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Maximum Power DFIG Control Algorithm using Interleaved and ANFIS Converter

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ABSTRACT: This study provides a review of past and present MPPT controllers used for extracting maximum power from the WECS and doubly fed induction generator (DFIG). Furthermore, some comparisons of two different methods have been carried out to validate the results. The chapter starts with a brief background of wind energy conversion systems of not needing the wind speed and wind turbine characteristics of the traditional HCS method, but it also improves the stability and accuracy of MPPT by estimating the exact loss torque. Then, main MPPT control methods are presented, after which, MPPT controllers used for extracting maximum possible power in WECS are presented. The presented strategy not only has the advantages the comparison analysis results indicate that the system using ANFIS can obtain higher voltage than the system using FLC. In addition, the proposed system is also able to reduce overshoot and be able to increase the output power.

KEYWORDS: Interleaved, ANFIS controlled, DFIG, direct drive; maximum power point tracking (MPPT).

I. INTRODUCTION

This method relies on a large amount of online computation, and thus, it would be difficult to achieve MPPT for fast varying wind speeds. Although the varying tracking step could be used to improve computation speed, this disadvantage cannot be eliminated. Recently, a proposed method of employing the power versus rotor speed characteristic curve is frequently used due to its simplicity in hardware and software [1]. The optimal reference power curve is constructed according to experimental tests and programmed in a microcontroller memory.

One could either measure the rotor speed or obtain the power reference to regulate the power or measure the wind speed and obtain the rotor speed reference to regulate the rotor speed [2]. The former produces more accurate output power while the latter will have faster control response. Aside from an accurate reference power curve, analysis is necessary to verify the stability of the method in terms of varying wind speed and output power [3] [4]. Few publications just address the stability issue of such method, but more detailed quantitative analysis should be conducted. This paper studies the performance of wind turbine under reference power curve MPPT power control. In particular, it presents a small-signal analysis on generator speed dynamics induced by variable wind speed. Also, an experimental setup to emulate the wind turbine operation in torque control mode is presented. Both steady-state and dynamic responses are implemented to verify the proposed analysis and conclusions [5]. Section II will present how to obtain the optimal reference power curve and analyze the stability of this method by conducting the small-signal.

II. RELATED WORK

• OPTIMAL REFERENCE POWER CURVE AND STABILITY ANALYSIS

The first important issue in characteristic power curve MPPT is how to obtain the reference power curve. The second issue is whether the generator speed and output power will converge to the points along this reference power curve regardless of the wind variations, i.e., “whether this method is stable with respect to the varying wind speed.” Section II-A will first capture the optimal reference operation points from the experimental tests when power variation

rate is zero through varying the generator speed and the measurements of power. Then, a reference power curve () for the fitting curve of connection of all the optimal operation points is constructed, where a simple mechanical model is utilized to do small-signal analysis and a transfer function is proposed based on the optimal reference power curve(). The transfer function reveals the relationship between the variation of wind speed and that of generator speed and helps in predicting the stability and dynamic responses.

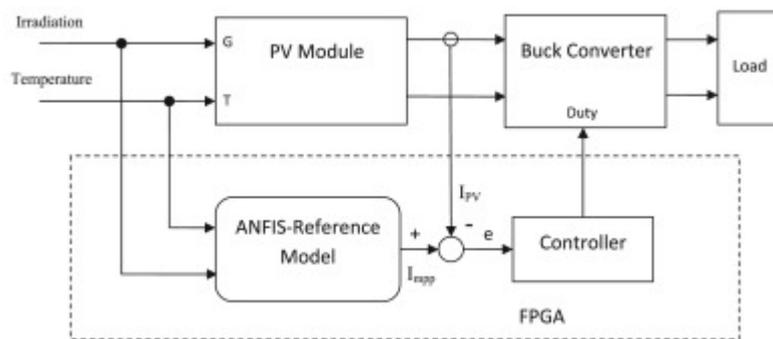


Figure: 1 ANFIS converter

• Optimal Reference Power Curve

The optimal reference power curve is obtained by finding the optimal power () and optimal generator speed for any given wind speed. For a given, the generator speed *is* swept, and the output power *P* is observed. The *and P* that would give the = 0 are selected as (and for the specific). By repeating the same procedure for different (), a fitting curve can be obtained by connecting all optimal operating points. The fitting curve is then used as reference power curve $P_{(\omega)}$. The procedure for preparing the $P_{(\omega)}$ curve is summarized, where *k* and *i* are the indices of operating point and wind speed. Since this is an offline procedure, the measurement and calculation will not affect the online system operation speed.

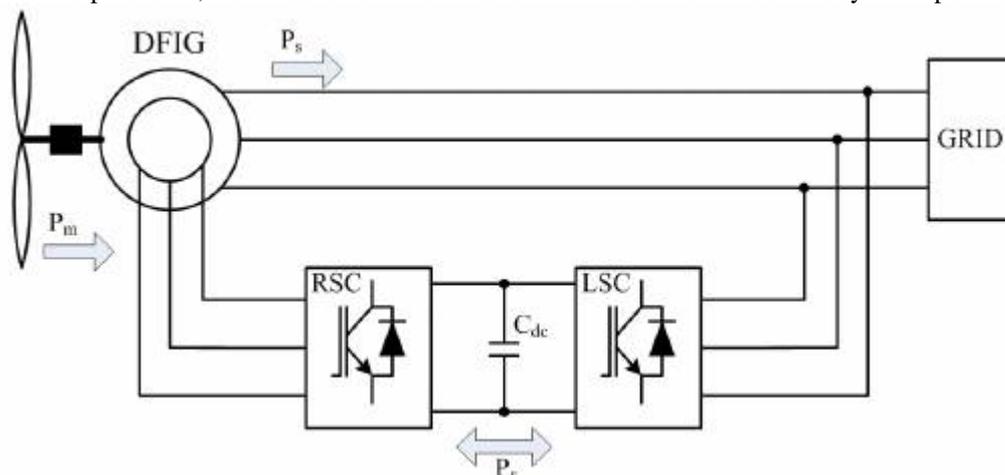


Fig. 2. Reference power generation DFIG control.

• Dynamic Stability Analysis:

Once the reference power curve $P_{(\omega)}$ is obtained, the stability of reference operating points is investigated. Whether the system (generator speed and output power) would converge to the *P* or not is a dynamic

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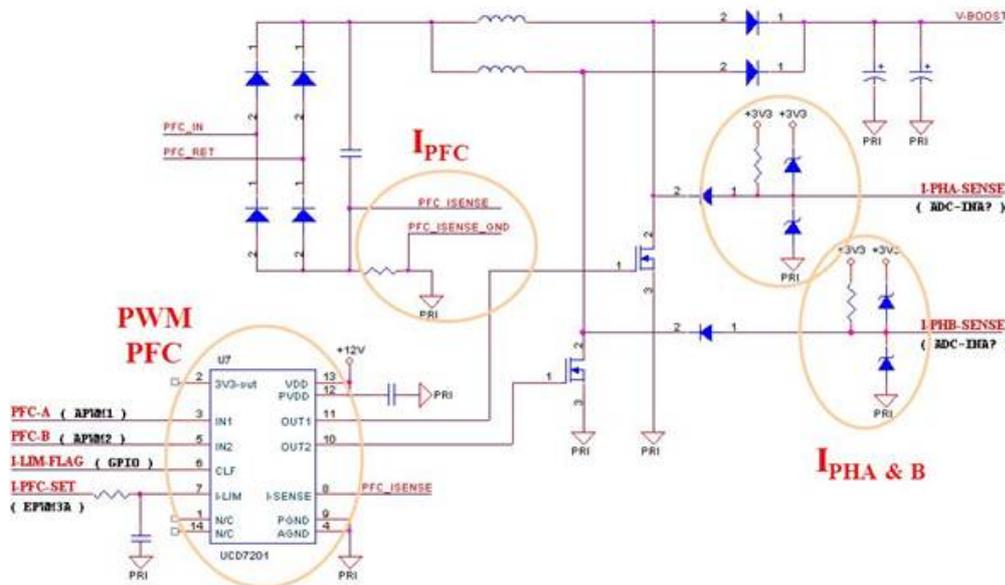
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III. WIND ENERGY INTERLEAVED CONVERTER

- **Wind Turbine Technology**

The wind turbine is the first and foremost element of wind power systems. There are two main types of wind turbines, the horizontal-axis and vertical-axis turbines.



- **Horizontal-axis Turbines**

Horizontal-axis turbines are primarily composed of a tower and a nacelle mounted on top of tower. The generator and gearbox are normally located in the nacelle. It has a high wind energy conversion efficiency, self-starting capability, and access to stronger winds due to its elevation from the tower.

- **Vertical-axis Turbines**

A vertical axis turbines' spin axis is perpendicular to the ground. The wind turbine is vertically mounted, and its generator and gearbox is located at its base. Compared to horizontal-axis turbines, it has reduced installation cost, and maintenance is easier, because of the ground level gear box and generator installation. Another advantage of the vertical axis turbine is that its operation is independent of wind direction. The blades and its attachments in vertical axis turbines are also lower in cost and more rugged during operation.

IV. SIMULATION RESULT

By substituting these speeds, the corresponding extracted mechanical power can be determined. The power extracted by the energy conversion system at the determined and actual speeds is 21709 W and 21766 W, respectively. The algorithm is successful in determining the maximum power point of the system because the difference in power between the actual and determined operating point is 57 W (approximately 0.1% of the maximum power).



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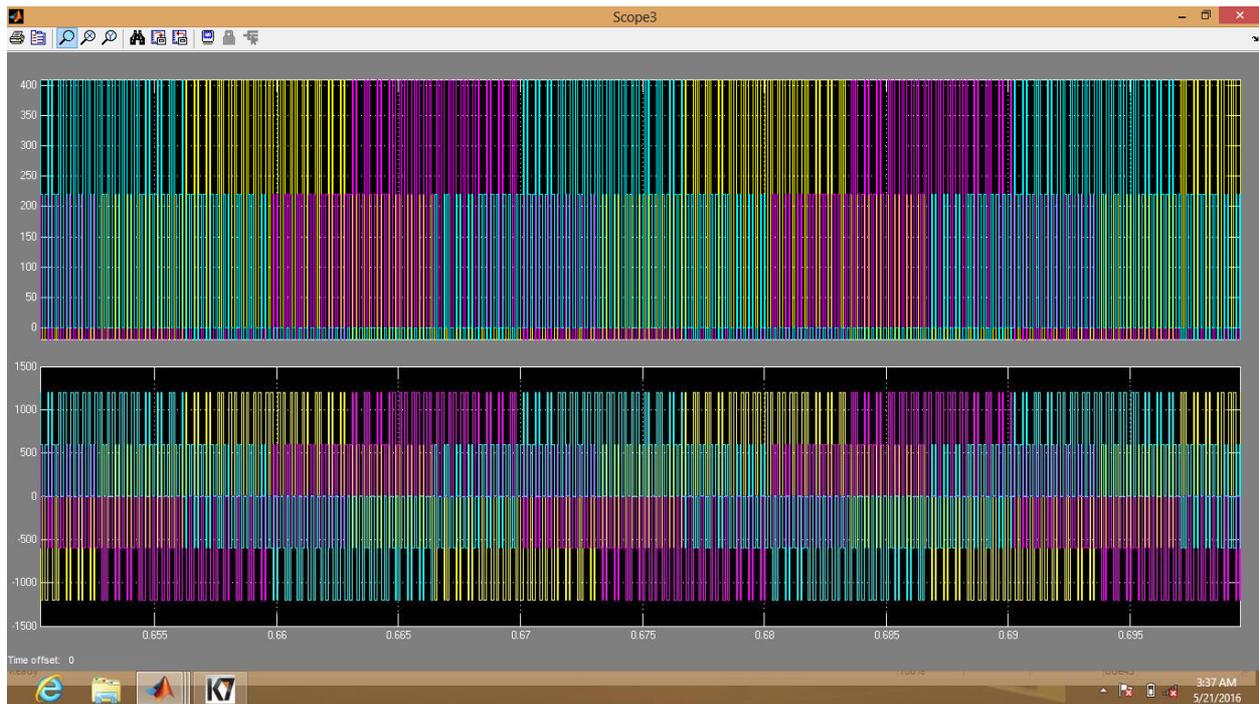
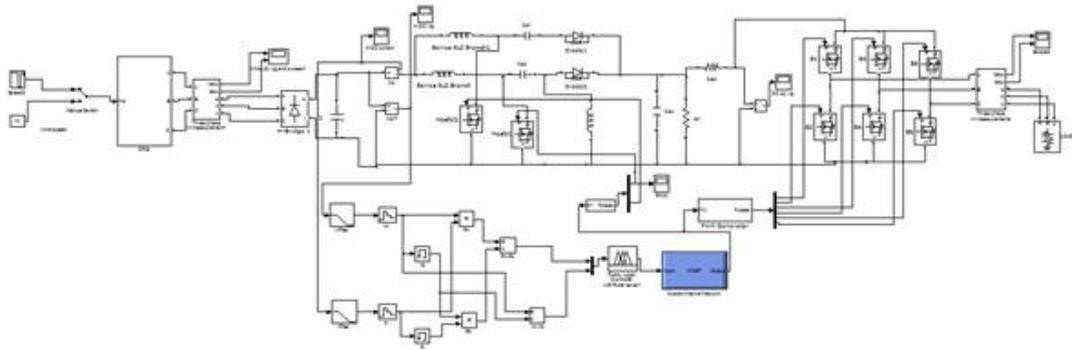


Figure: 4Output Voltage

At a wind speed of 9 m/s, the algorithm was able to determine the generator speed to be 3381 rpm through its search procedure, while the actual maximum power point is at 3480 rpm. The corresponding rotor speeds are 11.8 rad/s and 12.1 rad/s. The power coefficient was at 0.45 using the generic TSR value, and eventually became 0.478 at the determined maximum power point. The turbine's TSR was determined to be 0.787 which is relatively close.



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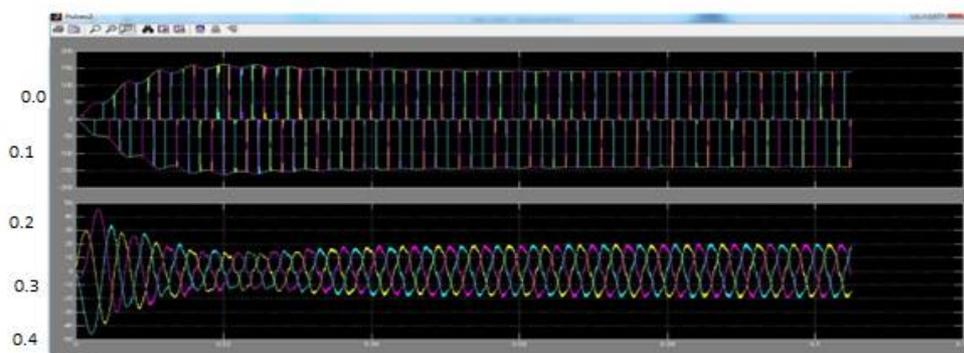


Figure: 5 Input Voltage and current

V. CONCLUSION

Due to wind's unpredictable nature, power management concepts are necessary to extract as much power as possible from the wind when it becomes available. The proposed algorithm has been developed to maintain the system at its highest possible efficiency by using its memory feature to infer the optimum rotor speeds for wind speeds that have not occurred before.

Another feature of the proposed algorithm is that it can be easily customized for various wind turbines since it is independent of turbine characteristics. The proposed algorithm uses a modified version of DFIG and intelligent memory to implement its power management scheme. This algorithm is most suitable for smaller grid or battery connected wind energy systems. In this we reduced below 4% loss DFIG simulation studies have confirmed the effectiveness of the proposed algorithm

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