Parallel Computing Techniques Based Control of Offshore Wind Turbine

M. Dheepak[1], Dr. S.V.Saravanan[2] and P.Veerakumar[3]

Assistant Professor [1, 2 & 3], Dept. of Electrical and Electronics Engineering

AMET Deemed to be university, Chennai.

dheepak.m@ametuniv.ac.in, *svsaravanan@gmail.com*, *pveerakumar1981@gmail.com*

Abstract—*Parallel computing techniques based control of offshore wind turbine system focus on monitoring and testing of Offshore Horizontal axis offshore wind turbine generator model employing parallel computing technique, Multicore CPU and graphical programming language. By using parallel computing techniques the computing time is faster than the sequential approach. The offshore wind turbine generator performance improvement can be done by using DSP multicore controller and by employing parallel computing technique. The method of real time testing is done by Hardware-in-the-loop simulation. The generator output can be monitored.*

Keywords- Offshore Horizontal axis offshore wind turbine, Parallel computing, Digital Signal Processors etc.

I. INTRODUCTION

Wind is simply air in motion. It is caused by the uneven heating of the Earth's surface by radiant energy from the sun. Since the Earth's surface is made of very different types of land and water, it absorbs the sun‟s energy at different rates. Water usually does not heat or cool as quickly as land because of its physical properties. An ideal situation for the formation of- local wind is an area where land and water meet. During the day, the air above the land heats up more quickly than the air above water. The warm air over the land expands, becomes less dense and rises. The heavier, denser cool air over the water flows in to take its place, creating wind. In the same way, the atmospheric winds that circle the Earth are created because the land near the equator is heated more by the sun than land near the North and South Poles. Today, people use wind energy to make electricity. Wind is called a renewable energy source

II. HORIZONTAL AXIS OFFSHORE WIND TURBINE

Horizontal-axis offshore wind turbines (HAWT) have the main rotor shaft and electrical generator at the top of a tower, and must be pointed into the wind. Most have a gearbox, which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electrical generator. Since a tower produces turbulence behind it, the turbine is usually pointed upwind of the tower. Turbine blades are made stiff to prevent the blades from being pushed into the tower by high winds. Additionally, the blades are placed a considerable distance in front of the tower and are sometimes tilted up a small amount.

Downwind machines have been built, despite the problem of turbulence, because they don't need an additional mechanism for keeping them in line with the wind, and because in high winds the blades can be allowed to bend which reduces their swept area and thus their wind resistance. Since cyclic (that is repetitive) turbulence may lead to fatigue failures most HAWTs are upwind machines.

III. ADVANTAGE OF HORIZONTAL AXIS OFFSHORE WIND TURBINE

- Variable blade pitch, which gives the turbine blades the optimum angle of attack. Allowing the angle of attack to be remotely adjusted gives greater control, so the turbine collects the maximum amount of wind energy for the time of day and season.

- The tall tower base allows access to stronger wind in sites with wind shear. In some wind shear sites, every ten meters up, the wind speed can increase by 20% and the power output by 34%.

- High efficiency, since the blades always moves perpendicularly to the wind, receiving power through the whole rotation. In contrast, all vertical axis offshore wind turbines, and most proposed airborne offshore wind turbine designs, involve various types of reciprocating actions, requiring airfoil surfaces to backtrack against the wind for part of the cycle. Back tracking against the wind leads to inherently lower efficiency.

IV. OFFSHORE WIND TURBINE CONTROL MECHANISMS

1. Power control

A offshore wind turbine is designed to produce a maximum of power at wide spectrum of wind speeds. The offshore wind turbines have three modes of operation:

- Below rated wind speed operation

- Around rated wind speed operation

- Above rated wind speed operation

If the rated wind speed is exceeded the power has to be limited. There are various ways to achieve this.

2 Stall control

Stalling works by increasing the angle at which the relative wind strikes the blades (angle of attack), and it reduces the induced drag (drag associated with lift). Stalling is simple because it can be made to happen passively (it increases automatically when the winds speed up), but it increases the cross-section of the blade face-on to the wind, and thus the ordinary drag. A fully stalled turbine blade, when stopped, has the flat side of the blade facing directly into the wind. A fixed-speed HAWT inherently increases its angle of attack at higher wind speed as the blades speed up. A natural strategy, then, is to allow the blade to stall when the wind speed increases. This technique was successfully used on many early HAWTs.

3 Pitch control

Furling works by decreasing the angle of attack, which reduces the induced drag from the lift of the rotor, as well as the cross-section. One major problem in designing offshore wind turbines is getting the blades to stall or furl quickly enough should a gust of wind cause sudden acceleration. A fully furled turbine blade, when stopped, has the edge of the blade facing into the wind. Standard modern turbines all pitch the blades in high winds. Since pitching requires acting against the torque on the blade, it requires some form of pitch angle control. Many turbines use hydraulic systems. These systems are usually spring loaded, so that if hydraulic power fails, the blades automatically furl. Other turbines use an electric servomotor for every rotor blade. They have a small battery-reserve in case of an electric-grid breakdown. Small offshore wind turbines (under 50 kW) with variable-pitching generally use systems operated by centrifugal force, either by flyweights or geometric design, and employ no electric or hydraulic controls.

4. Yaw control

Modern large offshore wind turbines are typically actively controlled to face the wind direction measured by a wind vane situated on the back of the nacelle. By minimizing the yaw angle (the misalignment between wind and turbine pointing direction), the power output is maximized and non-symmetrical loads minimized. However, since the wind direction varies quickly the turbine will not strictly follow the direction and will have a small yaw angle on average. The power output losses can simplify be approximated to fall with yaw angle.

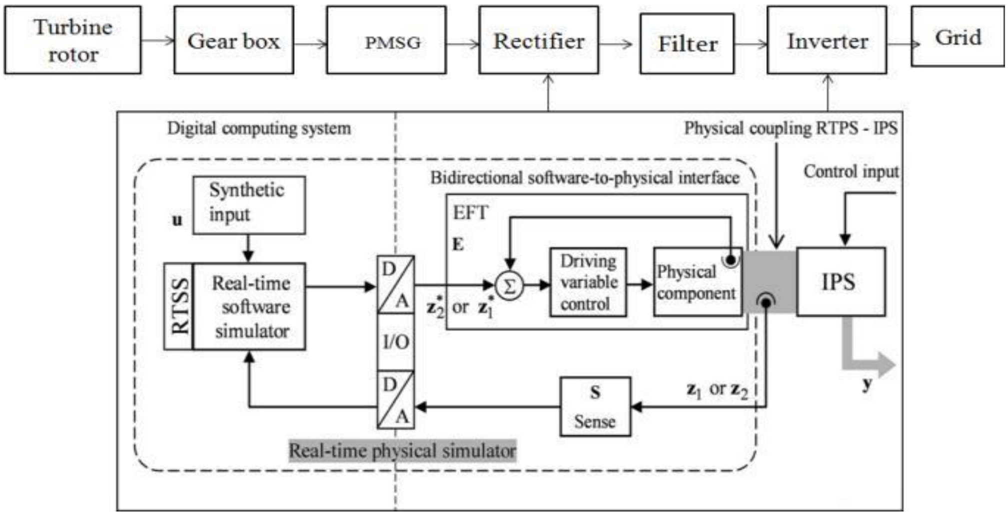
5. Electrical Braking

Braking of a small offshore wind turbine can also be done by dumping energy from the generator into a resistor bank, converting the kinetic energy of the turbine rotation into heat. This method is useful if the kinetic load on the generator is suddenly reduced or is too small to keep the turbine speed within its allowed limit. Cyclically braking causes the blades to slow down, which increases the stalling effect, reducing the efficiency of the blades. This way, the turbine's rotation can be kept at a safe speed in faster winds while maintaining (nominal) power output. This method is usually not applied on large grid-connected offshore wind turbines.

6. Mechanical braking

A mechanical drum brake or disk brake is used to hold the turbine at rest for maintenance. Such brakes are usually applied only after blade furling and electromagnetic braking have reduced the turbine speed, as the mechanical brakes would wear quickly if used to stop the turbine from full speed. There can also be a stick brake.

V.CONVENTIONAL BLOCK DIAGRAM



Drawbacks of Conventional System

- Poor Performance.
- Low Speed.
- High Computation time.
- High cost.

VI.PROPOSED SYSTEM

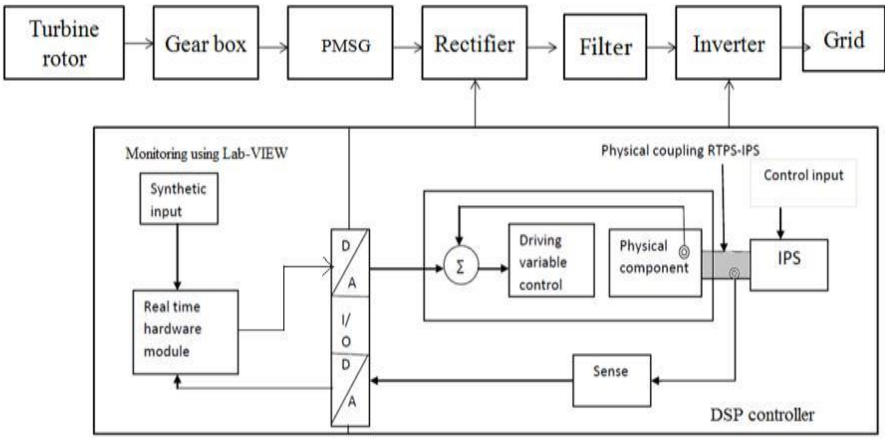
Special features of Proposed System

- Parallel computing technique.
- Parallel computing is classified into Multicore CPU and Multicore processor
- Pipelining concept makes the execution two times faster than sequential approach.
- Output in monitoring using Lab-VIEW.
- High performance.
- Provide concurrent execution.
- Use of non-local resources

The circuit diagram consists of following blocks

Turbine rotor, gear box, PMSG, converters, filter, controllers and grid. Turbine rotor converts energy in moving air to rotary mechanical energy. A mechanical interface consisting of a step up gear and a suitable coupling transmits the rotary mechanical energy to an electrical generator by PMSG.

PROPOSED BLOCK DIAGRAM



VII. SPECIAL FEATURES OF DSP PROCESSOR

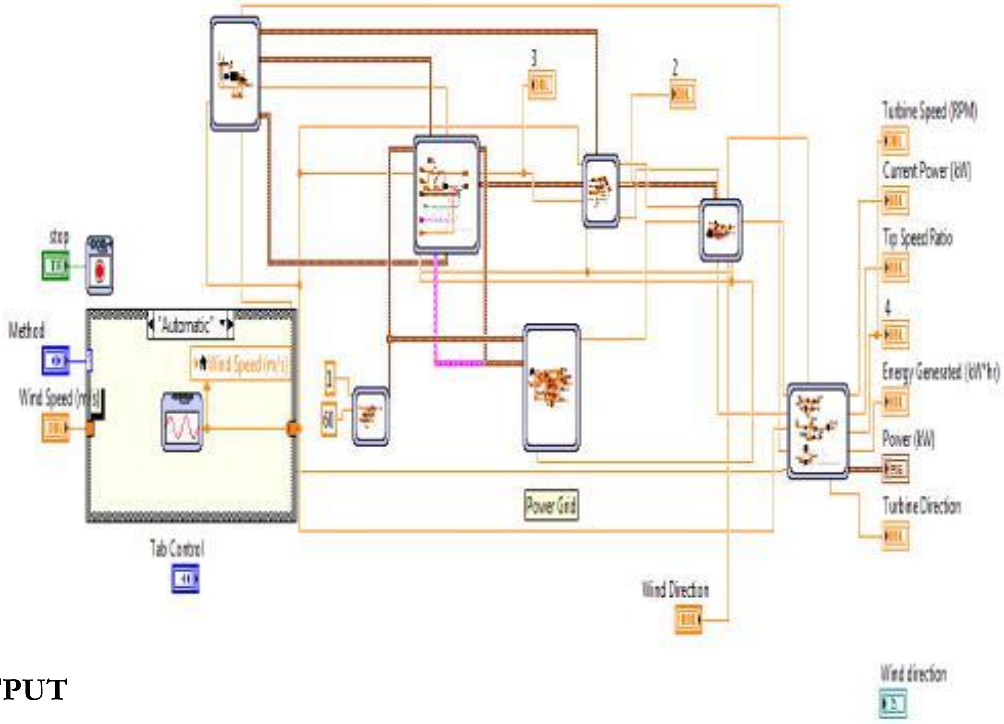
- TMS320F2812 Digital Signal Processor
- 150 MIPS operating speed
- 18K words on-chip RAM
- 128K words on-chip Flash memory
- 64K words off-chip SRAM memory
- 30 MHz clock
- 2 Expansion Connectors (analog, I/O)
- Onboard IEEE 1149.1 JTAG Controller
- 5-volt only operation with supplied AC adapter
- TI F28xx Code Composer Studio tools driver
- On board IEEE 1149.1 JTAG emulation connector

ADVANTAGES OF PROPOSED SYSTEM

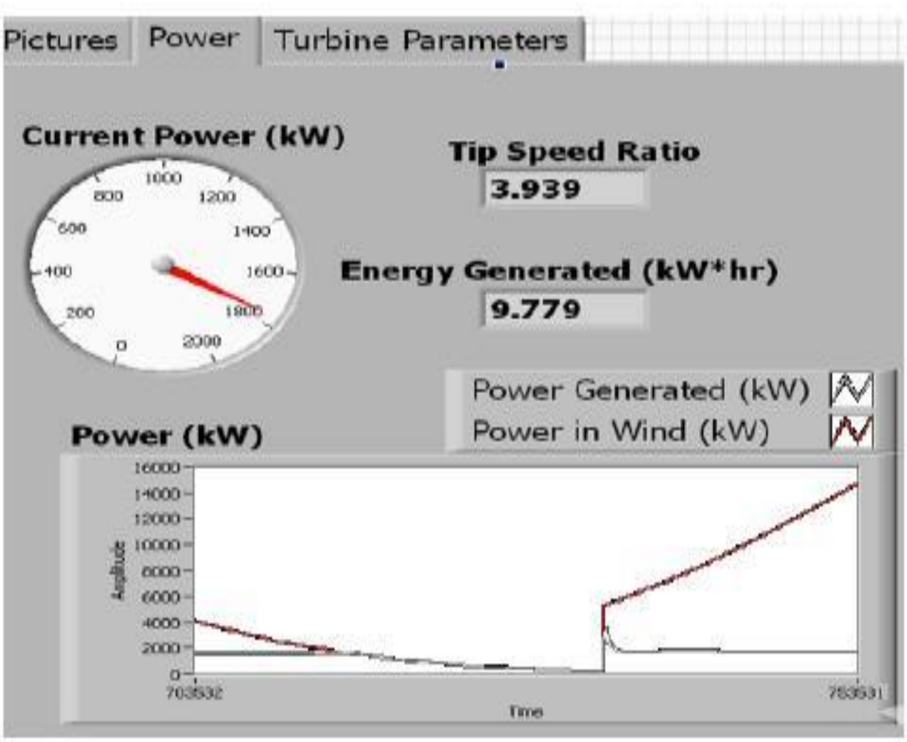
- Renewable source of energy.
- Economically efficient and Eco-friendly.
- Real-time latency.

- Field test carried in laboratory.
- Easily adapt to environment.

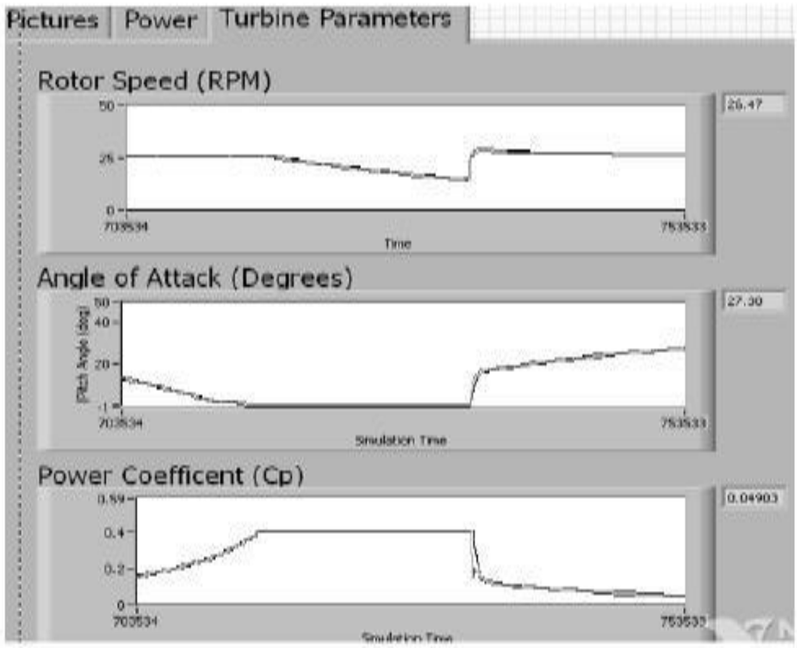
VIII SIMULATION BLOCK DIAGRAM



POWER OUTPUT



TURBINE PARAMETERS OUTPUT



CONCLUSION

In this model, performance improvement for variable speed Horizontal axis offshore wind turbine generator is present. This is achieved by parallel computing technique, multicore CPU and Lab VIEW graphical programming language. The offshore wind turbine parameters such as output power, rotor speed, pitch angle and co-efficiency are monitoring by Lab VIEW graphical programming language. By employing DSP multi core processor the real time testing of offshore wind turbine generator is done with low-cost.

REFERENCES

[1] Dheepak Mohanraj, Suresh Mahalingam, N Murugan," DSP based voltage stabilization using Z-Source buck boost Inverter". Journal of Engineering Research and Studies Vol.IV, Issue II,April-June, 2013,PP 01-04

[2] S.Sindhuja, M.Dheepak," Pspice Based Realisation Of Single-Phase Thirteeen Level Inverter Using Single Dc Source", International Journal Of Innovative Research In Technology, Volume 4, Issue 2,Pp79-85

[3] Dheepak, M., Sundar, R., Ali," Integrated energy management system for residential microgrid", Journal of Advanced Research in Dynamical and Control Systems,vol 9,Issue 11,pp 680-687.

[4] Julian Munteanu, Antoneta Iuliana Bratcu, Seddik Bacha, Daniel Rye, and Joel Guiraud "Hardware-in-the-Loop-based Simulator for a Class of Variable-speed Wind Energy Conversion Systems: Design and Performance Assessment", IEEE TRANSACTIONS ON ENERGY CONVERSION, VOL. 25, NO. 2, JUNE, 2010

[5] Hui Li, Mischa Steurer, K. L. Shi, Steve Woodruff, and Da Zhang,"Development of a Unified Design, Test, and Research Platform for Wind Energy Systems Based On Hardware-In-The-Loop Real-Time Simulation", IEEE Transactions On Industrial Electronics, Vol. 53, No. 4, August 2006

[6] R. Pena, J.C.Clare, G. M. Asher, "Doubly fed induction generator using back to-back PWM converters and its application to variable speed wind-energy generation", IEE Puoc.-Electr. Power Appl., Vol. 143, No 3, May 1996

*[7] S.v.Saravanan,Gugan.K, "**Optimization of** arithmetical operators for the enhanced wallace stag", **Indonesian Journal of Electrical Engineering and Computer Science**., Vol. 9,issue 3, Mar2018*