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Wind Energy fed Electric Vehicle Charger using MPPT at variable wind speed

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ABSTRACT
This paper presents an electric vehicle charger fed from wind energy using MPPT at different wind speeds. The charger can be used along with grid or can be used stand alone. P&O method is used for obtaining the MPPT in this paper. Wind turbine with PMSG is the source of power for charging and the battery with 50% SOC is considered for charging. A Boost DC-DC Converter is after rectifier for smooth charging. The available power for charging at different wind speeds is observed and the time for charging is for the proposed system is given in this paper. The proposed system is simulated using MATLAB/SIMULINK environment and the results are studied.
Keywords – EV Charging, P&O, MPPT, Variable Speed, Wind Energy.

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I. INTRODUCTION

Fossil fuel reserves are being depleted as a result of the increasing strain being placed on rapidly dwindling conventional sources. Wind Power is an affordable and sustainable alternative to traditional power sources [1-2]. Since wind energy is available continuously, it is preferred in applications where continuous power is required. Due to the erratic nature of wind energy, the system requires a power electronic interface to produce the required output.

For EV charging application a small wind energy plant is suitable. There are several rectification techniques used in these small-scale wind energy systems to connect the generator of the wind turbine to the battery bank. A DC to DC converter, an active synchronous receiver or a direct connection to the battery bank are all options for connecting wind turbine generators [3].

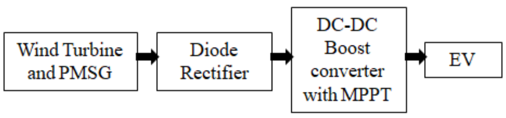

Fig. 1 : Block Diagram of Proposed System

A wind energy system's output power varies based on the wind speed. The non-linear nature of the wind turbine makes it challenging to maintain its maximum power production under all wind speed conditions. Numerous studies have been conducted on the MPPT (Maximum Power Point Tracking) control procedures for monitoring the wind turbines' peak power point [4]. For maximum power tracking the generator is connected to a diode rectifier and DC-DC Converter as shown in Fig. 1 which in turn reduces the losses of the system. The Parameters of the system is given in Table 1.

Table 1 : Parameters of the System

Parameter	Value
Base Speed of Turbine	16 m/s
Power of Turbine	8.5 KW
Initial SOC of Battery	50 %
Generator Inductance	835 μH
Base rotor speed	155 rad/sec
Mechanical Power Output of Turbine	8.5 KW

II. P&O METHOD

Wind Energy is unpredictable and changes with speed of wind. The voltage from PMSG changes for even small changes in Wind speed. Let us considered two speeds A and B. there will be two maximum points for these speeds. In P&O method the controller calculates the power by considering the rectifier current and voltages and gives the duty cycle pulses to the Boost converter [5].

P&O is implemented in Matlab using different blocks and the flowchart is shown in figure 2. The output from this simulated network is given to the MOSFET switch in Boost converter.

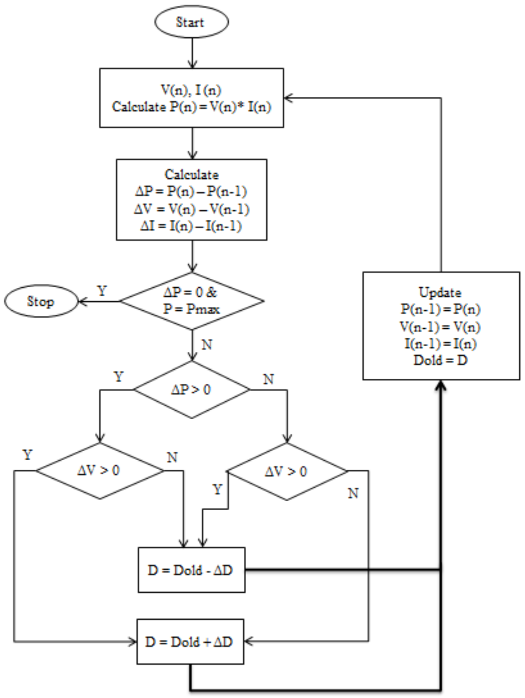

Fig. 2: P&O algorithm

III. PITCH ANGLE CONTROL

When high wind speeds are present the turbine rotates increase and this may result in breakage of PMSG-turbine link. To avoid this pitch angle is controlled to rotate the turbine at safe speeds [6]. As power coefficient of turbine is dependent on pitch angle changing pitch angle in turn changes the rotating speed of turbine. Pitch angle control is obtained by using a rate limiter and PI controller in the proposed system [7].

Although a pitch angle controller controls the turbine when it is stormy, there must be a mechanism to shut it down completely if the cut-off speed increases. To avoid a catastrophic breakdown of the entire system, the turbine must not operate at all in that scenario [8]. We used a cut-in speed of 3 m/s, which corresponds to the speed at which the turbine will start to generate useful electrical power. The running speed is calculated using a range of 3-18 m/s. When the wind speed reaches 18 m/s, the turbine must shut down. The turbine works only when the speed is in between this range.

IV. SIMULATION MODEL AND RESULTS

Wind Energy system with the pitch angle control and the converters are simulated using Matlab-Simulink environment and the model is shown in figure 3. PMSM is converted in reverse mode in the model to obtain the PMSG block and the control of the model is done in subsystem. EV Battery is represented by the battery shown in the figure. Negative current of the battery shows the charging mode of the battery and the power is consumed by the battery.

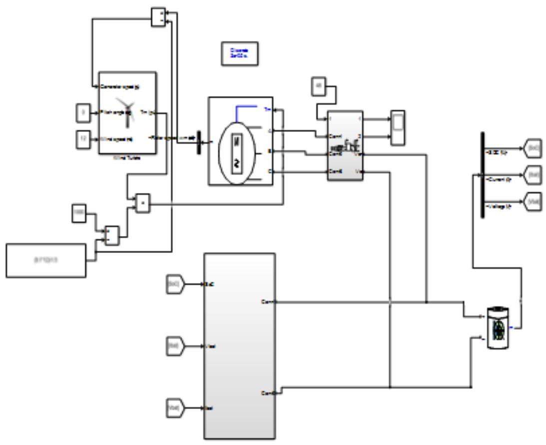

Fig. 3 : Simulink Model of the System

The simulated output of the system is extracted using the scope block and the resulting figures are shown below.

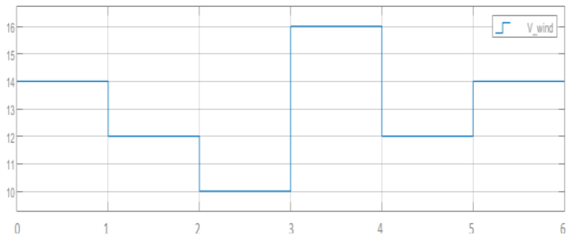

Fig. 4 variable wind Speed

Figure 4 shows the variable speeds given to the turbine. The speeds are varied form 10m/sec to 16 m/sec at different instants and these are generated using a stair-case generator. The Power output from the turbine is shown in the figure 5.

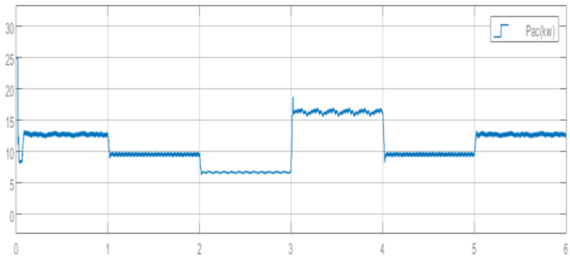

Fig. 5 AC Output power from wind turbine

The power output obtained form PMSG has some ripples that can be observed from figure 5. These can be smoothened using DC-DC converter and the ripple free output obtained from the converter is shown in figure 6. The DC power can be directly given to the battery for charging. The battery discharging is prevented by using a comparator such that the SOC do not drop under 50 percent which is the initial set value of the SOC.

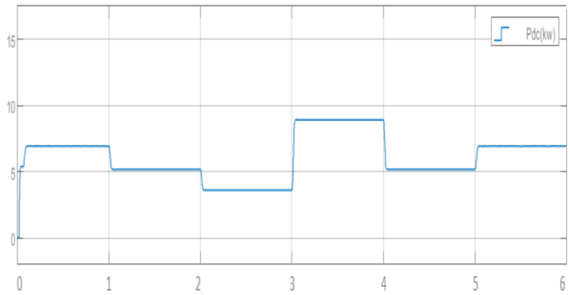

Fig. 6 Power output of DC-DC Converter

The SOC of battery is shown in figure 7. It can be observed the slope of the graph is changing at the instant when the speed of the turbine changes. The slope is greater when the speed of turbine is more and vice-versa.

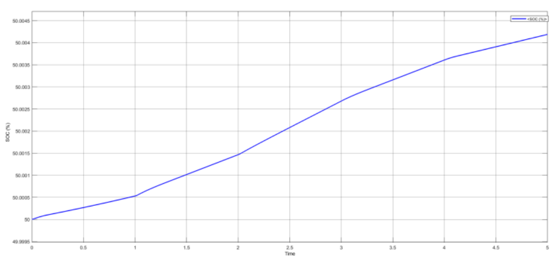

Fig. 7 SOC of Battery

V. CONCLUSION

To enhance power point tracking of wind turbines in nominal wind speed and safeguard wind turbines from damage for high wind speeds, the suggested method presents pitch angle control of wind turbine systems utilizing PI controller. According to the WECS simulation results, the angle between the wind direction and the turbine blade is zero, or =0, when pitch control is used.

In future a solar PV system can be added to this wind system [9] and the hybrid RE charging system can be obtained.

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