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Optimized Fuzzy Based MPPT Control for Wind Power Generation System

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ABSTRACT

In recent years, huge developments in wind energy production and meet consumer demand. Numerous researchers have focused on maximum energy generation techniques for the wind system. In this document, we have developed and modeled a 250-watt wind power system in a MATLAB environment and simulated it in different weather conditions. Based on the simulation results, it has been proposed an intelligent controller like Fuzzy for the maximum energy generation techniques in the wind system.

Key words: MPPT, Fuzzy, Wind Power System, MATLAB.

1. INTRODUCTION

Highlight Today, the application and use of widely developed renewable energy resources due to the growing need for electricity and the inconvenience and difficulties of generating energy through traditional energy sources have paved the way for greater attention to sources. Renewable in the future [1]. The survey of the article shows that renewable energy systems are economically very efficient compared to traditional and traditional systems for generating energy from fossil fuels, but the need for cleaner and quantum energy tends to many improvements in energy systems. Alternative electricity generation, which makes renewable systems the most popular. and widely used for many applications [2]. The research sector of the wind energy conversion system (WECS) has seen a lot of participation and analysis for its excellent potential for remote areas for which supplying distribution networks is an uneconomical and cumbersome process for installing the conventional generation system [3]. Among the most popular methods, PMSGs are often chosen for WECS, which act independently thanks to their high reliability, low cost maintenance and good efficiency. Despite the advantages, it is mainly suitable and widely used for variable speed operation, with 10-20% more power and high power in watts of energy, under mechanical stress and lower power fluctuations compared to constant speed operation. A PMSG variable speed wind turbine system is more flexible to adapt to sudden changes in the wind [4]. This document presents a direct design of the MPPT controller for PMSG variable speed wind turbines. In this, the wind generator produces maximum power regardless of the conditions or environmental characteristics of the generator. Independent control algorithm that obtains quick responses for the complex nonlinear system.

This literature provides a comprehensive analysis of past and present WECS-based controllers for full power extraction using permanent magnet synchronous generators (PMSG), squirrel-cage induction generators (SCIG) and dual-induction power supply generators (DFIG). These controller models are be classified into three main control methods, (i) the peak speed control system (TSR), (ii) the power signal feedback control method (PSF) and (iii) the upward search control method in suspended (HCS).

The phenomenon of global warming together with the scarcity and lack of availability of fossil fuels have further contributed to motivate the research work towards the generation of renewable electricity and the use of renewable sources. Among the various forms of renewable energy, wind energy has recognized as the primary and familiar source in the electricity sector. Renewable wind resources for energy production are huge all over the world. Only 10% of the available wind sources meet the criteria for the use of power generation established after the assessment [5]. In view of this, the improvement in the performance of wind turbines and WECS is progressively increasing as a trend research sector. Since then, the greater power range of wind turbines, the need to provide a correct interface between the renewable energy generation / conversion system and the grid system for optimal distribution. As a practical solution, methodologies and devices based on power electronics has already been introduced to connect; in the literature, several renewable topologies for power conversion schemes were presented. Many types of power generation conversion systems are commonly used as in [6, 7].

The popular conversion topology in the energy sector is the Pulse Width Modulation (PWM) inverter and the six-pulse diode rectifier due to their lower cost and efficiency, while this methodology allows for unidirectional energy flow Contrary to the subsequent converter of power. The back-to-back converter allows a bidirectional power flow, widely used and interesting in some applications.

Many research papers have already proposed a variety of control schemes for optimal energy extraction through WECS [8]. The very simple methodology to find and obtain the maximum power point is based on the PI controller and on the Perturb and Observe algorithm [9,10] but these schemes face a lack of adequate performance. Another well-known technique is the neural network for estimating wind speed from wind energy, the generator speed, which are already measured and, subsequently, checking the maximum power generator speed or the reference of the value of the pair can be derived for the operating point tracker [11, 12]. Although neural network-based methods ensure rapid response, controller performance fails during the change in the wind system. Furthermore, methods based on fuzzy logic have been widely used because of their better efficacy, as presented in [13, 14 & 15]. Although neural network-based methods ensure rapid response, controller performance fails during the change in the wind system. Performance analysis of a micro wind power system using a single-ended primary inductor converter (SEPIC). Depending on the intensity of the wind, the output voltage of the mill will fluctuate. To work around this, SEPIC is used. This DC-DC converter is mainly used to change the voltage levels, optimizing the losses of the voltage level obtained [16]. One of the best known advanced control techniques is checking fuzzy logic. This article aims to define the concept and Fuzzy Logic Control. In addition, this article It consists of a brief discussion of how this type of control works, and how it applies to various types of control systems. The procedure explained by this approach is explained and also presented in this document. This includes a discussion on three steps, or fuzzification, Fuzzy Logic have become a popular approach to science research, technology, engineering and medicine [17]. Single stage single isolated single pulse switch a converter is proposed to reach the power factor of the unit and for reduce the input current% THD. In this converter buck and Buck-boost converters are integrated with one block
transformer and managed by a single switch. The detailed analysis and operation of the isolated buck-boost buck converter in DCM it is explained with the necessary equations and methods [18]. In addition, methods based on fuzzy logic have been widely used due to their improved effectiveness. On the contrary, the main drawbacks and limitations of these methods are not reliable; lack of stability, uneconomical, according to the analysis of the controller, the maximum power point varies in a wide range. To overcome the problems mentioned, the control of the scrolling mode is adopted in various works, but the main disadvantage of the control of the scrolling mode is its complexity and the difficulty of implementation.

The rest of this document is presented as follows: in the second section, a dynamic modeling of the wind energy conversion system is presented with the importance of the MPPT controller for WECS based on PMSG. The third section deals with the control strategy. Then the modeling of the fuzzy system is presented in section III.

2. MPPT CONTROL METHODS FOR PMSG BASED WECS

The WECS based on the permanent magnet synchronous generator (PMFG) is widely used because research continues to identify more new designs due to the high power density, higher efficiency, and the possibility of smaller turbine diameter and the availability of permanent magnet material high energy at a reasonably lower price. Many research papers were published in the development of the WECS domain for WECS design, which is more efficient, highly reliable, low wear, low noise, compact and with lower maintenance costs.

There are three configurations of the Wind Energy Conversion System that are used with PMSG machines to convert and variable frequency power to fixed frequency, variable voltage power and fixed voltage power. Depending on the converter configuration, a specific WECS PMSG with a suitable MPPT controller is designed and developed for your control. Three methods of the MPPT driver algorithm are generally used for WMS PMSG.

3. PMSG DESIGN WITH AND WITHOUT MPPT CONTROLLER

In this paper, its tends to simulate the Fuzzy based MPPT controller.

The proposed PMSG design parameter as follows:

(i) . The Mechanical Power Output = 260 W
(ii). The Voltage Maximum V_{max} = 240 V
(iii). The Maximum Current I_{max} = 5 amp
(iv). Base Electrical Generator Power = 280 VA
(v). Base Wind Speed = 12 m/s
(vi). Base Rotational speed = 1 p.u
(vii). At base wind speed, Maximum power = 0.9 p.u
(viii). Pitch angle = 0°

The proposed system has been simulated MATLAB. Simulink environment at various weather conditions as shown in Figure 1. The generation speed Characteristics vs Turbine Mechanical Powers are presented in Figure 2.

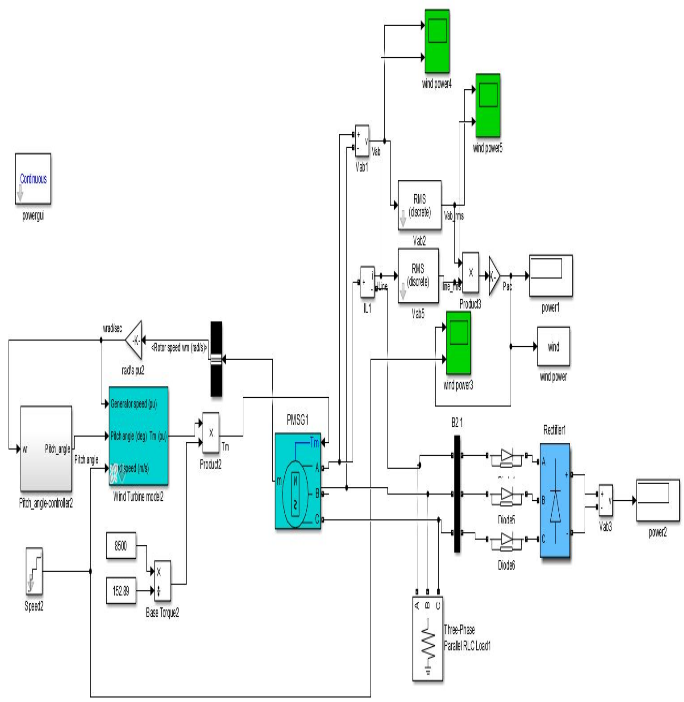

Figure 1: Simulation model of PMSG based WES without MPPT Controller

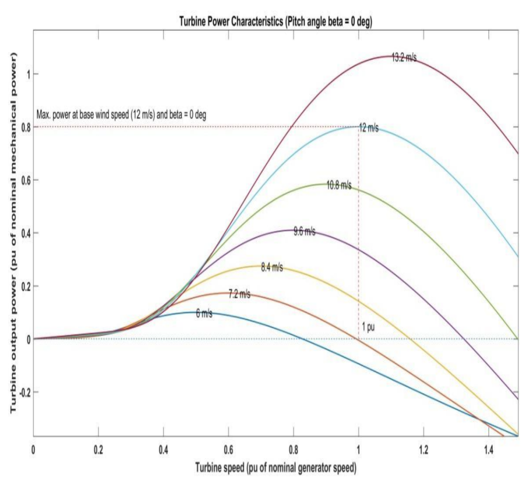

Figure 2: Wind Turbine Characteristics

The Fuzzy-based MPPT controller for WES with buck converter as shown in Figure 3. The proposed WES was developed in a MATLAB environment and analyzes its performance in various weather conditions. Based on the simulation results, fuzzy intelligence has been proposed for the MPPT technique. The proposed fuzzy MPPT controller has two input trapezoidal membership functions, such as the input of a WES voltage and the second input current. The output of the fuzzy control is the trapezoidal membership function, like the duty cycle (D), as shown in Figure 4. Input 1 and input 2 have three-member send functions with low, medium and high, just as the output has three functions of sending members has low, medium and high. The proposed controller developed by the trapezoidal type for fuzzification and the center of gravity method for defuzzification, as shown in Figure 5a. Fuzzy rules are developed according to Table 1 below and shown in Figure 5b.

Table 1: Fuzzy Rules

Parameters	**V- Low**	**V- Medium**	**V-High**
I-Low	D – High	D - High	D - Medium
I-Medium	D – High	D - Medium	D - Medium
I-High	D – Medium	D - Medium	D - Low

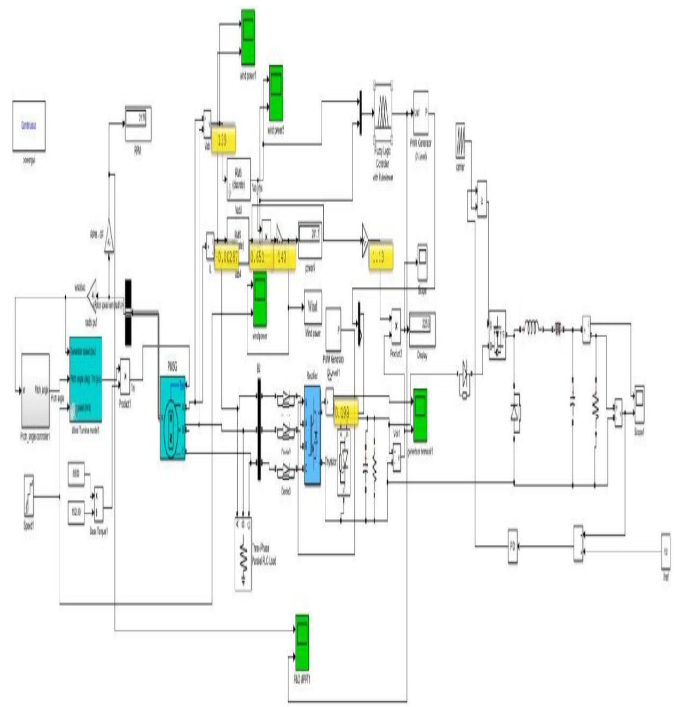

Figure 3: Fuzzy Based MPPT controller for WES with Buck Converter

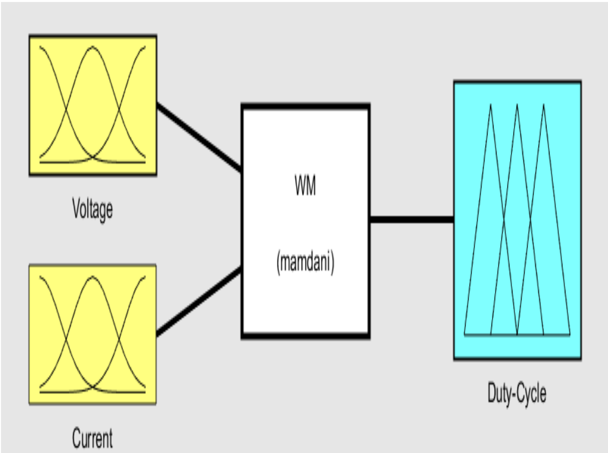

Figure 4: Fuzzy Based MPPT Controller

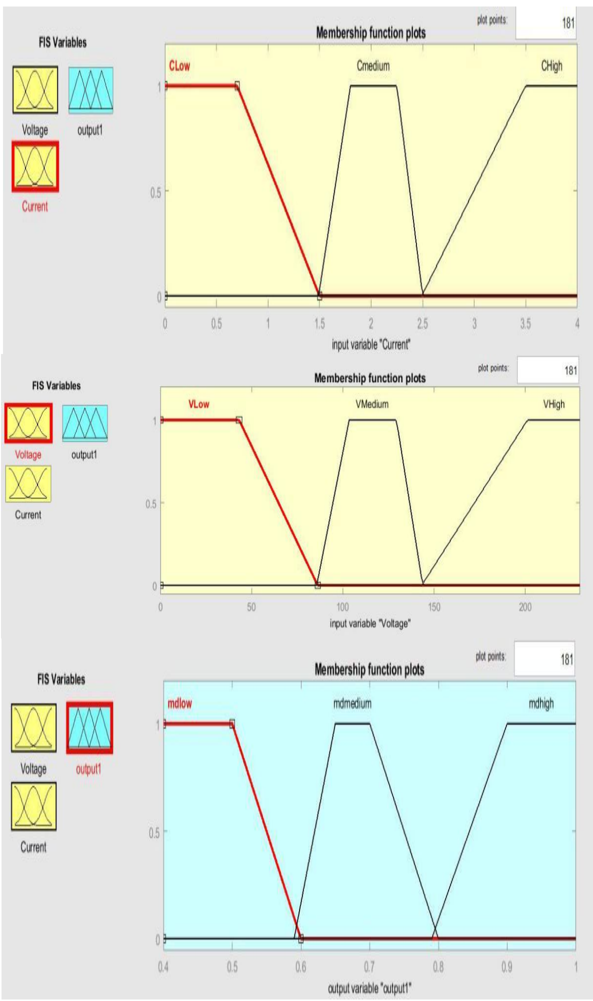

Figure 5a: Fuzzy Membership Function

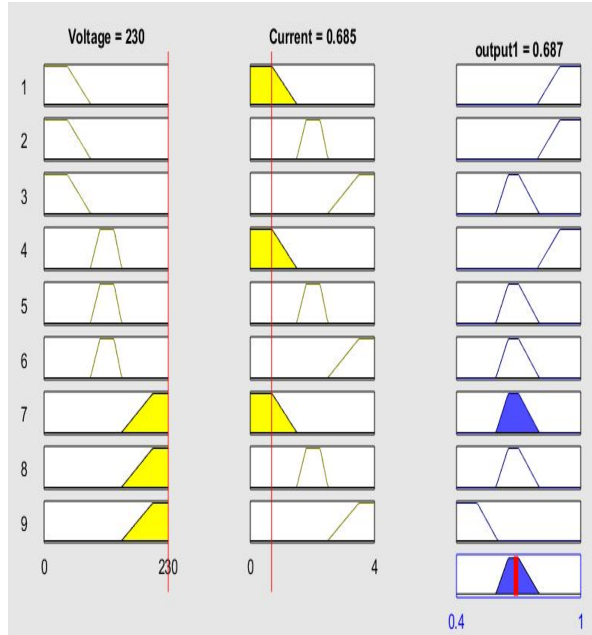

Figure 5b: Fuzzy Based MPPT controller rules

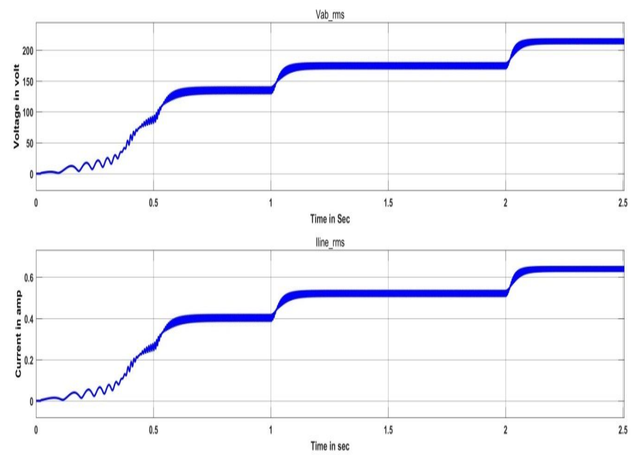

Figure 6: WES RMS Voltage and Current waveform

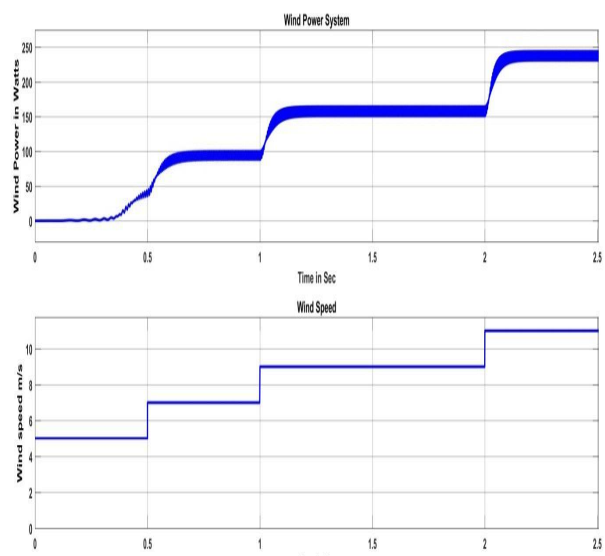

Figure 7: WES Power and wind speed waveform

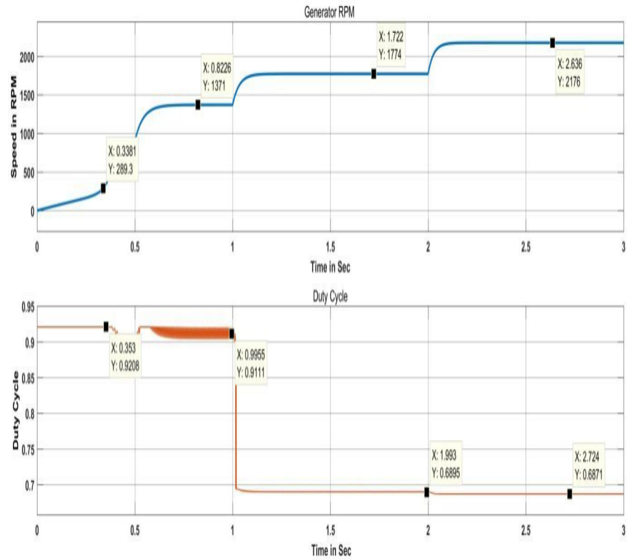

Figure 8: WES Speed and Duty Cycle waveform

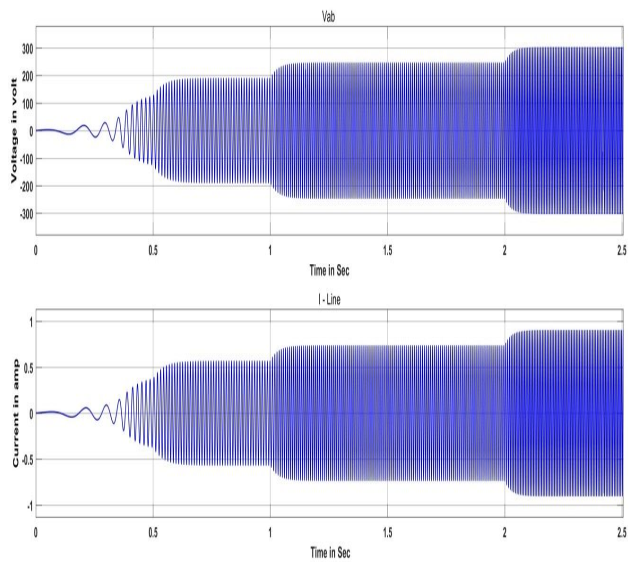

Figure 9: WES AC Voltage and Current waveform

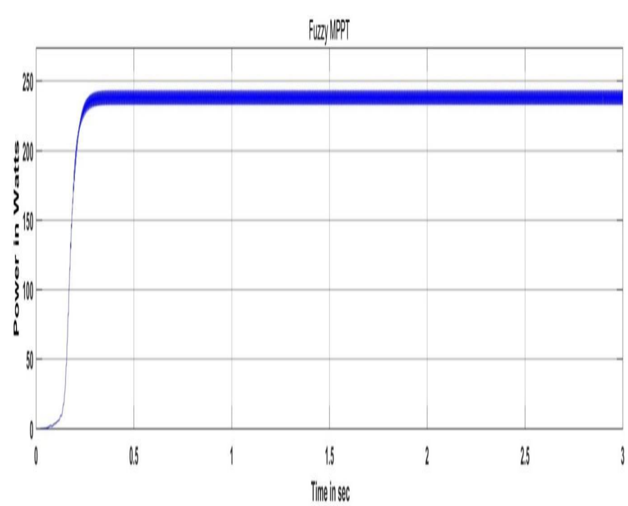

Figure 10: Fuzzy Based MPPT controller for WES power

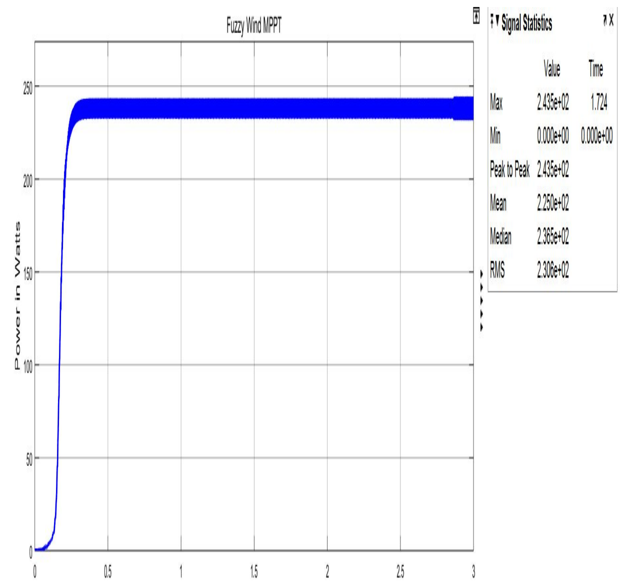

Figure 11: Fuzzy Based MPPT Controller Time Taken to Reach Maximum Power

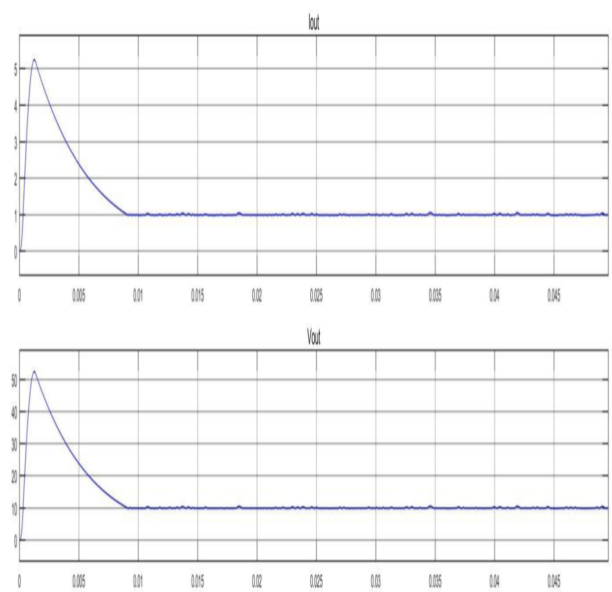

Figure 12: Buck converter O/P regulated voltage and current waveform

4. RESULT AND ANALYSIS

The proposed fuzzy logic controller has been applied for MPPT of PMSG and simulated under various operating condition such as wind speed at 5 m/s , 7m/s , 9 m/s, 11 m/s and 12m/s. The after simulation the following results are taken for analysis their system performance such as Wind power system RMS voltage and Current as shown in Figure 6. The 250 watts output power WES has been analyzed under wind speed as presented in Figure 7. The fuzzy controller has generated duty cycle with respected to change of wind speed as shown in Figure 8. AC output voltage and current waveform has presented in Figure 9. The fuzzy MPPT based WES maximum output power and time take to research maximum power are depicted in Figure 10 and Figure 11 separately. Finally the buck converter voltage and current waveform are presented and shown in the Figure 12. In this waveform the voltage has been maintained as a constant output during unequal power generation of wind power system.

Drawbacks and limitations of fuzzy based MPPT controllers are sorted out by the hybrid combination of the neural network and fuzzy systems applied to the functionality of the controllers. Neural networks, neuron based concepts are incorporated into fuzzy systems which can acquire knowledge relevant to the system automatically by executing the learning algorithms for the neural networks. Adaptive Neuro-fuzzy inference system (ANFIS), (Ref) constructs an mapping of input and output in the fuzzy rules form based on human knowledge and on generated input output data pairs by using a hybrid algorithm that is the combination of the least-squares and back propagation gradient descent method.

5. CONCLUSION

The best and efficient method of utilizing renewable sources for power generation is wind-based energy. Wind energy conversion system is the proven technology for power extraction and has been widest attention received among the different types of renewable energy systems. Maximum electric power is an important research area wide open for budding research scholars, among all controllers, sensor less MPPT control has been a very popularly analyzed and applied in this domain of research. In this paper, a concise review of MPPT control methods based on Fuzzy system for controlling WECS with various generators have been presented. As a unending determination to make MPPT converter based schemes for wind generator speed control to maximize the power generation, the Fuzzy system based methodology is proposed and the proposed methods is viability is verified by designing an efficient PMFG WECS system in MATLAB and Fuzzy controller is adopted with system and proven simulated results presented.

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