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Study And Analysis Of Photovoltaic Energy System

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Abstract: *The sun is a primary power source that can be turned into Electricity by means of PMW or multilevel inverters. Despite the actual higher cost-effectiveness of other power sources, approximately around +14-15%, even including the plant losses (cables, inverters, transformers etc.), sunlight is a free and unlimited source which cost-effectiveness can be improved up to 22% [1]. The paper drives the attention on the major issues in the converting process of sunlight into electrical energy, particularly when connected to weak electric grids where voltage variations, distortions of voltage wave form (THDv) and fundamental frequency variations can be mostly found. In this paper we present a residential design of a grid-tied photovoltaic (PV) system, with no batteries and net metering agreement, installed in Puerto Rico's west coast. The design follows the National Electrical Code 2014 (NEC 2014) regulations. Calculations of general lighting, general loads and voltage drop are performed and dedicated circuits, conductors and conduits, overcurrent protection devices, panel board distribution are selected. A PV system capable of generating an annual average of 300 kWh per month is designed for the two story dwelling unit.*

Keywords: *Photovoltaic System, DC-DC converters, on grid, HybridStorage Systems*

I. INTRODUCTION

Recently, worldwide transportation is an importance economic issue, decreasing natural resources, increasing fuel price and global warming. The energy conversion for battery charging is a key element that interfaces the ac utility or PV with the dc bus in the power train of the EV. It uses an ac/dc converter (AC mode) or a dc/dc converter (PV mode). For high-energy battery charging, an ac/dc converter is used, as well as a dc/dc converter with harmon. In the PV mode, the photovoltaic power systems are expected to become power resource for EV [4]-[1] because of free energy, no harmful greenhouse gas emissions and especially appropriate for smart energy networks with distributed power generation. However, there are external factors which affect to the power of PV such as light intensity, temperature and capability of the device. Due to these external factors, the maximum power point tracking (MPPT) have been proposed to ensure the maximum power output of a solar PV device. STANDALONE photovoltaic energy system (SAPESs) have been in use for remote electrification and rural irrigation since decades [1], primarily because these systems do not require costly infrastructure for installation. Moreover, they are environmentally friendly. Some studies estimate that by the end of 2017 the world will be generating more than 400 GW of electricity using solar PV systems [2]. The most vital issue related to their use is their dependency on environmental conditions. This does not only require backup energy devices for night time use but also demands special arrangements for harvesting the maximum available power. The quantum of the problem is magnified with the fact that besides the changing environmental conditions, the PV module exhibit non-linear characteristics. To cope with these issues, researchers have developed algorithms, commonly known as maximum power point tracking (MPPT) methods, to ensure the operation of the power electronic interface at the maximum power point (MPP). The use of MPPT enhances the efficiency up to 11% [3]. The second issue deals with the use of the power electronic interface to convert the solar power such that it is compatible with the common household device voltage levels.

The Energy Storage systems (ESS) provide several advantages and are necessary to get the most out of renewable energy and facilitate the conversion of these energies on reliable resources.

The super capacitors are a technology whose application in energy storage systems with renewable energy generation can be really useful. The importance of super capacitors is that they can work better, in certain conditions, than the conventional batteries used in current storage systems. Consequently, the energy storage system present a larger storage capacity, which could ensure a constant supply of electric energy with improved stability and security with current conventional batteries and capacitors whose capacity limits their use in applications such as ESS low power [1]. \

II. SCOPE OF ENCRYPTION SELECTION

Proposed Algorithm for Identifying Secret Message the proposed Power Factor Correction (PFC control strategy, the average current control method is used for regulating the sinusoidal input current waveform. The output response of the proposed control scheme is verified by simulation.

POWER FACTOR CORRECTION (PFC)

The control of PFC circuits combine the interleaved boost has been described at [6]-[8]. A block diagram of the PFC converter control system using average current control method is simplified. It is divided into four major parts including unit sinusoidal wave signal, inner loop current error amplifier, pulse width modulation generator and outer loop voltage error amplifier.

PROPOSED MPPT METHOD

This algorithm is presented in detail in [20] and it can be applied to multilevel topologies like [21]-[23]. The control block of the proposed SAPES method is quickly able to detect changes in environmental conditions using its two-stage operation. Thus, the proposed hybrid MPPT method has two stages Stage 1 utilizes short current pulse (SCP) MPPT to obtain an estimated value of the MPPT. Stage 2 performs fine tuning of the estimated MPP and operates the system near the exact MPP. The working of the algorithm is explained below.

OPERATING MECHANISM OF STAGE 1

Stage 1 is used to estimate the initial MPP under two conditions. First, when the system initiates and second when a dynamic weather condition is detected. This stage is based on the short current pulse MPPT. During this process the PV module is isolated from the SAPES. At that instant; Isc is measured and stored. Impp is present in close vicinity of Isc. Mathematically, this can be expressed as shown in eq.(1)

Impp = k1 × Isc Therefore, the stored value of Isc is multiplied by a factor k1 to obtain an approximate value of Impp. The value of Impp is then compared to the photovoltaic current Ipv. The computed error is fed into the PI controller for duty cycle calculations. Once the error is within the limit, the system shifts to stage 2. Stage 1 is then waiting for the signal from stage 2 to initiate this process again.

OPERATING MECHANISM OF STAGE II

The approximated operating point is further tuned to reach the true MPP, which is performed in stage 2. This stage, in addition to utilizing the conventional P&O with very small step sizes, also monitors the difference between Isc and Ipv. This limit estimates the rapid change in environment and, when surpassed, the system exits stage 2 and operate in stage 1 to obtain a new value of Isc. If the output of this limit remains false, then the system continues to fine tune the approximated MPP using conventional P&O.

The use of P&O is advantageous in this scenario because the power oscillations are low as a result of small step size and the tracking speed is enhanced by using the SCP in stage 1.

III. THE SYSTEM WITH ENERGY SUPPLIED BY

A. DIFFERENT ENERGY STORAGE SYSTEMS (ESS)

A. Techno- Economic and Environment Analysis of a Grid Connected Photovoltatic Energy system. Regard to importance of achieving a proper configuration of energy systems in grid-connected microgrids regard to implementation cost, uninterrupted load supplying, the non-linear nature of problem, determination of designing variables and existence of extreme complexities in design of microgrids in comparison with traditional systems, the utilization of a powerful tool such as HOMER software is necessary in order to perform optimized designing. In this paper, a technical, economic and environmental study with considering investment, installation and operation costs of photovoltaic conducted in order to supply the electricity of Defae-Moghadas mosque, which is located in Isfahan, Iran. The results show that the optimized hybrid system is constituted of 30KW of photovoltaic panels, 20KW of electrical converters and 7KW of capacity of grid. In the proposed hybrid system, 68% of total generation is provided by photovoltaic panels and the rest of power is absorbed from the main grid. Furthermore, the suggested hybrid system can decrease the carbon dioxide emissions by 2461 kg/yr which demonstrates the proper performance of the proposed hybrid system.

The incremental energy consumption trend has encountered the world with two acute crises. The first is the environmental pollution due to fossil fuels consumption, and the second is the drastic growing acceleration in exploiting these energy resources. The international energy agency (IEA), regard to total emission of carbon dioxide (CO_2) by all kinds of industry and total consumed fossil fuels in all countries, has published a list of the most polluting countries. According to the report, China has the first rank, and Iran is placed in the ninth rank of CO_2 emission. According to this report, the amount of produced emission of CO_2 was about 32.2 Gt until 2013. Surprisingly, just ten countries have a contribution of 21.6 Gt of the total produced emissions as it is represented in figure 1. This statistic shows, that Iran has had a drastic increase by 207.2% in CO2 emissions. This matter assigns this country in the third rank for emission growth after China and India. Many of the countries which are mentioned as the most polluting countries in figure 1 have heavy industries, high capacity of electricity generation and large population. Thus, in order to preserve the environment and battle with devastating impacts of pollutions, it is necessary that these countries adopt proper strategies for reduction of energy consumption, utilization of alternatives for current energy resources, improving the public transport fleet and ultimately reducing CO2 emissions. Integration of renewable energy resources such as the wind and solar energies and utilization of nuclear energy are effective options to reduce the greenhouse gasses emissions. Regard to increasing penetration of renewable energy resources such as wind energy in distribution network, the management and operation of microgrids can enhance the reliability and decrease the costs corresponded with energy, losses and pollution. The microgrids can inject their excess generation into the grid and also absorb their needed power. Therefore, extension of effective ways for management and operation of microgrids necessitate existence of an appropriate powerful tool for simulation of hybrid system in HOMER and optimal designing. In optimization process, in addition to reduction of the costs, the energy consumption (90~130KWh/d) and radiation (3-9KWh/m2day) terms are considered. Regard to conditions of considered site and the average of system loads, the best optimized system consists of 30 KW of photovoltaic panels, 20 KW of electrical converters and 7 KW of capacity of grid. In this case, the photovoltaic panels have the generation of 48492 KWh/yr and the main grid has the generation of 22684 KWh/yr. That constitutes contribution of 68% and 32% of total generation respectively. Moreover, the results show that the carbon dioxide emissions are decreased by 2461 kg/yr. This proves the proper performance of the proposed hybrid system.

Year	Author	Topic	Publication
2017	Mohammad-Reza Memar Majid Moazzami Hossein Shahinzadeh	Techno-Economic and Environmental Analysis of a Grid-Connected Photovoltaic Energy System	Electrical Power Distribution Conference
I. 2017	Jatuporn Changsrisuk Sakorn Po-Ngam	The Hybrid Photovoltaic Energy System for Electric Vehicle Battery Charger	[1] International electrical engineering congress
2017	Hadeed Ahmed Sher Arslan Abbas Rizvi Khaled E. Addoweesh	a single stage stand-alone photovoltaic energy system (sapes) with high tracking efficiency	[2] IEEE Transactions on Sustainable Energy
2015	Mona Sabry Mohamed Hashem Taymoor Nazmy	Photovoltaic Energy Systems: Considerations for Grid Interconnection	[3] IEEE THIRTY FIFTH CENTRAL AMERICAN AND PANAMA CONVENTION
2015	Iromi Ranaweera Santiago Sanchez Ole-Morten Midtgård	Residential Photovoltaic and Battery Energy System with Grid Support Functionalities	[1] IEEE 6th International Symposium on Power Electronics for Distributed Generation Systems (PEDG)
2015	Mónica I. Mercado-Oliveras Agustín A. Irizarry-Rivera	Residential Grid-tied Photovoltaic Energy System Design in Puerto Rico	[2] North American Power Symposium (NAPS)
Year	Author	Topic	Publication

Table 1

B. THE HYBRID PHOTOVOLTAIC ENERGY SYSTEM FOR ELECTRIC VEHICLE BATTERY CHARGER

This paper presents the hybrid photovoltaic (PV) energy system for the electric vehicle (EV) battery charger. The simple maximum power point tracking (MPPT) is introduced for charging the electric vehicle battery. In the AC mode, the interleaved ac/dc boost converter with power factor correction (PFC) is presented too. With the proposed PFC control strategy, the average current control method is used for regulating the sinusoidal input current waveform. Validity of the proposed control scheme is verified by simulations.

Recently, worldwide transportation is an importance economic issue, decreasing natural resources, increasing fuel price and global warming. Electrical energy from grid and renewable resources are gotten attention [1]. The electric vehicle technologies are thought to be the preferable solutions to this problem because of their reduced fuel consumption and greenhouse gas emissions causing global warming. Energy storage systems [2] like battery became more and more important in electric vehicle. The development of an efficient battery charger circuit is one of the main concerns of research nowadays. The energy conversion for battery charging is a key element that interfaces the ac utility or PV with the dc bus in the powertrain of the EV. It uses an ac/dc converter (AC mode) or a dc/dc converter (PV mode). For high-energy battery charging, an ac/dc converter is used, as well as a dc/dc converter with harmonic regulation and power factor correction) PFC([3]-[5].

Furthermore, Interleaved PFC converters [4]-[3], which are operated on continuous conduction mode (CCM) at high power applications, have been proposed for use in electric vehicle applications. It causes significant decreases in inductor size, conduction (I2R) losses, the input current and output voltage ripple. Also, overall efficiency compared to a single phase converter is increased. In addition, the interleaved PFC converters essentially provide the reduced values of reactive power and harmonics to be close to zero, lead to lower harmonic distortion and great power factor at input current.

This paper presents the interleaved ac/dc boost converter with PFC and MPPT photovoltaic control for electric vehicle battery charger. According to the regulatory standards, IEC 61000-3-2, the simple PFC control strategy is developed to

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improve the quality of the input current. In addition, the MPPT control strategy is operated by the perturbation and observation (P&O) method. The PSIM software is used to verity the proposed system. The control of PFC circuits combine the interleaved boost has been described at [4]-[2]. A block diagram of the PFC converter control system using average current control method is simplified. It is divided into four major parts including unit sinusoidal wave signal, inner loop current error amplifier, pulse width modulation generator and outer loop voltage error amplifier.

This paper presents the hybrid photovoltaic (PV) energy system for the electric vehicle (EV) battery charger. In the AC mode, the simulation results verify that there are %THDi (~1.62%), power factor of an AC electrical power system almost unity and the output voltage is constant for both transient and steady state conditions. In the PV mode, the MPPT controller can be tracked to the maximum power of the PV array. The validity of proposed system is verified by simulations.

C. A SINGLE STAGE STAND-ALONE PHOTOVOLTAIC ENERGY SYSTEM (SAPES) WITH HIGH TRACKING EFFICIENCY

A single stage flyback PV inverter with maximum point tracking (MPPT) high speed capability is presented in this research work. The proposed Off Grid photovoltaic energy system (SAPES) incorporates the use of hybrid MPPT to ensure peak energy harvesting under all weather conditions. The proposed hybrid MPPT method combines the perturb and observe (P&O) methods and the conventional short current pulse (SCP) MPPT method. Measurement of the offline parameter [short circuit current of PV module (Isc)] for SCP is formed on the idea of the difference between the offline parameter and therefore the instantaneous current of PV module (Ipv). Use of a single power conversion stage is achieved by employing a modified flyback inverter operating in discontinuous conduction mode (DCM). To incorporate the hybrid MPPT algorithm, the control structure of the conventional flyback inverter is also modified The proposed SAPES method is tested using computer aided simulations and real time hardware in the loop experimentation using dSPACE DS1104 board. The results obtained using the proposed system are better than those for the conventional algorithms under the environmental conditions tested.

Standalone photovoltaic energy system (SAPESs) have been in use for remote electrification and rural irrigation since decades [1], primarily because these systems do not require costly infrastructure for installation. Moreover, they are environmentally friendly. Some studies estimate that by the top of 2017 the planet are going to be generating quite 400 GW of electricity using solar PV systems [2]. The most concerning issue associated with their use is their dependency on environmental conditions. This does not only require backup energy devices for nighttime use but also demands special arrangements for harvesting the maximum available power. As the PV module exhibit non-linear characteristics, the quantum of the problem magnifies. To cope with these issues, researchers have developed algorithms, commonly known as maximum power point tracking (MPPT) methods, to ensure the operation of the power electronic interface at the maximum power point (MPP). The use of MPPT enhances the efficiency up to 11% [3]. The second issue deals with the use of the power electronic interface to convert the solar power such that it is compatible with the common household device voltage levels.

A prototype of the proposed single stage photovoltaic energy system was designed and implemented at the laboratory according to the specifications listed in Table I. The prototype has been simulated and used in an experiment so as to validate the theory presented above. The selected PV module is a Sanyo HIT-220A01 (specifications in table II) with a maximum voltage of 52 V. The load used is a variable resistor of 250 Ω. The chosen switching frequency is 100 kHz. Based on these specifications, a 250 W power rating flyback inverter was built. The devices used in the hardware implementation exhibits low turn-on resistance; therefore, they offer low turn-on losses. The decoupling capacitor bank consist of electrolytic capacitors (450μF, 450V) connected in parallel.

The proposed method is verified with two benchmark P&O algorithms with perturbation sizes of 0.001 and 0.005. Each algorithm is simulated for few minutes during the noon time, during which the environmental data was assumed to be within the error tolerance of ± 5%. The steady state condition means that the load was fixed at 75 Ω. The resultant waveforms are presented for the photovoltaic voltage (Vpv), photovoltaic current (Ipv), photovoltaic power (Ppv), energy extracted (in Joules) and the switch duty ratio (D) variations.

This paper has presented a modified 1φ flyback standalone inverter controlled through a novel hybrid MPPT method. The proposed SAPES is able to harvest more energy than the conventional flyback inverter. Additionally, the proposed SAPES operates at unity power factor. The performance enhancement is accomplished with the use of SCP and P&O MPPT. The limitation of conventional SCP MPPT is compensated by making it intelligent. This ensures that SCP is applied only when dynamic weather conditions exist. Moreover, steady-state analysis of different operational modes has also been performed. Concept validation has been accomplished using the co-simulation between PSIM and Simulink, and using hardware in the loop prototype. Our results demonstrate the following advantages when compared with the conventional SAPES.

D. PHOTOVOLTAIC ENERGY SYSTEMS: CONSIDERATIONS FOR GRID INTERCONNECTION

The sun is a major power source that can be twisted Into electricity through PMW or multilevel inverters. In spite of the actual higher cost-effectiveness of other power sources, something like approximately +14-15%, even counting the plant losses (cables, inverters, transformers etc.), sunlight is a boundless and indefinite foundation which cost-effectiveness can be increased up to 22% [1]. The paper drives the concentration on the most important issues in the switching process of sunlight into electrical energy, particularly when connected to weak electric grids where voltage changes, distortions of voltage wave form (THDv) and elementary frequency variations can be significantly found.

E. RESIDENTIAL PHOTOVOLTAIC AND BATTERY ENERGY SYSTEM WITH GRID SUPPORT FUNCTIONALITIES

This paper provides the planning of an impact system for a grid connected residential photovoltaic (PV) system with battery energy storage (BES). The control methods for the facility electronic converters areavailable and therefore the potential of utilizing BES for participating in primary frequency regulation of the grid is investigated. The charging and discharging rate of the battery is controlled by droop characteristic. The system performance is validated during a simulation study, during which fast response and excellent tracking of the set points are observed in (a) normal operating condition and (b) a case where the grid frequency varies. The amount of the battery's capacity which will be utilized for this purpose depends on the number of power generated by the PV system, also because the load level. The study shows that sometimes the rated capacity of the battery might be fully utilized for serving the first frequency regulation purposes.

The decline in PV module prices amid financial incentives, like feed tariffs, also as increased price of electricity, have caused a rapid increase in grid connected residential photovoltaic systems around the world. The increase within the adoption of distributed generation (DG) within the low voltage network creates several technical challenges like voltage rise, voltage fluctuations, current harmonics and DC current injection by the connected inverters, and unintentional islanding [1]–[3]. One of the main technical issues which has received much attention among these, is that the over-voltage problem caused by reverse power flow. Reactive power absorption by PV inverters and active power curtailments have been suggested and are already implemented in grid codes to deal with this issue [4], [5]. Initially, relatively high feed tariff (FIT) rates compared to the utility electricity prices were paid so as to market PV systems at the residential level. However, over time a decrease in FIT has been observed [2], which encourage customers to increase self consumption. The increase in self-consumption can be achieved by either demand side management or energy storage solutions (ESSs). The need for more energy storage in the grid also arises due to the general increase in renewable generators. As the number of such generators becomes significant, the difficulty of maintaining grid stability increases. This is mainly caused by the uncontrollable and intermittent nature of their power output. Hence, the grid requires ESSs for compensating the generation fluctuations caused by renewable sources. There are several potential applications of storage both within the residential scale and therefore the utility scale, like load leveling, peak shaving, capacity firming, spinning reserve and ancillary services such as frequency regulation, power quality improvement and voltage support.

The control system of the PV system with battery storageconsists of two levels: device level control and system level coordinated control. The power management system belongs to the system level control. The system level controller generates the facility references for the device level controllers. The energy management system, together with the power management system determines the amount of power need to be transferred to the battery and the grid based on energy price, sell back rate, grid feed in limitations, battery state of charge, and several others [1], [2]. From the facility balance, power exchanged with the grid in normal operation is

$$P_{grid} = P_{pv} + P_{bat} - P_{load},$$

where P_{grid} is that the power exchanged with the grid, P_{pv} is the power output of the PV system, P_{bat} is that the battery power and P_{load} is that the load. The applied sign convention: $P_{pv} > 0$, $P_{load} > 0$, Battery discharging: $P_{bat} > 0$, Power injection to the grid: $P_{grid} > 0$.

The control scheme for the PV system with BES connected to the grid through one phase DC-AC converter is presented with the simulation results. The potential of participating this technique in primary frequency regulation is investigated. The optimal performance of the controllers with low overshoot and fast response time are achieved for various operating conditions by proper tuning. Fast responses of the battery for grid frequency changes are observed consistent with the frequency droop characteristic. It is found that the potential contribution to the first frequency regulation of the battery can vary from zero to rated capacity of the battery. The capacity available for this purpose is determined by the power output of the PV array and the load.

F. RESIDENTIAL GRID-TIED PHOTOVOLTAIC ENERGY SYSTEM DESIGN IN PUERTO RICO

In this paper we present a residential design of a grid-tied photovoltaic (PV) system, with no batteries and net metering agreement, installed in Puerto Rico's West Coast. Calculations of general lighting, general loads and drop are performed and dedicated circuits, conductors and conduits, overcurrent protection devices, panel board distribution are selected. A PV system capable of generating an annual average of 300 kWh per month is meant for the twostory dwelling unit. Puerto Rico is the smallest of the Greater Antilles (Cuba, Hispaniola, Jamaica and Puerto Rico) and is surrounded by the North Atlantic Ocean (north) and the Caribbean Sea (south). Puerto Rico falls into the tropical zone, has annual average temperature of 82 F and excellent solar resource.

G. GRID-TIED PV ENERGY SYSTEM DESIGN

The PV system to be design must generate 300 kWh per month. Also, the system will require no batteries, will be grid-tied (interactive system), with a net-metering agreement.

NEC defines an Interactive Systems as "an electric power production system that is operating in parallel with and capable of delivering energy to an electric primary source supply system". Our interactive system is connected to the electrical grid, allowing the residents of the dwelling unit to use solar energy as well as energy from the electric utility grid. While the PV system is generating electric energy this energy is either consumed by the user or "stored" into the grid. A benefit of an interactive system is that at night or during cloudy days you use power from the utility instead of using batteries.

SOLAR RESOURCE

The dwelling unit is located in Mayagüez, Puerto Rico. The annual average peak sun hours are 4 hours per day. For the purpose of the design we presume 1000 W/m2 of solar radiation during these 4 peak solar hours.

PV MODULE SELECTION

The PV system shall generate 300 kW (AC) per month. Assuming an average month of 30 days the system shall supply 10 kWh/per day. A PV system with 2.5 kW capacity will provide an annual average 10 kWh per day with 4 peak hours of daily sun.

These photovoltaic modules are composed of 60 mono crystalline cell types. NEC Table 690.7 Voltage Correction Factors for Crystalline and Multi crystalline Silicon Modules states correction factors for PV modules located in places with ambient temperature ranging from 77°F to -40°F. In our case, Puerto Rico's ambient temperature is approximately 82°F during the year, and therefore there is no need to apply a correction factor.

Puerto Rico has an excellent solar resource while the average residential electricity price in Puerto Rico is currently about 0.23 $/kW and a good chance of an increase in these rates. The grid-tied PV energy system we designed has an installed cost of 3.92 $/W. O'Neill and Irizarry [4] completed a study to induce solar PV market transformation in Puerto Rico and on this study calculated the levelized cost of energy (LCOE) for solar PV roof-top systems, using net-metering with no batteries, and assuming 20 years of life, 1% annual degradation on energy production. Figure 6 summarizes the cost in $/kWh for different locations in Puerto Rico as a function of peak sun hours per location. In our system roundup the total cost to 4 $/W. Therefore, the LCOE in Mayaguez, is about 0.15 $/kWh. If we compare this cost with the current utility price of 0.23 $/kWh, the installation of a residential PV system would represent savings of 0.07 $/kWh at current prices. In addition to this, the addition of a PV system to the residence increases its resale value and also offers a green energy solution. Therefore, the installation of a grid-tied photovoltaic energy system is not only cleaner it is cheaper.

IV. PROSPECT FORECAST

Fig. 1 shows the block diagram of the electric vehicle battery charger system. The EV battery charger system is composed of the ac utility, PV panel, full-bridge rectifier, interleaved dc/ dc boost converter, DC bus, PFC controller, MPPT controller and EV battery. The switch 1 S and 2 S are represented the AC or PV mode operation, that operated on the complementary mode.

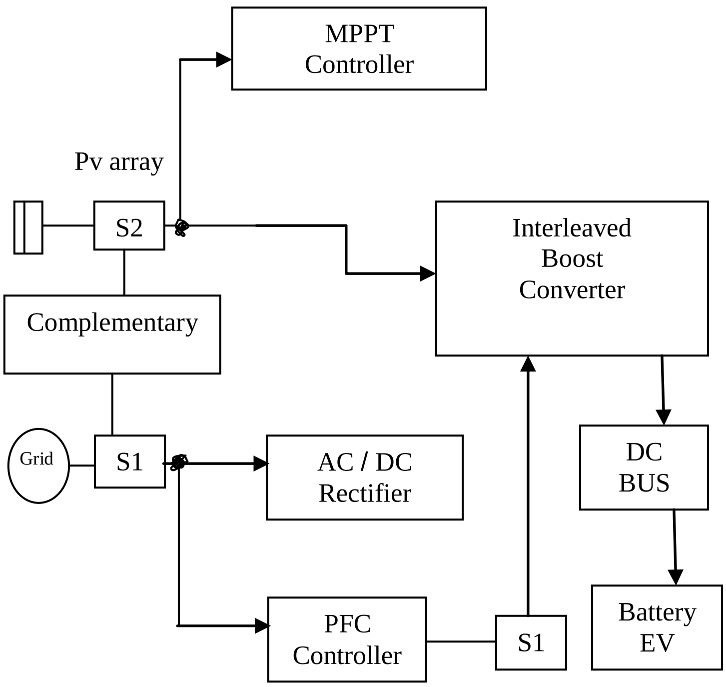

Figure 1: The block diagram of hybrid photovoltaic (PV) energy system for the electric vehicle (EV) battery charger

POWER FACTOR CORRECTION (PFC)

The control of PFC circuits combine the interleaved boost has been described at [2]-[4]. A block diagram of the PFC converter control system using average current control method is simplified. . It is divided into four major parts including unit sinusoidal wave signal, inner loop current error amplifier, pulse width modulation generator and outer loop voltage error amplifier.

MAXIMUM POWER OUTPUT TRACKERS (MPPT)

In this paper, the perturbation and observation method [1]-[3] is described. Using these methods to measure the photovoltaic power, the temporary operating is determined. According to the region, the duty cycle (D) of interleaved boost converter is controlled with the purpose of the system operates reach the maximum power point. Since only PV power is considered, productivity of this method is very simple. The MPPT method, where ( ) pv P k is the photovoltaic power present value, whilst (1) pv P k− is the photovoltaic power previous value.

V. CONCLUSION

This work presents the hybrid photovoltaic (PV) energy system for the electric vehicle (EV) battery charger. In the AC mode, the simulation results verify that there are %THDi (~1.62%), power factor of an AC electrical power system almost unity and the output voltage is constant for both transient and steady state conditions. In the PV mode, the MPPT controller can be tracked to the maximum power of the

PV array. The validity of proposed system is verified by simulations.

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