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Modeling And Control Of Hybrid Wind-Solar Energy System

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Abstract: In the recent years the demand of energy has been increased rapidly and all the explorer are searching for the better and reliable form of energy. That gave us the chance to seek new energy sources that can be harnessed easily and had better impact. This search has dragged all attention towards the renewable energy sources that are in abundant and easily available and most important economical. The most important application field of this search is renewable energy resources. Wind and solar energy have being popular ones owing to abundant, ease of availability and convertibility to the electric energy. This work covers realization of a hybrid renewable energy system. This project deals with the focus of implementing a hybrid design that can over-come our energy demand and provide a reliable source for future work. Batteries in the system are charged by either wind power via a small alternator or solar power via an MPPT Module.

1. Introduction

With exhausting of traditional energy resources and increasing concern on environment, renewable and clean energy is attracting more and more attention all over the world to overcome the growing demand of power. Out of all available resources the solar and the wind energy are gaining more attention in terms of energy generation as these has negligible impact on the environment. However the renewable energy has drawback that the change of the output characteristics becomes more intense as the output highly depends upon the climatic condition, including the solar irradiance, wind speed, temperature and so forth. In this paper a hybrid model of solar(photovoltaic)-wind energy generation system is discussed with its modeling and control. Combining the photovoltaic with the wind generation the instability of the output characteristics of each other was compensated. The wind-solar provides a reasonable power supply which makes a good use of wind and solar energy. Hybrid energy system is an excellent solution for electrification of remote rural areas where grid extension is difficult and not economical. The main objective is to meet the 24/7 demand of power in remote areas at economical price. Maximum power point tracker (MPPT) controllers are used in PV and wind system to maximize the photovoltaic array and the wind generator output irrespective of climatic conditions and of the load electrical characteristics. Recently, the availability of power in India has not just increased but also improved, although the demand consistently rose more than the supply. That's why nonconventional sources have become the center of attraction. Among these fast growing non-conventional sources the wind energy system and solar photovoltaic system are very common. Now India has become fifth in installed capacity of both wind and solar power plant. As of 30th September 2013 the installed capacity of wind power in India was 19881MW. But, as the wind is season and region based, it was not so reliable so we go for hybrid system of power generation.

2. Alternate Energy Sources

As the energy sources are depleting as fast as we imagine our new trends move towards the alternative sources and in order we found that the solar energy is our ultimate option. The solar energy when used with wind energy can generate enough energy to meet our partial growing demand of power. So here are some alternate sources of energy are- solar energy, wind energy, geo-thermal, tidal, hydro-thermal etc.

3. Solar Energy

Solar energy is renewable and eco-friendly form of energy, extracting useable electricity from the sun was made possible by the discovery of the photoelectric mechanism and subsequent development of the solar cell – a semi conductive material that converts visible light into a direct current. By using solar arrays, a series of solar cells electrically connected, a DC voltage is generated which can be physically used on a load. Solar arrays or panels are being used increasingly as efficiencies reach higher levels and especially popular in remote areas where placement of electricity lines is not economically viable. This alternative power source is continuously achieving greater popularity especially since the realization of fossil fuels shortcomings. Renewable energy in the form of electricity has been in use to some degree as long as 75 or 100 years ago. In

India solar energy has a vast potential as the sun shines in some areas of India over long period of year, especially in areas like Rajasthan and western part.

4. Wind Energy

The wind energy is a renewable source of energy. Wind turbines are used to convert the wind power into electric power. Electric generator inside the turbine converts the mechanical power into the electric power. Wind turbine systems are available ranging from 50W to 3-4 MW. The energy production by wind turbines depends on the wind velocity acting on the turbine. The wind energy can be harnessed easily over the areas where the wind speed is almost constant throughout the year specially in the coastal areas of India.

5. Hybrid Model

The hybrid system is designed and installed to generate electricity which combines diesel generator with multiple renewable energy resources PV array and wind turbine and operate with solar inverter and solar system software for remote power monitoring and control. The hybrid model system is renewable energy system that helps conserve energy by reducing use of diesel and other conventional sources of energy. The different types of renewable sources are specially evaluated in the economical performance of overall equipments.
The wind and the PV both these sources are clean and worldwide available. The comparative advantages of these sources in relation to other renewable energies are demonstrated by the intense expansion of both wind and photovoltaic production plant. These resources are extremely useful in low developed countries with need of growing demand of electricity.

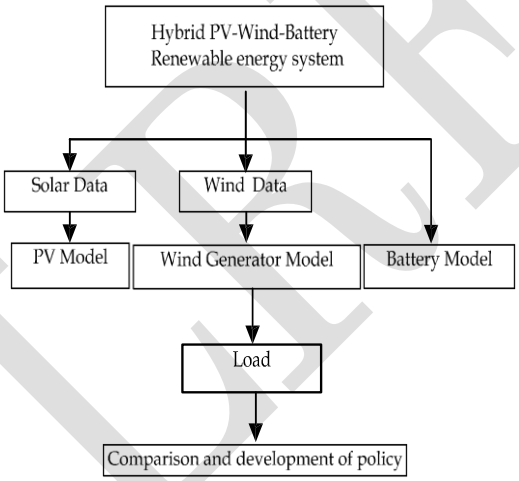

Fig.1. General diagram of Hybrid-system

6. Modeling of solar energy (pv) system

Solar energy is one of the most significant renewable energy sources that world needs. The major applications of solar energy can be classified into two categories: solar thermal system, which converts solar energy to thermal energy, and photovoltaic (PV) system, which converts solar energy to electrical energy. The photovoltaic (pv) power technology uses semiconductor cells (wafers), generally several square centimeters in size. From the solid-state physics point of view, the cell is basically a large area p-n diode with the junction positioned close to the top surface. The cell converts the sunlight into direct current electricity. Numerous cells are assembled in a module to generate required power. Unlike the dynamic wind turbine, the pv installation is static, does not need strong tall towers, produces no vibration or noise, and needs no cooling. Because much of the current pv technology uses crystalline semiconductor material similar to integrated circuit chips, the production costs have been high. The pv cell manufacturing process is energy intensive. A PV generator consists of an assembly of solar cells, connections, protective parts, supports etc. Solar cells are made of semiconductor materials (usually silicon), which are specially treated to form an electric field, positive on one side (backside) and negative on the other (towards the sun). Then solar energy (photons) hits the solar cell, electrons are knocked loose from the atoms in the semiconductor material, creating electron-hole pairs. If electrical conductors are then attacked to the positive and negative sides, forming an electrical circuit, the electrons are captured in the form of electric current (photocurrent).

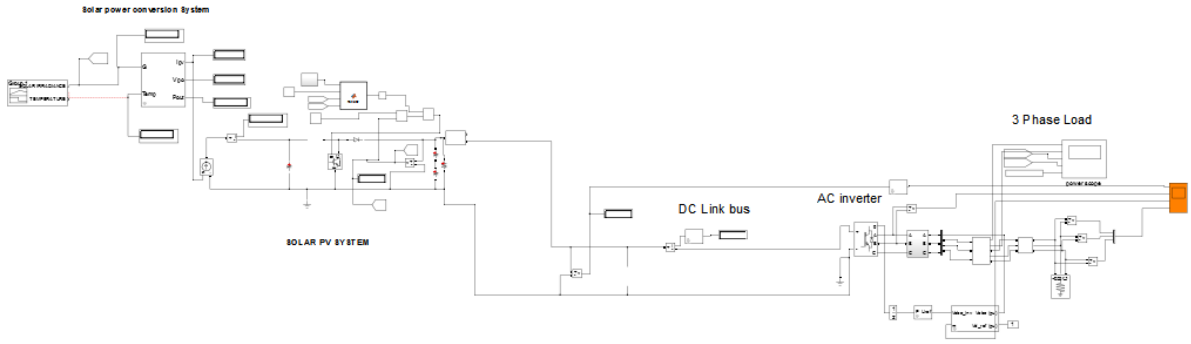

Fig.2. Matlab simulation block for solar (pv) module.

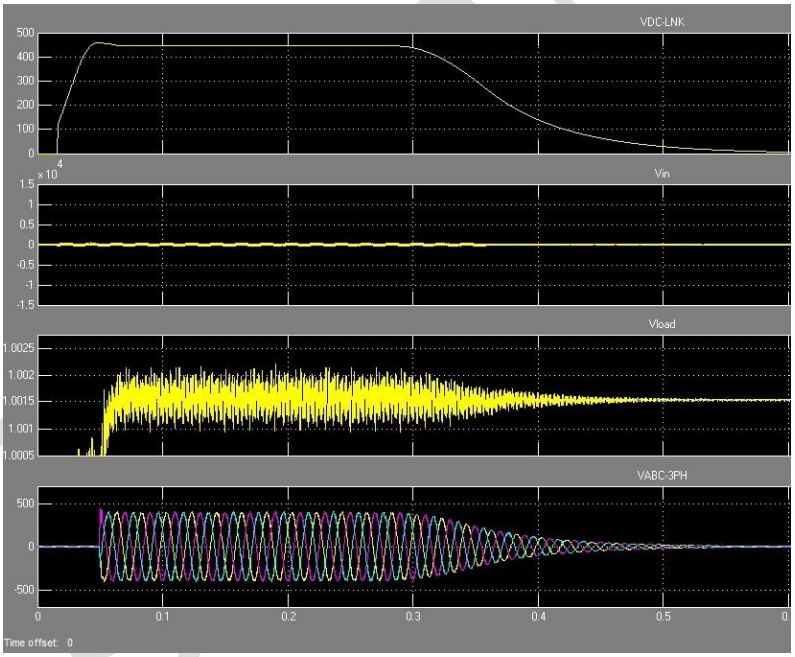

Fig.3. Waveform of solar voltage

The p-n junction has a certain depletion layer capacitance, which is typically neglected for modeling solar cells. At increased inverse voltage the depletion layer becomes wider so that the capacitance is reduced similar to stretching the electrodes of a plate capacitor. Thus solar cells represent variable capacitance whose magnitude depends on the present voltage. This effect is considered by the capacitor C located in parallel to the diode Series resistance RS consists of the contact resistance of the cables as well as of the resistance of the semiconductor material itself. Parallel or shunt resistance RP includes the "leakage currents" at the photovoltaic cell edges at which the ideal shunt reaction of the p-n junction may be reduced. This is usually within the kΩ region and consequently has almost no effect on the current-voltage characteristic. The module contains of four major blocks- the solar conversion block, solar pv system, DC link system and AC inverter system.

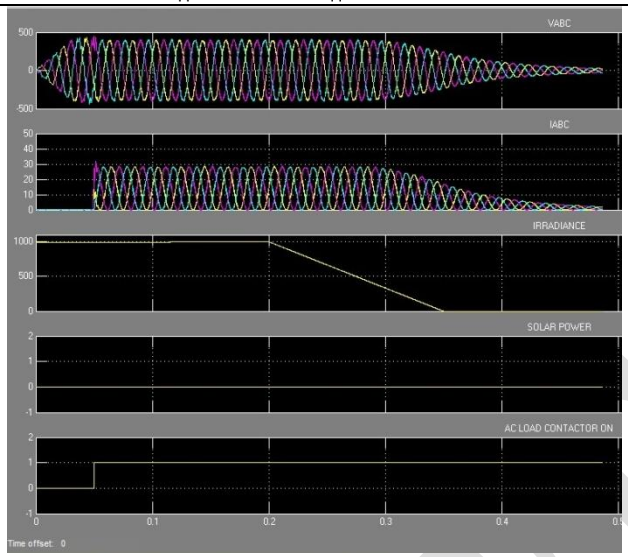

Fig.4. waveform of solar power

7. Modeling of wind energy system

Wind turbine is applied to convert the wind energy to mechanical torque. The mechanical torque of turbine can be calculated from mechanical power at the turbine extracted from wind power. The model of wind turbine is based on the steady-state power characteristics of the turbine. Modelling the wind energy converter is made considering the following assumptions- friction is neglected, stationary wind flow, constant and sheer wind flow, rotation-free flow, incompressible flow, free wind flow around the wind energy converter. So as per assumptions the kinetic energy of air can be expressed as:

$$E = \frac{1}{2} MV^2$$

M-mass of air,
V-speed of air

So power of wind can be expressed as:

$$P = \frac{1}{2} \rho AV^3 Cp$$

A-area at speed V,
Cp- coefficient of power of rotor.

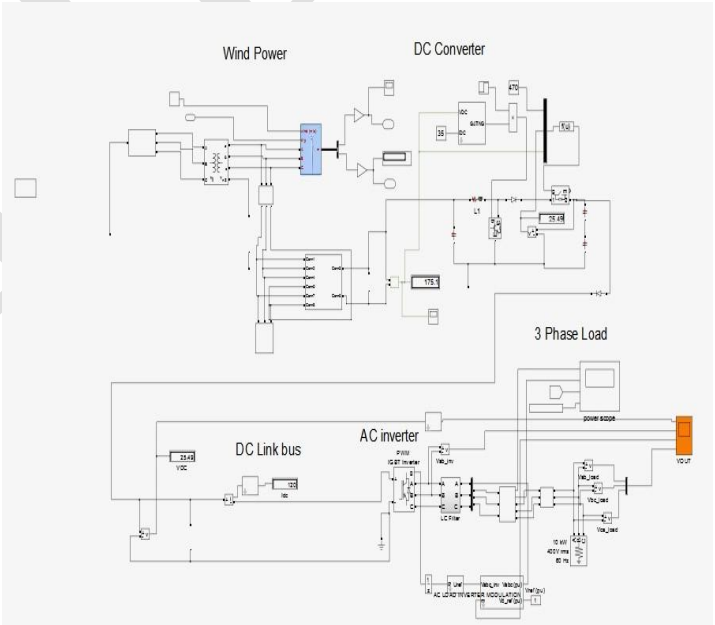

Fig.5. Matlab simulation block for wind turbine system.

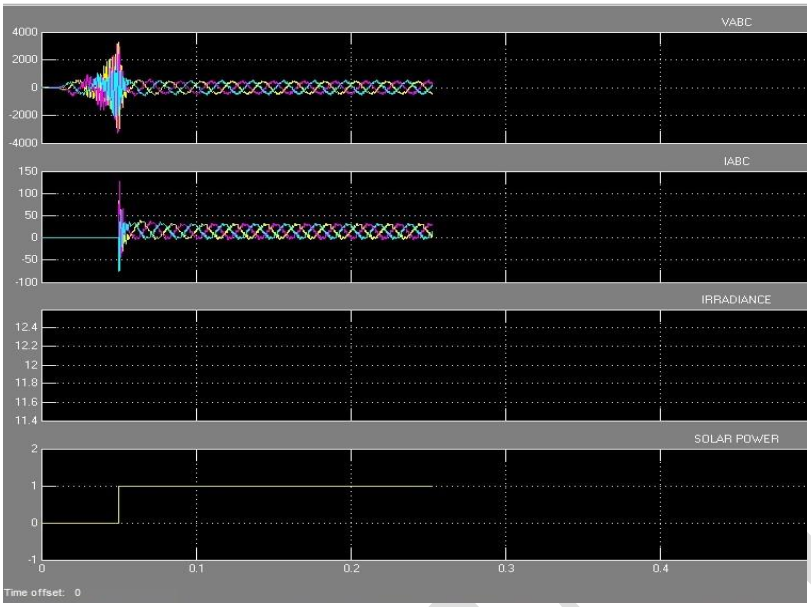

Fig.6. waveform wind power

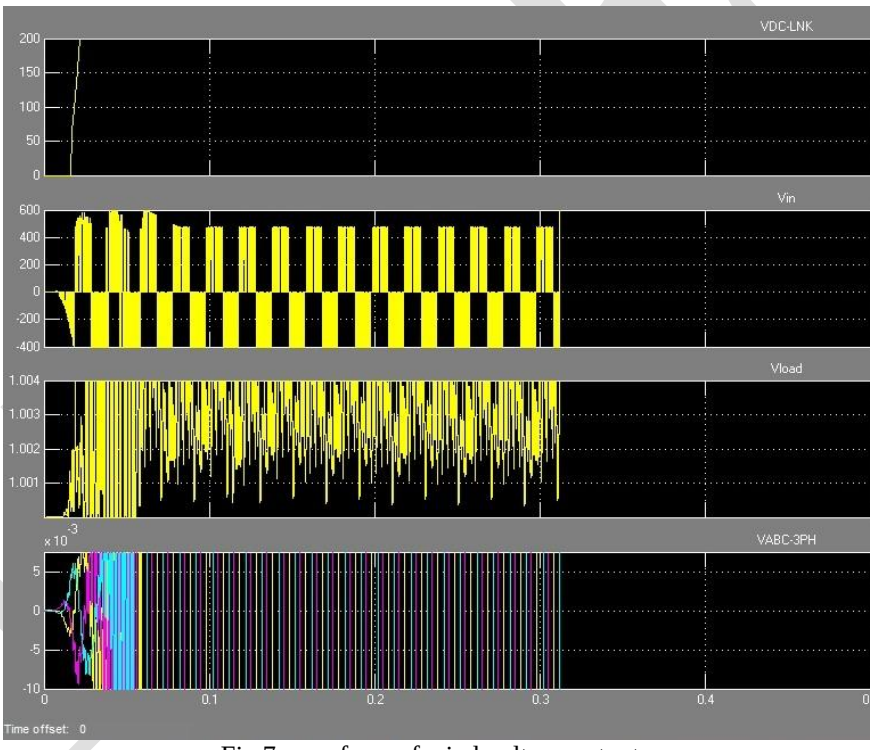

Fig.7.waveform of wind voltage output.

8. Hybrid design modeling

Proposed hybrid system has two basic inputs, one from the solar panel and other from the wind turbine. The output from the solar panel is passed through a mechanism for maximum power point tracking (MPPT**).** A grouping of Wind and PV energy system into a hybrid generation system may increase their efficiency by increasing their overall energy output, by reducing energy storage requirement. The topology of hybrid energy system consisting of variable speed WT coupled to a permanent magnet generator (PMG) and PV array. The two energy sources are connected in parallel to a common dc bus line through their individual dc-dc converters. The load may be dc connected to the dc bus line or may include a PWM voltage source inverter to convert the dc power into ac at 50 or 60 Hz. Each source has its individual control. The output of the hybrid generating system goes to the dc bus line to feed the isolating dc load or to the inverter, which converts the dc into ac. A

battery charger is used to keep the battery fully charged at a constant dc bus line voltage. When the output of the system is not available, the battery powers the dc load or discharged to the inverter to power ac loads, through a discharge diode. This makes system less costly and more reliable as compared to individual energy system.

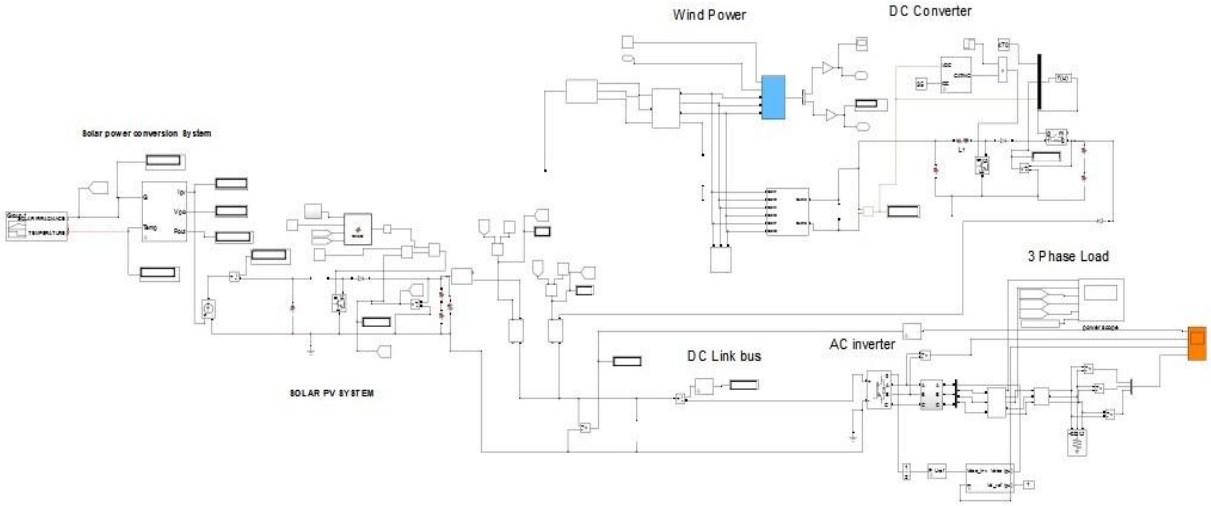

Fig.8. Matlab simulation Block for Proposed Hybrid wind-solar energy system.

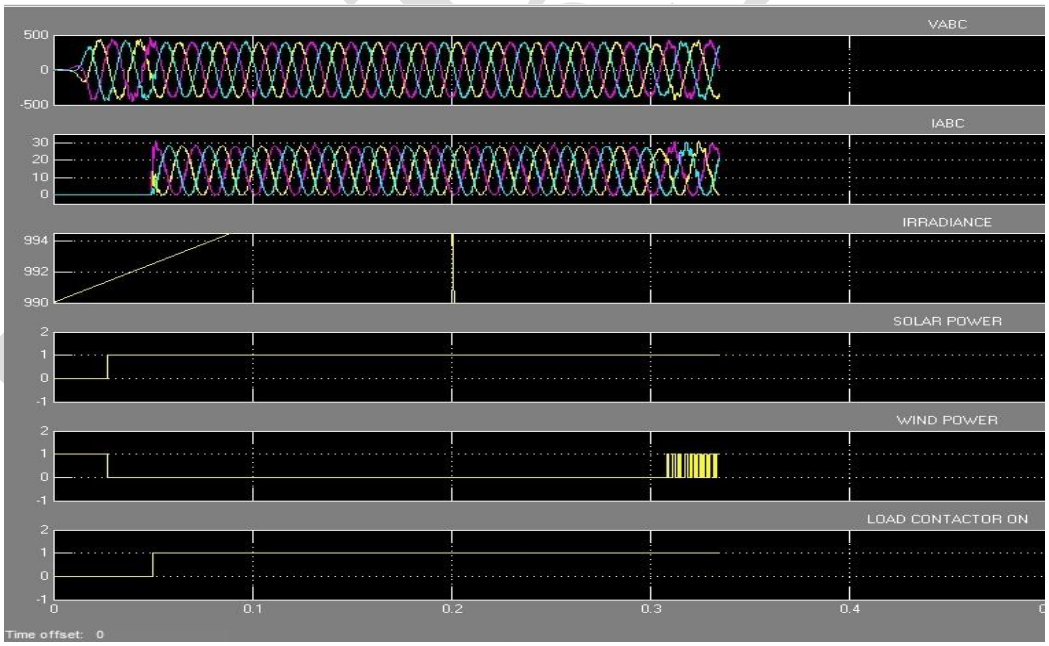

Fig.9. waveform of power delivered by the system.

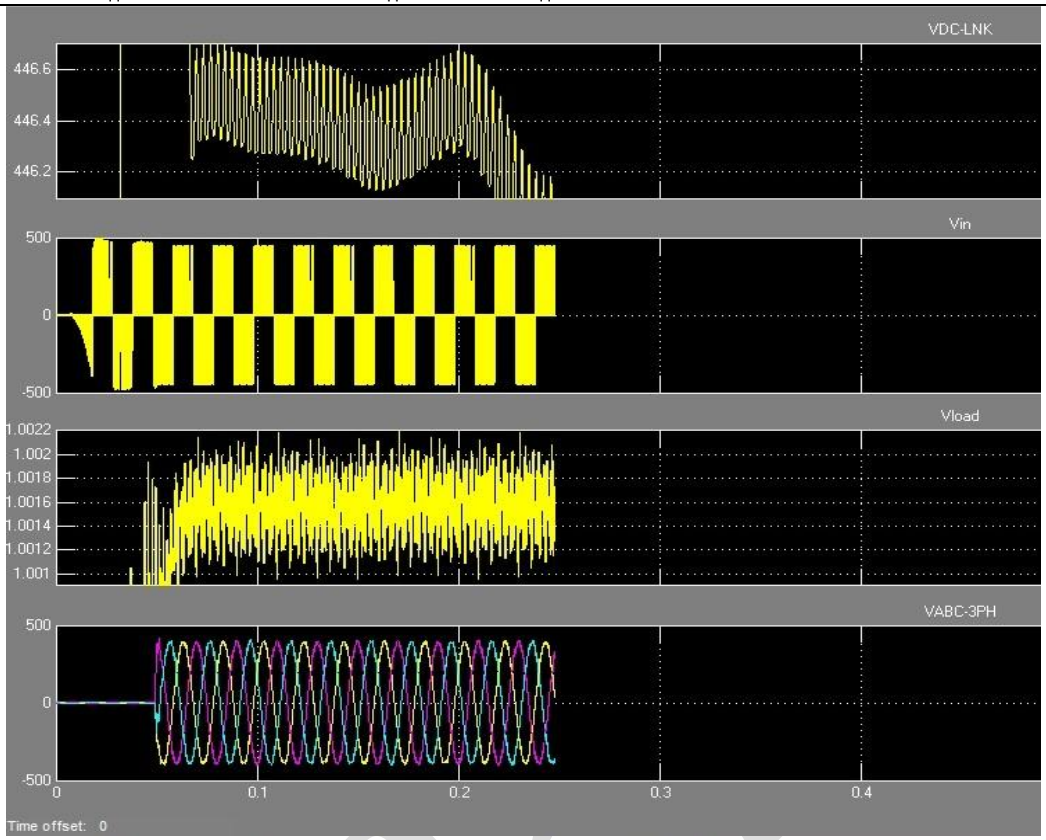

Fig.10. waveform of voltage output of the model.

9. Conclusions

Thus it can be concluded that generalized PV model which is representative of the all PV cell, module, and array has been developed in MATLAB/SIMULINK .The proposed model takes sunlight irradiance and cell temperature as input parameters and outputs the I-V and P-V characteristics under various conditions. This model has also been designed in the form of Simulink block libraries. The masked icon makes the block model more user-friendly and a dialog box lets the users easily configure the PV model. This paper describes renewable energy hybrid Wind-PV with battery energy storage system. In Hybrid Wind-PV System, PV system acts as a main source. A simple and cost effective maximum power point tracking technique is proposed for the photovoltaic and wind turbine without measuring the environmental conditions. The power fluctuation of the hybrid system is less dependent on the environmental conditions as compared to the power generated of individual solar (pv) and Wind generation system. The power fluctuation had been tried to minimize as par possible with introduction to battery in this system. The optimal operation of the system and its economical constrains are subject of future work.

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