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SIMULATION OF GRID INTEGRATED WIND ENERGY CONVERSION SYSTEM

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ABSTRACT:

One of the primary needs for socio-economic development in any nation in the world is the reliable electricity supply system. Renewable energy technologies offers clean, abundant energy gathered from self-renewing resources such as the sun, wind etc. As the power demand increases, power failure also increases. So, renewable energy sources can be used to provide constant loads. Wind energy is expected to be one of the most prominent sources of electrical energy in years to come. In this paper wind energy conversion system is integrated with the grid. Wind turbines are packaged systems that include a rotor, a generator, turbine blades, a drive and coupling blades. This process reveals a unique step in electricity generation and availability from natural resources without hampering the ecological balance. The goal of this paper to build a complete model of integrated wind energy conversion system with grid in MATLAB/Simulink.

KEY-WORDS: Socio-economic, Wind energy, MATLAB/ Simulink, integrated generation

INTRODUCTION:

Recent developments and trends in the electric power consumption indicate an increasing use of renewable energy resources (RES). Maximum energy demand is supplied by the burning of fossil fuels. Hence increasing air pollution, global warming, diminishing fossil fuels and their increasing cost have made it necessary to look towards RES as a future energy solution.[2]

Solar energy and wind energy is clean, inexhaustible, unlimited, and environmental friendly. Such characteristics have attracted the energy sector to use renewable energy sources on a larger scale. However, all renewable energy sources have drawbacks. Wind is dependent on unpredictable factors such as weather and climatic conditions.

Wind power is another most competitive renewable technology and, in developed countries with good wind resources, onshore wind is often competitive with fossil fuel fired generation. Wind power generation has experienced a tremendous growth in the past decade, and has been recognized as an environmental friendly and economically competitive means of electric power generation.[5] The wind energy system generates power in the form of AC with different voltage and frequency levels in case of variable speed operation.

In this paper wind energy conversion system is simulated using MATLAB. Output of this system is connected to the grid through point of common coupling (PCC).

WIND ENERGY SYSTEM:

Wind power systems convert the kinetic energy of the wind into other forms of energy such as electricity. Although wind energy conversion is relatively simple in concept, turbine design can be quite complex. Most commercially available wind turbine uses a horizontal – axis configuration with two or three blades, a drive train including a gearbox and a generator and a tower to support the rotor.[6]

The power available in the wind is proportional to the cube of its speed. This means that if wind speed doubles, the power available to the wind generator increases by a factor of 8 (2 x 2 x 2 = 8) Since wind speed increases with height increases to the tower height can mean enormous increases in the amount of electricity generated by a wind turbine.

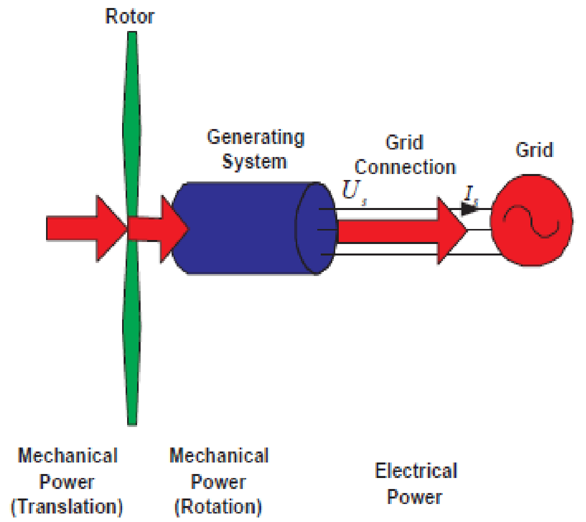


Figure 1. Proposed system of grid interconnection of RES

POWER CONTAINED IN WIND:

Wind is natural phenomenon related to movement of air masses caused primarily by the differential solar heating of the earth's surface. The wind turbine captures the winds kinetic energy in a rotor consisting of two or more blades mechanically coupled to an electrical generator.

The amount of power transferred to a wind turbine is directly p density of the air, and the cube of the wind speed.[7]

The power P in the wind is given by,

$$P = ½\ Cp.\ \rho.A.\ V3 \quad (1)$$

Where Cp is the turbine power coefficient. A theoretical maximum value of 0.593 has been proposed for Cp

ρ = air density (kg/m3),

A is the rotor swept area (m2)

PROPOSED WIND SYSTEM:

In proposed wind power system turbine, permanent magnet synchronous generator (PMSG) is used. The main advantages of PMSG are less maintenance, high efficiency, high power factor operation, eliminates DC link excitation circuit thus reduces its complications. Output of system is AC and directly fed to the PCC through a circuit breaker. The grid is also connected to PCC and load is supplied from the PCC.

Applications of Wind Power System are listed below:

i) Remote and rural village electrification.

ii) Residential colonies & apartments for general lighting.

iii) Integration with photo voltaic system.

With the use of renewable energy based system the emission of carbon and other harmful gases are reduced to approximately 80% to 90% in environments. Figure. 2 shows the simulation model of wind turbine.

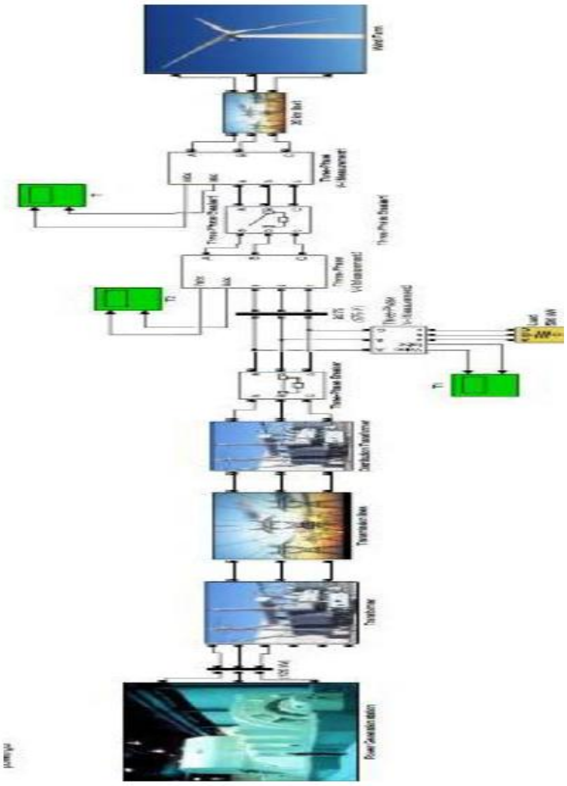


Figure2. Simulation model of wind turbine

SIMULATION MODELS:

SIMULINK MODEL OF WIND TURBINE:

Turbine is main part of wind generation system. Aerodynamic design of turbines coverts the wind energy into the mechanical power. This mechanical power is delivered to the rotor of synchronous generator which coverts it into the electrical form. Output of this system is AC and fed to grid through (PCC).Simulink model of wind turbine

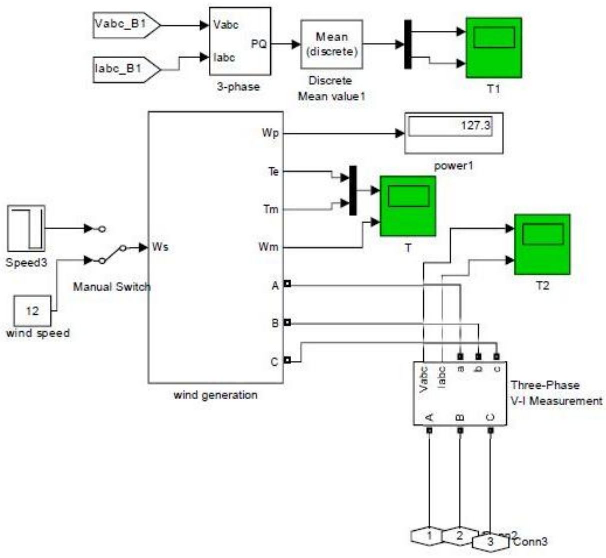


Figure 3. Simulation model of wind turbine system

SIMULINK MODEL OF WIND TURBINE SUBSYTEM:

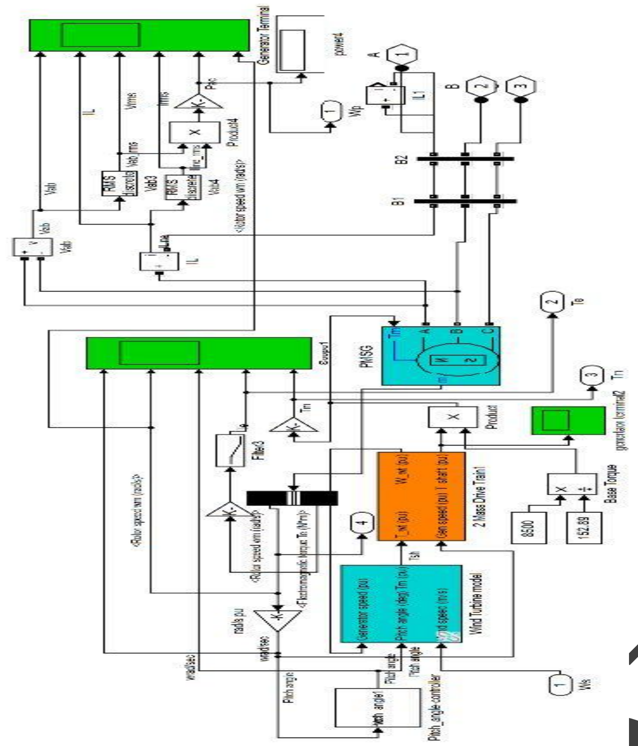


Figure 4 simulation model of hybrid system

PERMANENT MAGNET SYNSCHRONOUS GENERATOR:

The wind energy conversion system drives a high speed PMSG for conversation of mechanical energy to electrical energy.[8] The PMSM model used is a 2 pole with a non-salient rotor. The dynamic equations of PMSM expressed in the rotor reference frame (dq frame) a follow:

ELECTRICAL EQUATIONS :

$$\frac{d}{dt}id = \frac{1}{Ld}vd - \frac{R}{Ld}id + \frac{Lq}{Ld}p\omega_r iq \qquad (2)$$

$$\frac{d}{dt}iq = \frac{1}{Lq}vq - \frac{L}{Lq}iq - \frac{Ld}{Lq}p\omega_r id - \lambda\frac{p\omega_r}{Lq} \qquad (3)$$

$$Te = 1.5\,p(\lambda\, iq + (Ld - Lq)idiq) \qquad (4)$$

MECHANICAL EQUATION :

$$\frac{d}{dt}\omega_r = \frac{1}{J}(Te - F\omega_r - Tm) \qquad (5)$$

$$\frac{d}{dt}\theta = \omega_r \qquad (6)$$

where, Lq and Ld are q and d axis inductances, iq and id are q and d axis currents, R is Resistance of the stator windings, vq & vd are q and d axis voltages, ωr is Angular velocity of the rotor, λ is Flux induced by the permanent magnets in the stator windings, P is Number of pole pairs, Te is Electromagnetic torque, J is combined inertia of rotor and load, F is Combined viscous friction of rotor and load, Θ is Rotor angular position and Tm is Shaft mechanical torque.

RESULTS:

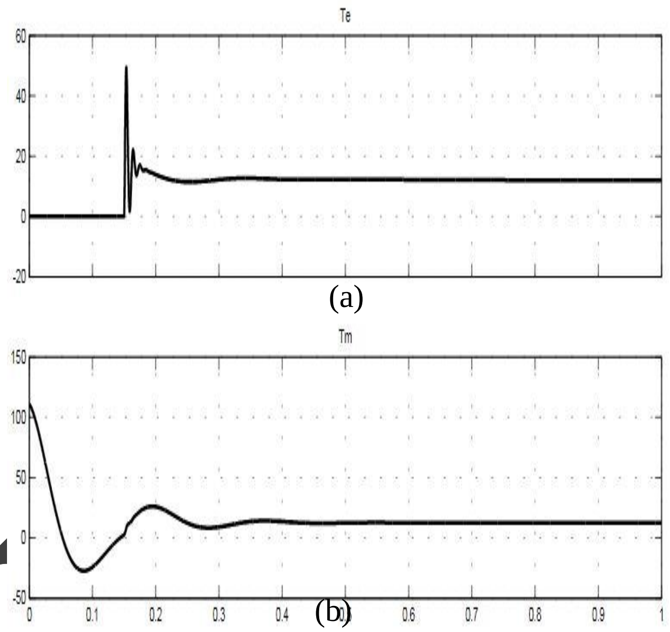


Figure 5 waveform of (a) Electromagnetic torque vs time (b) Mechanical torque vs time

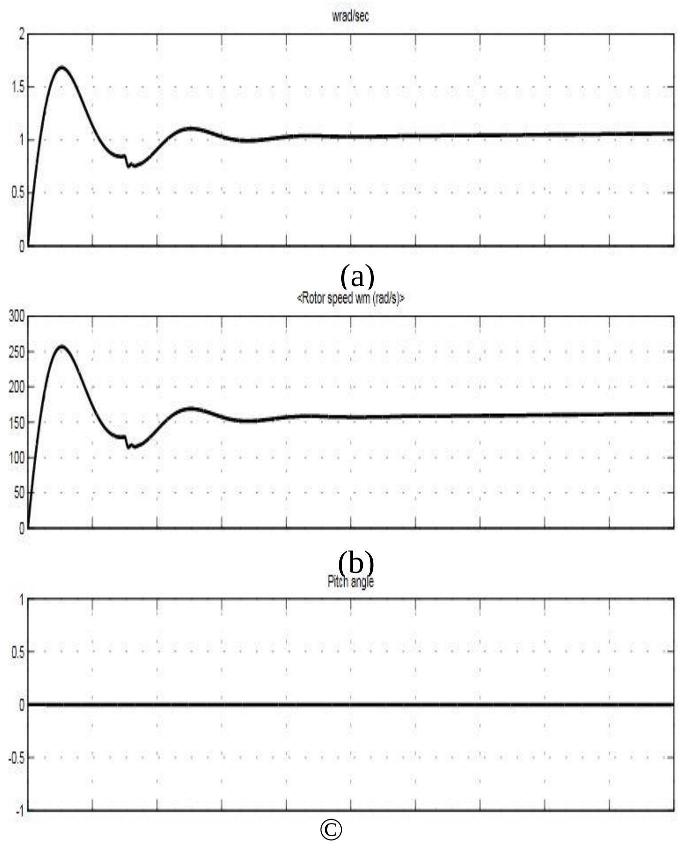
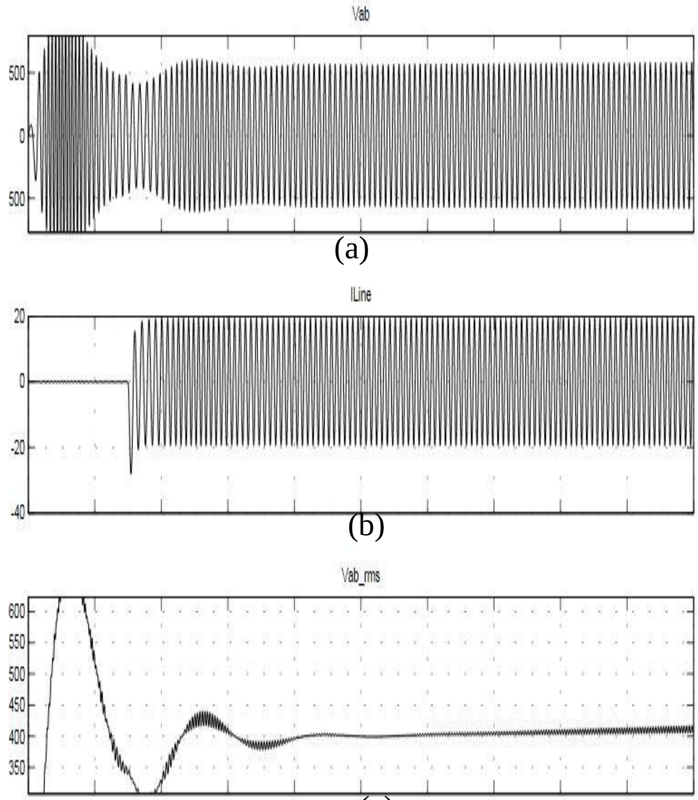


Figure 6waveform of (a) Time vs. Wind speed (b) Rotor speed vs. time (c) Pitch angle vs. time



(a) (b) (c)

Figure 7 waveform of (a) Phase voltage vs time, (b) Line current vs time (c) Phase voltage(rms) vs time

CONCLUSION:

The use of wind power generation is an especially vivid and relevant choice for students of electrical technology as it is a power source of technological, political, and economic importance in country. This technique has lower overhead and finds applications in remote space power generation, energy conversion systems and rural electrification. Relatively small power generations such as small wind or solar system, would be an approach to penetrate renewable to the power systems. Small renewable energy sources are connected to the low side of the distribution systems. The proposed system is employed by using MATLAB/ SIMULINK to model the wind power, turbine and therefore planned the system.

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