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Integration of Battery Energy Storage System with Grid Tied PV

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ABSTRACT: The proposed system illustrates the reduction in power quality problems faced in the power system and the power electronic devices that causes current harmonics, unbalanced loading and voltage unbalance due to increase in reactive power. To solve these problems, grid current should be maintained, harmonics should be reduced, energy systems should be maintained, reactive power compensation should be maintained and the power demand should be satisfied. This system focus on the design of the solar PV with Landsman converter (DC – DC) attached to the AC grid. Along with solar PV, a Battery Energy Storage System (BESS) is present to balance the power run in the proposed model. A globalized MPPT is achieved through the Fuzzy Logic Controller to abstract the maximum power from the solar PV system irrespective of change in the input obtained. Power flow Management System is attained by the Bidirectional converter with BESS. The dc voltage from the Landsman converter will be fed to the Voltage Source Inverter (VSI) and the output AC voltage is associated with the three phase AC grid. Grid synchronization will be achieved by the Hysteresis Controller using d-q theory with Park and its inverse and then Clarkes and its inverse Transformations is also used. Fast Fourier Transform (FFT) is used to derive the THD values and the system efficiency values are measured. This proposed model will be simulated using MATLAB and the hardware is developed using DSPIC30f4011 microcontroller.

KEYWORDS: Battery tester,Frequency Regulation,LCD display

I. INTRODUCTION

The integration of battery energy storage systems with grid-tied PV is an innovative and increasingly popular approach to renewable energy systems. This project aims to develop an efficient and sustainable solution for managing renewable energy sources. It involves combining solar power systems with energy storage systems to improve the overall efficiency, reliability, and resilience of the grid. By integrating these systems, we can help reduce greenhouse gas emissions and enhance energy security. The integration of battery energy storage systems with grid-tied PV is a complex process that requires careful planning, design, and installation to ensure maximum performance and optimal efficiency. This project will explore the different components, technologies, and strategies needed for a successful integration of these systems, and how they can be implemented in various scenarios. Ultimately, the goal of this project is to promote the adoption of renewable energy systems and contribute to the transition towards a more sustainable and resilient energy future.

Proposed system

The proposed system will integrate battery energy storage systems with grid-tied PV to enable efficient energy utilization. The system will use smart controllers to manage the flow of energy between the grid, the PV system, and the battery storage system. During periods of excess energy production from the PV system, the excess energy will be stored in the battery storage system for later use. When the PV system cannot meet the energy demands of the building, the stored energy in the battery storage system will be used to supplement the energy needs. This integration will improve energy efficiency and reduce reliance on the grid while ensuring reliable power supply.

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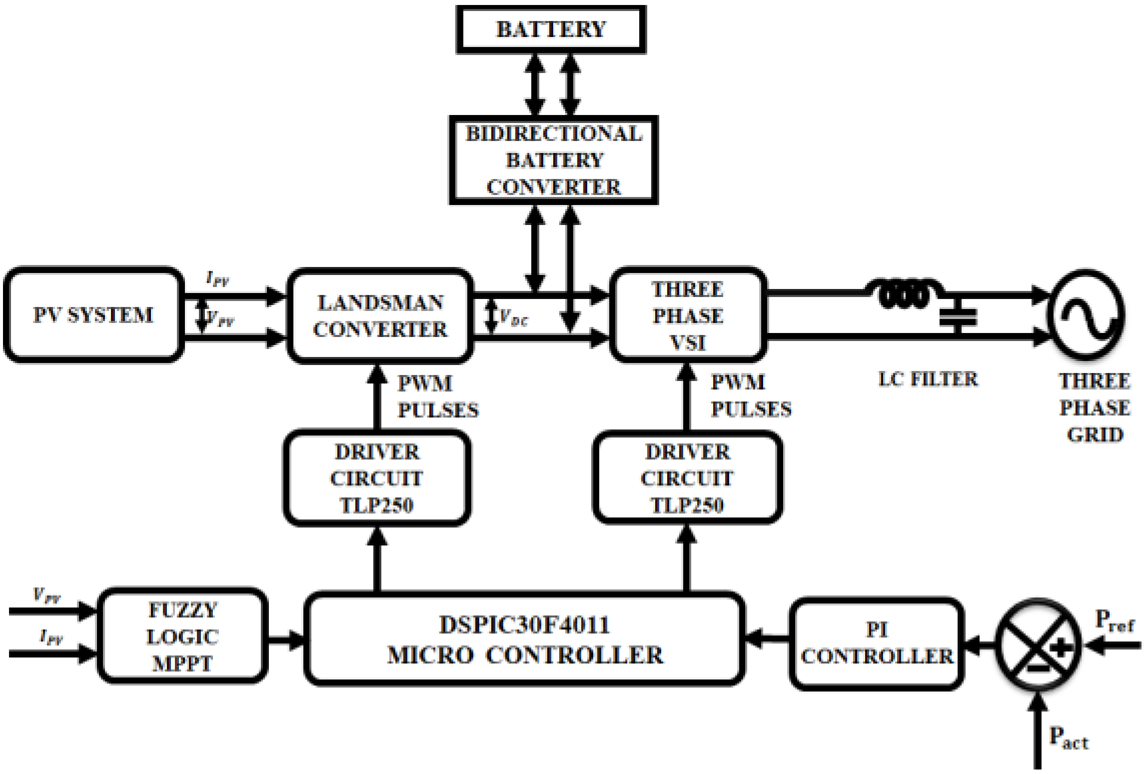
BLOCK DIAGRAM



BLOCK DIAGRAM DESCRIPTION

The integration of battery energy storage systems with grid-tied PV involves multiple components, including the PV array, inverter, battery storage system, power conditioning system, and grid connection. The PV array generates DC power, which is converted to AC power by the inverter and supplied to the load or the grid. Excess power is stored in the battery storage system and released during low generation periods or high demand. The power conditioning system manages power quality and ensures compatibility with the grid.

Components used

PV Module:

A single cell generate very low voltage (around 0.4), so more than one PV cells can be connected either in serial or in parallel or as a grid (both serial and parallel) to form a PV module. When we need higher voltage, we connect PV cell in series and if load demand is high current then we connect PV cell in parallel. Usually there are 36 or 76 cells in general PV modules. Module we are using having 54 cells. The front side of the module is transparent usually buildup of low-iron and transparent glass material, and the PV cell is encapsulated. The efficiency of a module is not as good as PV cell, because the glass cover and frame reflects some amount of the incoming radiation.

Transformer:

A transformer is a passive component that transfers electrical energy from one electrical circuit to another circuit, or multiple circuits. A varying current in any coil of the transformer produces a varying magnetic flux in the transformer's core, which induces a varying electromotive force (EMF) across any other coils wound around the same core. Electrical energy can be transferred between separate coils without a metallic (conductive) connection between the two circuits. Faraday's law of induction, describes the induced voltage effect in any coil due to a changing magnetic flux encircled by the coil.Transformers are used to change AC voltage levels, such transformers being termed step-up or step-down type to increase or decrease voltage level, respectively. Transformers can also be used to provide galvanic isolation between circuits as well as to couple stages of signal-processing circuits. Since the invention of the first constant-potential transformer in 1885, transformers have become essential for the transmission, distribution, and utilization of alternating current electric power. A wide range of transformer designs is encountered in electronic and electric power applications.

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Transformers range in size from RF transformers less than a cubic centimeter in volume, to units weighing hundreds of tons used to interconnect the power grid.

Fuzzy Logic Controller:

An intelligent fuzzy based MPPT is presented to trace the optimum power point of the PV module. Fuzzy Logic Control (FLC) has proven effective for complex, non-linear and imprecisely defined processes for which standard model based control techniques are impractical or impossible. Fuzzy Logic, unlike Boolean or crisp logic, deals with problems that have vagueness, uncertainty and use membership functions with values varying between 0 and 1. Fuzzy Logic tends to mimic human thinking that is often fuzzy in nature.In fuzzy logic a particular object has a degree of membership in a given set, which is in the range of 0 to 1. The essence of fuzzy control algorithms is a conditional statement between a fuzzy input variable A and a fuzzy output variable B. This is expressed by a linguistic implication statement such as in general a fuzzy variable is expressed through a fuzzy set, which in turn is defined by a membership function.

Three Phase Voltage Source Inverter:

There are a number of well-known methods of controlling the d-c voltage supplied to an inverter or the a-c voltage delivered by an inverter. It includes the use of storable reactor, magnetic amplifier, and induction regulator, phase controlled rectifiers and transistor series or shunt regulators. With the introduction of high speed, efficient and extremely reliable solid state switching devices, including transistor and silicon controlled rectifier, considerable effort has been put to develop new methods of voltage control. In general, these improved controls involve switching techniques where the voltage control is achieved by some form of switching time-ratio control. One of the most advantageous means of controlling inverter output voltage is to incorporate switching time-ratio controls within the inverter circuit. This basic form of inverter voltage control is the principal emphasis of this chapter. With implementation of this technique, it is often possible to include inverter output voltage control without significantly adding to the total number of circuit components.

LC Filter:

A simple L-filter is widely used for the inverter to reduce the current harmonics. The L filter should be designed with line frequency, so that it requires high inductance value, resulting in cost rising in the order of several kilowatts. In additions, the dynamic response may become poor. Thus, LC or LCL filters consisting of quite small values of inductor and capacitor can replace the low pass filter. The LCL filter needs more space and cost because of two inductors. The efficiency, cost, losses, weight and size are different, depending of the filter type. In this work, an LC filter is designed. In order to design the LC filter, firstly the maximum ac current ripple should be defined. In this design, the inverter side inductance is selected with 5% of the phase current at rated power. Based on this guideline, the fundamental component of grid current is assumed to be zero. Then, the fundamental component of the filter inductor voltage is to be also zero.

DSPIC30F4011 Microcontroller:

The dsPIC30F4011 Controller is designed for motor control and is ideal for motor controller applications. Utilising the powerful, high-performance Microchip dsPIC30F4011 microcontroller, this microcontroller features a high speed core optimized to perform complex calculations quickly. The microcontroller includes a large 48kB internal flash memory and a wide range of timers together with a number of PWM modules for adjustable motor speed control.The dsPIC30F4011 Microcontroller also includes a 9-channel 10-bit A/D convertor with fast response time together with support for SPI and I²C communciation. In-circuit programming is available for both the Futurlec PIC Programmer as well as the Microchip ICD2 unit. Programs can also checked and debugged with the Microchip In-Circuit Debugging tool, the ICD2.The dsPIC30F4011 Controller also includes a large number of general I/O points with standard header connections for easy connection to external devices. All the necessary support components are included on the board, together with a Power and Programming LED's for easy status indication. A reset switch and prog/run switch is provided, with a LCD connection provided for standard character LCD's, together with contrast adjustment for easy set-up.

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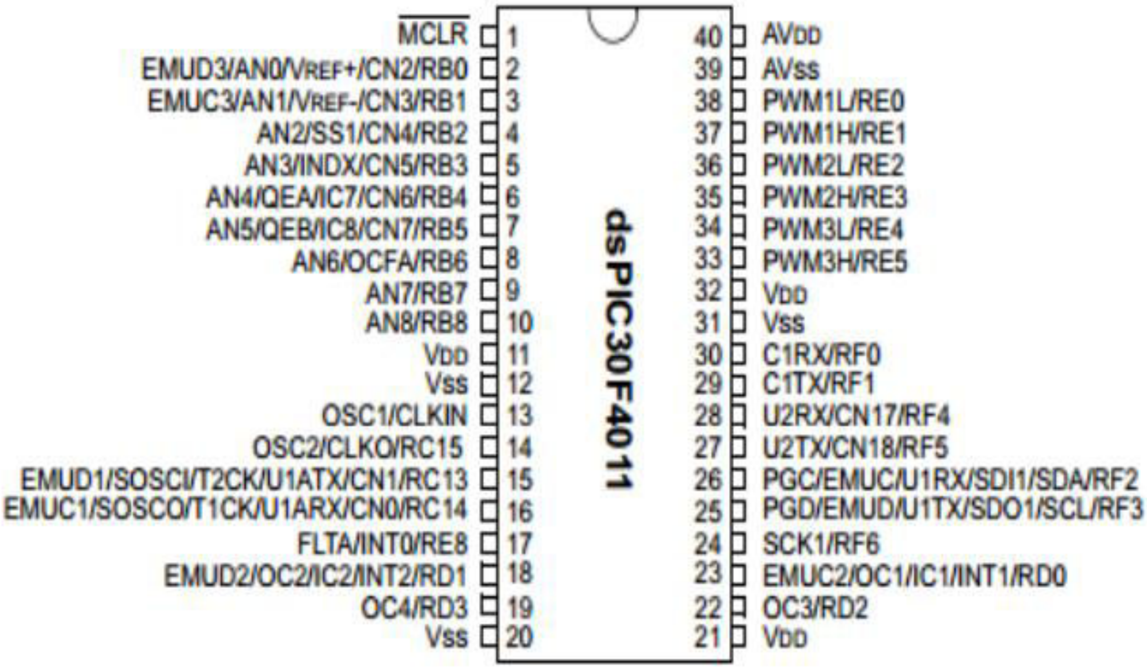

PI Controller:

The PI controller (proportional integral controller) is a feedback controller. It drives the plant which is to be controlled with a weighted sum of error and the integral of that value. PI-Controllers have been applied to control almost any process in current use, from aerospace to motion control, from slow to fast systems. Alongside this success, however the problem of tuning PI-controllers has remained an active research area. Furthermore, with changes in system dynamics and variations in operating points PI-Controllers should be returned on a regular basis. This has triggered extensive research on the possibilities and potential of the so-called adaptive PI controllers. Loosely defined, adaptive PI-controllers avoid time-consuming manual tuning by providing optimal PI-controller settings automatically as the system dynamics or operating points change.

Capacitor:

A capacitor is a device that stores electrical energy in an electric field by virtue of accumulating electric charges on two close surfaces insulated from each other. It is a passive electronic component with two terminals.Most capacitors contain at least two electrical conductors often in the form of metallic plates or surfaces separated by a dielectric medium. A conductor may be a foil, thin film, sintered bead of metal, or an electrolyte. The nonconducting dielectric acts to increase the capacitor's charge capacity. Materials commonly used as dielectrics include glass, ceramic, plastic film, paper, mica, air, and oxide layers. Capacitors are widely used as parts of electrical circuits in many common electrical devices. Unlike a resistor, an ideal capacitor does not dissipate energy, although real-life capacitors do dissipate a small amount (see Non-ideal behavior). When an electric potential difference (a voltage) is applied across the terminals of a capacitor, for example when a capacitor is connected across a battery, an electric field develops across the dielectric, causing a net positive charge to collect on one plate and net negative charge to collect on the other plate. No current actually flows through the dielectric. However, there is a flow of charge through the source circuit. If the condition is maintained sufficiently long, the current through the source circuit ceases. If a time-varying voltage is applied across the leads of the capacitor, the source experiences an ongoing current due to the charging and discharging cycles of the capacitor.

FLC Based MPPT:

A new FLC based MPPT method is proposed to achieve tracking the maximum power of the PV module under changing the weather conditions. The proposed input variables are the PV voltage (), PV current (), and the PV cell temperature ().

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The output variable is the duty cycle, which is used to control the DC-DC switched boost Landsman converter in order to keep tracking maximum power. Since the modeling of the conventional FLC is based on trial and error, the probability of obtaining the optimal performance is low. Therefore, obtaining membership functions and fuzzy rules can be done through learning using FLC.FLC is capable of developing the input-output mapping of training data sets when it is trained with sufficient number of epochs. By adjusting the values of membership functions, generates the set of fuzzy rules in order to produce appropriate output for different values of inputs. Parameters of membership functions are adjusted or changed till the error is reduced to minimum value. Once all the parameters of membership function are adjusted, the FLC model becomes learning model which is ready to be used in MPPT control scheme. But before using FLC learning model for MPPT control, its results are checked by using checking data which is different from training data. Again if error produced is more than desired value, parameters of membership functions are adjusted to bring down the error. A DC-DC switched boost Luo converter is designed to be placed between solar PV module and load in order to transfer maximum power to load by c.

LCD Display:

The project's ongoing procedures are displayed on an LCD. It serves to show the input and output voltage values in this case. It is coded in the Arduino microcontroller and connected to the LCD to obtain these values the LCD used measures 16 by 2. The LCDs are thin and light, measuring only a few millimetres. While LCDs use power, they may be powered for extended periods of time and are compatible with low power electrical circuitry. As the LCD doesn't produce light, light is required to read the panel. Reading in the dark is made feasible by the use of backlighting.

Driver Circuit TLP250:

TLP250 is an isolated IGBT/Mosfet driver IC. The input side consists of a GaAlAs light-emitting diode. The output side gets a drive signal through an integrated photodetector. Therefore, the main feature is electrical isolation between low and high power circuits. It transfers electrical signals optically via light.Users can use it to drive gate terminal of high voltage switches in both configurations such as high side and low side drive. It is available as an 8-pin DIP package.

III. CONCLUSION

In this proposed model involves the AC grid which feeds from the solar PV Renewable Energy Source. The purpose of the grid is to fulfill the load demand from the distribution side. The proposed micro-grid system is fed from RES is found fit for meeting load requirement of a far-flung remote location involving few households. FLC based MPPT is used to extract the maximum power from the solar PV system and then the controlled output is served to the switch present in the Landsman converter as a PWM signal from PWM generator. The power feature of the system is maintained due to the steady power flow balanced by the battery storage system and the harmonics are reduced due to the LC filters present in the system. The proposed system acts as an Energy Management System as the power flow is smooth and continuous irrespective of the change in the input. This is the most effective method and it is proved by the test results taken. The chosen converter provides better efficiency and voltage-gain ratio when compared with other converters. PI assists in the generation of reference signal, so that the harmonics that occurs in the system are effectively mitigated. The validation of the proposed work is carried out through simulation in MATLAB.

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