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Wind Energy Conversion System Using PMSG for Standalone Load

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Abstract

This paper is aim to presenting Wind Energy conversion System. In this article, we focus on the technique used in the converter. We discuss on the wind turbine modelling introduced in this work. There is new circuit topologies PMSG with rising focus aimed towards Wind Turbine manufacturing. The output of the PMSG is Three Phase Sinusoidal Waveform. The all topology simulate in the MATLAB Simulink environment.

Keywords: PMSG, Wind Turbine, Controlled Rectifier, Uncontrolled Rectifier, Sinusoidal Pulse Width Modulation, Space Vector Controlled technique

1 Introduction

Wind energy is now incipient as renewable source of electricity assembly. Direct focused, standalone or grid connected permanent magnet synchronous generator (PMSG) exemplifies as new leaning in embryonic power from wind. Wind generation levels are growing in power systems around the domain in response to increased density to ease carbon dioxide CO2 ranks and reliance on fossil fuels. There has been rising awareness in wind energy. For pull out power from wind energy and different type of generator are used to generate electricity. The communal AC generator type, which are utilized in up-to-the-minute wind turbine system are asbelow:

- Squirrel-Cage Rotor Induction Generator(SCIG)
- Wound-Rotor Induction Generator(WRIG)
- Synchronous Generator (With External Filed Excitation)
- Doubly-Fed Induction Generator(DFIG)
- Permanent Magnet Synchronous Generator(PMSG)

The above mentioned system uses PMSG in standalone wind energy conversion system. But nowadays it is implemented on grid connected load. The advantage of PMSG compared to induction generator include better efficiency and dependability and external excitation is not required, and its size is small and demonstrates simple control. PMSG is more striking solution in variable speed wind turbine application. An actual WECS can be considered as of two types:

- Isolated standalone system
- Grid connected system

A full scale voltage source converter is connected with PMSG: generator converter is utilized for controlling torque as well as speed. Grid side converter is employed for controlling the power flowing, so that, there will be a constant DC-link voltage. Two converters are connected using dc link capacitor so that self- determining control of two converters is ensured. Recently many converter topologies have been evolve for integrating wind generator to the grid[1-14].

2 Wind Energy Conversion Systems

The technology of Wind energy has grown increasingly over the past three periods.

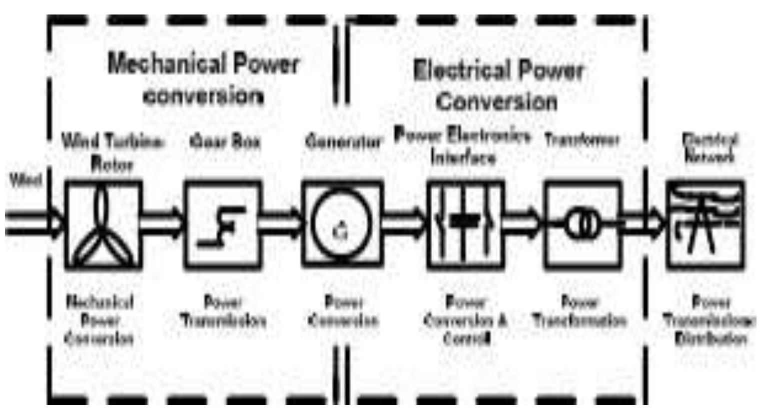

Figure 1 Elements of Wind Energy Conversion System

Blades (Aerodynamically made) of wind turbine seizure power from wind and transforms wind's kinetic energy into rotating mechanical energy. In order to be in part with the operational speed of wind turbine to speed of generator a gear- box is hosted. A multi-pole PMSG either completely removes the gearbox or reduces its size. For de-coupling the generator from grid and to permit wind turbine's variable speed control, power electronic converter is used as shown in the Fig.1

3 Modelling of Wind Energy Conversion System

The Wind Energy Conversion System modelling is done in the Simulink environment of MATLAB. So, in footing we take the wind speed. We know that speed of wind is variable in nature and it is varies with respect to the time that is 5-25m/sec. It means it is not flow in a constant routine. So we take the manual switch whose one input is wind speed and other input is lookup table with define the variation of wind speed as shown in Fig.2.

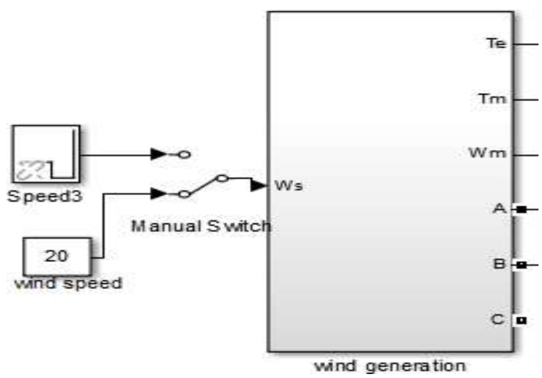

Figure 2 Manual Switch Connected to the Wind Generator

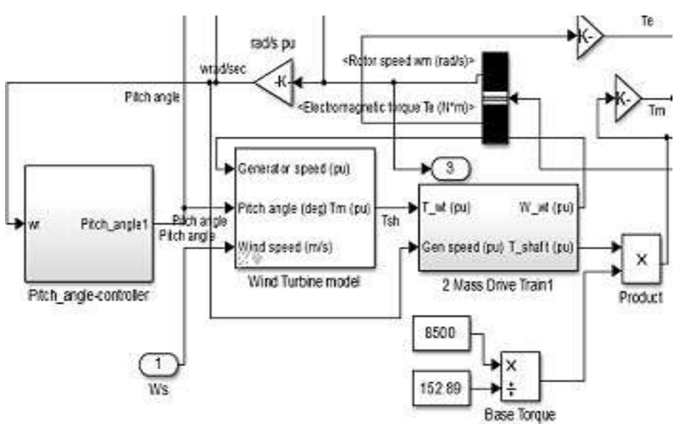

Figure 3 Wind Energy Conversion System

This manual switch is the wind turbine'sinput. The wind turbine's input is generator speed, pitch angle and wind speed andthe resultant output of the wind turbine is obtained from the mechanical torque shown in Fig 3.

The relationship between wind power and speed is

$$P_{win} = 0.5 \rho_{air} \pi R^2 (V_{wind})^3 \quad (1)$$

Where,

ρ_{air} refers to air density (1.23 kg/m3) and it relies on pressure, temperature and humidity.

R indicates rotor radius

and V_{wind} stands for wind speed.

Tm is the mechanical torque Now,

$$P_{mech} = C_p P_{wind} \quad (2)$$

Where C_p is around 0.59

$$P_{mech} = 0.5\, C_p \rho_{air} \pi R^2 (V_{wind})^3 \quad (3)$$

$$P_{mech} = f(\omega_{turb},, V_{wind}, \beta) \quad (4)$$

Now torque is expressed as

$$T_m = P_{mech} / \omega_{turb} \quad (5)$$

For getting the pitch angle the rotor speed of turbine is compare with the reference rotor speed and the output of this is gain by pitch gain and limit the value to get the pitch angle model shown Fig.4

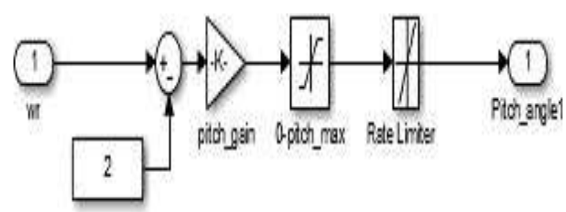

Figure 4 Pitch Angle Model

After this wind energy conversion system the PMSG is connected to wind turbine's output that is the mechanical torque. And this PMSG rotor speed and electromagnetic torque forms the input to the pitch angle and wind turbine. The whole model make the close loop.

4 Modelling of PMSG

The PMSG is to be regarded as a system that renders the possibility of generating electricity from mechanical energy received from wind true. In this modelling the three phase rotating phase is converted in to the two phase stationary axis that is d-q axis. The mathematical model of the PMSG in the two stationary axis.

did/dt = Vd/Lds – rs*id/Lds+Lqs*we*iq/Lds (6)

diq/dt = (Vq/Lqs)– (rs*iq/Lqs) –(Lds*we*id/Lqs)–(Ψ*we/Lqs) (7)
we=P*wm (8)
Te= 1.5*P((Lds – Lqs)id*iq+iq*Ψ (9)
dwe/dt = (Te –F*wm –Tm)/J (10)

Where,

Vd /id refers to d-axis voltage according to current, Vq /iq refers to q-axis voltage according to current, rs indicates resistance of stator, Lds represents inductance of stator d-axis , Lqs indicates inductance of stator q-axis, Ψ represents permanent magnetic flux, we represents electrical speed, P indicates pole pairs, Wm gives mechanical speed, J indicates load and rotor's combined inertia moment, F indicates rotor and load's combined viscous friction, Tm represents mechanical shaft torque.

5 Specification of Parameters

WIND ENERGY CONVERSION SYSTEM	
SPEED OF THE WIND	15 m/sec
NOMINAL MECHANICAL OUTPUT POWER	10 KW
ELECTRIC GENERATOR'S BASE POWER	10KW/0.9
MAXIMUM POWER AT BASE WIND SPEED	0.8
SPEED OF BASE ROTATION	1
PITCH ANGLE	0
SPEED OF THE TURBINE	152.89 RAD/SEC
PERMANENT MAGNET SYNCHRONOUS GENERATOR	
PHASE COUNT	3
BACK EMF SHAPE	SINUSOIDAL
TYPE OF ROTOR	ROTOR
MECHANICALINPUT	TORQUE TM
RESISTANCE OF STATOR	0.425
INDUCTANCE OF ARMATURE	0.000835 H
FLUX LINKAGE	0.433
VOLTAGE CONSTANT	392.6876
TORQUE CONSTANT	3.2475
INERTIA'S MOMENT	0.01197
POLECOUNT	10
LOAD	10KW

6 Simulation Waveform

This paper deals with the resistive load which is connected to permanent magnet synchronous Generator and wind energy converted into electrical energy. The simulation waveforms of mechanical torque, rotor speed of PMSG, Electromagnetic torque of PMSG and load voltage waveform are as following below figure 5,6,7,8.

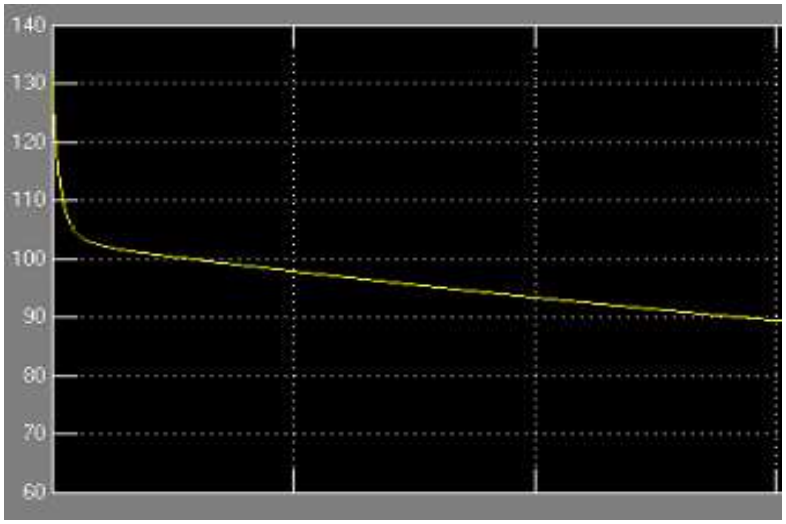

Figure 5 Mechanical Torque

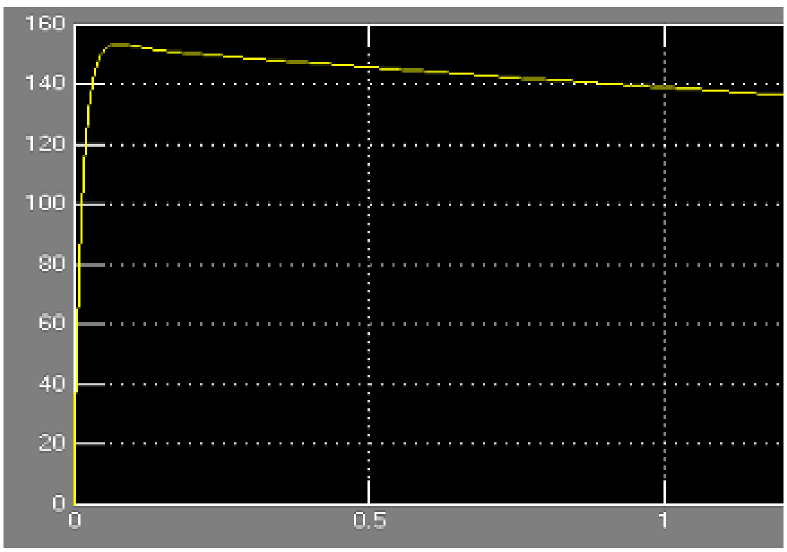

Figure 6 PMSG Rotor Speed

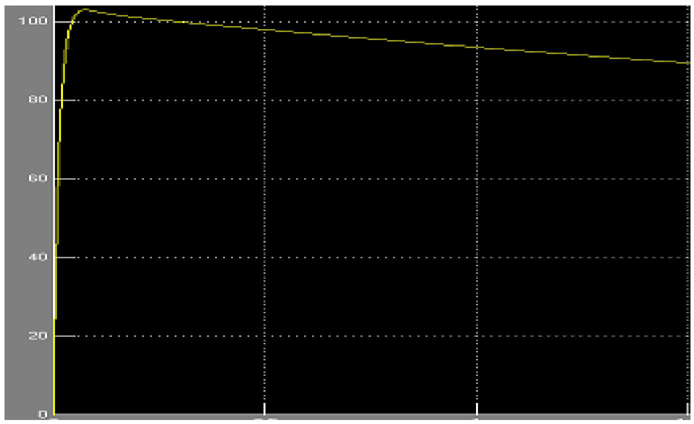

Figure 7 Electromagnetic torque of PMSG

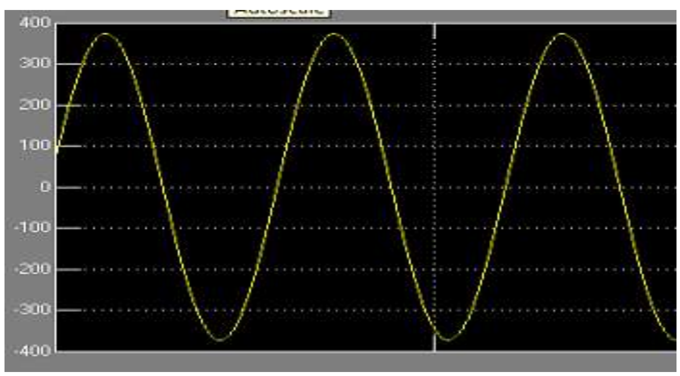

Figure 8 Load Voltage Waveform

The THD of the load at 50Hz is 15.98%(figure 9)

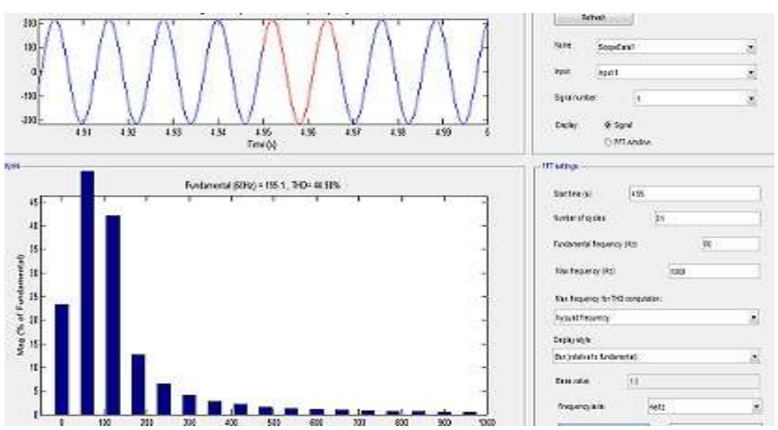

Figure 9 THD of the load

7 Conclusion

In this paper we can see that the output voltage that is the load voltage is near about the desired voltage. This is the one of the prominent environmental condition observed of the wind energy plant site. The THD is very that is the 15.98%withoutanycontrollingtechnique.Thismodel is useful for the low cost application. In future we can work for the rectifier circuit and dc link for DC load, and inverter for AC load.

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