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# Solar Powered UPS

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**ABSTRACT:** Abstract - The Solar UPS device can provide constant, uninterruptible low-voltage system power in low-power equipment. Power can come from a low-power solar panel, but it is also possible to charge from a mains power supply. Power is stored in a Lead-acid battery pack. The battery pack is recharged intelligently with a battery charger, by the efficient use of energy supplied from the solar panel. The devices are powered by an uninterruptible power supply via a buck-boost DC-DC stabilized power supply and the output voltage is completely independent of the battery pack voltage. It has 4 different modes of operation for charging, solar, grid and battery backup. The system consists of solar panels, Buck Boost DC-DC controller, switching circuits and an inverter

**KEYWORDS:** UPS, Inverter, Buck-Boost Controller, Solar

## I. INTRODUCTION

Over the last few decades, advancements in computer and software technologies have reached an impressive level. These technologies improved not only very common areas of our daily life, but also areas of education, health, production industries, and so on. Since the development of computer systems and the internet, the number of sensitive computerized systems that require an absolute reliable power supply has increased sharply. Systems for uninterruptible power supply (UPS) protect highly sensitive equipment in hospitals, airports and data centres while guaranteeing a continuous supply of clean power even in the case of blackouts in the conventional power grid. In online UPS systems, this is achieved through continuous treatment of the electricity to remove sags and spikes by first rectifying and then inverting the incoming electricity during normal operation. In the case of a blackout, the UPS system enters islanding mode, powering the load from a battery bank designed to last until either mains power supply is restored or back-up generators have started. The number of UPS systems in use is predicted to continue to rise as critical computer systems become increasingly common. UPS systems and small scale solar power systems share many technical components related to power electronics and could thus potentially be combined.

A UPS system is used to protect sensitive electric loads in a wide variety of applications. The UPS is situated upstream from the load it is designed to protect, and is tailored to fit the requirements of the individual load that it is used to power. Generally, a UPS system consists of power electronic components to rectify and invert electricity, an energy storage medium, filters to suppress distortions in the power output and static switches that detects power failures and switches the system into islanding mode which powers the load from the inbuilt energy storage (i.e. battery).

Since the introduction of the internet, the amount of critical computerized equipment in operation has increased sharply. Because of the sensitivity of such loads, the demand for absolute reliable power supply and high power quality has increased the usage of UPS systems at the same pace. UPS system and its principal functionality is not a new invention. In fact, the functionality of UPS has remained the same for several decades, but the increased demand has improved efficiency and sharply decreased costs of UPS systems. Certain advanced designs of UPS have also been developed for large-scale applications consuming much power (i.e. large data centres) to increase conversion efficiencies in order to save electricity.

Paper is organized as follows. Section II describes literature review. The operation and working of the project are explained in detail, the Section III. Section IV presents experimental results showing results of images tested. Finally, Section V presents conclusion.

## II. RELATED WORK

Fossil fuels cannot remain the dominant sources of energy forever. Whatever the precise time for their depletion, oil and gas supplies will not keep up with the growing energy demands. For a long-term, sustainable energy source, solar power offers an attractive alternative. Its availability far exceeds any conceivable future energy demand. Photovoltaic sources are used today in many applications such as battery charging, water pumping, home power supply, satellite power systems etc. They have the advantage of being maintenance and pollution-free but they require a power conditioner (DC-DC or DC-AC converter) to interface with the load and storage. Since PV modules still have relatively low conversion efficiency, the overall system performance can be improved using high-efficiency power conditioners which are also designed to extract the maximum possible power from the PV module.

## III. METHODOLOGY

Many types of solar photovoltaic power conversion systems are being developed including the grid-supported system for reducing the power usage from the grid and the grid-connected system for pumping the extra produce to the grid and the stand-alone system for satisfying the load power completely without the supply from the grid. The stand-alone system requires a battery for energy storage to supply the load power when there is not enough solar power. The P-V characteristic of the solar PV module is varied with the insolation level as well as the temperature if the peak power voltage of the PV module does not match with the battery voltage, there is need for DC-DC converters which accepts variable DC voltage from the panel and supplies a constant DC voltage to the DC bus for battery charging purpose. This Project proposes an isolated DC-DC converter for battery charging application with the concept of constant current charging.

Here, the current control strategy is mainly used for regulated current supply. A single-stage half-bridge converter is proposed for DC voltage regulation and power factor correction. The performance of the converter depends upon inductor operation mode, whether discontinuous or continuous conduction mode. If the proposed converter is operating in discontinuous conduction mode it not only has a high power factor but also avoids the use of a bulk capacitor from high voltage stress at light loads. So compared to a two-stage half-bridge converter, a single-stage converter has the advantage of having one controller instead of two separate controllers as in a two-stage converter, thereby reducing cost and complexity [3].

The energy management system and controller design of the solar aided UPS are implemented with the half-bridge converter. The proposed DC-DC converter employs the voltage mode control using Maximum Power Point Tracking (MPPT) and the battery charging control loop. The control objective is to balance the power output from the PV module to the battery and the load such that the PV power is utilized effectively and the battery is charged with three charging stages. Unlike conventional UPS systems, the control technique prioritizes solar power over the grid to charge the battery. To improve the battery efficiency and life-time, different State of Charge (SOC) levels have been chosen and energy management is done by monitoring the SOC. The TRIAC switching helps in providing the UPS action by avoiding the blink while switching from grid side to the inverter side and vice-versa.[1]

### BLOCK DIAGRAM

The proposed UPS system consists of power electronic components to rectify and invert electricity, an energy storage medium, control elements and static switches that detects power failures and switches the system into islanding mode which powers the load from the inbuilt energy storage (i.e. battery).

#### A. Inverter:

The objective of an inverter (also called DC-AC converter) is to convert direct current to alternating current, and in some cases to also adjust the voltage level. Inverters are common in solar power systems and required in UPS systems with batteries as energy storage. Here we use a three-level inverter that gives modified sine wave as output.

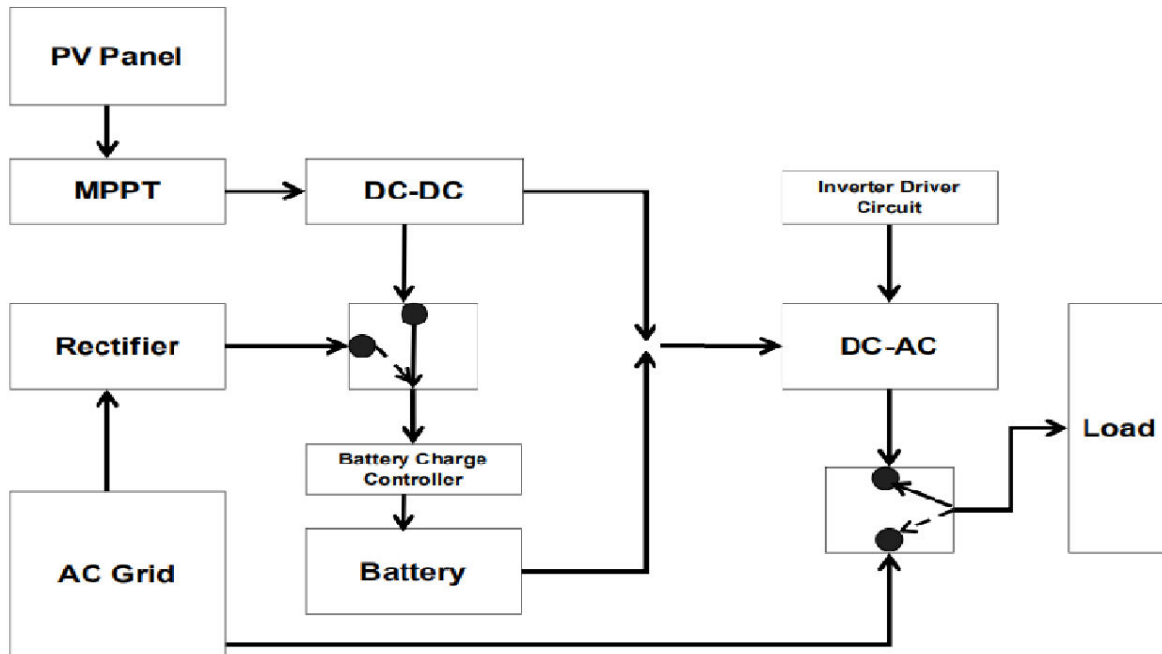


FIG. 1 BLOCK DIAGRAM OF SOLAR AIDED UPS

**B. MPPT Buck-Boost Controller:**

The LM5118 wide voltage range Buck-Boost switching regulator controller features all of the functions necessary to implement a high performance, cost-efficient Buck-Boost regulator using a minimum of external components. The BuckBoost topology maintains output voltage regulation when the input voltage is either less than or greater than the output voltage, making it especially suitable for automotive applications. The LM5118 operates as a buck regulator while the input voltage is sufficiently greater than the regulated output voltage and gradually transitions to the buck-boost mode as the input voltage approaches the output. This dual-mode approach maintains regulation over a wide range of input voltages with optimal conversion efficiency in the buck mode and a glitchfree output during mode transitions. The control method of regulators is based upon current mode control using an emulated current ramp.

**C. Battery Charger:**

A Smart Sealed Lead Acid (SLA) Battery Charger with current limiting is used. The charger uses a two-step process for charging SLA batteries – a current limited ‘fast’ mode followed by a constant voltage ‘float’ mode. An onboard LED indicates when the charger is in ‘fast’ mode. When the LED goes out the battery is charged and the charger has switched to ‘float’ mode. Charging starts at the maximum current limit. The battery terminal voltage will gradually increase until it reaches the regulator set voltage. As the battery becomes fully charged the current will start to decrease. When the charging current drops to around 140mA (see later) the regulator voltage is decreased to a safe float voltage at which the battery can be left on indefinitely.

**MODES OF OPERATION**

In the proposed UPS system, there are 4 modes of operations namely- Solar mode, Solar + Battery mode, Battery mode, Grid mode. There are two control relays for switching between the modes for smooth operations. All of these signals are fed to the microcontroller. Microcontroller decides between the modes based on the availability of PV power, the battery SOC, and the load condition. Through the proposed control arrangement, the PV module will operate at MPPT, and move away from MPPT only when the available PV power is larger than the total power for battery charge and supplying the load. By this way solar PV power is utilized in the most effective way. In addition, the battery will not be overcharged or over discharge and will stay at a specified SOC voltage.

MODE 1 –

Solar Mode This mode is activated when the available power from PV is more than that required by the load and the battery together as shown in Fig 6. At this time the current tends to increase thereby giving a MODE 1 – Solar Mode This mode is activated when the available power from PV is more than that required by the load and the battery together as shown in Fig 6. At this time the current tends to increase thereby giving a negative signal which is added with normal MPPT signal to adjust the PWM such that the system operates in reduced MPPT level i.e. the panel is made to operate such that it gives the power required only to satisfy load and battery requirements.

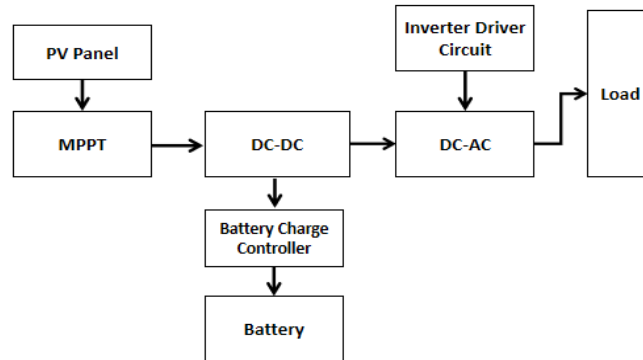


Fig 2: Solar Mode

**MODE 2 –**

Solar + Battery Mode: As shown in Fig. 4, when the available maximum PV power is less than the load power and the available charge in the battery is above healthy SOC, the insufficient power will be automatically supplied by the discharge of the battery. So the converter is made to operate at MPPT and the panel power and battery together supplies the load.

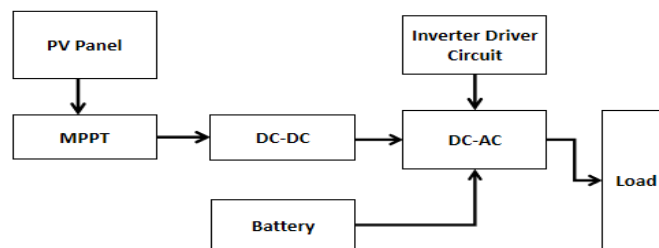


Fig 3: Solar + battery model

**MODE 3 –**

Battery Mode: While working in Battery mode, if occasionally the power output from PV fails to meet the load requirement or is unavailable, the battery is allowed to discharge till the critical SOC. In this mode, grid availability is checked if the battery level goes beyond the critical SOC.

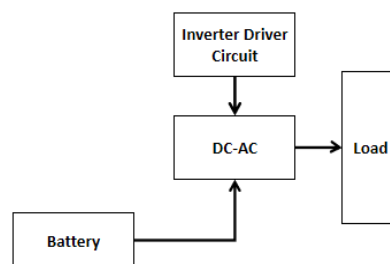


Fig 4: Battery Mode

D. MODE 4 - Grid mode

Grid mode is activated when PV power together with battery power cannot satisfy the load. While working in Battery mode, when battery level goes beyond low SOC level and the grid is available, then the system is switched to the grid side using a pulse from the microcontroller. At the same time, the battery is allowed to charge from the grid.

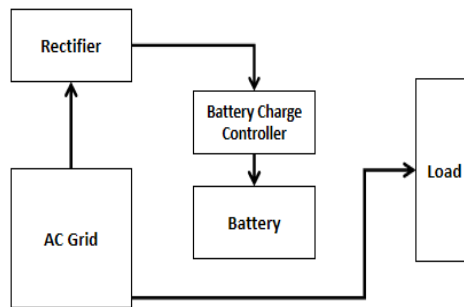


Fig 5: Grid Mode

IV. EXPERIMENTAL RESULTS

Large-scale commercially available UPS systems are designed to be of very high efficiency and with very high power quality. Since the components of a commercial UPS are designed to fit together, the power quality and conversion efficiency are likely to be higher than for the prototype system. This is due to both the efficiency and power quality parameters of the individual components (which were not designed for UPS systems) and the fact that the components were bought separately and not as a system. The absolute level of power quality and efficiency is thus not directly comparable with commercial UPS systems. The inverter used has a maximum output power of 200 W. Because of the initially high current when starting to charge the battery, the load has to be decreased for the rectifier to handle the power demand.

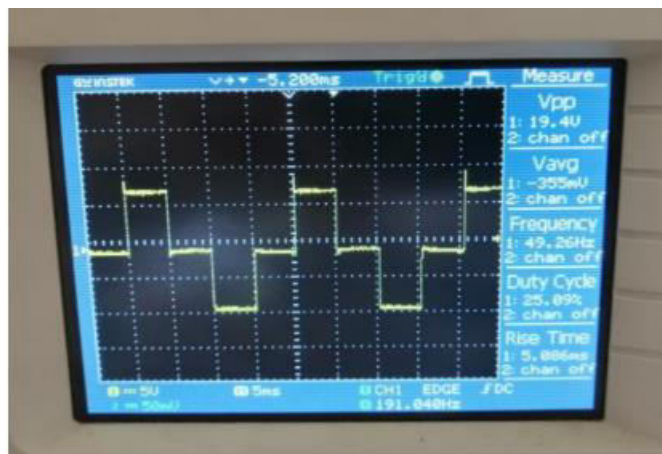


Fig 4. Output waveform of inverter circuit

V. CONCLUSION

It is technically possible (with minor modifications) to combine solar energy and UPS systems on a common DC-line. The addition of solar energy does not have any significant impact on the power quality of the UPS system. In the case of power outages in the electricity grid, solar power can benefit the system with both less impact on power quality at the point of disconnection from the grid and also increase the autonomy time of the UPS. The economic synergies related to the combination of solar power and UPS systems are two-fold: the investment cost of the system and the total generated energy. Based on prices for commercially available inverters and solar charge controllers the conclusion is drawn that the investment cost of the combined system is significantly lower than for separate systems. In the solar



generation model, the combined system is concluded to have higher total system efficiency than a stand-alone solar power system. This is due to the decreased need for power to pass the rectifier resulting in decreased conversion losses in the combined system and thus a higher total energy yield.

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