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ASYNCHRONOUS WIND TURBINE GENERATOR: OUTPUT POWER EVALUATION

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ABSTRACT

In addition to photovoltaic (PV) power plants, wind turbine generators represent the most ubiquitous renewable energy use today. The stochastic and intermittent character of wind as a key source of electricity is one of the fundamental challenges associated with wind turbines WT. This paper describes an induction generator used in wind turbines. The implemented Turbine utilizes a straightforward output power against wind speed relationship to convert wind speed to turbine output power. When the wind speed is below or above the cut-in speed, the turbine produces no real power. Constantly, the machine consumes reactive power. This implemented block compensates for the machine's reactive power demand. Local load consumption is 75 kW. The electricity grid makes up for any shortage in wind turbine generation. When the generator's output exceeds 75 kW, the excess energy is exported to the grid.

INTRODUCTION

A wind turbine turns the kinetic energy of the wind into electrical energy. Hundreds of thousands of big turbines in wind farms now generate over 650 gigawatts of electricity, with an annual increase of 60 gigawatts. [1] They are a growing source of intermittent renewable energy and are utilized in many nations to minimize energy prices and reliance on fossil fuels. In 2009, according to one study, wind energy had the "lowest relative greenhouse gas emissions, the lowest water consumption requirements, and the most favorable social impacts" among photovoltaic, hydro, geothermal, coal, and gas energy sources. [2]

Modern wind turbines (WT) of medium and large power are being designed at high nominal wind speed VN = 11-13 m/s, characteristic of coastal regions [3]. Nonetheless, the continental portion of Russia is bounded by a dominant annual wind flow range of 3-10 m/s in the majority of locations, and the average yearly wind speed does not surpass 4-6 m/s [4, 5]. Due to the dependence of wind energy on the third degree of wind speed, these WT cannot operate effectively everywhere. Mass use in Russia could be anticipated for autonomous WT with 7-15 meter diameter, generating P_N = 5-15 kilowatts nominal power [7] in areas of low wind speeds, supplying uninterrupted electricity to consumers [6, 7] along with energy static storage (GB). In reality, the topic of discussion is the reversal of the widespread use of energy devices resembling windmills in size, but constructed on a predominantly new platform to meet tiny energy demands.

Generally, autonomous WTs are incapable of capturing and flattening the impulse energy flow. To maintain the grid's nominal power level, the WT parameters and control system must meet the criteria of a positive energy balance in accordance with the differential characteristics of local area wind flows and consumption structure.

LITERATURE REVIEW

Wind generation system

A power system consisting of a wind turbine with a doubly fed induction generator connected to a three-phase grid has been considered [8], as shown in figure 1. The stator of the induction generator is directly connected to the grid, while the rotor winding is connected via slip rings to a converter.

The induction generator transforms the mechanical energy captured by the wind turbine into electrical energy and sends it to the grid. The rotor-side converter is used to control the wind turbine output power and the voltage measured at the grid terminals.

Volume 1, **Number** 2, November 2021
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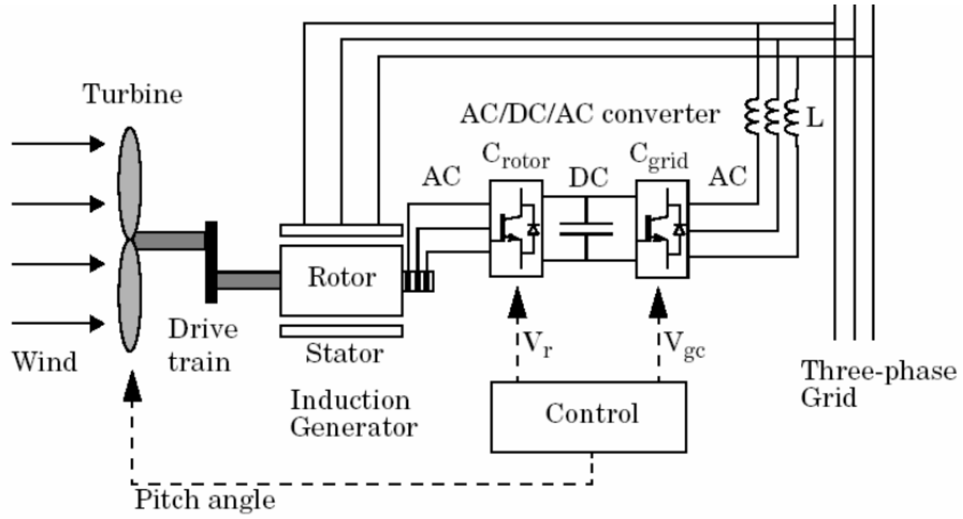

Figure 1: Wind Turbine and Doubly Fed Induction Generator System.

Wind turbine power

The extracted power from a wind turbine is determined by the available wind power, the machine power curve, and the machine's responsiveness to wind fluctuations. The wind's extracted power and torque can be stated as [9]:

$$P_m = \frac{1}{2}\rho C_p(\delta,\beta)AV_w^3$$

Where: P_m is the rotor mechanical power in watts; V_w the wind speed at the centre of the rotor (m/s); $A = \pi r^2$ m is the wind rotor swept area (m^2); ρ is the air density (kg/m^3); r is the turbine radius (m); C_P is the rotor power coefficient; β is the pitch angle of rotor blades in degrees; and δ is the tip speed ratio.

The figure below shows a sketch a how the power output from a wind turbine varies with steady wind speed, where the turbine begins to operate at the cut-in speed $V_{C,}$ then the power output increases with wind speed following a cubic curve until wind speed reaches the rated speed, where the turbine begins to operate at its rated power.

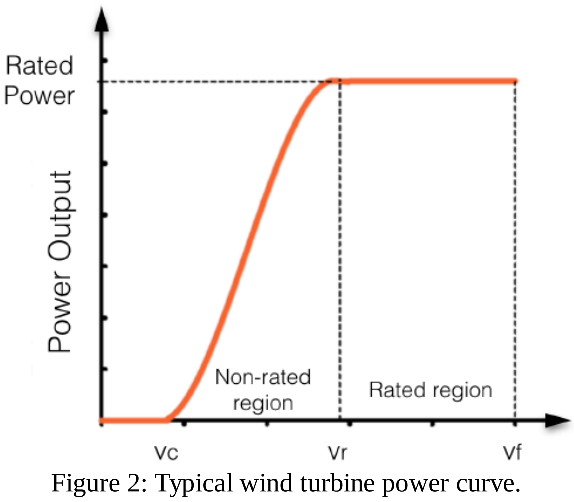

Figure 2: Typical wind turbine power curve.

METHOD

Modeling for asynchronous wind turbine

As depicted in Figure 3, the Asynchronous wind turbine is modeled in Matlab/Simulink. The wind turbine uses the input wind speed to control the output power of the asynchronous generator. The wind turbine model was obtained from Matlab Demos. The output torque of the wind turbine was calculated using a two-dimensional table based on the Wind Speed.

Volume 1, **Number** 2, November 2021
https://doi.org/10.47709/brilliance.v1i2.1565

In Matlab Simulink, it can easy to use the wind turbine function, where this function implements a simple power versus wind speed characteristic to represent a wind turbine. Given an input of wind speed, m/s, the function outputs turbine power, W. The parameters must meet the following requirement: Cut-in speed, rated output speed, and Cutout speed.

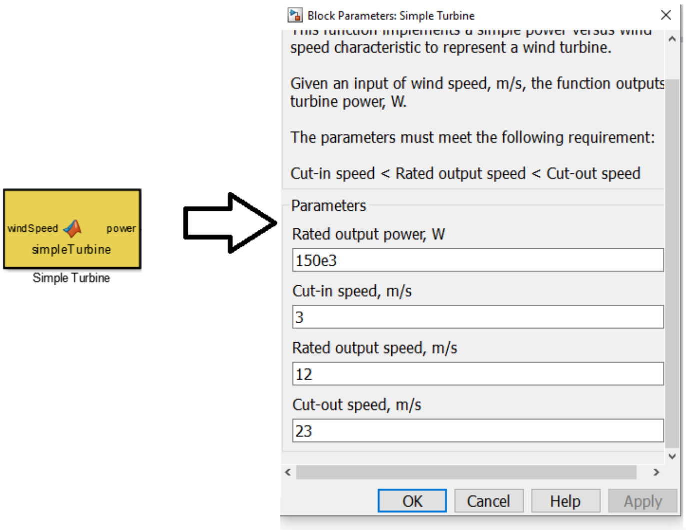

Figure 3: Simple turbine function and parameters.

Figure 4 shows a full Simulink model of a three-phase asynchronous wind turbine generator. The Basic Turbine block uses a simple output power vs wind speed characteristic to translate wind speed to turbine output power.

The machine creates no real power when the wind speed is below the cut-in speed or above the cutout speed. Reactive power is always consumed by the machine. The machine's reactive power need is countered by the Reactive Compensation block. The local load consumes 75 kW. The electricity grids infeed cover any shortage in wind turbine generation. Excess electricity is sent to the grid when the generator produces more than 75kW.

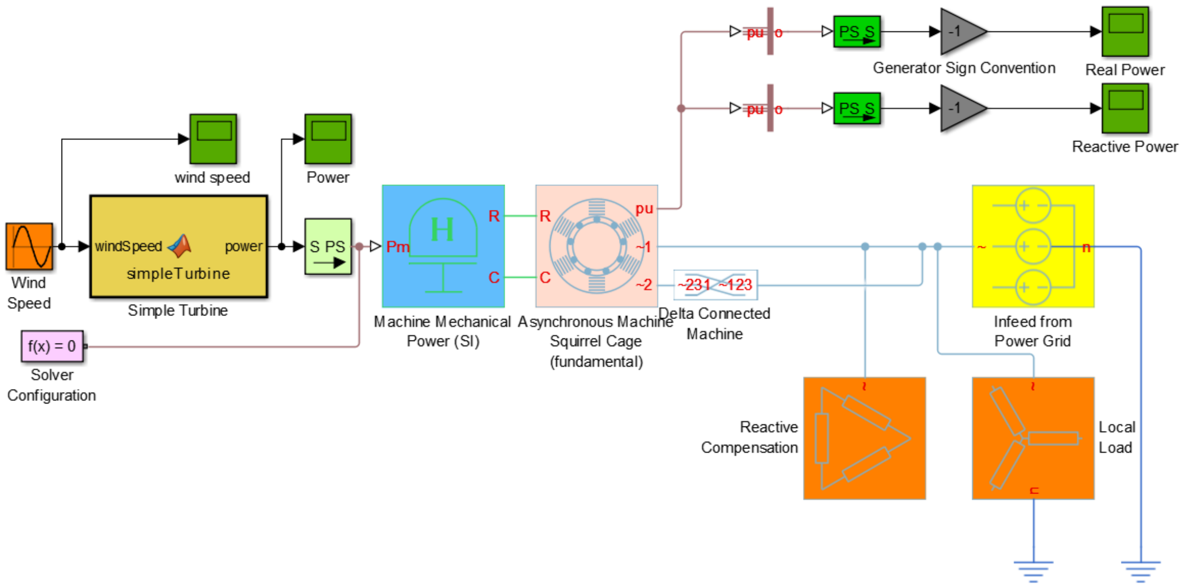

Figure 4. Simulink model of a three-phase asynchronous wind turbine generator.

Volume 1, **Number** 2, November 2021
https://doi.org/10.47709/brilliance.v1i2.1565

DISCUSSION

The results and the outputs characteristics of the wind turbine

The main objective of this paper is to explain and analyze the outputs of a three-phase asynchronous wind turbine generator available within the MATLAB program library, but it has been clarified in a simplified and more understandable way.

Figure 5 and figure 6 show the input wind speed and output power of the Simple turbine function
The wind speed model of the wind turbine is set as a sinusoidal signal. We got the port characteristics of the wind turbine and both of active power and reactive power as figure 7 and figure 8.

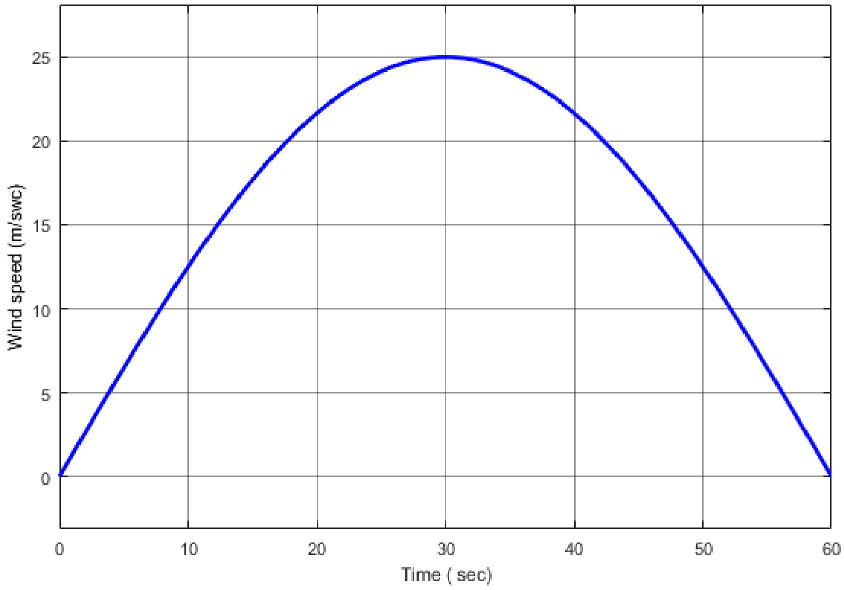

Figure 5: Wind speed waveform.

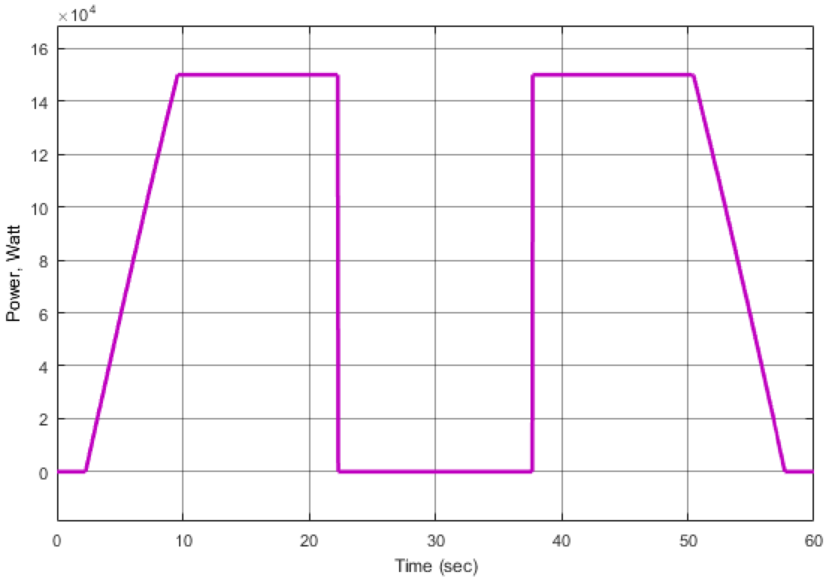

Figure 6: Power waveform.

Volume 1, **Number** 2, November 2021
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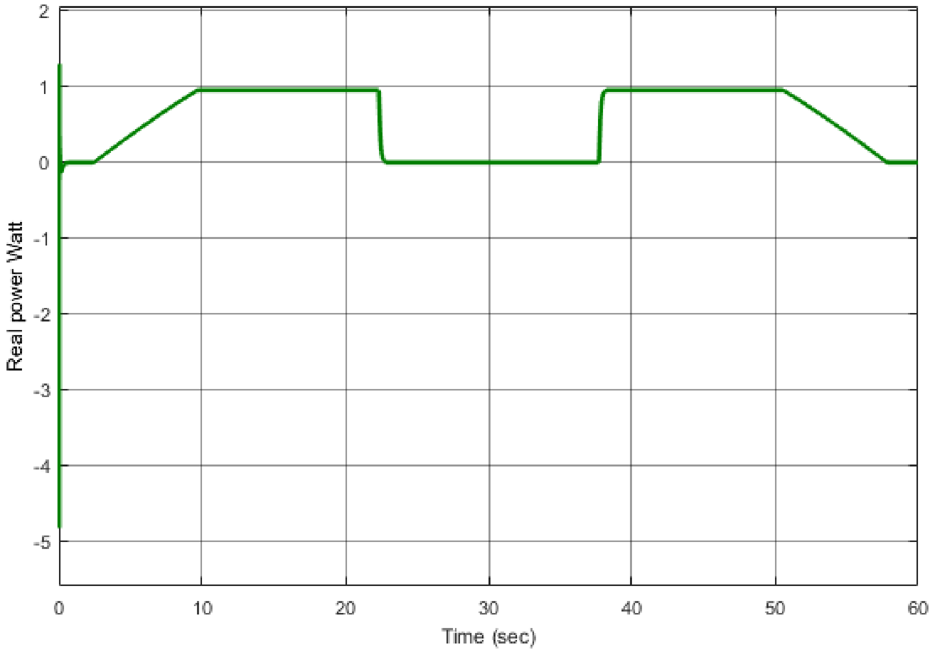

Figure 7: Active power of the energy storage device.

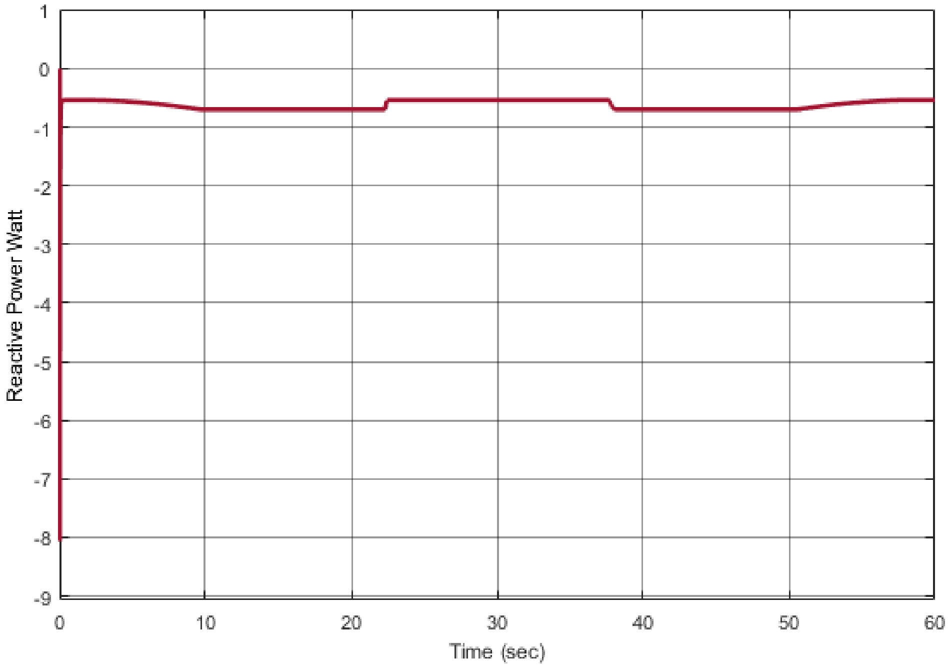

Figure 8: Reactive power of the energy storage device.

CONCLUSION

In this paper, a model of the an induction machine used as a three-phase asynchronous wind turbine generator is described and evaluated then the wind speed, output power, active power, and reactive power are shown. In fact, this paper re-understood and analyzed the three-phase Asynchronous wind turbine generator, but in a more clear way, as the original model of the turbine is available in the Matlab program library and any researcher can download and run it. The outputs of the wind turbine generator are presented in the form of curves so that the reader of the paper can understand them. For future work, I would recommend studying how to design and implementation of some controllers for wind generators to get better performance and optimization.

Volume 1, **Number** 2, November 2021
https://doi.org/10.47709/brilliance.v1i2.1565

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