CONTRIBUTIONS TO THE DEVELOPMENT OF ACID BATTERY CHARGING REGULATOR FROM SMALL SIZE WIND TURBINE WITH MPPT FUNCTION

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Abstract. *Wind energy at global level is developing rapidly especially in the countries where energy resources are limited or even missing and which energetically depend on another country and are interested to fully capitalize this resource. Thus, Republic of Moldova aims at developing renewable energy resources to cover 20% of country's energy needs up to 2020. This study provides a review of MPPT controllers used for extracting maximum power from the wind energy conversion system using permanent magnet generators and storage in acid battery.*

Keywords: *renewable energy resources, MPPT controllers,wind energy conversion system.*

I. Introdction

Power produced by a wind turbine is given by [1]

$$P_m = 0.5\pi C_p(\lambda,\beta)R^2 v_\omega^3 \qquad (1)$$

where R is the turbine radius, v_ω is the wind speed, ρ is the air density, C_p is the power coefficient, λ is the tip speed ratio and β is the pitch angle bat if is not used β = 0.The tip speed ratio is given by:

$$\lambda = \frac{\omega_r R}{v_\omega} \qquad (2)$$

where ω_r is the turbine angular speed.

Thetarget optimum power from a wind turbine can be written as

$$P_{max} = K_{opt} \quad \omega_{opt} \qquad (3)$$

$$K_{opt} = \frac{0.5\pi\rho C_{p\,max} R^5}{\lambda_{opt}^3} \qquad (4)$$

$$\omega_{opt} = \frac{\lambda_{opt} v_\omega}{R} \qquad (5)$$

Fig.1 shows turbine mechanical power as a function of rotor speed at various wind speeds. The power for a certain wind speed is maximum at a certain value of rotor speed called optimum rotor speed ω_{opt} . This is the speed which corresponds to optimum tip speed ratio λ_{opt}. In order to have maximum possible power, the turbine should always operateat λ_{opt}. This is possible by controlling the rotational speed of the turbine so that it always rotates at the optimum speed of rotation.

The maximum power extraction algorithms researched so far can be classified into three main control methods, namely tip speed ratio (TSR) control, power signal feedback (PSF) control and hill-climb search (HCS) control [2].

TIP method requires both the wind speed and the turbine speed to be measured or estimated in addition torequiring the knowledge of optimum TSR of the turbine in order for the system to be able extract maximum possible power.

In PSF control, it is required to have the knowledge of the wind turbine's maximum power curve, and track this curve through its control mechanisms.

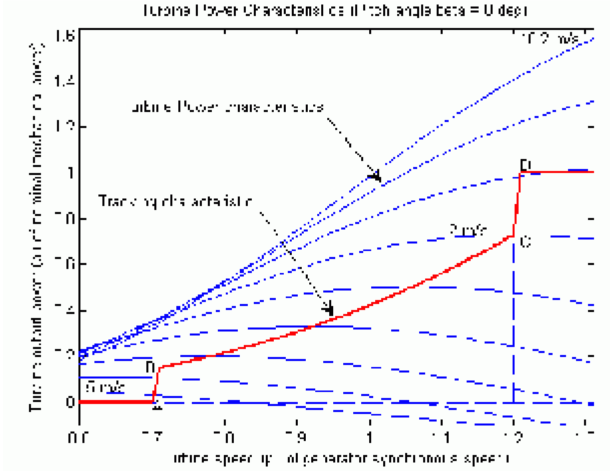

Figure 1 Turbine Characteristics and Tracking Characteristic

The HCS control algorithm continuously searches for the peak power of the wind turbine. It can overcome some of the common problems normally associated with the other two methods. The tracking algorithm, depending upon the location of the operating point and relation between the changes in power and speed, computes the desired optimum signal in order to drive the system to the point of maximum power.

II. MPP tracking algorithm

The MPPT controller computes the optimum speed for maximum power point using information on magnitude and direction of change in power output due to the change in command speed. The flow chart in Fig. 19 shows how the proposed MPPT controller is executed. The operation of the controller is explained below.

The active power $P_0(k)$ is measured, and if the difference between its values at present and previous sampling instants $\Delta P_0(k)$ is within a specified lower and upper power limits P_L and P_M respectively then, no action is taken; however, if the difference is outside this range, then certain necessary control action is taken. The control action taken depends upon the magnitude and direction of change in the active power due to the change in command speed.

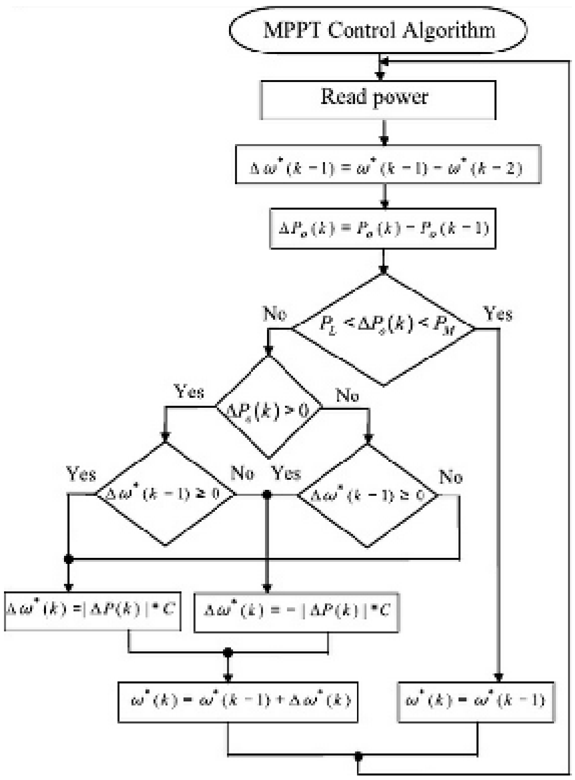

Figure 2 Flow chart of MPPT controller.

III. DC/DC converter

Due to temperature and wind velocity variations, the PV module generated power feeding the load is going through a regulated converter to hold its maximum.

Hence, the efficiency of the photovoltaic system is performed. In this section the design the used boost converter is detailed Fig.3.

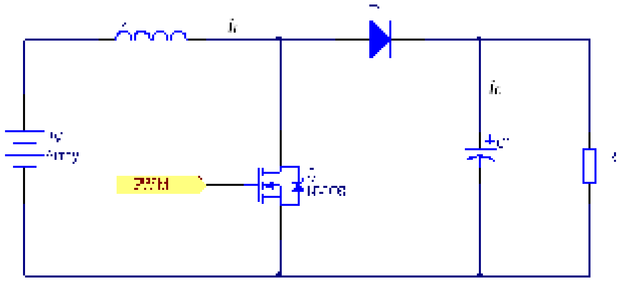

Figure 3. Circuit diagram of proposed Boost converter

The output voltage is always larger than the input voltage. Even if the transistor is not switched on and off the output capacitor charges via the diode until Vout = Vin. When the transistor is switched the output voltage will increase to higher levels than the input voltage.

A distinction is drawn between discontinuous and continuous mode depending on whether the inductor current IL reduces to zero during the off-time or not. With the help of Faraday's Law the continuous mode and steady state conditions can be established.

$$\Delta I_L = \left(\frac{1}{L}\right) V_{in} \cdot t_1 = \left(\frac{1}{L}\right) [(V]_{out} - V_{in}) (T - t_1)$$

From this it follows that:

$$V_{out} = V_{in} \cdot \frac{T}{T - t_1}$$

The ratio between on-time and the period t1/T is Duty Cycle.

For continuous mode the output voltage is dependent on the duty cycle and the input voltage, it is independent of the load

IV. Battery Charge

When lead-acid batteries are charged from a variable source, such as PV panels, three charging stages are normally provided by the charge controller:

- Bulk Charge – Current is sent to the batteries of the maximum safe rate they will accept until their voltage rises to about 80 to 90% of their fully charged value. The bulk charging voltage is typically about 14.8V but may be as high as 15.5V for a 12V system, this may vary so that the maximum possible current in maintained. Gel batteries often have lower recommended voltages in the region of 13.8 to 14.1V.
- Absorption Charge – The voltage remains constant, typically about 14.2V for a 12V system (depending on temperature) and the current tapers off as the battery reaches 100% charge.
- Trickle or Float Charge – For a 12V battery bank a voltage of about of about 12.8 to 13.2V is maintained across the batteries to keep them in good condition. Some charge controllers have pulse width modulation

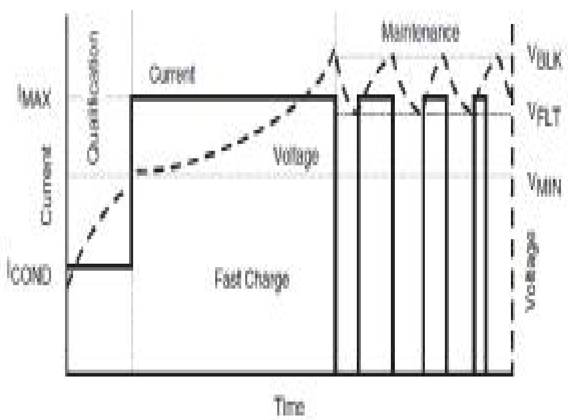

Figure 4 PbSO4 battery-charging profile

(PWM) which can be used to provide the last bit of charge and maintain a trickle charge. Rather than letting the current taper off a larger current is pulsed into the battery, the length of the pulses reduces as less charge is required.

A key rule is that the cell gassing voltage should not be exceeded except during the finishing step of charge. The gassing voltage is the voltage at which the predominant reaction consuming charge current is electrolysis of water in the electrolyte with evolution of oxygen at the positive plates and hydrogen at the negative plates.

Gassing voltage decreases with increasing electrolyte temperature. See Table 1 In PV systems the electrolyte temperature is usually close to (neglecting thermal time lags) room temperature due to relatively low charge and discharge rates represented by many days of autonomy.

Table 1 Temperature Compensated Charge Voltage

Ambient Temperature	Charge Voltage Per Cell
-20°C	2.970V
-10°C	2.650V
0°C	2.540V
+10°C	2.470V
+20°C	2.415V
+25°C	2.390V
+30°C	2.365V
+40°C	2.330V
+50°C	2.300V

In a small autonomous power system (i.e. one without a mains grid connection) the batteries will be continually charged and discharged. The life span of a deep-cycle battery is normally quoted in the number of cycles that it can be expected to perform, a cycle being a discharge followed by re-charging. Deep cycle batteries should not be discharged by more than 60% of their capacity and the less one regularly discharges a battery the longer it will last. A battery in daily use and discharged by no more than 40% of its capacity should last for more than 3000 cycles and may not need replacing for up to 12 years. A battery that is frequently heavily discharged may last no longer than 2 years.

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