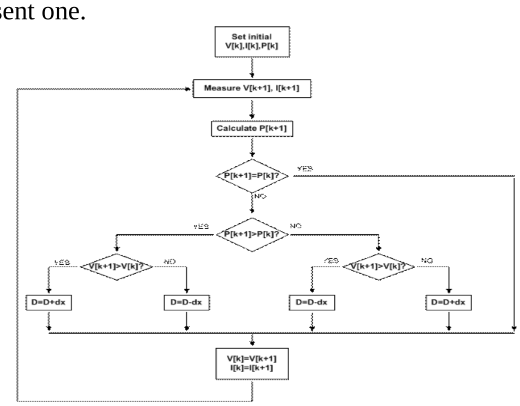


Figure 5. Method of Perturbation and Observation

If the existing power value is less than the previous power, then it is an indication that the variation of duty cycle leads to an operating point, which is going another way from the extreme power point. So the duty cycle can be changed in the opposite direction to the previous one. i.e., the step value given to the following duty cycle is the same step value but with the negative direction to the previous. To do this, simply (-1) can be multiplied to the step value.

Thus the algorithm is very simple in mathematical calculation but with proper logical decisions. Hence it is considered as one of the easiest algorithm available for the highest power tracking point.

Merits of this method are, it is easy to put into action practically because the algorithm involves less mathematical calculation and involves more logical decisions. Also it operates in the area of extreme power point region. Drawbacks of this method are, this algorithm is unsuitable for speedily varying atmosphere conditions. It is slow in the method of directing extreme power point and at steady state, oscillations are unavoidable.

IV. INCREMENTAL CONDUCTANCE METHOD

In this process the conductance value is calculated and compared with the previous value and is taken as incremental conductance. The duty cycle cannot be changed if its value is equivalent to the value of present conductance. If the value is greater than the negation of existing conductance, then the duty cycle can be improved, otherwise reduced. The algorithm connected to Incremental conductance is indicated graphically in the Figure 7. At first of all the voltage levels and current values are measured. The variation in conductance gives the consideration with which we ought to proceed further. However, if any alteration regarding in the value of voltage become equivalent to zero, then no change in duty cycle is required.

The basic strategy of Incremental Conductance MPPT control algorithm is equation (2). These formulas will be written in relation to the current and voltage.

$$\frac{dP}{dV_{dc}} = \frac{d(V_{dc}I_{dc})}{dV_{dc}} = I_{dc} + V_{dc}\frac{dI_{dc}}{dV_{dc}} \qquad (11)$$

Above mentioned equation will be written in the procedure of the conductance ($G = I_{dc}/V_{dc}$) and incremental conductance ($dG = dI_{dc}/dV_{dc}$). Under the constant voltage source region, the *dP/dV* value is negative. However as per the direction of variation of voltage the conductance value will be considered either positive or negative. So the determination of MPOP can be failed for this reason. In this case, the *G* + *d*G Incremental Conductance method is

$$G + dG = \frac{I_{dc1}}{V_{dc1}} + \frac{I_{dc1} - I_{dc2}}{V_{dc1} - V_{dc2}} \qquad (12)$$

There are two probabilities if the change in valuation voltage is not equal to zero, then. If the valuation of change in voltage is more than zero, then the valuation of changement in current is considered. If the change value in power is equivalent to zero, then no alteration in duty cycle is required. If the changed value in power is more than zero, then it is an indication that the system is operating in constant voltage source region. Now the duty cycle is increased to increment of the voltage. Otherwise it is an indication that the system is operating in constant voltage source region. Now the duty cycle is decreased to decrease the voltage. Next if the increased value of conductance is more than that of present value of conductance, then it is an indication that the system is operating in constant current source region. So we require to improve the voltage to reach the maximum power-operating region. Otherwise it is an indication that the system is in constant voltage region. Thus we ought to decrease the voltage to reach the maximum power-operating region. The merits of this method are, it is very appropriate for altering the atmosphere conditions quickly and it is having response characteristics in which the oscillatory part at the stable condition when there is no modification in environmental conditions is absent. Drawbacks of this method are more difficult to implement because of high-end mathematics is involved and it is very likely to wrong decision of extreme power point.

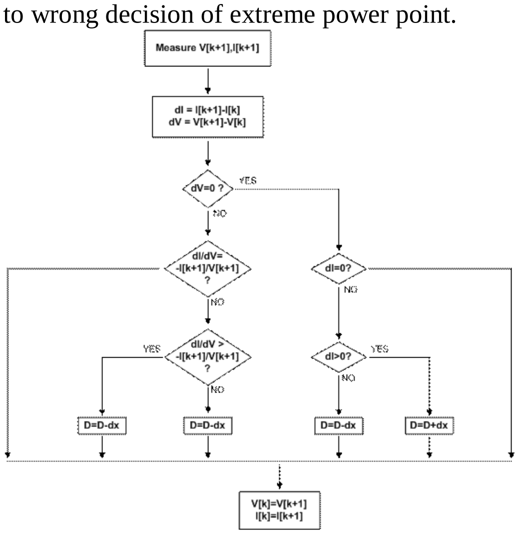


Figure 6. The Method of Incremental Conductance

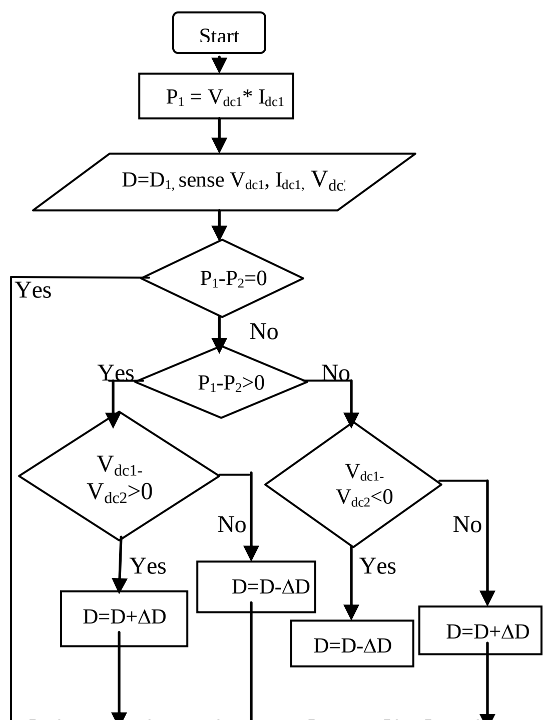
Where D is duty cycle for the converter, V_{dc}, V_{dc1}, V_{dc2} are voltages in relation to the particular duty cycles at the consecutive changes, I_{dc}, I_{dc1}, I_{dc2} are currents in relation to to the particular duty cycles at the consecutive changes and P_1, P_2 are powers in relation to the particular duty cycles at the consecutive changes

The conventional algorithm method of Perturbation and Observation has the disadvantageous which is not appropriate for speed varying of atmosphere conditions.

V. HYBRID METHOD

This method discusses a new and simple control method for extreme power gaining at carious speed levels of wind turbine or magnet synchronous generator by employing a buck converter. The output level of voltage regarding permanent magnet generator is linked to arrange to dc-link with a rectifier at three-phase and the dc-dc converter. An extreme power-gaining algorithm calculates the Voltage command that connects to maximum power output level of turbine. The dc-dc converter uses this Voltage command to control the productivity energy of the permanent magnet generator, which the generator's voltage tracks the command voltage.

This algorithm is hybrid to suppress the drawbacks of the aforementioned conventional methods of extreme power tracking, and it also incorporates the benefits of both the methods. The Method of Perturbation and Observation is erroneous because it cannot consider whether the present operating value of duty cycle is correct or not. But it always concerns the next duty cycle to which it has to change. When the speed level of the wind changes slowly the algorithm varies the duty cycle with its own speed whether the present operating condition is at an extreme power functioning region or at least nearer to it. Hence the output value of the power wills permanently not more than that it could have yielded. Choose the initial reference rotor speed and measure the output value of the power of the generator. As per the value of measured DC output level of the voltage of generator, the reference voltage of wind generator may grow or decline by one step and measure the output power again. Calculate Sign (ΔP) and Sign (ΔV). Moreover the variation of duty cycle at a particular instant might cause an increase in power. In order to overcome these disadvantages here, the voltage generated at a particular wind speed is considered initially. The speed level of wind will affect voltage of which the output level of generator is produced. So, speed level of the wind is straightly relative to the output voltage level of generator in fixed magnet synchronous generators. The drawback of incremental inductance method is application of the algorithm which is very difficult since we require more accurate sensors, which will calculate the efficient impedance of the system at the particular instant. So, in this hybrid algorithm we are taking the value of voltage as the controlling degree and calculation of power disparities, which are to be allotted to the duty cycle of the converter. This process is always operating at MPPT algorithm and is very easy to apply.



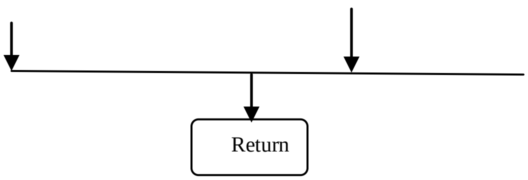


Figure 7.Flow chart for the Hybrid Method

VI. SIMULATION RESULTS

The simulation of the system with Hybrid Method is available in simulink with the control circuit as indicated in the above figure. First of all the power is measured and it is provided a transport delay with which we are able to get the previous output value of power. Both are compared. Both voltage level and outputs of power given to MATLAB embedded block. In which initially the power is compared with previous power and if the difference between them exists then the level of voltage in consecutive intervals is compared. If the level of voltage is matched with the previous value the outputs block either the positive or negative based on the power variation. The compared output has to be given to the comparator. Output level of the Comparator is added to the earlier output level of the comparator by means of zero order hold circuit. The output will be matched with the saw tooth wave form of switching frequency so as to get PWM of duty cycle. The difference is compared with 0. If the outcomes are is more than zero then the output is 1, which indicates the switching on of the switch, MOSFET otherwise gives a 0, which indicates the switching off of the MOSFET.

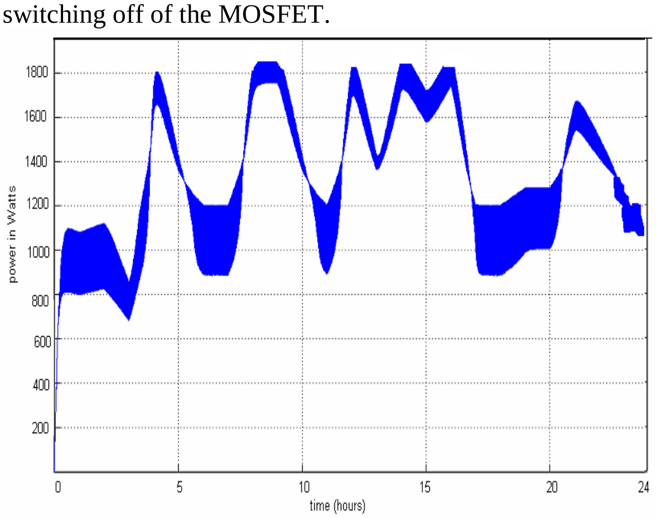


Figure 8. Power output without MPPT.

Without MPPT unit highest power is 1835W, Average power is 1.21kW and energy is to be taken from the WECS on complete day is 29.11kWh

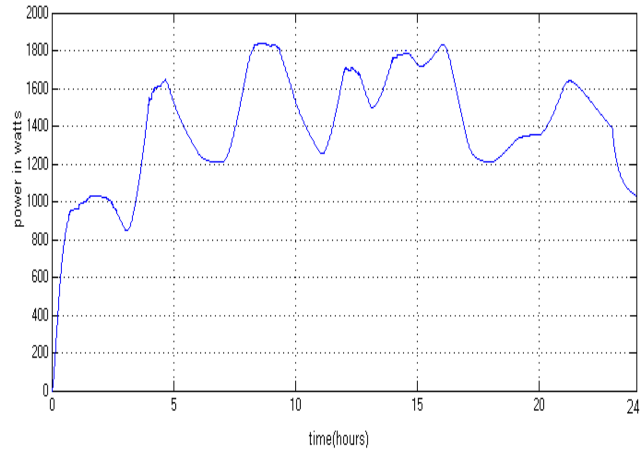


Figure 9.PAO method output power (constant load)

When PAO method is employed for the MPPT for constant load, Extreme power is 1810 W, Average power is 1.6kw Wind energy is drown from the WECS on complete day is 32.71kWh

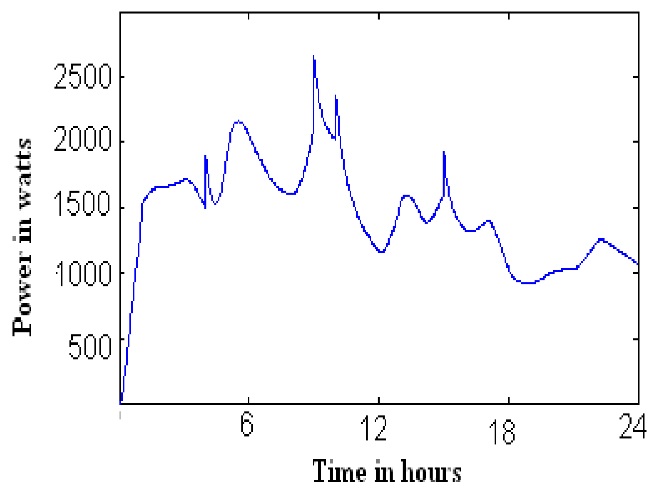


Figure 10.PAO method output power (Variable load)

When PAO method can be employed for the MPPT for variable load, Maximum power is 2540 W, Average power is .992kWand energy drown from the WECS on complete day is 23.82kWh

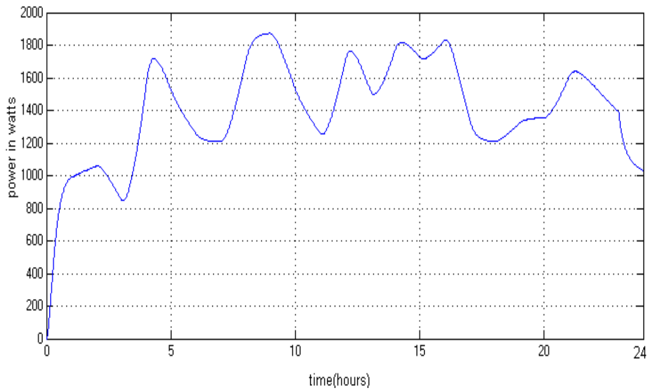


Figure 11.Power output using IC method (Constant load)

When IC method is used for the MPPT for constant load, Maximum power is 1835 W; Average power is 1.38kW and energy gained from the WECS on complete day is 33.2kWh

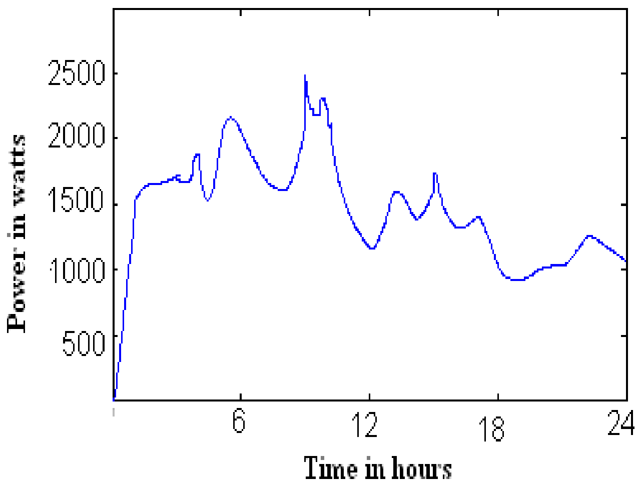


Figure 12.Power output using IC method (Variable load)

When Method of Incremental conductance can be employed for the MPPT for variable load, Maximum power is 2546 W, Average power is 1.006kW and energy taken from the WECS on complete day is 24.15kWh

When we use Hybrid Method for the MPPT for constant load, Maximum power is 1835 W, Average power is 1.6kW and energy can be taken from the WECS on complete day is 33.91kWh

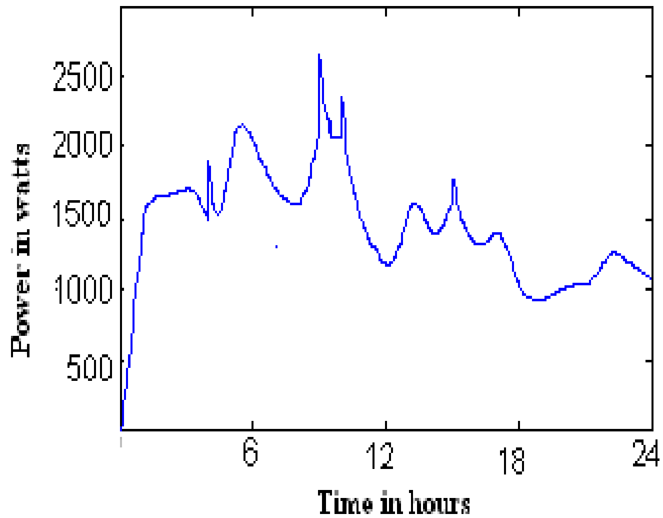


Figure 13.Power output using Hybrid Method (Variable Load)

When Hybrid method is employed for the MPPT for variable load Maximum power is 2548 W, Average power is 1.025kW and energy attained from the WECS on complete day is 24.62kWh.

CONCLUSION:

In this piece of writing, WG highest power tracking controls are discussed including of a great efficient buck-type dc/dc converter and its controlling unit. However the quality of WG optimal power or the speed level of the wind is necessary as WG functions at flexible speed rate by suffering lower stress on the shafts and gears. The MPPT methods cannot take the support on the WG wind and speed level ratings of rotor or power rating of the dc/dc converter. For getting highest power tracking point of the conversion systems of the wind energy a hybrid method can be employed. In PAO method, the positive change in power is observed irrespective of the correct flow direction of the converter in the power-conditioning unit of the conversion system of wind energy. The PAO method is slow in reaching the maximum power and may bring MPOP mistakenly based on fast alteration of atmosphere or load circumstances. The average output of power can be increased by using the conventional methods is 14%.Therefore this abstract presents a hybrid method of algorithm to attain the highest power from the transformation system of wind energy by eliminating the drawbacks. From the above said results this is obvious that utilizing the hybrid method, the power output is increased by 3.54% in relation to constant load condition when matched to the conventional PAO method. For flexible load condition it is increased by 4.2%. When compare to the Method of Incremental Conductance the power output is improved. In the matter of constant load condition it is 2.11%, and under flexible load condition it is 1.98%.

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