Measurement and Analysis of Power in Hybrid System

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Abstract
Application with renewable energy sources such as solar cell array, wind turbines, or fuel cells have increased significantly during the past decade. To obtain the clean energy, we are using the hybrid solar-wind power generation. Consumers prefer quality power from suppliers. The quality of power can be measured by using parameters such as voltage sag, harmonic and power factor. To obtain quality power we have different topologies. In our paper we present a new possible topology which improves power quality. This paper presents modeling analysis and design of a pulse width modulation voltage source inverter (PWM-VSI) to be connected between sources, which supplies energy from a hybrid solar wind energy system to the ac grid. The objective of this paper is to show that, with an adequate control, the converter not only can transfer the dc from hybrid solar wind energy system, but also can improve the power factor and quality power of electrical system. Whenever a disturbance occurs on load side, this disturbance can be minimized using open loop and closed loop control systems.

Keywords: power quality, hybrid, harmonic, PWM-VSI, push- pull inverter, solar, wind, open loop, closed loop control.

1. Introduction

Stand-alone power generation systems are utilized by many communities and remote area around the world that have no access to grid electricity Renewable energy sources are predicted to become competitive with conventional power generation systems in the near future. Unfortunately, they are not very reliable. For example, the PV source is not available during the night or during cloudy conditions. Other sources such as fuel cells may be more reliable but have economic issues associated with them.

Because of this, two or more renewable energy sources are required to ensure a reliable and cost- effective power solution. Such a combination of different types of energy sources into a system is called a hybrid power system. With increasing concern of global warming and the depletion of fossil fuel reserves, many are looking at sustainable energy solutions to preserve the earth for the future generations. Other than hydro power, wind and photovoltaic energy holds the most potential to meet our energy demands. Alone, wind energy is capable of supplying large amounts of power but its presence is highly unpredictable.

Hybrid means utilization of two or more sources for the single load. So many advantages may be derived from Hybrid wind-solar generation. System is using these are:
a. Continuous power can be supplied to the consumers.
b. Environmental pollution can be reduced by using Hybrid solar- wind generation system.
c. Hybrid solar-wind can be made available to the far away consumers at economical rate from the utility saving hydraulic energy, which can be Kept in the dams during the dynamic, to be used at height. That is the dams ma y operate as an energy storage system.
d. The maintenance cost of hybrid solar-wind generation system is less when compared to conventional generation system. We can supply the power with low cost to the consumers.
e. In spite of a very attractive alternative with a reasonable price, the feeding of energy generated by a hybrid solar-wind generation into an existing AC grid poses some problems to the control of the converters that connect the two systems. This is especially true if the AC system cannot supply reactive power and absorb harmonic current.

2. Solar Photo Voltaic System

The physical of PV cell is very similar to that of the classical diode with a p-n junction formed by semiconductor material. When the junction absorbs light, the energy of absorbed photon is transferred to the electron-proton system of the material, creating charge carriers that are separated at the junction. The charge carriers in the junction region create a potential gradient, get accelerated under the electric field, and circulate as current through an external circuit. The solar cell is the basic building of the PV power system it produces about 1 W of power. To obtain high power, numerous such cell are connected in series and parallel circuits on a panel (module), The solar array or panel is a group of a several modules electrically connected in series-parallel combination to generate the required current and voltage. The equivalent circuit of solar cells shown in Figure.1
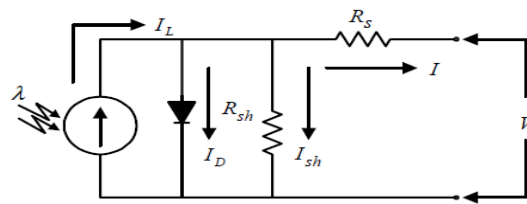

Figure. 1. Equivalent Circuit of Solar Cells

Figure 2 shows the I-V characteristics of the photovoltaic module at different solar illumination intensities. The I-V characteristic of the solar PV decreases gradually as the voltage goes up and when the voltage is low the current is almost constant. The power output of the panel is the product of the voltage and current outputs. The PV module must operate electrically at a certain voltage that corresponds to the peak power point under a given operation conditions.[1]-[5]
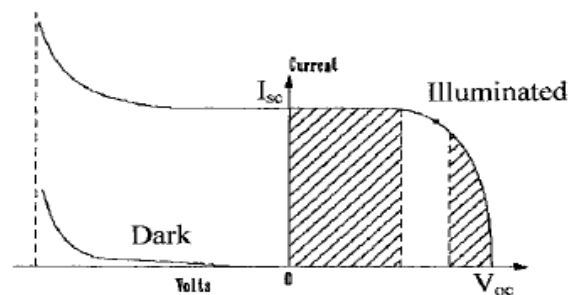

Figure. 2. I-V Characteristics of PV Module

The PV array must operate electrically at a certain voltage which corresponds to the maximum power point under the given operating conditions, i.e. temperature and irradiance. To do this, a maximum power point tracking (MPPT) technique should be applied. Various MPPT techniques like look-up table methods, perturbation and observation (P & O) methods and computational methods have been proposed in the literature. The perturbation and observation (P&O) method has been used in this work. If the array is operating at voltage V and current I, the operation point toward the maximum power point by periodically increasing or decreasing the array voltage, is often used in many PV systems. The advantage of this method is that it works well when the irradiation does not vary quickly with time, however, the P&O method fails to quickly track the maximum power points. In incremental conductance method the maximum power points are tracked by comparing the incremental and instantaneous conductance values of the PV array. Figure. 3 presents the flow of the perturbation and observation technique implemented. [4][5]

For most PV modules, the ratio of the voltage at the maximum power point for different insulation levels to the open circuit voltage is approximately constant. Also, the ratio of the current at the maximum power point for different insulation levels to the short circuit current is constant. If the direction of the perturbation i.e an increase or decrease in the output voltage of a PV array results in a positive change in the output power, then the control algorithm will continue in the direction of the previous perturbation. Conversely, if a negative change in the output power is observed, then the control algorithm will reverse the direction of the pervious perturbation step. In the case that the change in power is close to zero (within a specified range) then the algorithm will invoke no changes to the system operating point since it corresponds to the maximum power point (the peak of the power curves). The MPPT technique proposed in this work makes use of a predetermined relationship between the operating voltage or current and the open circuit voltage/short circuit current to obtain MPPT at any operating conditions.
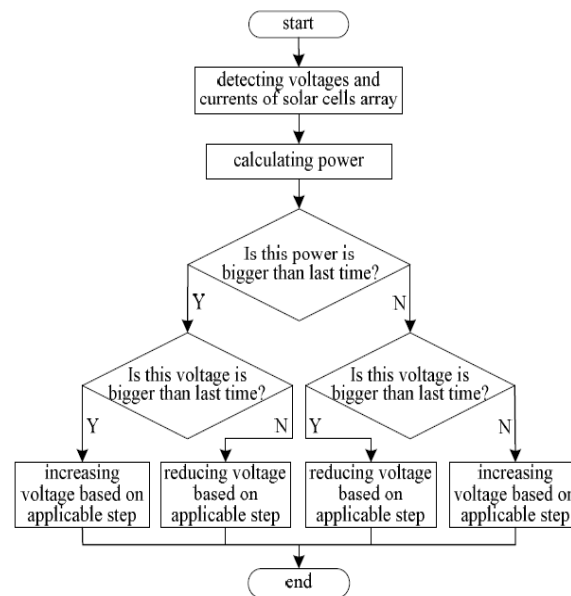
Figure 3. Flow Chart of the MPPT Technique Implemented

3. Wind Energy Conversion System

Power from the wind turbine, real and reactive power, is basically controlled by the wind-side converter and stalled by the wind blade. Below rated wind speeds, the real power from the wind generator is regulated to capture the maximum wind energy from varying wind speed. Reactive power generation is maintained at zero to minimize the thermal rating of the generator and the converter. Above rated wind speeds the maximum power control is overridden by stall regulation for constant power. In this study, the wind blade is assumed to be ideally stall regulated at rated power so that rotor speed can keep constant at rated speed under high wind speeds.

The typical turbine torque vs. rotor speed and power vs. rotor speed characteristics are shown in Figure.5 and Figure.6 respectively. The maximum power for different wind speeds is generated at a different rotor speeds. Therefore, the turbine speed should be controlled to follow the ideal TSR, with an optimal operating point which is different for every wind speed. This is achieved by incorporating a speed control in the system design to run the rotor at high speed in high wind and at low speed in low wind.
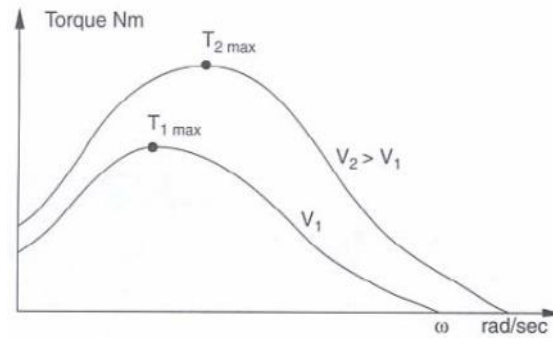
Figure 4. Wind Turbine Torque vs. Rotor Speed

4. Proposed System Configuration

The proposed standalone hybrid wind-solar power generation system is, as shown in Figure,in outline composed off our power sources: a wind power generation system (with a WT converter and a WT inverter), solar power generation system (with a PV inverter), storage battery (with a bidirectional inverter), and engine generator (EG); and a control unit .

The control unit acts to send ON/OFF operation commands to individual power sources and monitor power status via a simple communication line, which is all that is needed since the data traffic volume is small. Once an ON command is sent, each power source is autonomously operated via individual inverters; however, manual setting of inverter operating conditions is also possible if required. The inverters enable redundant parallel operation, making a reliable, stable power supply possible.
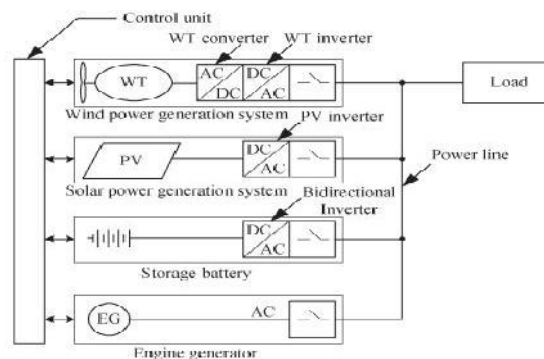

Figure 5. Proposed Standalone Hybrid Wind Solar Power Generation

5. Hardware

Data sheets for all hardware components give operational data as well as limitations of the products and best conditions at which the product operates. The data sheets were very important reference to ensure circuits were being setup correctly.

5.1. Microcontroller

The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density non volatile memory technology and is compatible with the industry standard 80C51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non volatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications. The AT89S52 provides the following standard

features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89S52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power-down mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next interrupt or hardware reset.
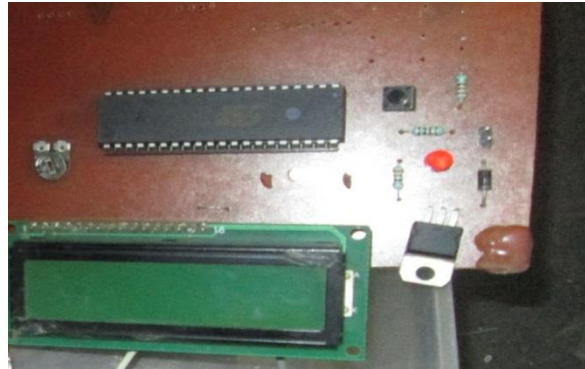

Figure 6. Microcontrollers

5.2. Oscillator Characteristics:

XTAL1 and XTAL2 are the input and output, respectively, of an inverting amplifier which can be configured for use as an on-chip oscillator, as shown in Figure 1. Either a quartz crystal or ceramic resonator may be used. To drive the device from an external clock source, XTAL2 should be left unconnected while XTAL1 is driven as shown in Figure 7. There are no requirements on the duty cycle of the external clock signal, since the input to the internal clocking circuitry is through a divide-by-two flip-flop, but minimum and maximum voltage high and low time specifications must be observed.
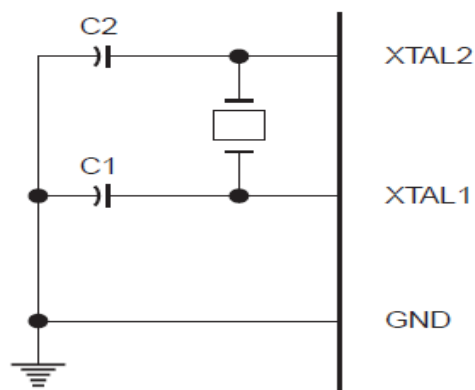

Figure 7. Oscillator Connections

5.3. Relay :

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical

isolation between control and controlled circuits), or where several circuits must be controlled by one signal.

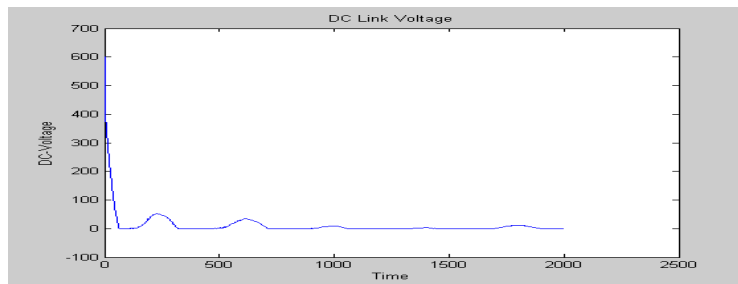Figure 8. Hardware of Hybrid System

6. Results

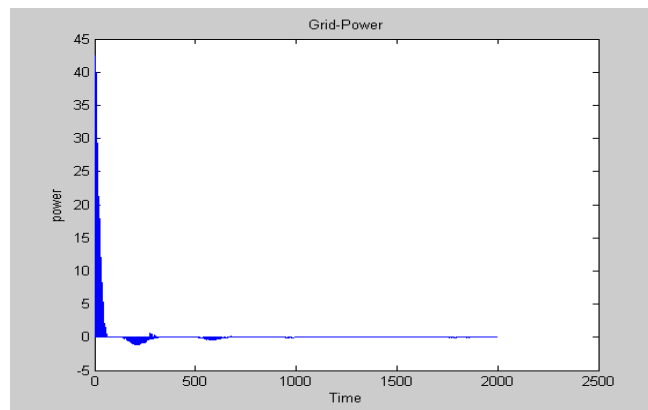Figure 9. DC Link Voltage

Figure 10. Power Delivered to the Grid

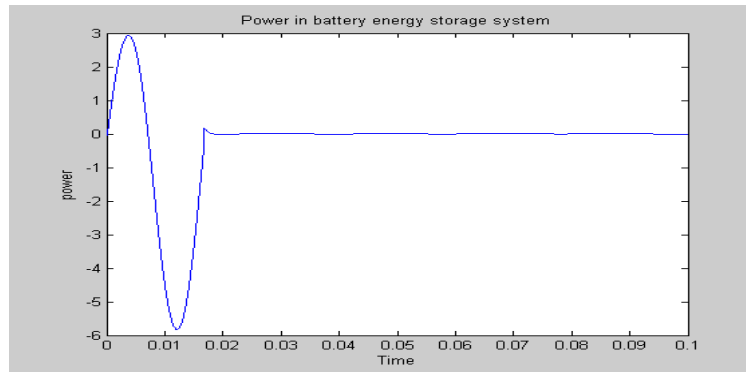The power stored in battery energy system is as shown in Figure 11.

Figure 11. Power in Battery Energy Storage System

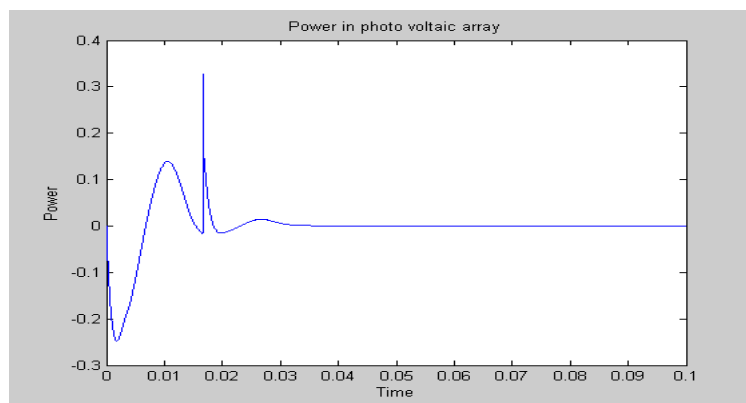The power developed by photo voltaic array is as shown in Figure 12.

Figure 12. Power In Photo Voltaic Array

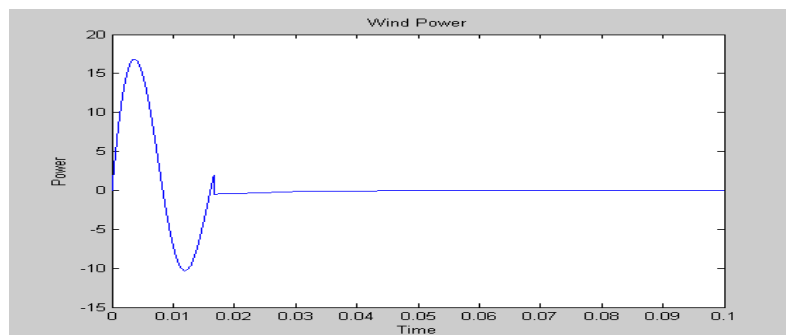The power developed by wind turbine is shown in Figure 13.

Figure 13. Power Developed by Wind Turbine

From the results it is observed that the variations in output power are more in PV system because the voltage across PV module is changing rapidly whereas the variations in output power in wind energy conversion system is less   because the voltage across wind system is almost constant and the battery voltage decreases exponentially and the battery current increases exponentially.

6. Conclusion

Wind and solar power are safe, and do not send emissions or residues to the environment. The production of clean energy, which is harmless and does not aggravate the greenhouse effect, must be promoted. The use of electricity generated from renewable non-pollutant energy sources (green electricity), and all technologies involved must increase the scientific community is also contributing with technological innovations. Nowadays, the development of Power Electronics enables economical solutions for the production of renewable energy based on small power plants. Portugal presents good conditions for the implementation of a large number of these systems, based on wind power and photovoltaic energy. This paper proposes the development of a low-cost high efficiency hybrid system (wind and solar) with an interface to the load that ensures the power quality of the produced energy. The proposed solution may be a contribution to a better, cleaner and safer environment and to a decrease in energy dependence.

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