



Comparative Study of Different MPPT Methods for Wind Energy Conversion System

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Abstract-- We describe an evaluation of two MPPT methods for a wind energy conversion system using permanent magnet generators throughout this paper (PMSG). Hill Climbing Search (HCS), Optimal Torque Control (OTC), Power Signal Feedback (PSF), and Fuzzy Logic Control are some of the techniques used (FLC). These methods were created with the goal of comparing their performance in terms of wind system energy conservation, responsiveness, thermal efficiency to be achieved, and class diagram during the MPP (maximum power point). Designers also simulated the device under fluctuating wind velocity situations for a more careful analysis. In comparison to all other MPPT algorithms, the research shows that consciousness artificial neural network is more reliable and has good efficiency.

Keywords-- TIP (Tip Speed Ratio), FLC (Fuzzy Logic Control), HCS (Hill Climbing Search), OTC (Optimal Torque Control), PSF (Power Signal Feedback), MPPT, Wind Turbines

I. INTRODUCTION

Despite the economic and operational performance over other technologies consumption of fossil power sources. In distant regions, renewable energy is one of the most frequently had been using solar and wind energy sources. The results of incremental conductance research studies of constricted renewable power are determined by a number of research papers. Because of their good reproducibility, synchronous generator turbines (PMSG) demand less monitoring, do not permit braking systems, and will be more efficient [1]-[3]. Furthermore, considering the quality with weather conditions, an MPPT controller is implemented to tackle these problems at its maximum power at most of those important times. There are two different types of Maximum power point tracking approaches in the literature: direct and indirect methods. Global Optimization Scan (HCS) [5] [6] and Fuzzy Logic Controller (FLC) [4]-[8] are unique advancements that would not demonstrate personality traits or climatic factors related to wind energy. The indirect processes depend on ability to understand of generator traits like Optimal Torque Control (OTC) and Power Signal Feedback (PSF) [3] [11].

A simulation - based analysis of a wind turbine with a power plant, PMSG generator, ac/dc converter, dc/dc booster converter, and a DC load is reported in this section. As a result, an MPPT controller was designed to

optimize process power consumption by measuring the optimum operating point or even observing and identifying relevant MPPT algorithms to boost their confidence on our structure.

II. MODELLING OF WIND ENERGY SYSTEM

In this paper, we suggested a distributed energy storage structure that incorporates a turbine, a PMSG alternator that transforms the turbine's mechanical power into electrical power. A dc/dc diode rectifier besides trying to convert AC voltage to DC voltage, a dc/dc boost converter for manipulating the MPPT controller and can provide a DC flow of electricity to that same has everything machinery via a Constant current bus line. Figure 1 depicts the systems integration architectural features.

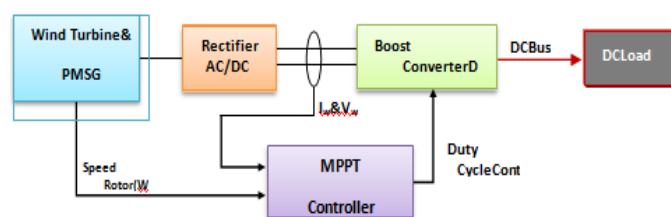


Figure 1: Wind energy system architecture.

A. Wind Turbine Modelling

Tables 1 and 2 context the barriers of the wind generator and PMSG generator shown in this research project.

Table 1: The Turbine Limitations

Parameter	Value
Nominal mechanical output power	8.5 kw
Base wind speed	12m-s
Air density	$\rho 1.225 \text{ kg-m}^3$
Pitch angle beta	0°

Table 2: PMSG's specifications

Parameter	Value
Number of Pole Pairs	5
Resistance to the Stator Phase	0.425Ω
Inductance of the coil	0.000835 H
Friction Factor	0.001189 N-m-s
Inertia constant	0.01197 kg-m^2

Figure 2 illustrates the mechanical force of a wind generator as a structure of rotational speed P_m () for numerous different atmospheric conditions:

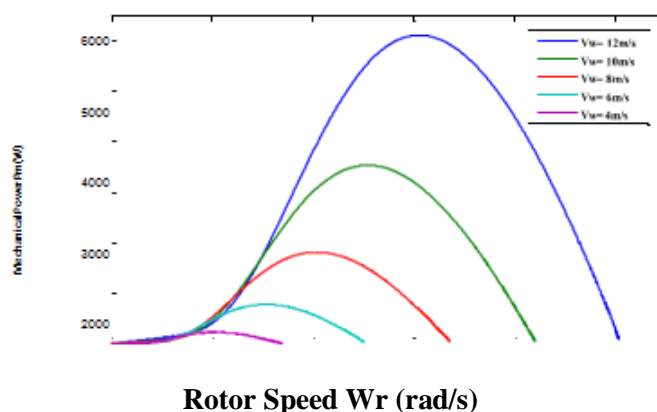


Figure 2: P_m () Mechanical properties of wind generators at numerous different atmospheric conditions.

Fig. 3 shows the wind turbine mechanical torque as a function of the rotor speed T_m () for different wind speed values.

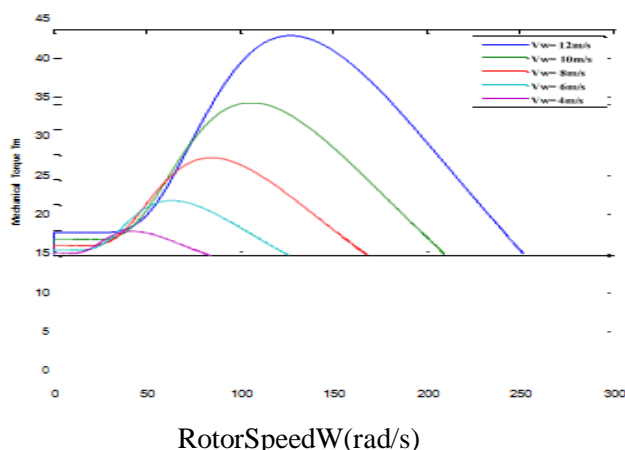


Figure 3: (T_m) Mechanical power output of a power plant at multiple atmospheric conditions.

Fig. 4 shows the power coefficient $C_p(\lambda)$ for various pitch angle values β . the optimal value of C_p is corresponding to $\beta=0$ and to the tip speed ratio optimal value ($\lambda_{opt}=8.144$) which equal to 0.48.

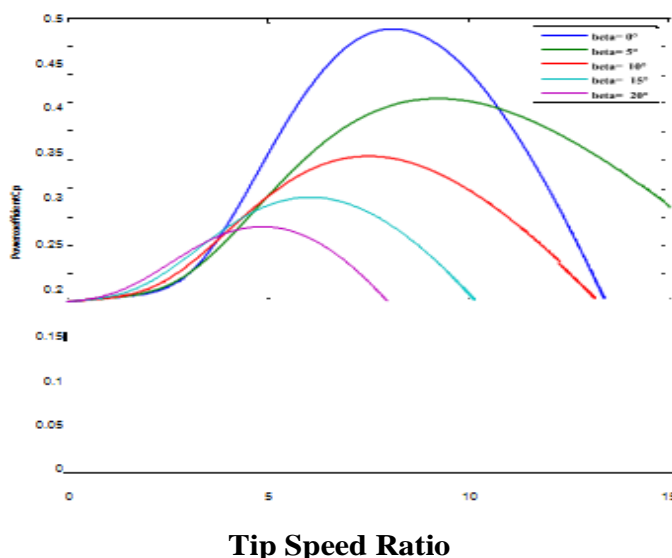


Figure 4: For varying values of that same wind velocity, the angular velocity was included.

It can be seen from these wind turbine traits that for various wind speed values, there is an operating point where these attributes P_m , T_m , and C_p are suitable. This illustrates the use of an MPPT controller to achieve and manage this maximum power output despite of atmospheric temperature variations.

B. Modelling of DC/DC Boost Converter:

A DC/DC boost converter process of converting a low voltage output to a high terminal voltage and are among the most often used converter topologies in the distributed energy storage sequence. It has a transformation interface between some of the PMSG power source and also the load demand in order to manipulate its Use an MPPT controller to run a technology semiconductor without using a Gate pulses and the frequency response to drive the machine at its maximum output. The circuit diagram of a boost system is shown in Figure 5. The boost converter's duty cycle is written in terms of the input signal by:

(6) The duty cycle is denoted by the letter D.

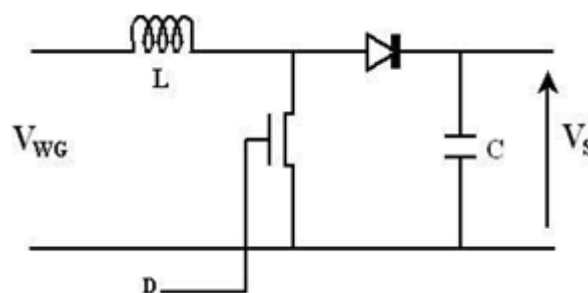


Figure 5: Boost converter.

Figure 5: The above fig shows equivalent circuit of boost converter

III. MPPT ALGORITHMS

Something like an MPPT controller in a wind turbine is extremely crucial, given its significant role in obtaining the maximum power generated by the PMSG transformer regardless of wind velocity. Its method is based mostly on implementation of an MPPT algorithm that allows to reach and track the maximum power point MPP. In wind turbines, there are also several MPPT methodologies that can then be divided into two categories: direct methods and indirect methods. Optimal Torque Control (OTC) as well as Power Signal Feedback (PSF) are indirect methods that rely on C_p -opt and opt knowledge. [1] [3] Direct methods, on the other hand, do not involve previous understanding among those traits.

Researchers suggested the expansion of its techniques in this publication and compare their results on the cost effectiveness of our framework.

A. Optimal Torque Control (OTC) Method:

The OTC control principle is to adjust the PMSG generator's power output to its reason for adding for various surface temperatures, which necessitates knowledge of the adaptive power station character traits Cp-opt and opt.

Wind gust, mechanical work, and maximum horsepower can be written as follows in the efficiency is based (Cp-opt and opt) and according to equations (1), (4), and (5):

Where K_{opt} is a constant determined by the wind turbine characteristics and is defined by:

$$K_{opt} = \frac{1}{m_p^2} \quad (10)$$

Fig.6 shows the block diagram of the OTC method:

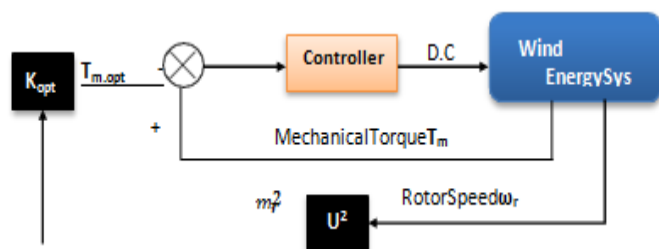


Figure 6: OTC method.

B. Power Signal Feedback (PSF) Method:

By estimating the complete authority for a terminal velocity, the PSF technique can verify peak value this same signal strength of a PMSG alternator using the monitoring optimal equation (8). The calibrated electricity is then added to the actual energy to power a servo controller that would be sent to the power converter, trying to ensure that only the capacity factor Cp and the airspeed will always be at their best bargains. The PSF process is illustrated in Figure 7:

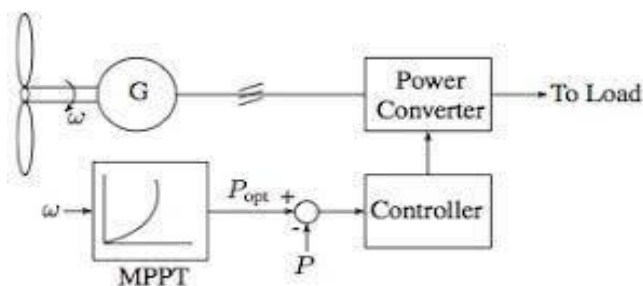


Figure 7: PSM method

C. Hill Climbing Search (HCS) Method:

For its simple structure and individuation from windmill traits, such as the total pressure greatest possible Cp-opt and the high bypass public distribution best possible opt, the HCS method is the most widely used MPPT strategy in a wind generator. Its idea has been generally focussed on a Small jump constant on disturbances (incrementing or decrease the temperature) of the horizontal axis wind turbine speed, then viewing the effect of this oscillation on the PMSG Identify the predicted investment opportunities of the electricity with its original value to determine the generator's dc voltage as shown in Fig. 8, a

modest increase in rotor angle results in a higher in power output (case $P > 0$).

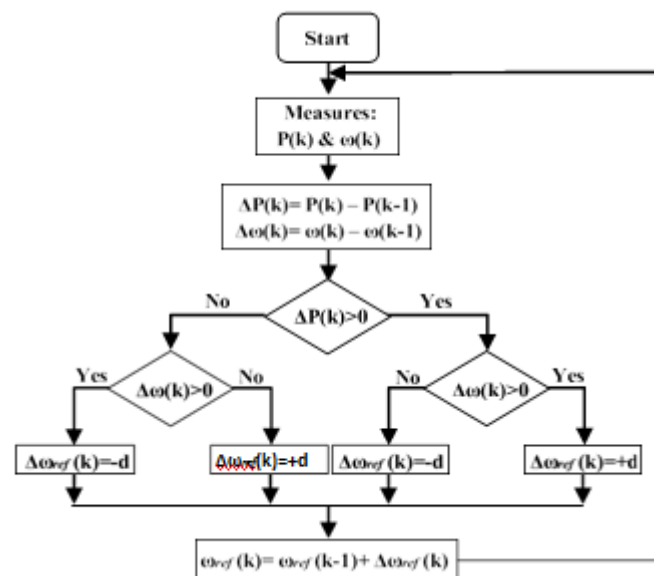


Figure 8: Hill Climbing Search method flowchart.

D. Fuzzy logic (FLC) MPPT:

In trade winds, the neuro - fuzzy MPPT technique is also one of the classification methods used to identify and manage the operating temperature related to regardless of the weather, maximum output is achieved. The overall agency is rather more inclusive than classical management techniques, and which might or might not involve the strongest quality mixture of the framework mathematical formulas. Quantization, Application interface, and Discretization are the various related blocks of an FLC controller. Input parameters, output variables, fitness function, and fuzzy rules interpret it. Figure 9 depicts the circuit design of an FLC MPPT controller for such a bidirectional converter.

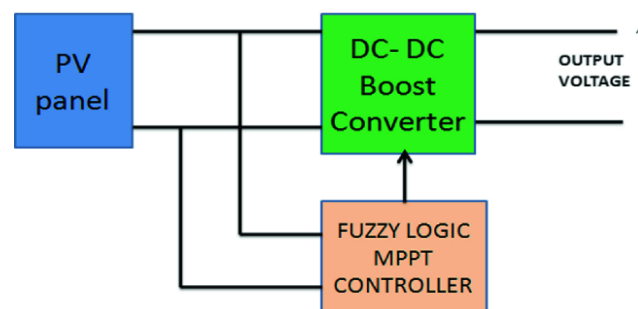
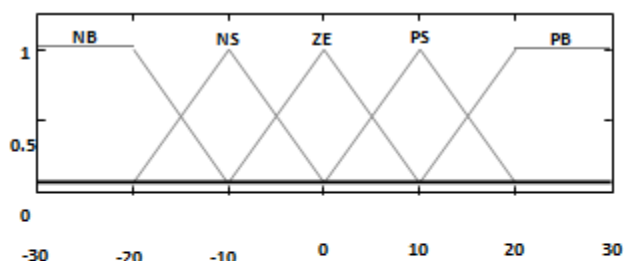


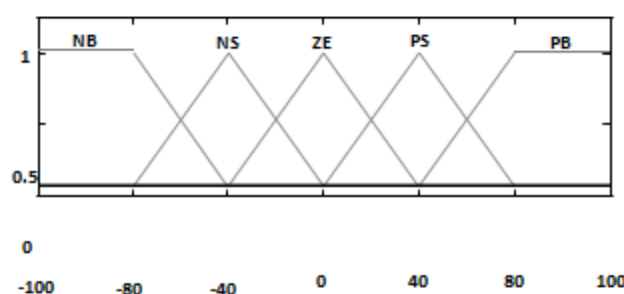
Figure 9: FLC MPPT controller.

The fuzzy logic controller contains the following basic concept to reach its maximum powerpoint presentation: The interference management the transfer function into hidden layers (fuzzy output step) in the first stage, which also are identified in five substrings: NB (negative big), NS (negative small), ZE (zero), PS (positive small), and PB (positive big) (positive big). The transfer functions of $E(k)$, $dE(k)$, and D are shown in Figure 10. (k). In the second stage, the module contains the MIN-MAX extrapolation technique to evaluate logical relationships between input parameters and the desired output while defining participation rules (extrapolation step).

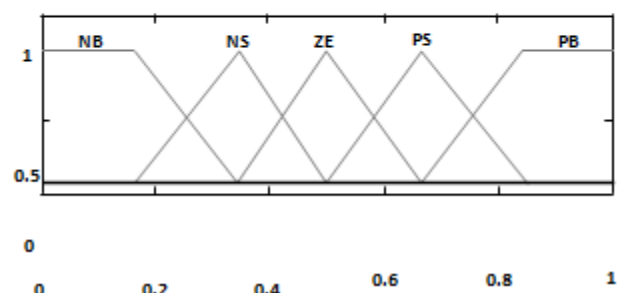
The designated feature set is shown in Table 3. The operator then the process of converting the fuzzy subcategories of the independent variables into a mathematical formula, which is the switching frequency implemented to the dc/dc voltage source inverter, in the final option, using the central area of gravitation contains traces, which is also the easiest method and quickest way.



(a)



(b)



(c)

Figure 10: Membership functions for: (a) InputE, (b) InputdE, (c) OutputD.

Table 3: Fuzzy logic rules

E	dE				
	NB	NS	ZE	PS	PB
NB	NB	NB	NS	PS	PB
NS	NB	NB	NS	PB	PS
ZE	ZE	ZE	ZE	ZE	ZE
PS	NS	NS	NS	ZE	ZE
PB	NS	NB	NB	ZE	ZE

IV. SIMULATION RESULTS AND DISCUSSION

Based on the theorems and parameter values of the turbine and PMSG transformer accumulation, a combinatorial optimization and control system of a bidirectional converter had been performed out how to use the matlab/Simulink technology in this study. In contrast, an MPPT controller was proposed to facilitate

the performance of the proposed approach under different wind circumstances, using different Control techniques that were designed to simulate, evaluated, and compared.

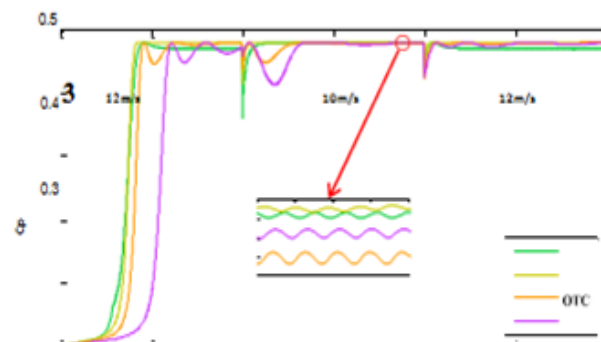


Figure 11: Various MPPT techniques' power coefficient is calculated (C_p).

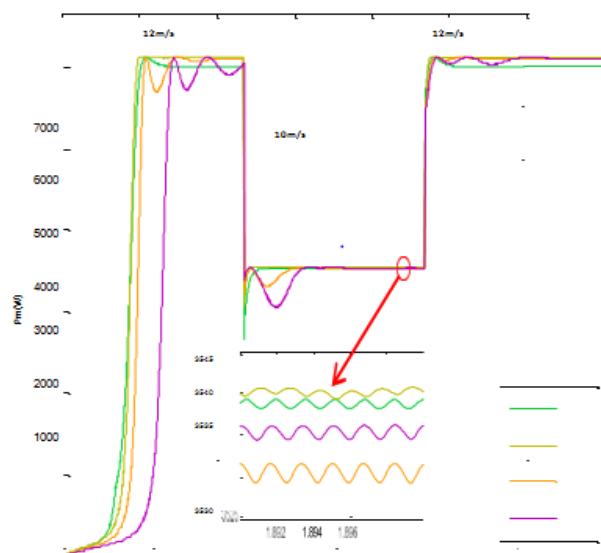


Figure12: Wind turbine mechanical power for different MPPT methods.

Based on this result, we discovered which artificial neural network is the most suitable tool when compared to other sources. It manages to achieve power output with good specificity, reliability, and speed of response. The PSO and OTC strategies, is from the other hand, create a larger feedback opportunity to assess the MPP, which would still be lower than that of FLC, energy loss can be reduced with a few more feedback loops. As a side effect, it can be noted that FLC research thrust is an effective and stable system that produces improved performance and under widely varying sustained winds, transient characteristics are observed.

CONCLUSION

Four MPPT technologies, including OTC, PSF, HCS, and FLC, have been developed and correlated in this paper to modify the carbon emitted by a wind turbine under various conditions. In reference to other committee provides on OTC, PSF, and HCS, the MPPT controller artificial neural network enables us to evaluate



and reporting the maximum power output with better flexibility, greater sensitivity, and greater reliability. As a side effect, that even for a converter, the methodology based on FLC provides better economic benefits and success.

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