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Improvement Of Voltage Stability In WECS Using Of Two Mass Drive Train And PWM Converter

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Abstract

This paper deals with the wind power generation using asynchronous generator (PMSG) Feeding 3ø load at grid side and its problem associated with it. In WECS comprising PMSG, capacitor bank, diode rectifier, dc link, 3ø pulse width modulation inverter ,LC filter,3ø load feeding the grid .3ø ac-dc-ac converter ,wind turbine, PMSG , Two mass drive train is modelled in this paper using MATLAB/SIMULINK . voltage stability analysis has been done and also get the maximum power from wind ,variable speed wind energy conversion system should be established. The many variables, which influence harmonics and resonance in wind power plants, will described with respect to analysis methods, mitigations, avoidance. The entire system has been modelled and simulated using power system block set in MALAB to obtain the result.

Keyword *–WECS, Two Mass Drive Train, PMSG, Ac-Dc-Ac Converter*

1. INTRODUCTION

Wind energy is one of the fastest growing renewable energies in the world. The generation of wind power is clean and non-polluting; it does not produce any by products harmful to the environment. Nowadays, modelling and simulation is the basic tool for analysis, such as optimization, project, design and control. Wind energy conversion systems are very different in nature from Conventional generators and therefore dynamic studies must be addressed in order to integrated wind power into the power system. differential heating of earth and surface by the sun causes the movement of air masses on the surfaces of the earth i.e. the wind W.E.C.S. convert the K.E. of wind into electrically or other forms of energy. Wind power generation has experienced a tremendous growth in past decade and has been recognised as an environmentally friendly and economically completive means of electric power generate. In fig.1 shown a layout of such a WECS . The prime mover employed is generally a wind turbine and the variable speed generator is use a PMSG on account of its simplicity, ruggedness, low cost and ease of implementation .The erratic nature of wind speed , the generator acts as a source of variable voltage and frequency. Directly interfacing this PMSG to the grid give rise to the following problem like the voltage fluctuation, inability of the generator to extract and feed power to grid at speeds below the synchronous speed and the added tendency to act as a motor, generation of sub harmonics or harmonics associated with the pulsating torque characteristic of wind driving the PMSG. The configuration of the interface employed is generally a rectifier-inverter system connected through a DC link.

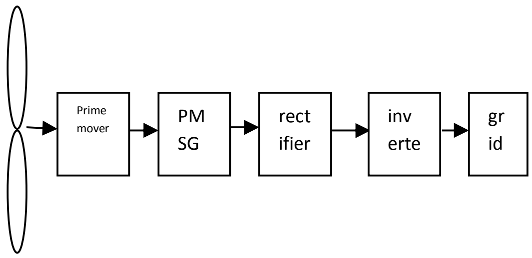

Fig.1 generalized block diagram of wind energy conversion system

WECS produce electricity by using the power of wind to drive an electrical generator. The conversion of the kinetic energy of the incoming air stream into the electrical energy takes place in two steps: the extraction device, i.e., the wind turbine rotor captures the wind power movement by means of aerodynamically designed blades, and converts it into rotating mechanical energy, which drives the generator rotor. The electrical generator then converts this rotating mechanical power into electrical power. A gear box may be used to match the rotational speed of the wind turbine rotor with one that is appropriate for the generator. The electrical power is then transferred to the grid through a transformer. The connection of the wind turbine to the grid is possible at different levels of voltage, with a common level being 450-500 V. Power electronics converters can also be used for enhanced power extraction and variable speed operation of the wind turbine.

2. PROPOSEDSYSTEM CONFIGURATION

Figure 4-1 illustrates the topology of a typical power converter of (asynchronous generator) PMSG for grid connection with a 3-phase diode bridge voltage source converter (VSC). At the generator side, the 3-Ph diode rectifier circuit consists of six diodes, a dc link capacitor and at the grid side, the full bridge inverter is possessed of 6 (MOSFET)IGBTs. For this type of converter, the current from the wind turbine generator can only flow toward to the grid, i.e. one way power flows from the generator to the grid. AC power from the permanent magnet synchronous generator is converted into DC power through the rectifier diode bridge, and then inverted to AC for grid connection by means of the full IGBT inverter bridge.

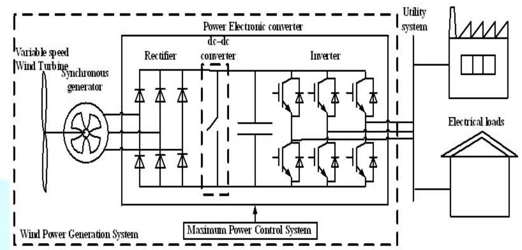

Fig.2.1 layout of PMSG based on WECS

This configuration decouples the wind turbine generator from the grid by the diode bridge. The VSC controller stabilises the voltage V_{dc} of the DC link using the capacitor between the rectifier diode-based bridge and the full IGBT inverter bridge. Because most wind turbines work at start up with a large drag especially for a large scale wind turbine, the wind turbine generator requires high torque to drive it. The popular solution for this problem is either to design a wind turbine with low start up wind speed or to provide an additional driver component.

2.1 Wind Turbine Model

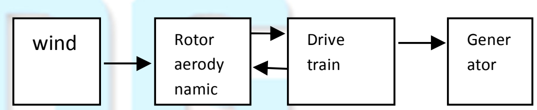

Fig.2.2 Diagram of wind turbine

The wind turbine model consisting of aerodynamic, drive train .electrical generator The wind turbine extracts a portion of wind power (P_{wind}) from the swept area of the rotor disc and converts it into mechanical power (P_m) as determined below

$$Pm = 1 \div 2Cp(\alpha, \beta)\rho A v \qquad (2.1)$$

Tw = Pwind/ωm (2.2)

Tw = {1/2Cp(α, β)ρAv3}/ωm (2.3)

Where

P_m= mechanical power extracted from turbine

T_w=mechanical torque extracted from turbine rotor

A=rotor area or covered area=$A = \pi R^2$

v= velocity of the wind [m/s]

ρ=air density [kg/m^3]

C_P= performance coefficient

α =tip speed ratio

□□rotor blade pitch angle[rad.]

Rotor Torque Tw = {1/2πCp(α, β)ρR2v3}/ωm

$$1 \div \gamma = \left\{\frac{1}{\alpha + 0.08\beta}\right\} - \frac{0.035}{1+\beta 3} \quad (2.4)$$

is the free wind speed (m/s). The power coefficient (C_P €0. 0.593) can be maximized for a given wind speed by optimally adjusting the values of tip speed ratio and the blade pitch angle using data supplied by the manufacturer. In this thesis, through the optimal choice of CP for a given wind speed, P_m and ω_m (rotor mechanical speed) are assumed to be known and are used as inputs to the synchronous generator. Introduction to variable-speed wind turbine with PMSG

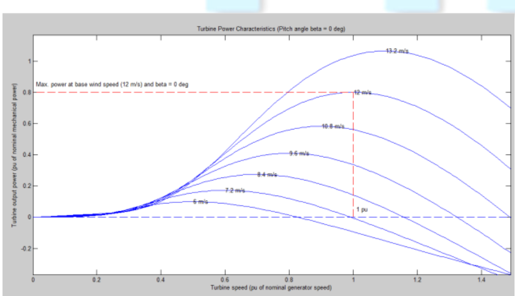

Fig.2.3C_p-α characteristics curve

2.2 MODELLING OF THE PMSG

The generator can be magnetised electrically or by permanent magnets. Two types of synchronous generators have often been used in the wind turbine industry: (1) the wound rotor synchronous generator (WRSG) and (2) the permanent magnet synchronous generator (PMSG. The synchronous generator with a suitable number of poles can be used for direct-drive applications without any gearbox. PMSGs do not require external excitation current, meaning less losses, improved efficiency and more compact size. This is the topology studied in this paper. Parameters of electrical generators are often specified in terms of per unit. Calculations are simplified because quantities expressed as per unit are the same regardless of the voltage level. Similar types of apparatus will have impedances, voltage drops and losses that are the same when expressed as a per-unit fraction of the equipment rating, even if the unit size varies widely. Although the use of p.u. values may at first sight seem a rather indirect method of expression there are several reasons for using a

TABLE3.1 PMSG WIND TIRBINE PARAMETER

PARAMETER	Value	Unit
Nominal power	8.5e3	W
Wind speed	12	m/s
Base rotational speed	1	-
No. of poles	6	-
Frequency	50	Hz
Voltage constant	500	V
Moment of inertia	0.002	Kg.m^2

- the use of the constant √3 is rduced in three-phase calculations.
- per unit quantities are the same on either side of a generator, independent of voltage level.
- by normalizing quantities to a common base, both hand and automation calculations are simplified.

3. IMPLEMENTATION OF WECS IN MATAB/SIMULINK

In this various component of WECS like wind turbine, PMSG, diode rectifier, dc link , LC filter drive train and their control system is implemented in MATLAB/SIMULINK power system library.

3.1 PROPOSED WECS BASED ON AC-DC-AC PWM CONVERTER

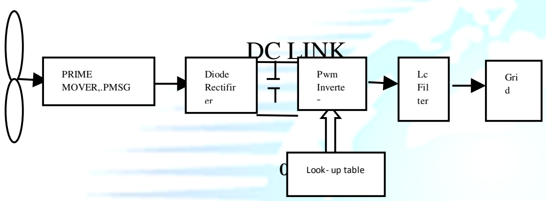

Fig.3.1 proposed WECS

The whole system is modelled using MATLAB/SIMULINK environment by using power system library and its tool box the proposed WECS system as shown in fig.3 is implemented using MATLAB /SIMULINK shown in fig.4.

3.2 TWO MASS DRIVE TRAIN

The two mass drive train model implemented in MATLAB/SIMULINK is shown in fig.5. In this model there is coupling between turbine and shaft. The above subsystem will give shaft torque T.shaft (pu) , wind power W_{wt} as output and T_{wt}(pu), generator speed as input. It is an example of closed loop control system where feedback is provided just before the gain (1).The input is amplified through gain then it multiplied by given transfer func.

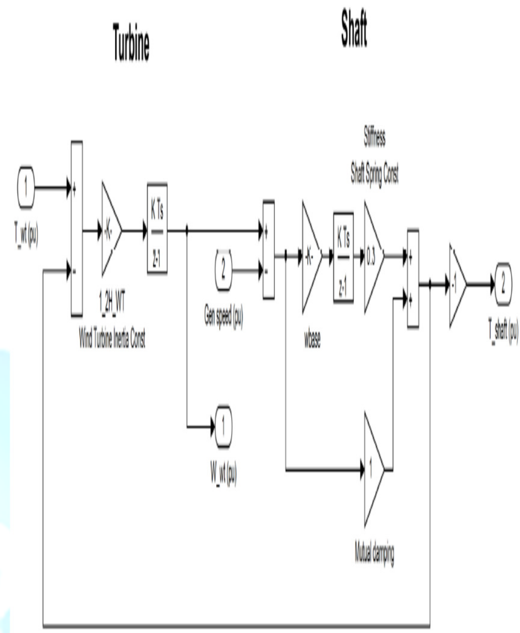

Fig.3.2 two mass drive train

4. SIMULATION MODEL AND RESULT

The comparison between experimentation and simulation wave forms are observed with per unit and the same are displayed.

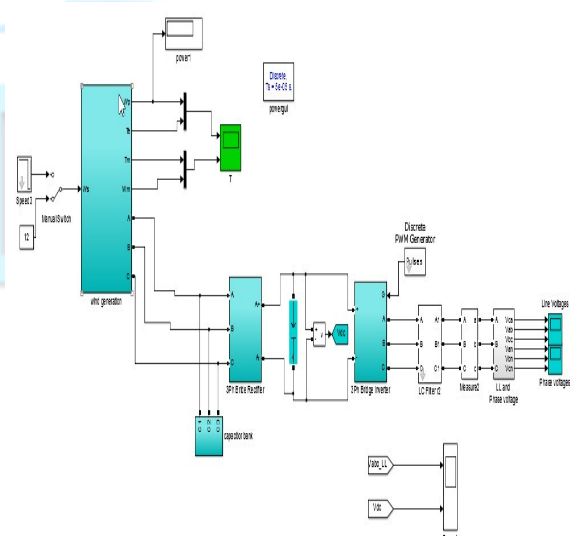

Fig5.1 MATLAB/SIMULINK model of WECS

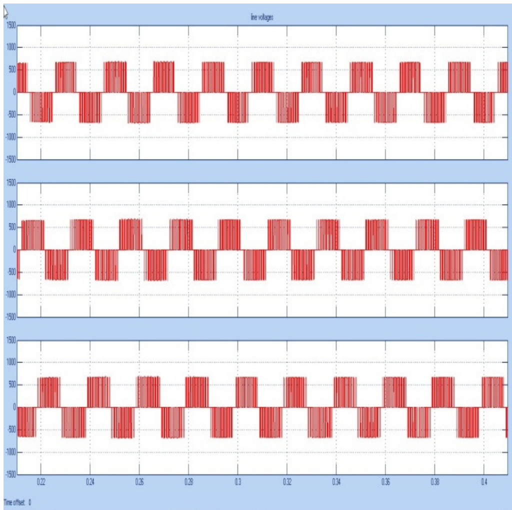

Fig.4.1(a)Line voltage at grid side

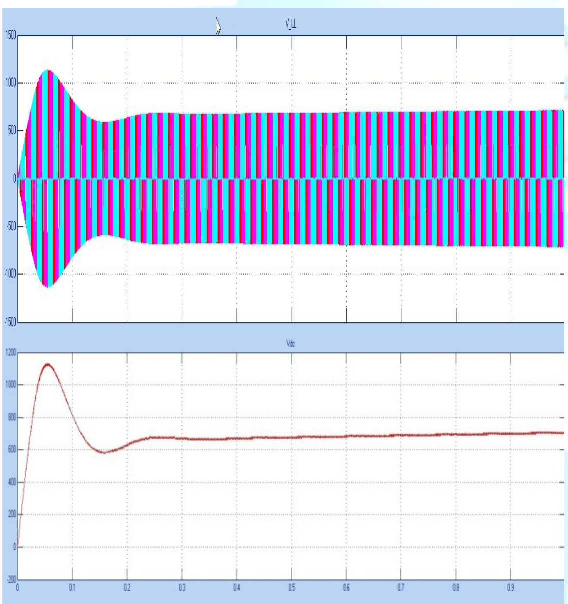

Fig.5.2(b) volatage at inverter and rectifier side

(a) and (b) experimental dc voltage at rectifier side and line voltage at inverter side waveform

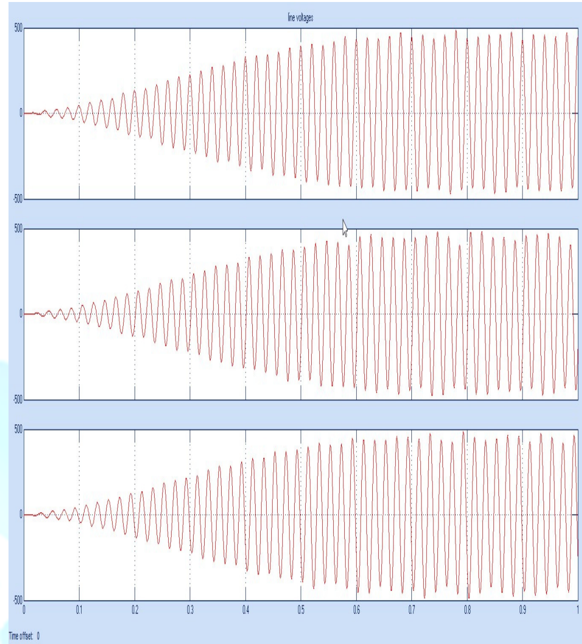

Fig.4.3(c) line voltage at grid side without harmonic

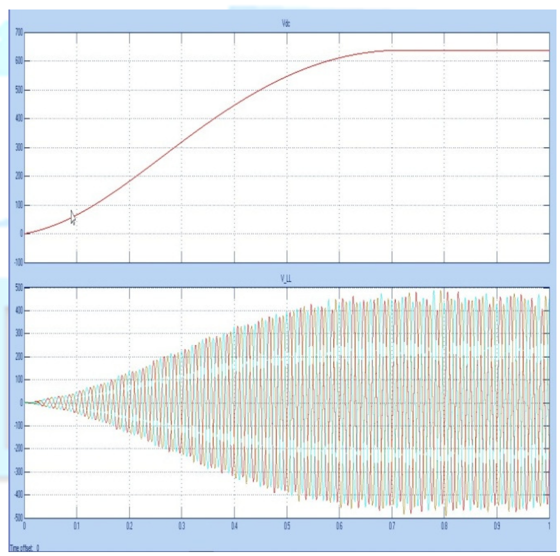

Fig.4.4 (d) voltage at inverter and rectifier side with DC link Capacitor, LC filter

(c) and (d) simulated dc voltage at rectifier side and line voltage at inverter side waveform

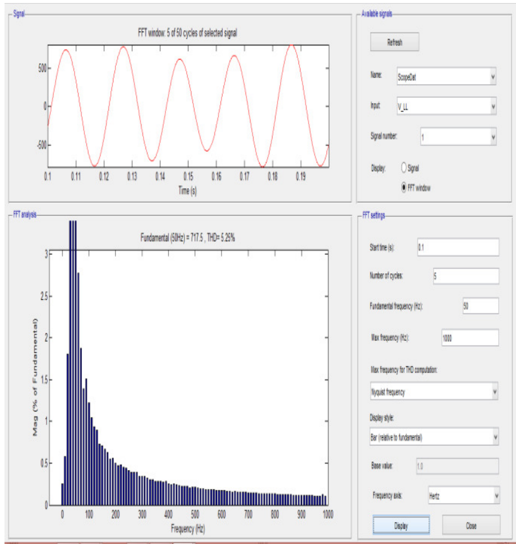

Fig .4.5 FFT analysis

5. CONCLUSION

In this paper, a variable speed wind energy conversion system (WECS) has been developed using MATLAB/SIMULINK. Mathematical model of various components of the WECS like wind turbine, two mass drive train, PMSG generator, and AC-DC-AC converter along with their controls has been discussed and developed. The energy extracted from wind is transferred from the generator to the dc-link by the generator-side rectifier and then to the utility by the grid side inverter. The capacitor bank is effectively avoided input displacement factor is zero and draws no reactive power. The dc-link capacitor provides decoupling between the generator-side and grid-side converter, a thereby offers separate control flexibilities for the power converters .The developed model and its control was simulated in MATLAB/SIMULINK and tested/validated for different conditions i.e. constant and variable wind speed, different faults like three phase to ground etc**.**

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