International Journal of Control, Energy and Electrical Engineering (CEEE)
Vol.7 pp.40-43

Wind turbine generator based on PMSG connected to DC microgrid system

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***Abstract*— In this paper, the presentation of DC microgrid and wind turbine generator based on PMSG (permanent magnet synchronous generator) is presented. The system contains a permanent magnet synchronous generator based WECS (wind energy conversion system) connected with DC-microgrid through an AC/DC converter and DC/DC converter type boost converter to fed a DC load under 400 VDC. Wind turbine model has been utilized for generation a 10 KW, and the MPPT technique has been utilized here for more efficiency. The modelling and the simulation of WECS under Matlab environment has been effectuated and the result are obtained.**

***Keywords*— DC microgrid, WECS, PMSG, DC-DC converter, MPPT**

I. INTRODUCTION

Now day, the world ongoing to the renewable energies because it's free, clean and environment friendly to decreasing fossil fuel consummation and CO_2 emission.

Renewable energies as wind energy conversion (WEC) and solar photovoltaic (PV) systems and geothermal, are now well developed, cost effective and are being widely used, while some others like fuel cells (FC) and biomass are in their advanced developmental stage [1]. Wind energy is the fastest growing energy technology in terms of percentage of yearly growth of installed capacity per technology source [1].

There are two main types of wind energy conversion systems: fixed speed and variable speed WECS. The variable-speed WECS uses power maximization method and algorithms to extract as much power as possible from the wind [2].

PMSG is direct drive, can be used without gearbox, has high efficiency and low maintenance, and it's the prefer for standalone system [3][4].

MPPT technique can be used to capture the maximum power from available wind, by mechanical way (pitch angel control) or electrical method (electronics converter).

Various techniques of MPPT have been considered in WECS like hill climbing search HCS, tip speed ratio control TSR, optimal torque control OTC, perturb and observe P&O, fuzzy logic controller and many evolutionary technique [4][5].

P&O algorithm is well known MPPT method due to its simplicity and effectiveness [4], which requires no information about the turbine characteristics, need only voltage and current measurements.

A microgrid system integrates the several types of renewable energy sources, such as solar system (PV), wind turbine, fuel cell, to the household and industrial load [7].it can be classified to AC microgrid and DC microgrid.

DC microgrid is Aggregation of renewable energy sources such as PV, wind energy and FC, storage devise such as batteries, super capacitor and fly wheel, DC loads such as dc machines and plug-in electric vehicles.

Today's many of consumer loads are DC supplied. Electronic based office and home appliances, such as computers, laptops, tablets, phones, printers, TVs, microwave ovens and lighting, consume electricity in DC form [6].

This paper proposes a modelling and control of PMSG based on wind turbine generator as a part from DC microgrid.

II. PROPOSED SYSTEM

The figure 1 shows a DC microgrid model, the last includes 2 renewable sources and their converters, a battery for storage with bidirectional converter for charging and discharging and 2 kinds of loads.

The study in this paper is about WECS, modelling and simulation. And the benefits of this clean source on DC microgrid operation.

ISSN 2356-5608

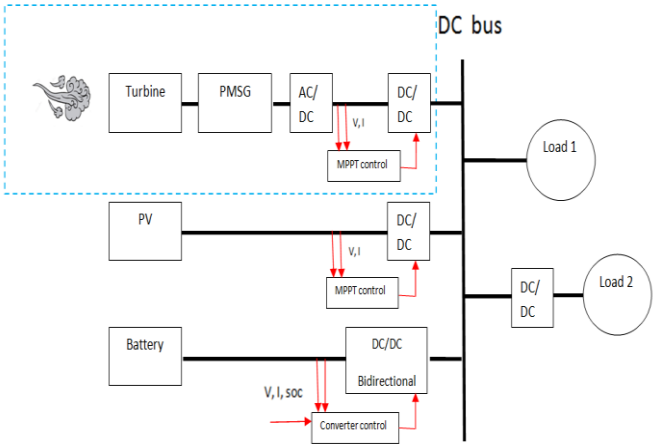

Fig.1 standalone DC microgrid PV/wind/battery.

III. MODELLING OF WECS

A. Modelling of wind turbine

The wind turbine is used for the conversion of wind kinetic energy to mechanical work.

The mechanical power $P_{m\ captured}$ by wind turbine rotor blades [1,2,3]

$$P_m = \frac{1}{2}\rho\pi R^2 V^3 C_P(\beta,\lambda) \quad (1)$$

Where,
ρ is the air density (kg/m^3).
R is radius of wind turbine blade (m).
V is wind speed (m/s).
$C(\lambda, \beta)$ is the power coefficient, which expresses the relationship between the tip speed ratio λ and the pitch angle β.
The power coefficient is the ratio between obtained power and the available power. C_P can have a max of 0.59 (Betz limit), and we can calculate it as:
To eliminate the mechanical control of pitch angel, we take $\beta = 0$.
The power coefficient is as

$$C_P(\lambda) = 0.5176\left(\frac{116}{\lambda} - 9.06\right)e^{\frac{-21}{\lambda}+0.735} + 0.0068\lambda \quad (2)$$

And tip-speed ratio given by:

$$\lambda = \frac{R.w}{V} \quad (3)$$

Where w is the blades angular velocity.

B. Modeling of permanent magnet synchronous generator

To simplify the study of the PMSG, it is convenient to transform the equations from the stationary stator frame into the d-q axis using Park transformations. The mathematical model of PMSG can be described in the d-q reference system as follows [7]

The equations for d-axis and q-axis currents are defined in [3,4] as:

$$\frac{di_{sd}}{dt} = -\frac{R_{sa}}{L_{sd}}i_{sd} + w_s\frac{L_{sq}}{L_{sd}}i_{sq} + \frac{1}{L_{sd}}u_{sd} \quad (4)$$

$$\frac{di_{sq}}{dt} = -\frac{R_{sa}}{L_{sq}}i_{sq} - w_s\left(\frac{L_{sd}}{L_{sq}}i_{sd} + \frac{1}{L_{sq}}\psi_p\right) + \frac{1}{L_{sq}}u_{sq} \quad (5)$$

The electromagnetic torque obtained from the rotor of PMSG is given by:

$$T_e = 1.5\,\frac{P}{2}[\,\psi_p i_{sq} + i_{sd}i_{sq}(L_{sd} - L_{sq})] \quad (6)$$

Here,
Isd, isq, usd and udq are the current and voltage of d and q axis respectively. Ws is the angular frequency of the generator. Lsd and Lsq are the inductance of the generator. p is the permanent flux. Rsa is the resistance of the stator and P is the number of poles.

IV. MPPT AND BOOST CONVERTER

To reduce of cost energy must be use an effective technique for truck and capture the maximum power from wind turbine that is called the maximum power point tracking MPPT [8].

Perturb and observe P&O is the algorithm widely used to extract MPP because it is simple and easy to implement [9].

The boost converter is electronic intermediate to implement the MPPT in the system by reducing the duty cycle. (fig 2) and (fig 3) show the MPPT flow chart of P&O algorithm and boost scheme respectively.

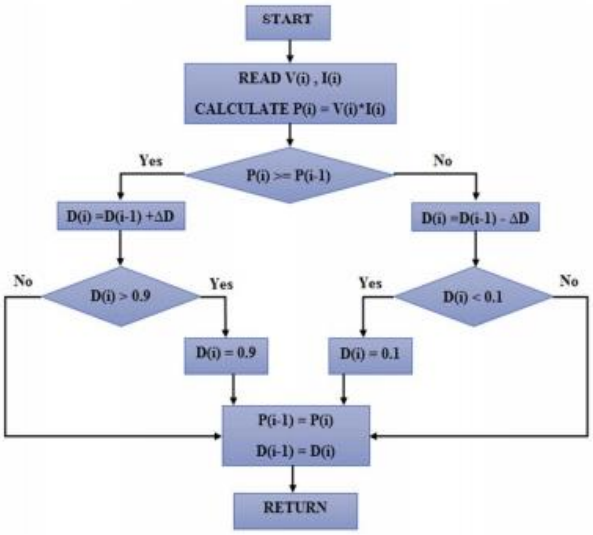

Fig. 2 P&O algorithm Flow chart [10]

ISSN 2356-5608

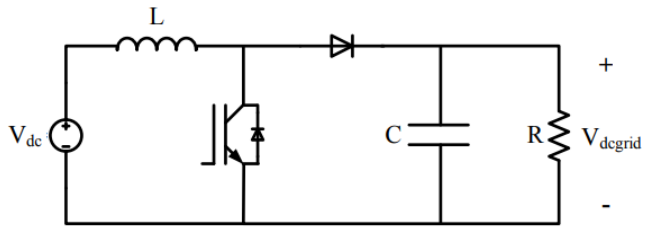

Fig. 3 boost converter scheme

V. SIMULATION AND RESULT

The proposed WECS is simulated by Matlab/Simulink fixed wind speed for rated speed of wind 11m/s.

In rated wind speed, the system extracts 10 KW, and DC bus has 400V.

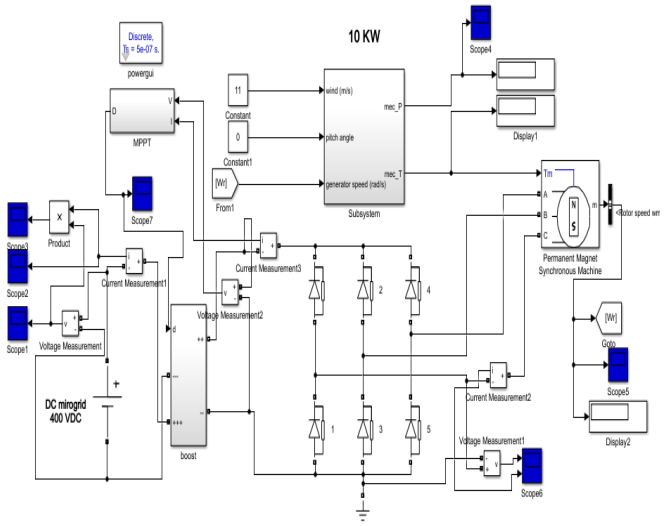

Fig .4 simulation scheme of the system

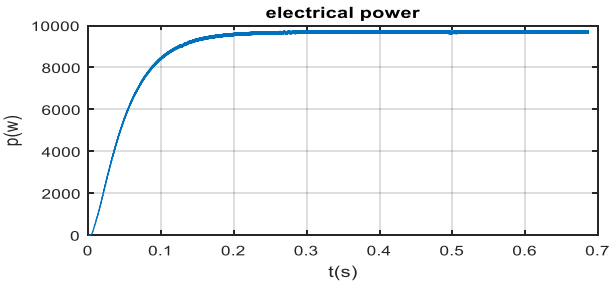

Fig .5 curve shows load power

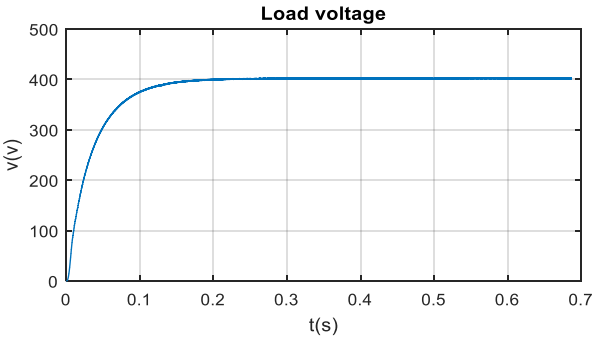

Fig. 6 curve shows dc load voltage

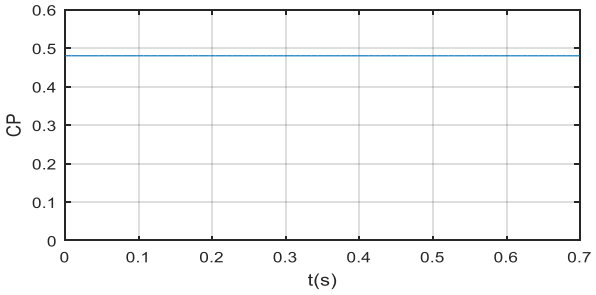

fig. 7 curve illustrates cp value in fixed speed

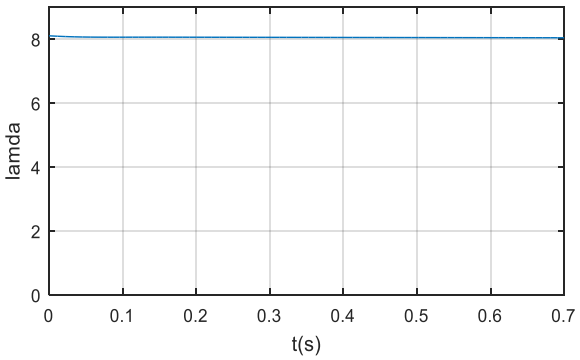

Fig. 8 Curve illustrates lamda value when beta=0

In DC microgrid system there is only one condition for the connection, this condition is $V_{wind} = V_{DC\_microgrid}$, for that we can achieve V_load=400v at all time on the simulation.

VI. CONCLUSION

This paper presented a modelling and simulation of WECS based on PMSG in DC microgrid system.

the proposed MPPT algorithm based on P&O control the boost converter by varying the duty cycle.

In the simulation section, we implemented the global system and got the results in the case of fixed speed generator.

ISSN 2356-5608

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ISSN 2356-5608