

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 12, December 2018

# Power Conditioning Unit for Wind Energy Conversion System Using SEPIC Converter

N.Vinothini, S.Pavithra

Assistant Professor, Department of EEE, AVS Engineering College, Salem, Tamil Nadu, India

Department of EEE, AVS Engineering College, Salem, Tamil Nadu, India

**ABSTRACT:** This paper presents a novel power conditioning unit (PCU) for variable speed micro wind turbine applications. It contains a simple generator side rectifier, galvanic isolation with a simple dc-dc converter, and a single-phase full-bridge inverter at the grid side. Variable speed micro wind turbines based on a permanent magnet synchronous generator (PMSG) are increasingly used in residential and small commercial buildings, despite their relatively low output voltage. Therefore, they can be used easily for battery charging, while their grid integration requires a PCU with galvanic isolation. Most of available PCUs provide no galvanic isolation, or use relatively complicated topologies or four stage energy conversion for that purpose. The dc-dc converter proposed allows reducing the complexity of the PCU. Steady state analysis shows that the converter is capable of regulating voltage in a wide range suitable for micro wind turbines, which is supported by experimental results within the input voltage range of 40 V to 400 V. The prototype built for integration of a 1.3 kW PMSG based micro wind turbine shows good performance over the entire 1:5 range of the given wind turbine output voltage. A study of efficiency and power losses was conducted according to the wind turbine power profile.

## I. INTRODUCTION

Small scale wind energy conversion systems have become a rising trend due to increased demand for green and secure electricity supply, especially in remote areas. As a result, more than one million units have been installed worldwide. Nowadays, more than 250 producers are marketing small Wind Turbines (WTs) that are usually limited to 100 kW power according to different national and international regulations. Small WTs with rated power up to 40 kW dominate the market, however, the average power of a small WT installed is about 1 kW. There are special feed-in tariffs introduced by many countries for small WTs that make micro WTs with rated power up to 3 kW an attractive solution for residential buildings and small communities in those countries.

Solar energy and wind energy are the two renewable energy sources most common in use. Wind energy has become the least expensive renewable energy technology in existence. Photovoltaic cells convert the energy from sunlight into DC electricity. PVs offer added advantages over other renewable energy sources in that they give off no noise and practically require no maintenance.

Hybridizing solar and wind power sources provide a realistic form of power generation. When a source is unavailable or insufficient in meeting the load demands, the other energy source can compensate for the difference. Several hybrid wind/PV power systems with Maximum Power Point Tracking (MPPT) control have been proposed earlier. They used a separate DC/DC buck and buck-boost converter connected in fusion in the rectifier stage to perform the MPPT control for each of the renewable energy power sources. This system requires passive input filters to remove the high frequency current harmonics injected into wind turbine generations. The harmonic content in the generation current decreases its lifespan and increases the power loss due to heating.

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 12, December 2018

## II. PROPOSED PCU SYSTEM

In order to eliminate the problems in the stand-alone wind system and meeting the load demand, the only solution to combine one or more renewable energy sources to meet the load demand. So the new proposed input side converter topology with maximum power point tracking method to meet the load and opt for grid connected load as well as commercial loads. The implementation of new converter topology will eliminate the lower order harmonics present in the hybrid power system circuit.

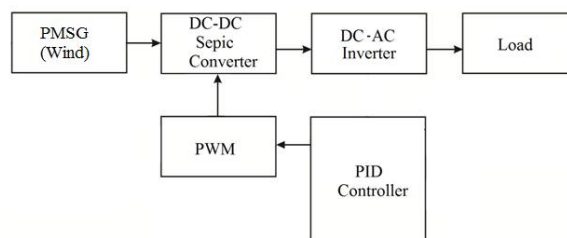
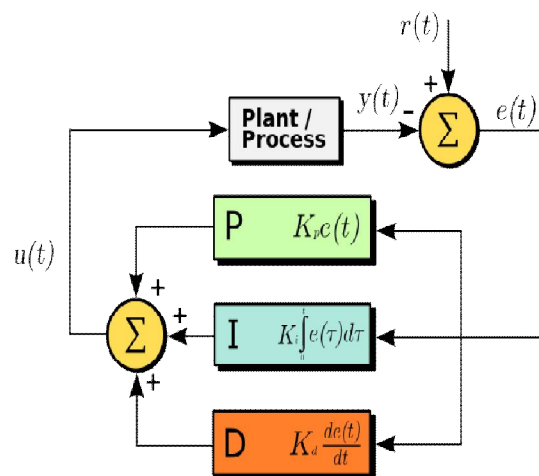


Fig 1. Proposed System

### PROPORTIONAL-INTEGRAL-DERIVATIVE CONTROLLER (PID)

A proportional-integral-derivative controller (PID controller) is a control loop feedback mechanism (controller) widely used in industrial control systems. A PID controller calculates an error value as the difference between a measured process variable and a desired set point. The controller attempts to minimize the error by adjusting the process through use of a manipulated variable.

The PID controller algorithm involves three separate constant parameters, and is accordingly sometimes called three-term control: the proportional, the integral and derivative values, denoted P, I, and D. Simply put, these values can be interpreted in terms of time: P depends on the present error, I on the accumulation of past errors, and D is a prediction of future errors, based on current rate of change. The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve, a damper, or the power supplied to a heating element



## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 12, December 2018

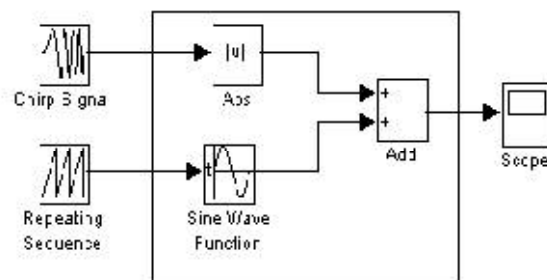


Fig 2.PID Controller

In the absence of knowledge of the underlying process, a PID controller has historically been considered to be the best controller. By tuning the three parameters in the PID controller algorithm, the controller can provide control action designed for specific process requirements. The response of the controller can be described in terms of the responsiveness of the controller to an error, the degree to which the controller overshoots the set point, and the degree of system oscillation. Note that the use of the PID algorithm for control does not guarantee optimal control of the system or system stability.

Some applications may require using only one or two actions to provide the appropriate system control. This is achieved by setting the other parameters to zero. A PID controller will be called a PI, PD, P or I controller in the absence of the respective control actions. PI controllers are fairly common, since derivative action is sensitive to measurement noise, whereas the absence of an integral term may prevent the system from reaching its target value due to the control action.

### WIND MILL

A **windmill** is a machine which converts the energy of wind into rotational motion by means of adjustable vanes called sails. The main use is for a grinding mill powered by the wind, reducing a solid or coarse substance into pulp or minute grains, by crushing, grinding, or pressing. Windmills have also provided energy to sawmills, paper mills, hammermills, and windpumps for obtaining fresh water from underground or for drainage (especially of land below sea level).



#### Vertical-axis windmills

The first practical windmills were the vertical axle windmills invented in eastern Persia (what is now Afghanistan), as recorded by the Persian geographer Estakhri in the 9th century. Made of six to twelve sails covered in reed matting or

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 12, December 2018

cloth material, these windmills were used to grind grain or draw up water, and were quite different from the later European horizontal-axis versions. Windmills were in widespread use across the Middle East and Central Asia, and later spread to China and India from there.

### PERMANENT MAGNET SYNCHRONOUS GENERATOR: (PMSG)

The amount of energy captured from a WECS depends not only on the wind at the site, but depends on the control strategy used for the WECS and also depends on the conversion efficiency. Permanent magnet synchronous generators (PMSG) wind energy converters system (WECS) with variable speed operation is being used more frequently in low power wind turbine applications. Variable speed systems have several advantages such as the reduction of mechanical stress and an increase in energy capture. In order to achieve optimum wind energy extraction at low power fixed pitch WECS, the wind turbine generator (WTG) is operating in variable-speed variable-frequency mode. The rotor speed is allowed to vary with the wind speed, by maintaining the tip speed ratio to the value that maximizes aerodynamic efficiency. The PMSG load line should be matched very closely to the maximum power line of the WTG. MPPT control is very important for the practical WECS systems to maintain efficient power generating conditions irrespective of the deviation in the wind speed conditions.

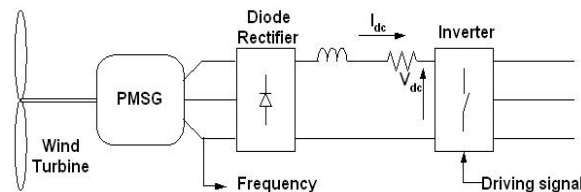


Fig 4.PMSG System

In spite of, all this complex control theory to get MPPT on PMSG WECS the standard way to implement a grid connected PMSG WECS at variable speed is using two power conversion stages: the first one an AC-DC stage and the second one a DC-AC stage. To realize the first one a classical three phase full bridge rectifier associated to a bulky capacitor is used and the second stage could be implemented by two types of converters schemes Voltage source current controlled inverter (VS-CCI) and Line commutated inverter (LCI) as shown in Figure 4.

This paper has the main focus in the first energy conversion stage the AC-DC converter, which is responsible by an injection of a high harmonic current content into the PMSG. The circulation of harmonic currents into the generator will produce significant additional power losses. Normally, the useful life of an electrical machine is specified based on the assumption of operation under rated load. When considering the proper rating for a machine the voltages and load currents are usually assumed to be sinusoidal. Therefore, the additional increase in the steady-state temperature caused by the harmonics can lead to premature ageing of the insulation and breakdown. Also the mechanical stress due to harmonics can reduce the useful life of the machine. This work applies three well-known approaches to harmonic mitigation in three-phase AC-DC energy conversion systems: a) harmonic trap filters, b) single-switch three-phase boost rectifier and c) three-phase boost type PWM rectifier. Using these approaches is possible to minimize or to eliminate the current harmonic content.

### SINGLE- ENDED PRIMARY INDUCTOR CONVERTER (SEPIC)

The single-ended primary-inductor converter (SEPIC) is a type of DC/DC converter that allows the electrical potential (voltage) at its output to be greater than, less than, or equal to that at its input. The output of the SEPIC is controlled by the duty cycle of the control transistor.

A SEPIC is essentially a boost converter followed by a buck-boost converter, therefore it is similar to a traditional buck-boost converter, but has advantages of having non-inverted output (the output has the same voltage polarity as the input), using a series capacitor to couple energy from the input to the output (and thus can respond more gracefully to a

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 12, December 2018

short-circuit output), and being capable of true shutdown: when the switch is turned off, its output drops to 0 V, following a fairly hefty transient dump of charge.

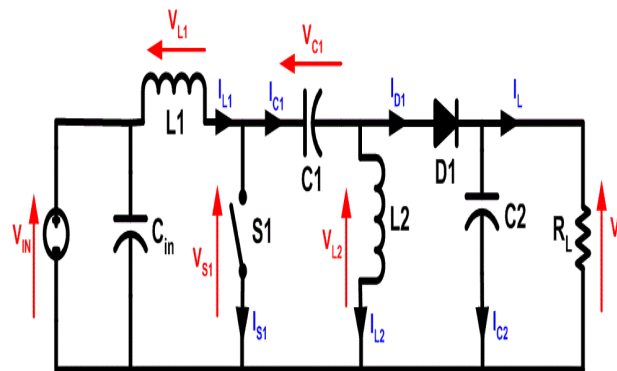


Fig5. Proposed DC-DC Converter

SEPICs are useful in applications in which a battery voltage can be above and below that of the regulator's intended output. For example, a single lithium ion battery typically discharges from 4.2 volts to 3 volts; if other components require 3.3 volts, then the SEPIC would be effective.

The schematic diagram for a basic SEPIC is shown in Figure 5. As with other switched mode power supplies (specifically DC-to-DC converters), the SEPIC exchanges energy between the capacitors and inductors in order to convert from one voltage to another. The amount of energy exchanged is controlled by switch S1, which is typically a transistor such as a MOSFET. MOSFETs offer much higher input impedance and lower voltage drop than bipolar junction transistors (BJTs), and do not require biasing resistors as MOSFET switching is controlled by differences in voltage rather than a current, as with BJTs.

### III. SIMULATION RESULT

A software simulation model developed in using PSIM® software, which allows easy performance evaluations is used to estimate the behaviour of these three different schemes associated with the PMSG WECS. Simulation results showed the possibility of achieving maximum power tracking, output voltage regulation and harmonic mitigation simultaneously.

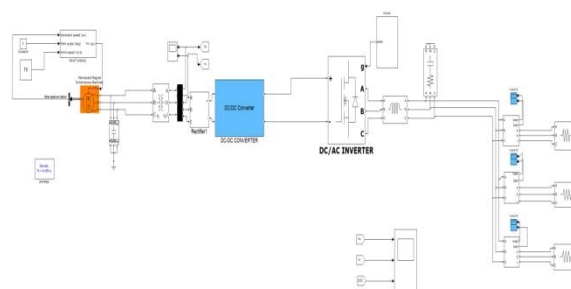


Fig 6. Simulation Diagram

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 12, December 2018

## WAVEFORMS

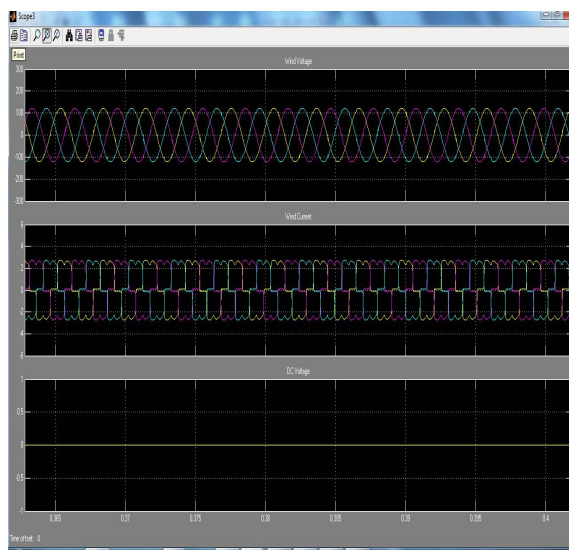


Fig 7. Wind voltage, Wind current and DC Bus voltage

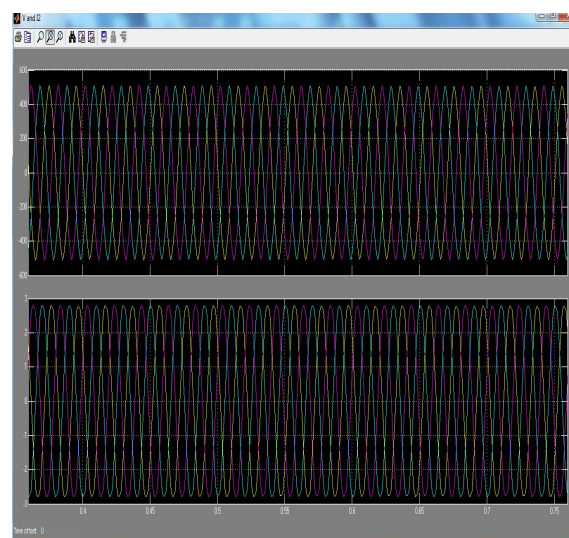


Fig 8. Load Voltage and current



# International Journal of Innovative Research in Science, Engineering and Technology

*(A High Impact Factor, Monthly, Peer Reviewed Journal)*

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 12, December 2018

## IV. CONCLUSION

This Project proposes a novel galvanic ally isolated power conditioning unit intended for variable speed micro wind turbines based on the permanent magnet synchronous generator. This unit enables grid integration of sub-kW residential wind turbines into the distribution grid. Usually, reports on small scale wind energy conversion systems are dedicated to the enhanced control methods. However, performance of a power electronics converter used is often overlooked, in particular, proper analysis of the efficiency and losses according to the operating profile of a corresponding wind turbine. The proposed approach does not require any significant changes of the conventional control systems. Therefore, this paper pays special attention to energy conversion performance by means of the efficiency and power losses.

## REFERENCES

- [1] Stefan Gsänger and Jean-Daniel Pitteloud, World Wind Energy Association. Small Wind World Report. 2015. Summary, Mar. 2015.
- [2] M. Malinowski, A. Milczarek, R. Kot, Z. Goryca and J. T. Szuster, "Optimized Energy-Conversion Systems for Small Wind Turbines: Renewable energy sources in modern distributed power generation systems," IEEE Power Electron. Mag., vol. 2, no. 3, pp. 16-30, Sept. 2015.
- [3] M. Malinowski, A. Milczarek, D. Vinnikov and A. Chub, "Wind energy systems," Chap. 12 in Power Electronic Converters and Systems: Frontiers and Applications, Ed. A. M. Trzynadlowski, London, UK: IET, 2015, pp. 351-394, DOI: 10.1049/PBPO074E\_ch12.
- [4] American Wind Energy Association. AWEA 2010 Small Wind Turbine Global Market Study. [5] R. Wisner and M. Bolinger, 2014 Wind Technologies Market Report, U.S. Department of Energy, Aug. 2015.
- [5] R. Lanzafame and M. Messina, "Power curve control in micro wind turbine design," Energy, vol. 35, no. 2, pp. 556-561, Feb. 2010.
- [6] L. Mariam, M. Basu and M. F. Conlon, "Community Microgrid based on micro-wind generation system," Proc. UPEC'2013, pp. 1-6, 2013.
- [7] A. Chub, T. Jalakas, A. Milczarek, A. Kallaste and M. Malinowski, "Grid integration issues of PMSG-based residential wind turbines," Proc. PQ2014, pp. 147-154, 2014.
- [8] L. Bisenieks, D. Vinnikov and I. Galkin, "PMSG based residential wind turbines: Possibilities and challenges," Agronomy Research, vol. 11, no. 2, pp. 295-306, June 2013.
- [9] M. Godoy Simoes, F. Alberto Farret and F. Blaabjerg, "Small Wind Energy Systems," Elect. Power Components and Syst., vol. 43, no. 12, pp. 1388-1405, July 2015.