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Analysis of PMSG based Variable Speed Micro Wind Turbine

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Abstract:
Power generation from wind energy can be achieved by available types of generators i.e., DFIG,SCIG and PMSG etc. our main objective is to have reliable ac power to distribution system. This paper illustrating the model of wind power generators working as a Permananet Magnet Synchronous Generator(PMSG). The aims to analyse the characteristics and performances of PMSG under short circuit fault, generation capability at mutual imcompatible current of air speeds, generator's current distortions at different operating speeds. Effectiveness and feasibility of the system proposed system topology were verified using MATLAB/Simulink. Performance of a generator in different scenarios are studied from the obtained results, i.e., the cause of wind speed variations, during normal and during fault condition. After the successful modelling of the proposed system the simulated results will prove the superiority of wind generator type under normal and faulty conditions in distribution system . For the proposed system,the topology and the different conrol strategies were verified effectively using MATLAB/Simulink simulations.

Keywords: *Permanent Magnet Synchronous Generator (PMSG), Wind Turbines(WTs), Power Control Unit(PCU).*

I. INTRODUCTION

As the power demand has been drastically increasing because of increase in population and development in technologies, people are going in search of alternate sources of power. Renewable energy resources like solar, wind, etc. replaces conventionally used fuels in areas like power generation, space heating, motor fuels and rural energy services.

Small Scale conversion systems are the rising trend due to enormous demand for green and clean energy. Due to this, a million units had been installed worldwide. And nearly 250 producers are promoting small wind turbines with the rating of 100 KW. Small Wind turbines with rated power up to 40kw dominate market. However, the average power of installed small wind turbine is about in the range of 1Kw. Special feed-in tariffs were introduced in many countries for Wind turbines(WTs) that make micro WTs with rated power to 3Kw, which was an optimal solution for small communities and residential buildings for those countries.

Wind power uses air flow molecules for a wind turbines to mechanically power generators for electrical power generation. As an alternative to burning fossil fuels Wind power were widely distributed which are abundant, renewable, widely distributed, clean, no greenhouse gas emissions while in operation, no more water consumption and less land is occupied. A wind farm contains large number of single wind turbines, that are coupled to the electric grid. Wind energy is an low-cost source of electrical power than gas or coal plants. With modern technology, wind can be captured efficiently with free of cost. Once Wind turbine is built, it does not cause air pollution. Although wind turbines are installed at greater height, it take up only a small plot

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of land.. Farming is still continued with the available wind farm space in an agricultural areas.. This means that the farm land can be utilized still. Unconnected areas to the power grid can use wind turbines for their energy requirements.WTs play in both the development and third world.

II. PROPOSED MODEL

Conventional PCUs has bridge rectifier and boost converter. In the proposed PCU, galvanically isolated dc–dc converter was utilized. Diode bridges and inverter can be chosen based on power levels, rated for different currents and standard dimensions of heat sinks.

Micro WTs driven by Variable-speed PMSG has various features like wide range of output voltage with the voltage ratio of 1:5. For residential WECS, single switch dc–dc converter is used because of its simple design that yields high output. While injecting the power to the grid from the second stabilized dc link generator side controller is not required. For safe operation, A braking chopper with a resistor is required for safe operation of PCU. The resistor rating is chosen based on power rating of the wind turbine. The proposed METHOD uses a single switch qZS converter which is galvanically isolated. This can be controlled similar to conventional boost converter, which enhances high reliability and high efficiency.The block diagram for the proposed system is given in Fig. 1 and the circuit diagram is shown in Fig. 2.

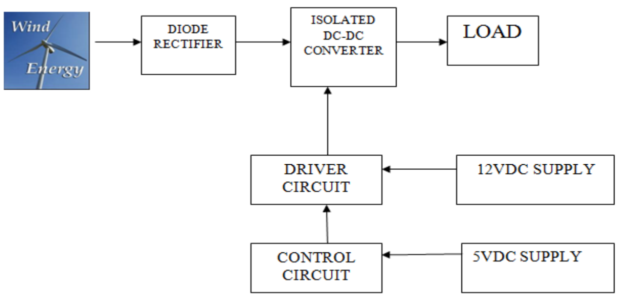

Fig. 1.Block diagram of a proposed system

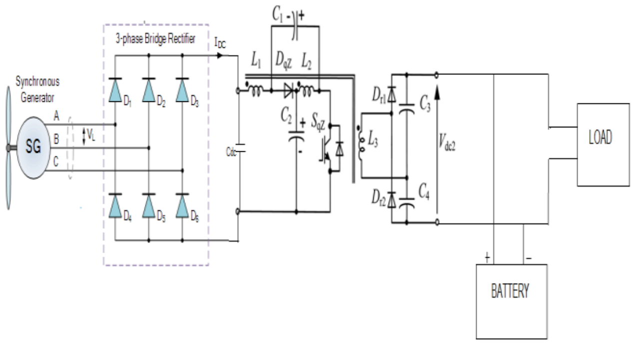

Fig.2.Circuitary setup of a proposed system

III. CALCULATION ANALYSIS

Let Vo=output voltage
Vs=Supply voltage
Ton=Turn on time
Toff= Turn off time
T=Total Time
A=duty cycle
I_R= Ripple Current of an inductor
F=PWM Frequency
V_C=Ripple Voltage of filter capacitor
I_{in}= input current
Io=output current

From the mearurement we obtained, Vo =18
Vs=40.5V
F= 2khz
I_o= 0.272A
I_{in}= 0.612

TABLE 1 PROTOTYPE PARAMETERS OF THE EXPERIMENTAL SETUP

PARAMETER	VALUE
Input voltage range, Vin	40-400V
Maximal input current,Iin	10A
Output voltage,Vout	400V
Swithchingfrequency,Fsw	100kHZ
Turns ratio of the coupled inductors(n)	1:1:1
Magnetizing inductance of the coupled inductors(L_m)	1mH
Leakage inductance of the	15μH

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inductors,(L_l)	
qZS and VDR capacitors, C1to C4	3μF

(i)Duty Cycle calculation

a=Ton/T

Vo= Vs/(1-a)

1-a = Vs/Va

a=1- (Vs / Vo)=1-(18/40.5)

a= 0.6*100= 60%

(ii)***Inductor(L) Calculation***

Since inductor currents are unknown, the ripple current of an inductor cannot be calculated. Hence the estimation for the ripple current is assumed to be in the range of 0.2 to 0.5 the resultant current.

$L_1= dV_{in}/f^* IR_l$

(iii)Capacitor(C) calculation

$C= dV_o/(1-D)f^*R^*VRc1$

$Co= dV_o/f^*R^*VRco$

(iv) Resistor(r) calculation

R= Vo/Io

(v) Selection of Diode

Schottky diodes are used in the converter circuit since it is capable of producing less losses. Forward current ,(I_F)rating is equal to the maximum output current(I_O (max) in this diode.

For better efficiency, the decoupling capacitor value must be selected greater than 1000 or equal to 1000 micro farad.

Schottky diodes have maximum current rating than average rating. Therefore the peak current in the system is not an issue. The other parameters also need to check that the diode should not dissipates more power. It has to handle following parameters:

Simulation has made and several behavior of PMSGs on Generator Terminal ,Output voltage line current power , rotor speed, Pitch angle and Mechanical Torque Waveforms are studied. The simulation circuit and wave modeling circuit using Simulink is given in Figure 3 and Figure 4.

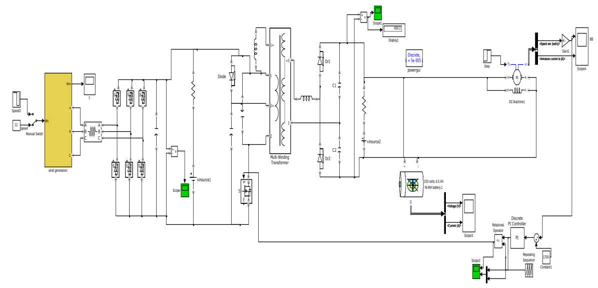

Fig 3.Simulation Circuit of a proposed system

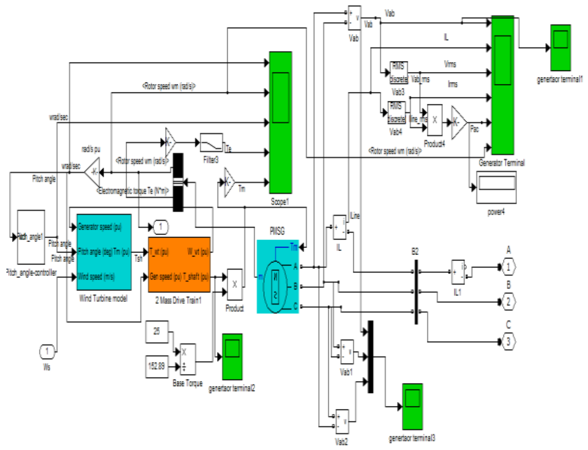

Fig 4. Wave modeling Circuit of a proposed system

Simulation has made and several behavior of PMSGs on Generator Terminal, Output voltage line current power, rotor speed, Pitch angle and Mechanical Torque Waveforms are studied

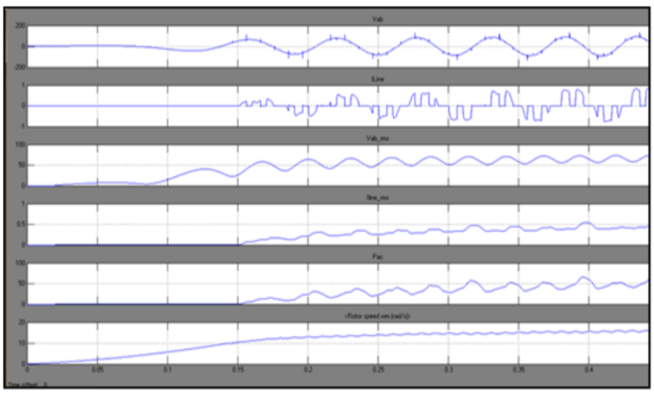

Fig 5**:** Generator terminal: Output voltage, line current power , rotor speed

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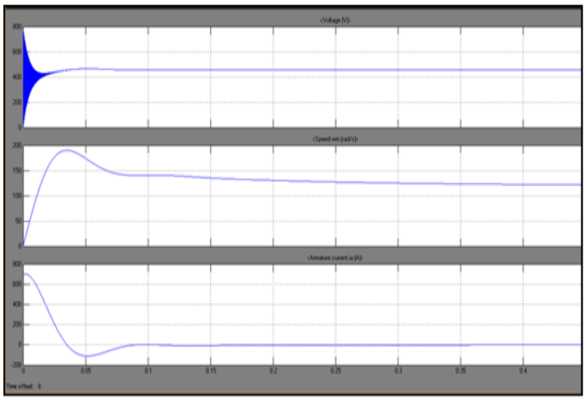

Fig 6: Voltage, Speed, Armature Current

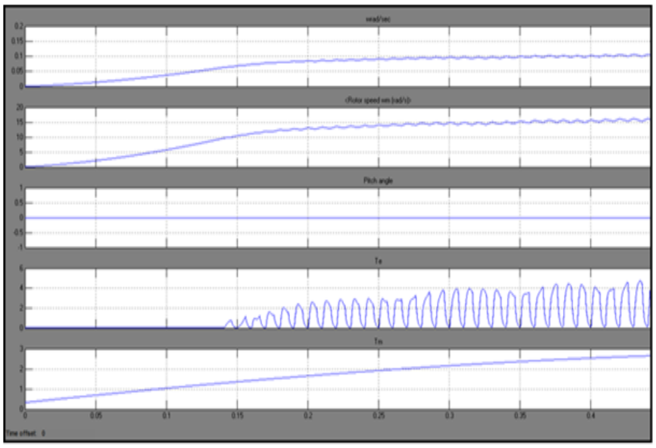

Fig 7: Rotor speed, pitch angle,T_m ,T_e

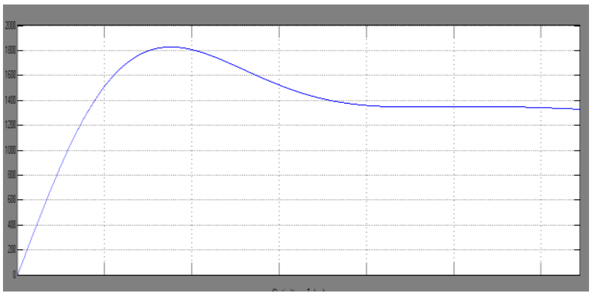

Fig 8: Output Waveform for Speed

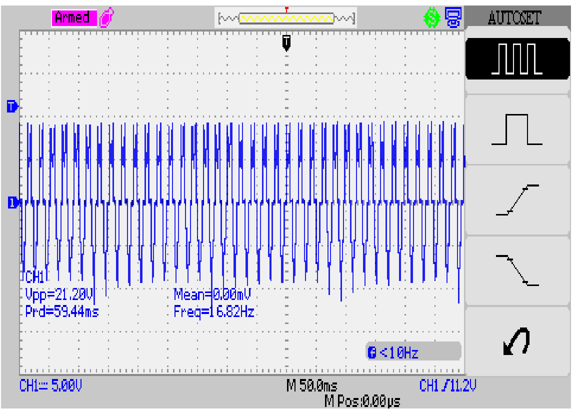

Fig 9: Input Ac Voltage

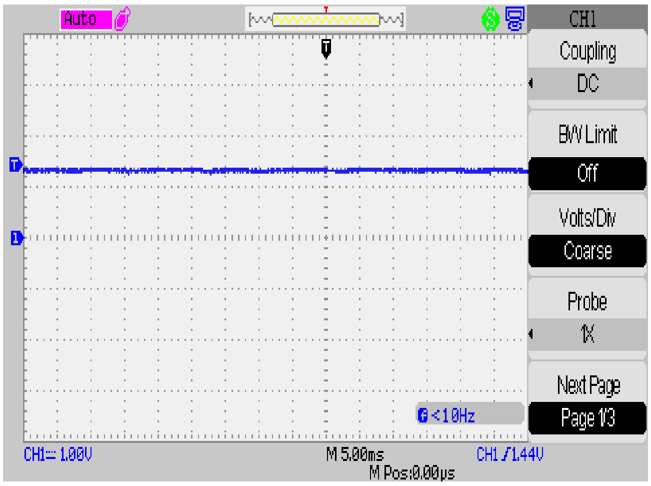

Fig 10: Dc Input Voltage

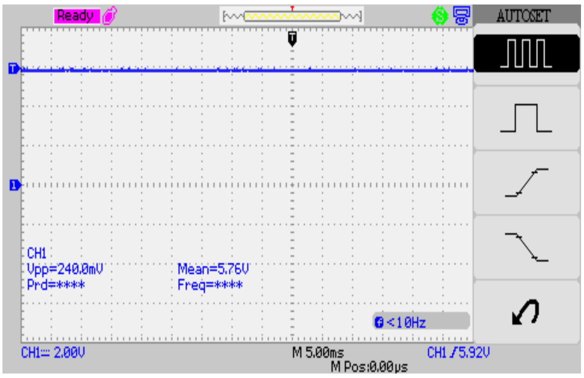

Fig 11:Dc Output Voltage

IV. CONCLUSION

This paper analyses the galvanically isolated PCU coupled with PMSG exclusively meant for micro wind turbine. Integration of sub-KW residential WTs into the distribution grid is made compatible with this kind of arrangement. Performance analysis of the converters is often unnoticed according to the operating profile of a Wind turbine This methodology does not need significant changes of the conventional control systems. Hence an analysis is made on energy conversion performance by means of the efficiency and power losses. The proposed design can reduce the manufacturing costs to several kilo-watt, which makes the number of modules reasonable. To study the scope of WT an experimental prototype based on the dc-dc converter comprised of two modules has been developed. It possess the competence of covering the entire working range of the corresponding WT. The designed module achieves a peak efficiency of 90%

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approximately, inspite of voltage and power variations which complicates the design for achieving greater efficiency.

This proposed method reduces either energy conversion stages or isolated topologies. To design suitable heat sink the power loss measurement based on the experimental study is used. Switching losses and the inductor losses are equal which dominates the other losses.

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