MPPT WITH CURRENT CONTROL FOR A PMSG SWT IN A GRID CONNECTED DC MICRO GRID

Ms. Sanjana U P[1], Ms. Vanitha B[2], Prof. Praveena Anaji[3], Prof. Nagaraja B[4]

[1, 2]UG Students, [3, 4]Assistant Professor
Department of EEE, JIT, DVG

***Abstract*: The increasing demand for electricity and rapid depletion of fossil fuels lead to increased use of renewable energy sources for the power generation. The wind energy is one of the important renewable energy sources which is a better alternative for the future requirements. Although wind energy is available in plenty, it's speed is not constant throughout. So, the work followed is to utilize maximum output power from this variable wind as and when it is available. A simple maximum power point extraction project for a Permanent Magnet Synchronous Generator (PMSG) connected wind turbine supplying power to a DC micro-grid under grid connected condition has been proposed in this paper. The system consists of a small wind turbine directly coupled with a permanent magnet synchronous generator, the three-phase output voltage of the generator has been rectified using a three-phase rectifier whose DC output voltage is controlled using a DC-DC boost converter. The boost converter is then connected to the DC micro-grid, or to a grid-connected single-phase AC inverter which is directly connected to the grid supply. To obtain maximum power transfer to the DC micro-grid at all wind speeds, the reference current produced by the MPPT system varies according to the DC link voltage. The proposed system has been simulated using SIMULINK under varying wind conditions and the maximum power is obtained.**

1. INTRODUCTION

With the depletion of fossil fuels and environmental threats, now-a-days non-conventional means of energy has become an alternative for the conventional source of energy. Non-conventional mode of generation of electricity has got several advantages over conventional sources of generation. Wind energy as a renewable, non-polluting and affordable source proves to be the most effective solution to the problem of depletion of fossil fuels, importing of coal, greenhouse gas emissions, global warming etc. Thus, has become the most popular source of renewable energy, increasingly wind turbines are becoming more and more efficient. In order to capture as much power as possible from wind during wind speed variation, maximum power point tracking controller is implemented. In countries where high wind speeds are common, installation of Small Wind Turbines (SWTs) in remote sites can be viable option for energy generation. SWTs are the turbines which do not exceed 50KW and are mainly found installed close to populated areas where large scale wind turbines cannot be placed. Remote areas consisting of a small block of buildings erected relatively close to each other make the application of a micro-grid system very appealing for supply of electricity.

A micro-grid is defined as a group of loads interconnected each other and distributed energy resources within electrical boundaries that acts as a single controllable operation with respect to the grid. A micro-grid can connect and disconnect from the grid to enable it to operate in both grid-connected mode or island mode. A micro-grid system consists of a cluster of generation sources and electrical loads which can function in both electrical grid connected mode as well as directly to the supply network. The control of the micro-grid aims at maintaining a constant voltage under all operating conditions. There exist two types of micro-grids, mainly AC and DC. DC micro-grids have got a number of advantages over AC micro-grids, such as lower conversion losses, no synchronisation, no phase or frequency issues and also independent from voltage sags, dips and other power quality issues which occurs on AC electrical grid side. An attractive feature of micro-grid is the ability to operate both in grid-connected mode as well as in island mode. In grid connected mode the micro-grid is connected to the electrical grid through a coupling point, while in islanded mode the micro-grid is operated in an autonomous way disconnected from the electrical grid. In this paper, the connection of a SWT to a grid-connected DC micro-grid has been discussed.

SWT grid-connected systems normally consist of a Permanent Magnet Synchronous Generator (PMSG). PMSG due to its lower weight and size, self-excitation, low maintenance cost and no gear box, give high efficiency and power factor, thus being more popular among the synchronous and asynchronous generators. Moreover, PMSGs may be used at low varying speeds, allowing the generator to be directly coupled to the wind turbine, without using a gearbox which would decrease the availability of the system, increase its weight and the need for maintenance. As PMSGs are AC machines, a controlled AC/DC converter is needed to supply a DC load systematically. PMSG with a three-phase rectifier, boost converter and inverter were proposed for power extraction. PMSG feeds a three-phase rectifier whose DC output voltage is controlled via a DC-DC converter. The latter converter has a boost topology and is used to interface the rectifier output to the DC micro-grid.

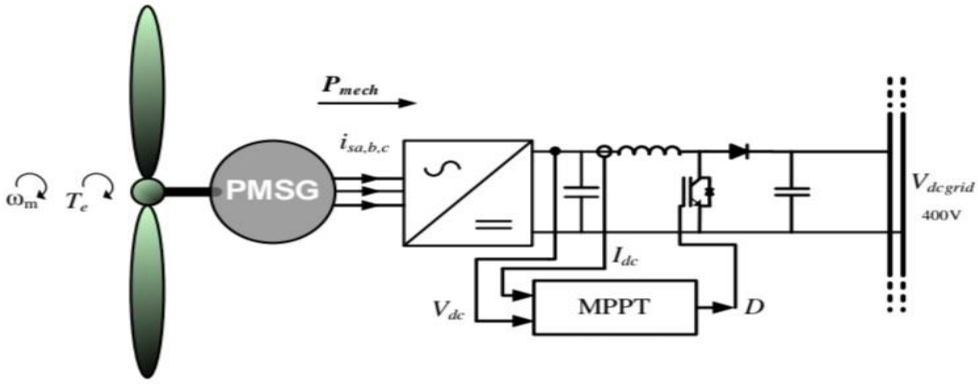

Figure 2.1: Block diagram of power electronic system

This project focuses on the modelling and simulation of wind turbine including the PMSG and the boost converter using MPPT.

3. SYSTEM MODELLING

Maximum power point tracking (MPPT) is well known technique used commonly with wind turbines to maximize power extraction under all wind conditions. A maximum power point tracking method for a variable speed wind turbine using permanent magnet synchronous generator is presented in this paper. Simulation of boost converter topology is implemented in MATLAB/SIMULINK. Results of this simulation show that the system with MPPT has better and fast performance under changing wind condition.

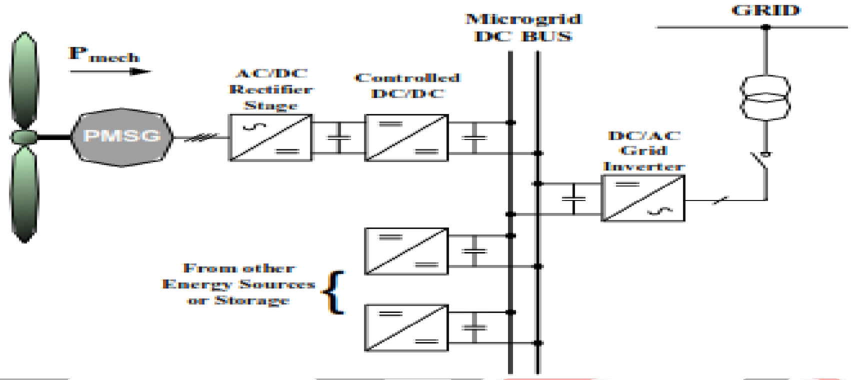

Figure 3.1: Small Wind Turbine connected to a DC Micro-grid.

For the instance being considered in this paper, the micro-grid is assumed to be operating in grid-connected mode through the grid inverter. SWT which do not exceed 50KW consists of a 5KW PMSG feeding 3-phase rectifier whose DC output voltage is controlled via a DC-DC converter. The 3-phase rectifier usually has got a capacitive DC link that determines the voltage across the PMSGs terminals.

4. SIMULINK MODEL

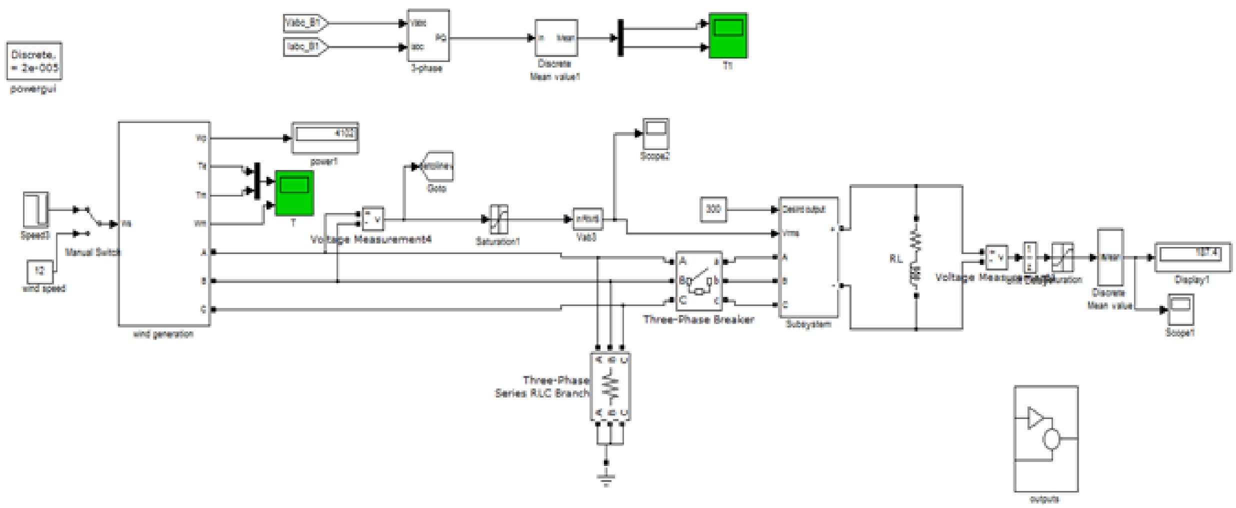

Figure 4.1: Simulink model

The simulink model of the micro-grid system carried out for a SWT including PMSG and the boost converter using MPPT is shown in the above figure. The simulation reviewed the operation of the SWT with the micro-grid operating at a fixed DC voltage $V_{dc-grid}$ of 400V under grid-connected conditions and with varying wind speed conditions. A typical wind speed profile from 6m/s to 12m/s is provided to wind turbine model in steps according to wind speed. PWM frequency is set to 10 KHz, step size voltage constant is taken as 0.1V.

5. RESULT

The simulation results for DC link output power, the DC link voltage, DC link current, and the PMSG rotor speed showing the attainment of the maximum power transfer according to variation in wind speed are shown in the figures below.

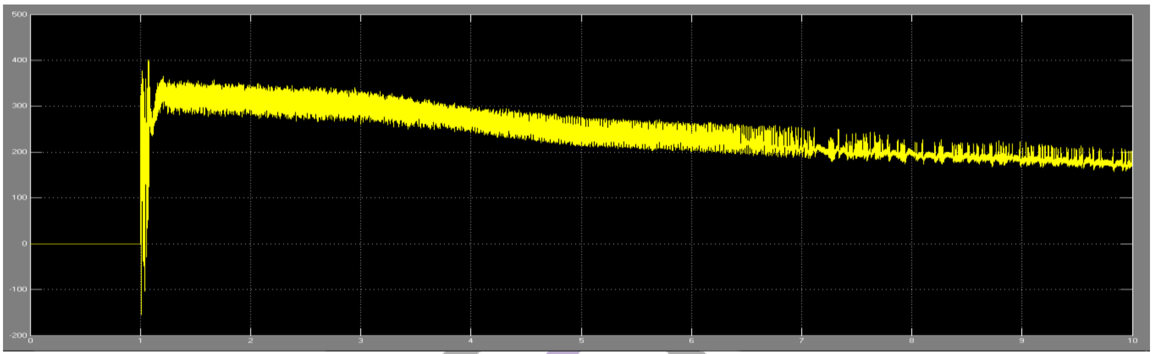

Figure 5.2: DC link voltage

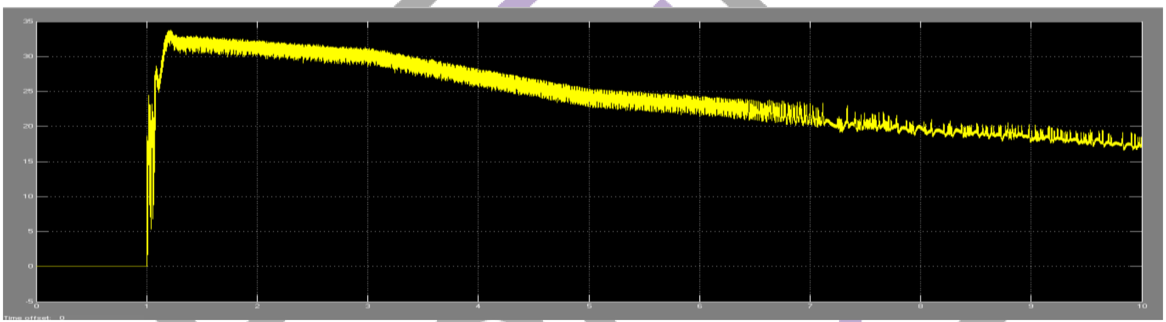

Figure 5.3: DC link current

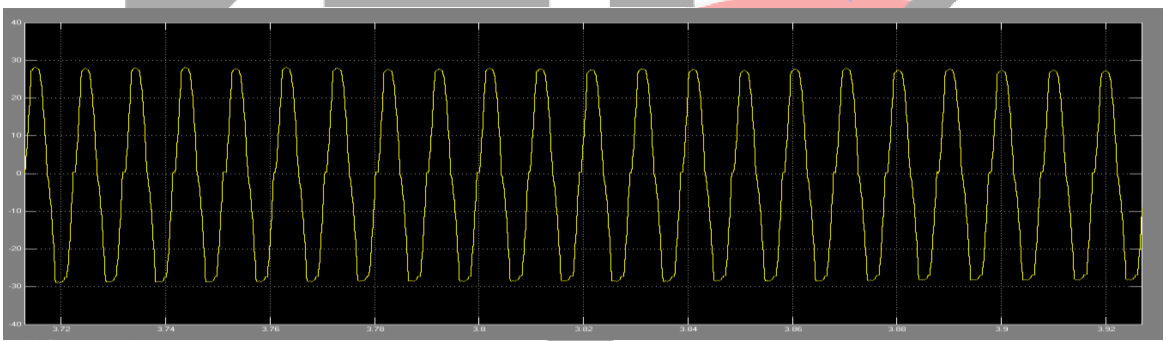

Figure 5.4: Stator current

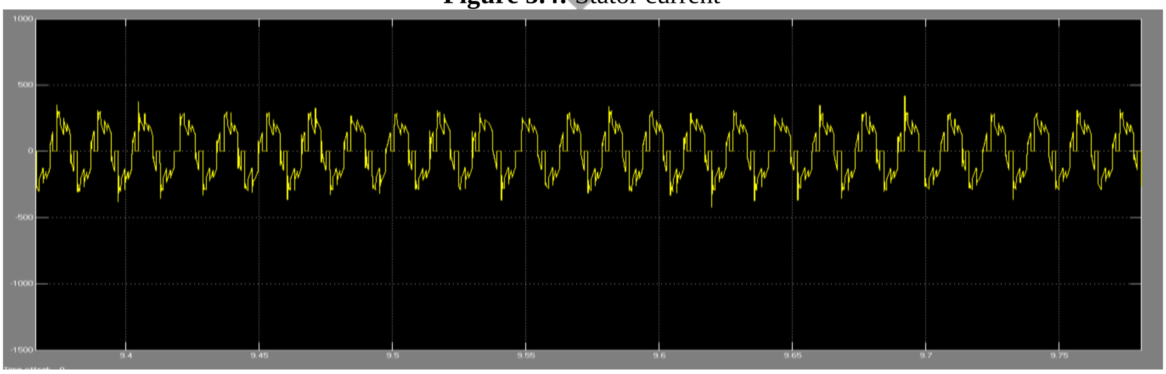

Figure 5.5: Line to line voltage

6. CONCLUSION

Many small wind turbines come up against difficult start-ups due to their large rotor inertia and also low starting torques. The simulation of the MPPT controlled small scale wind turbines connected to a DC micro-grid is performed and the results are obtained. The simulation results showed that the optimal power operating point was achieved for all wind speeds, providing maximum power output to the DC micro-grid under all wind conditions.

REFERENCES

1. A. Suyampulingam, V. Subbaiah **"PMSG based wind turbine system connected to DC micro-grid with MPPT control"** International journal, vol. 118.

2. Anjana Jain, S. Shankar **"Power generation using PMSG based variable speed WECS"** Journal of green engineering, vol.7_4,477-504

3. V. Sheeja, Bhim singh **"BESS based voltage and frequency controller for a stand-alone WECS employing PMSG"** IEEE 2009.

4. Daniel Zammit, Alexander Micallef **"Incremental Duty cycle based MPPT for a PMSG SWT in a grid connected DC microgrid"** ResearchGate.

5. He Xu, Jing Hui, Dinghui Wu, Wenxu Yan and He Xu, **"Implementation of MPPT for PMSG-based small-scale wind turbine,"** *2009 4th IEEE Conference on Industrial Electronics and Applications*, Xi'an, 2009, pp. 1291-1295.

6. Rene Aubree, Francois Auger **"A new low-cost sensor-less MPPT algorithm for small wind turbines"** ReseachGate.

7. Y. Errami, M. Benchagra, M. Hilal, M. Maaroufi and M. Ouassaid, **"Control strategy for PMSG wind farm based on MPPT and direct power control,"** *2012 International Conference on Multimedia Computing and Systems*, Tangier, 2012, pp. 1125-1130.