ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

Design of Fuzzy Controller Based Boost Converter to Improve DWIG Speed Range in Wind Power System

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***ABSTRACT-----*Due to lack of conventional energy sources, world is moving towards wind energy as a substitute for the energy need. In this paper, fuzzy controller based boost converter is proposed to regulate maximum power point of wind turbine. Generally, the alternator overloadrestricts the potential of DWIG at low rotor speeds; by using boost converter high dc voltage is produced during low potential and low speed. The duty ratio of boost converter is regulated by fuzzy controller. Fuzzy logic controller is able to steppeak power for uncertain wind circumstances, and vigorous with respect to specification changes in turbine. The proposed system is very simple and effective. By adopting MATLAB/SIMULINK platform, the integrated arrangement is simulated and outcome make evident of variable speed range operation.**

***Index terms----* Fuzzy Based Boost Converter, Dual Stator Winding Induction Generator, Control-Winding Voltage Oriented Control, Voltage Source Converter.**

I.INTRODUCTION

Wind energy, the world's rapidly flourishing renewable energy source. In recent years, wind power generation treated as an option to typical fossil ammunition power plants. On an average, the summary prosperity rate of wind turbine coronation is over 30% since far 10 years. It concludes that the overall retail for electrical power formed by wind turbine generator was expanding drastically, which drives the applied science into greater ambitious area.

In past, [1] fixed speed wind generator systems used with a multiple-stage gearbox and a SCIG are precisely linkedto grid via transformer. Although SCIG standoff reactive power grid, it was drawn-out with a capacitor bank for reactive power remittance. The SCIG is prosperous, effortless and comparatively economical for majority production while suffering from some disadvantages like the speed is not administrable and fluctuating over a very precise range. To overcome this, a limitedvariable speed concept using a wound rotor induction generator (WRIG) [2][3] having volatile rotor resistance whose stator is precisely associated to grid. With increment in speed range, a high slip i.e. high potential is withdrawn by the rotor and low alternator adaptability means the valuation of resistor must also become higher. In order to reduce these drawbacks, a variable speed wind turbine with WRIG and a sectional range power converter on the rotor circuit known as DFIG is configured, where stator exactly united to grid and rotor is linked to power electrical converter. It back ends wide speed range operation. Compared to WRIG concept, it can implement reactive power settlementand glossy grid network. Nonetheless, DFIG still requires a multi stage gearbox in drive train which has drawback of dissipation from friction, audible noise and regular maintenance.

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A permanent magnet synchronous generator (PMSG) scenario with multiple gearboxes is used to curtail generator's volume and to enhance efficiency of generator in variable speed wind turbine with adequate extent power converter. In spite of these advantages it is more expensive and losses in converter are higher. In recent years, DWIG generation arrangement is recommended in literature. The dual stator winding induction generator DC generation scheme achieves reliable performances and has advantages like mop less construction, less preservation and low alternatorprice. In [4]a boost converter is used in DWIG planted scheme to govern the acceleration of generator for MPPT objective.

The proposed method consists of dual stator winding induction generator, fuzzy controller based boost converter, semiconductor excitation controller, wind power.

This paper is standardized in 5 sections succeeding the introduction in section I, section II presents proposed topology and section III consists of simulation results, section IV associates conclusion and section Vcomprise of references.

II.PROPOSED TOPOLOGY

To assure that the maximum power point tracked(MPPT) by wind turbine, fluctuating speed procedure is essential. Notably, to hike the power output during low wind speed status, the alternator preconditioned to work at flat acceleration in order to expand the blade aerodynamic performance. It boosts the power gain and reduces the duration of capital restoration.

In aforementioned paper, a fuzzy based boost converter is employed in the DWIG structure to govern the speed of generator for maximum power point tracking objective in wide range of speed. The proposed topology exploits a SCIG having two sets of convolutions, one is control winding used to regulate agitation of generator, other is power winding worn for propagation of real power. The topology is depicted in the figure 1.

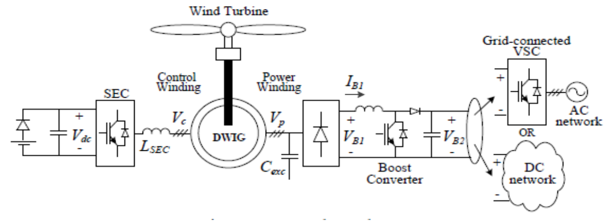

Fig 1: Proposed topology

A semiconductor excitation controller is associated with the winding through a coupling inductor on control winding side. To startup the system, capacitor has to get charged which is on the dc side of semiconductor excitation controller, connected to a low voltage battery via a series diode. The major aspect of SEC is to improve the voltage of control winding. An excitation capacitor and a three-phase diode rectifier are connected on power winding side. Diode rectifier output is united with boost converter. The fluctuating amplitude and frequency voltage is transformed to dc potential by the diode rectifier. Later boost converter modifies power output at maximum power point, which can be achieved by governing the input current of converter. By the help of grid linked converter the gain voltage of boost converter is organized to higher steady value. In extension, the outcome of boost converter is linked to dc network with generator potentiallike HVDC.

The proposed topology is standardized into four sections preceding DWIG, Boost Converter, Fuzzy Logic Controller, Fuzzy based Boost Converter.

1. DUAL STATOR WINDING INDUCTION GENERATOR

For standalone power systems and renewable energy power systems, it has become an encouraging guidance. DWIG is incredible of appearing multiport electronic machine. By considering voltage Vs frequency characteristics semiconductor agitation controller of dual stator winding induction generator take advantage of control winding

In order to excite DWIG semiconductor excitation converter plays a major role of regulating the control winding voltage (V_c). To serve this aspiration, the SEC dc link voltage (V_{dc}) is adjusted to a quotation value. In

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aforementioned paper, to regulate V_C and V_{DC}, control winding voltage adapted control strategy is hired delineated in figure 2.

Voltage oriented control mechanism to monitor the control-winding voltage and DC-link voltage. This can be achieved by supervise of control winding d-axis current and control winding q-axis current. In this control strategy, a decoupling strategy with PI controller is used by the controller to control d-axis and q-axis currents separately. DC link voltage is correlated with its reference value and the glitch is given as input to the PI controller, then the control winding d-axis current is determined. In the same way, the control winding d-axis voltage is correlated with its mentioned value adopting another PI controller, and then control winding q-axis reference current is resolved.

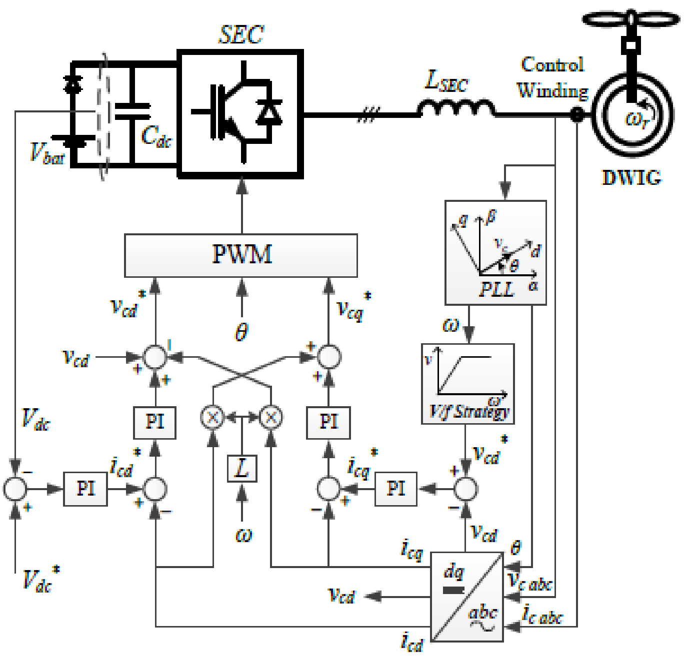

Fig 2: Control winding voltage oriented control strategy of DWIG

In aforementionedscenario, q-axis voltage is zero by coordinating control winding voltage with d- axis which can be described in [5]. By considering the equations explained in [4][6]it is determined that the SEC dc link potential and control winding voltage are supervised by the regulation of i_{cd} and i_{cq} respectively.In control winding voltage oriented agitation control scenario shown in fig 2 handles a voltage V_s frequency strategy, at low frequency operation analogous to little alternator speed so that d axis voltage of control winding is resolved based on operating frequency.

2. BOOST CONVERTER

Boost converter is a power device; it gives a constant high DC voltage as output without varying the voltage on input. It comprises of semiconductor devices, diode and switching devices such as IGBT, thyristor or MOSFET etc. The duty cycle of switching device is controlled by the input output voltage ratio. The duty ratio varies between 0 and 1. The boost converter output derived as follows.

i.e., $V = V_S / (1-D)$

$$D = T_{ON} / T$$

$$T = T_{ON} + T_{OFF}$$

In this paper, the boost converter regulates the alternator real power established on maximum power point tracking with the guidance of fuzzy logic controller. Conferring V/f scenario the DWIG voltage is declined then the boost converter contributes vast speed range of application even at low speed status. It also entertains the rise in yield voltage and links alternator to above steady level of voltage.

Boost converter is connected on power winding side of DWIG through a diode rectifier, whose output dc voltage is given as input to boost converter. It regulates the power output at maximum power point, based on power v_s speed curve.

3. FUZZY LOGIC CONTROLLER

The duty ratio of boost converter is having a non-linear function, fuzzy control technique i.e., non linear control method is applied to restrict the boost converter. The tracking performance was improved using fuzzy logic control algorithm.

For developing a fuzzy logic controller, four essential components are requireddisplayed in figure 4.

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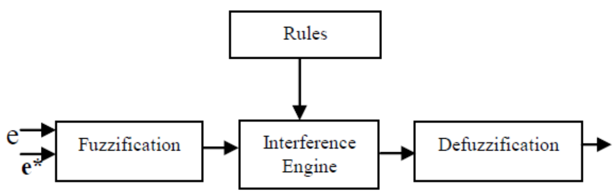

Fig 4: Fuzzy Logic Controller

FUZZIFICATION:

The rule table of fuzzy controller is shown in table 1. The table depicts membership function values that designate to linguistic variables utilizing seven subsets of fuzzy, which are Negative big, Negative medium, Negative small, Negative zero, Positive big, Positive small, Positive medium. Here e and e^* are input variables. The error between actual voltage to reference voltage is represented by e and the change in error is represented by e^*.

Table 1: Fuzzy Logic Controller RULE table

e^* / e	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	NM	NM	NS	ZE	PS
NS	NB	NM	NS	NS	ZE	PS	PM
ZE	NB	NM	NS	ZE	PS	PM	PB
PS	NM	NS	ZE	PS	PS	PM	PB
PM	NS	ZE	PS	PM	PM	PB	PB
PB	ZE	PS	PM	PB	PB	PB	PB

INFERENCE ENGINE:

Mamdani's method, it is a fuzzy inference approach which utilizes max-min fuzzy operation combination. It is based on fuzzy rule base system. In the engine block, the rules are framed and the commonly used method is Max-Min.

DEFUZZIFICATION:

Fuzzy subset, output of fuzzy controller. If a non fuzzy value is essential for actual system then defuzzification is mandatory. By using defuzzifier the actual value can be obtained from linguistic fuzzy. The input of pulse width modulator generator, error and change in errors membership functions are shown in figure 5.

The membership function of duty ratio is shown in figure 6.

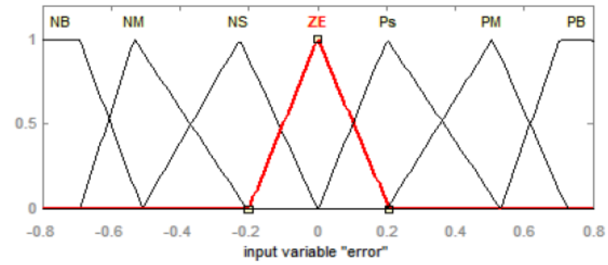

Fig 5: Error Membership Function (e)

Fig: 13 Membership functions for Error (e)

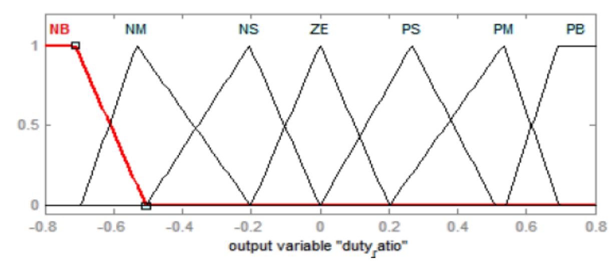

Fig 6: Duty Ratio Membership Function

The fuzzy logic controller rule base surface is shown in figure7.

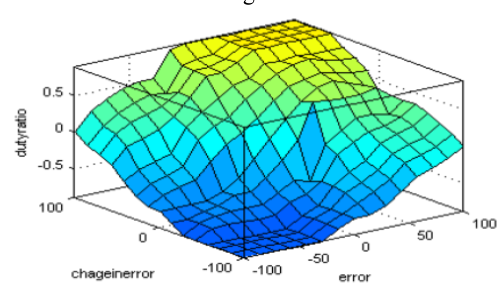

Fig 7: FLC Rule Base Surface

4. FUZZY BASED BOOST CONVERTER

To sustain steady output voltage in boost converter fuzzy logic controller is popularized. The fuzzy controller based boost converter Simulinkrepresentation is shown in figure 8.

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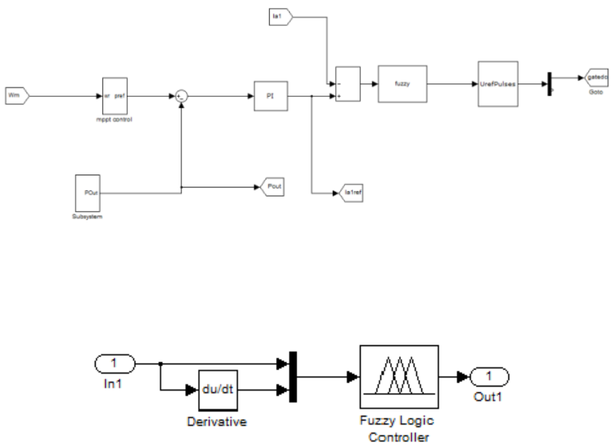

Fig 8: Simulink model of fuzzy based boost converter and fuzzy controller design

The fuzzy based boost converter Simulink model parameter configuration is depicted in table 2.

Table 2: Simulink circuit configuration of fuzzy based boost converter

Carrier frequency of PWM generator	2500H Z
Sample time	50e-6
Proportional gain (Kp)	3
Integral gain (Ki)	0.6

III.SIMULATION RESULTS

Employing MATLAB/Simulink platform, the proposed topology is simulated to figure out its achievement. In the proposed structure, the boost converter is associated with the grid through a three-phase voltage source converter. Here the used DWIG system has rating of about 2.3MW.

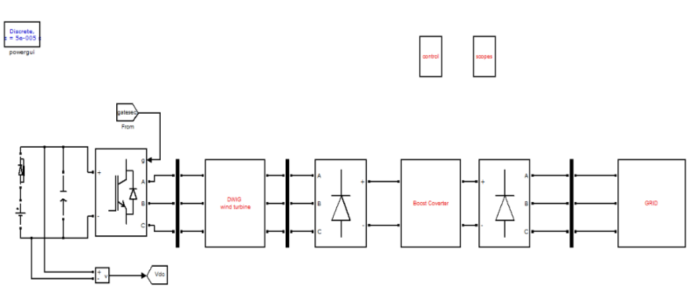

Fig 9: Simulation diagram for proposed system using MATLAB/SIMULINK

The parameters of dual winding stator induction generator system are tabulated in table 3.

Table 3: Parameters of DWIG System

Output power	1Kw
Control winding line voltage	230V
Pole pair	2
Base frequency	50Hz
Base rotation speed	1 5 0 0 rpm
Power winding leakage inductance	4.9mH
Control winding leakage inductance	5.2mH
Battery voltage	48V
SEC dc link voltage	400V
SEC coupling inductor	8mH
SEC dc link capacitor	560uF
Excitation capacitor	77uF
Boost converter output voltage	200V
Boost converter inductor	10mH
Boost converter capacitor	470uF

*All generator parameters are referred to power winding side

The simulation results of proposed system are shown in figure 10.

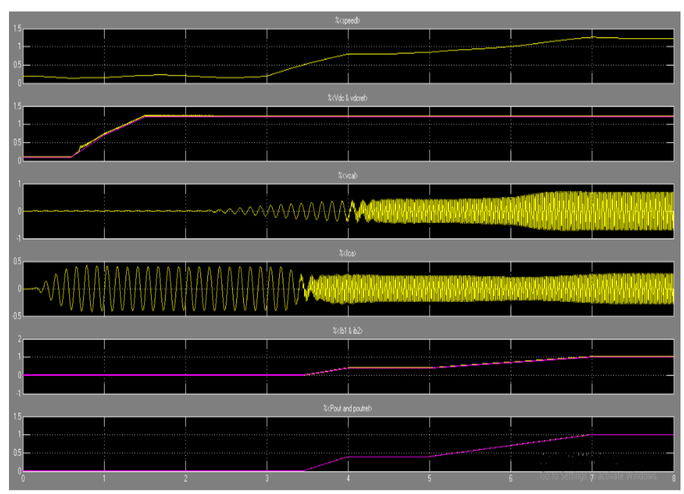

Fig 10: Simulation results of 2.3MW DWIG system

The simulation results shows change in speed, change in dc link voltage, control winding

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voltage of phase A , control winding current, boost converter input current, power output.

The speed graph shows, the rotor speed kickoff of prime mover from 0.2p.u to 0.8p.u and from 0.8p.u to 1.22p.u at t=3s and at t=5s respectively.

The dc link voltage graph shows that it pursues its reference indicator to attain its nominal rate of 1.22p.u.

By examining the dc link voltage and control winding voltage, it is determined that DWIG agitation scenario has a good conduct in control winding voltage management.

The power output graph shows the power infused into the grid with the help of semiconductor excitation controller.

The simulation results demonstrate the voltage source converter excites DWIG, the boost converter perform the controlling of output power at variable speeds. By utilizing fuzzy based boost converter in the proposed system, maximum power point chase can be accomplished when compared with PI based one.

IV.CONCLUSION

This paper comes up with a topology for volatile speed wind power utilization with the help of DWIG. A fuzzy based boost converter is used for extensive fluctuating speed range operation and MPP. The use of fuzzy instead of PI controller is due to faster settling response with lesser eruption. At low speeds voltage of DWIG get discarded due to V/f scenario and to develop the voltage level in order to reach the steady and higher voltage stipulation, boost converter is used. Decisively, to validate the legitimate operation of recommended topology, simulation results are conferred to verify the ample speed operation.

V.REFERNCES

[1] H.Li and Z. CHEN, “Overview Of Different Wind Generator Systems And Their Comparisons”, IEEE Journal of Renewable Power Generation, volume 2, issue 2, June 2008.

[2] Lars Henrik Hansen, L Helle, F. Blaabjerg,“Conceptual Survey Of Generator And Power Electronics For Wind Turbines”, in Power Conversion And Control of Wind Energy Systems,June 2002.

[3] “Developments in Wind Turbine Generator Systems”, Scholarly article, May 2009.

[4] Ayoub Kavousi, S. Hamid Fathi,“Boost Converter application to Increase the Speed Range of Dual Stator Winding Induction Generator in Wind Power Systems”, IEEE Journal on Power Electronics, June 2018.

[5] H. Xu, F.Bu, W.Huang, “Dynamic Performance And Control Of Five Phase DWIG DC Generating System”, volume 64, no.7, in IEEEJournal on Industrial Electronics, July 2017.

[6] M.P., “Theory (Instantaneous Power Theory and Applications to Power Conditioning; Akagi, H.et al; 2007),”IEEE Industrial Electronics Magazine, Fall 2007.

[7] F. Bu, Y. Hu, W. Huang, “Wide Speed Range Operation DWIG DC Generating System For Wind Power Applications”, in IEEE journal on Power Electronics, Feb 2015.

[8] “Grid Connected DWIG Wind Power System For Wide Wind Speed Range”, K.Shi, P. Xu, Z.Wan, Journal of Power Electronics, volume16, no.4, July 2016.

[9] “Rotor Speed Stability Improvement of DWIG Based Wind Farms by Control Winding Voltage Oriented Control”, M. Hassan Zamani, G. Hossain Riahy, IEEE Transaction on Energy Conversion, vol 31, Aug 2016.

[10] “Analysis, Comparison, and Discussion of Control Strategies For DWIG DC Generating Systems”, H. Xu, F.Bu, Y.Hu, H.Liu, IEEE Transaction on Power Electronics, volume .4, Sept 2016.

[11] “Variable Speed Wind Energy Conversion System Based on Dual Stator Winding Induction Generator”, J. A. Barrado-Rodriago, J. I. Tapolane and L. Martinez, IET Journal of Emerging and Selected Topics in Renewable Power Generation, vol.11 2017.

[12] “DWIG Problems, Progress, and Future scope”, S. Basak and C.Chakraborty, IEEE Transactions on Industrial applications, volume 62, July 2015.

[13] “Parameter Design And Static Performance Of DWIG Variable Frequency AC Generating

ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

System With Inductive And Capacitive Loads", F. Bu, Y.Hu, W. Huang and S.Zhung, IEEE Transaction on Industrial Electronics, vol. 61, Aug 2014.

[14] "Asymmetrical Operation Analysis for DWIG Variable Frequency AC Generating Systems with Unbalanced Loads", F.Bu, S.Zhuang, W.Huang, N.Su, IEEE journal on Industrial Electronics, Jan 2017.

