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PERFORMANCE ANALYSIS OF STANDALONE PV SYSTEMS USING UNIFIED POWER QUALITY CONDITIONERS

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Abstract: In this project, a methodology for implementation of an automated transition of a solar PV array and Battery integrated Unified Power Quality Conditioner (PV-BUPQC) between standalone and grid connected modes of operation is presented and analyzed. This system consists of a shunt and series active filters connected back-to-back with a common DC-link. The system addresses the issue of the integrating power quality improvement along with the generation of clean energy. Moreover, due to the automated transition, the critical loads have continuous power supply irrespective of grid availability. The key challenges addressed are implementation of automated transition in a PV-B-UPQC system with minimal disturbance to the local loads. The system operation is validated through simulation under a number of dynamic conditions such as automated transition, supply voltage variations, unavailability of the grid, variation in solar power generation, load variation, etc., which are typically encountered in a modern distribution network.

Keywords: Arduino, 16x 2 LCD Modules, Voltage Regulator

1. INTRODUCTION

There has been a rapid increase in the use of sophisticated electronic systems such as data centers, semiconductor industries, etc. which require regulated and good quality power. Moreover, there has been an increased focus on the use of renewable power sources, reduced dependence on depleting sources of fossil fuels, which not only cause pollution but also leads to global warming. There is a need for renewable energy systems, which also improve power quality and also have the capability for operation during the unavailability of the grid. The addition of a battery energy storage, enables the standalone mode of operation. Moreover, the battery energy can also be used for smoothening the power fluctuations due to intermittent conditions of solar PV power. Research has been going on recently into multi-objective systems, which have the capability to improve power quality along with clean energy generation. Primarily, the investigation has been on shunt connected topologies, which combines functions of a DSTATCOM (Distribution Static Compensator) and solar inverter. A novel scheme, of power quality management of PV power plant has been presented through the transformer integrated filter method. This technique is, however, dependent on transformer design and cannot be later programmed as compared with active filtration methods.

A technique for seamless transition between the standalone operation and grid connected operation for a PV array and battery integrated shunt compensation system, has been proposed. For operational requirements in small households, single phase PV-battery integrated systems have been proposed. Integration of renewable energy and storage along with UPQC system provides solution for voltage regulation, load current quality compensation and clean energy generation.

1.1. NEED FOR SOLAR ENERGY

Solar Panels are a form of active solar power, a term that describes how solar panels make use of the sun's energy: solar panels harvest sunlight and actively convert it to electricity. Solar Cells, or photovoltaic cells, are arranged in a grid-like pattern on the surface of the solar panel. Solar panels are typically constructed with crystalline silicon, which is used in other industries (such as the microprocessor industry), and the more expensive gallium arsenide, which is produced

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exclusively for use in photovoltaic (solar) cells.

Solar panels collect solar radiation from the sun and actively convert that energy to electricity. Solar panels are comprised of several individual solar cells. These solar cells function similarly to large semiconductors and utilize a large-area p-n junction diode. When the solar cells are exposed to sunlight, the p-n junction diodes convert the energy from sunlight into usable electrical energy. The energy generated from photons striking the surface of the solar panel allows electrons to be knocked out of their orbits and released, and electric fields in the solar cells pull these free electrons in a directional current, from which metal contacts in the solar cell can generate electricity. The more solar cells in a solar panel and the higher the quality of the solar cells, the more total electrical output the solar panel can produce. The conversion of sunlight to usable electrical energy has been dubbed the Photovoltaic Effect.

2. SYSTEM DESCRIPTION

2.1. EXISTING SYSTEM

In existing method for improving power quality unified power quality conditioner (UPQC) is integrated with the micro grid. This work gives the results on actual scaled down hardware prototype thereby validating the performance of the system. While in islanded and grid interactive modes are described, the system configuration has no storage system at the DC-link. So the system performance in islanded mode is highly dependent on PV power generated.

3. PROPOSEDSYSTEM

3.1. DETAILED DESCRIPTION OF PROPOSED SYSTEM

3.1.1. COMPONENTS

ARDUINO

. The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

16x 2 LCD MODULES

Liquid crystal displays (LCDs) have materials which combine the properties of both liquids and crystals. Rather than having a melting point, they have a temperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped together in an ordered form similar to a crystal.

VOLTAGE REGULATOR

A voltage regulator is an electronic circuit that provides a stable DC voltage independent of the load current, temperature and AC line voltage variations. A voltage regulator may use a simple feed-forward design or may include negative feedback. It may use an electromechanical mechanism, or electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages.

SOLAR CELL

A solar cell panel, solar electric panel, photo-voltaic (PV) module or solar panel is an assembly of photo-voltaic cells mounted in a framework for installation. Solar panels use sunlight as a source of energy to generate direct current electricity. A collection of PV modules is called a PV panel, and a system of PV panels is called an array. Arrays of a photovoltaic system supply solar electricity to electrical equipment.

BATTERY

An automotive battery is a rechargeable battery that supplies electrical energy to a motor vehicle and its main purpose is to start the engine. Once the engine is running, power for the car's electrical systems is supplied by the alternator. Typically, starting discharges less than three per cent of the battery capacity. SLI (Starting, Lighting and Ignition) batteries are designed to release a high burst of current and then be quickly recharged.

CAPACITOR

A capacitor is a device that stores electrical energy in an electric field. It is a passive electronic component with two terminals. The effect of a capacitor is known as capacitance. While some capacitance exists between any two electrical conductors in proximity in a circuit, a capacitor is a component designed to add capacitance to a circuit. The capacitor was originally known as a condenser or condenser. This name and its cognates are still widely used in many languages, but rarely in English, one notable exception being condenser microphones, also called capacitor microphones.

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3.1.2 SYSTEM MODEL & WORKING

The Drawbacks of the existing system is overcome through the system by which the use of alternative source of energy. Solar Photovoltaic panels is the important source for the system tobe operated. The below block diagram shows the schematic representation of this proposed system.

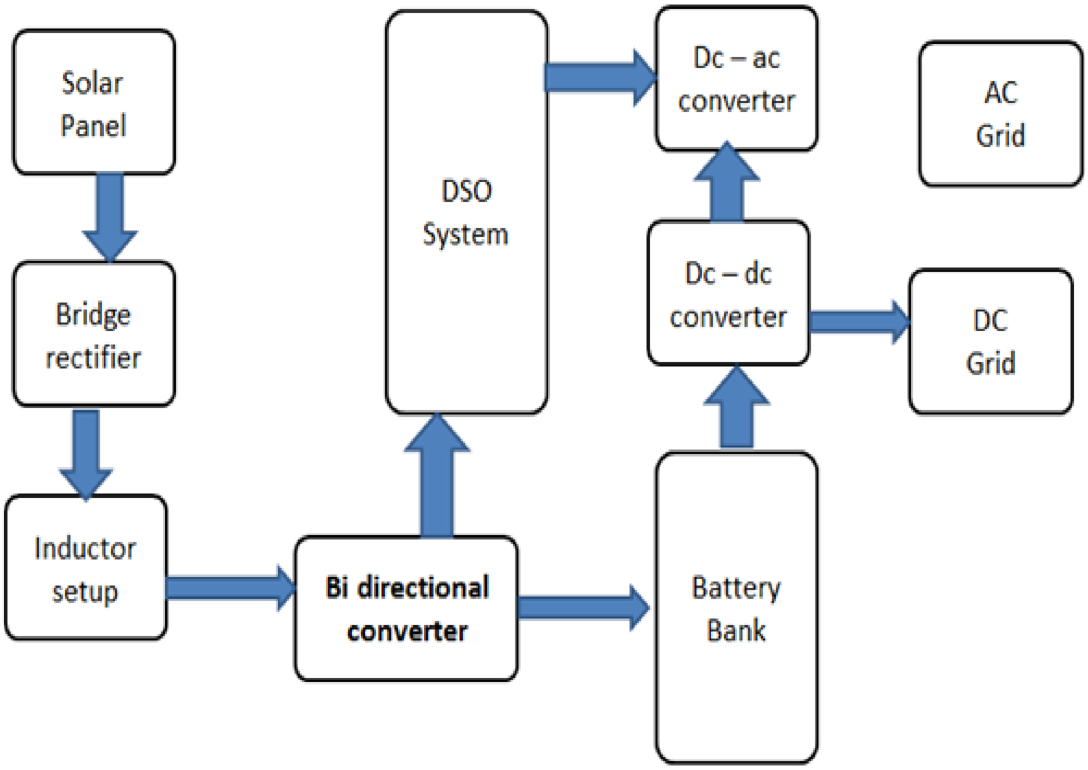

Figure1 (Block Diagram)

The system comprises of solar panel which will absorb sunlight and generate an electric current, 12V battery where the current from solar panel is stored, Arduino which will measure the voltage available in the battery, Bidirectional DC-DC convertor, voltage regulator, LCD display, lamp. Solar panel: A solar panel is a collection of interconnected silicon solar cells that form a circuit. They are also known as photovoltaic solar modules, solar plates, solar PV modules, and solar power panels, etc. Solar panels absorb sunlight and generate an electric current, which travels to your home appliances via DC wires. On the front of the panel, there is a glass layer, followed by an insulating layer and a protective back sheet. A single solar panel can generate a certain amount of electricity.
Solar panels produce direct or DC current, meaning the solar electricity generated by the photovoltaic panels flows in only one direction only. So in order to charge a battery, a solar panel must be at a higher voltage than the battery being charged. In other words, the voltage of the panel must be greater than the opposing voltage of the battery under charge, in order to produce a positive current flow into the battery. A Bidirectional DC-DC convertor is used as a battery voltage regulator, which is an electronic device used in off-grid systems and grid-tie systems with battery backup. The convertor regulates the constantly changing output voltage and current from a solar panel due the angle of the sun and matches it to the needs of the batteries being charged. The charge controller does this by controlling the flow of electrical power from the charging source to the battery at a relatively constant and controlled value. Thus maintaining the battery at its highest possible state of charge while protecting it from being overcharged by the source and from becoming over-discharged by the connected load. Since batteries like a steady charge within a relatively narrow range, the fluctuations in output voltage and current must be tightly controlled. The Bidirectional DC-DC convertor turns-off the circuit current when the batteries are fully charged and their terminal voltage is above a certain value, usually about 14.2 Volts for a 12 volt battery. This protects the batteries from damage because it doesn't allow them to become over-charged which would lower the life of expensive batteries. To ensure proper charging of the battery, the regulator maintains knowledge of the State of Charge (SOC) of the battery. This state of charge is estimated based on the actual voltage of the battery. When the load flows in the circuit, Bidirectional DC-DC convertor boost up both the positive and negative cycle to the battery to maintain constant current.

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4. CIRCUIT DIAGRAM

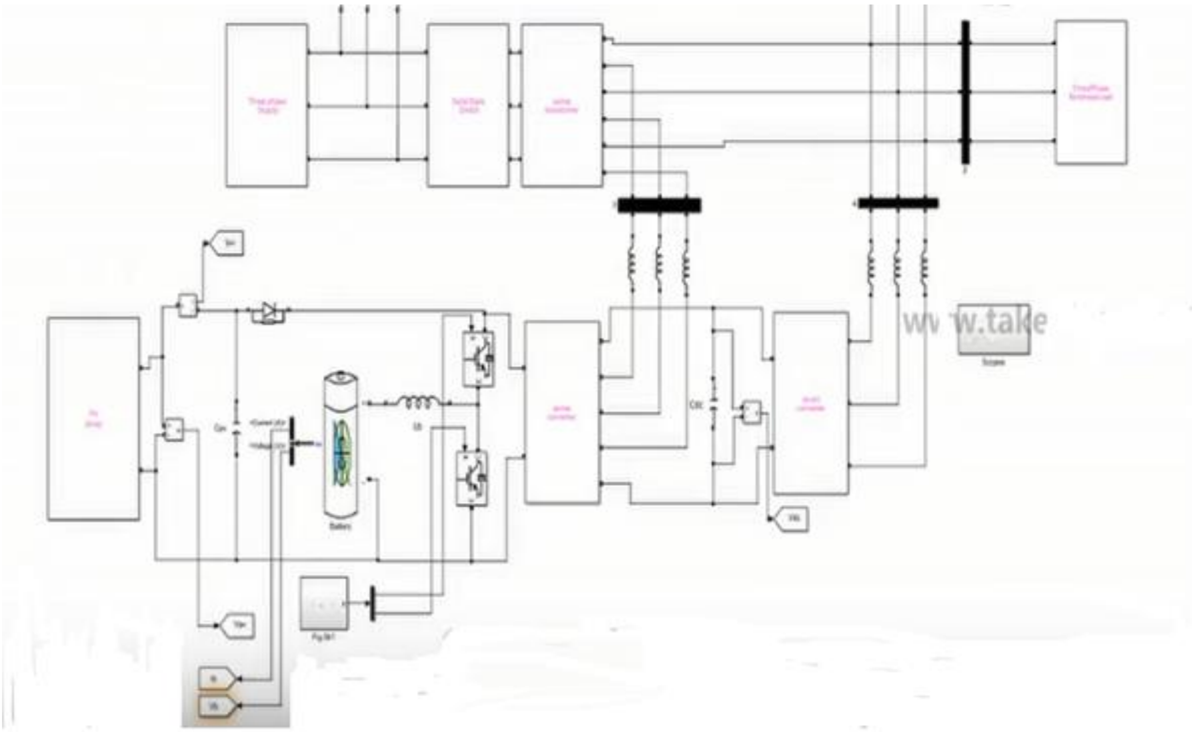

Figure2 (Circuit Diagram)

5. ADVANTAGES

- This system has a better utilization with respect to conventional solar grid-tied inverter system.
- Continuous power supply for critical electronic loads.
- This system regulates load voltages while maintaining grid current sinusoidal and til power factor close to unity.
- The system supplies constant power to the grid, even during fluctuations in PV power generation and voltage fluctuations thereby enhancing the stability of the distribution network.

6. CONCLUSION

The design and performance of solar PV and battery integrated UPQC have been presented in this work. Due to the presence of energy storage in form of battery bank, the system operates In standalone mode of operation whenever grid is not available thus maintaining continuity of power supply to critical loads. Moreover, the system mitigates power fluctuations occurring in PV power generation due to weather conditions, thus enabling smooth power generation. This leads to increased stability of the overall system. The response of the PV-B-UPQC has been extensively evaluated under both standalone and grid connected modes of operation. The response of PV-B-UPQC is found satisfactory under various conditions of irradiation variation, load unbalance and sags/swells in PCC voltage. Under all these disturbance conditions, the PV-B-UPQC is able to feed constant power into distribution network. The system automatically changes from the grid-tied operation to islanded operation and vice versa with minimal disturbance to the sensitive and critical load. The three wire PV-B-UPQC is suitable for the systems with operating with sensitive and critical load such as in data centers, hospitals, factories where interrupted, power supply is of prime importance. The integration of battery and renewable energy, enables minimum dependence on the grid for power demand while the surplus PV power can support the grid by giving power to nearby loads at PCC.

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