PV Inverter with Integrated Battery Energy Storage

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***Abstract*—In this study, a transformer-less hybrid PV inverter with integrated battery energy storage is suggested. With the capacity to control for optimal power transmission as well as manage the charge and discharge operations of a battery energy storage system, the proposed converter incorporates both solar PV and battery sources.In this study, a high-step-down DC to DC converter for battery banks and solar PV is presented.The converter's efficiency and power density are enhanced as a result. The suggested converter can increase voltage gain while putting less strain on output diodes and MOSFET switches.**

Keywords—Hybrid PV- Battery system, MPPT control, DC DC converter.

I. INTRODUCTION

Hybrid power systems are those that generate electricity from two or more sources, usually renewable, sharing a single connection point**.** Although the addition of powers of hybrid generation modules are higher than evacuation capacity, inverted energy never can exceed this limit. In that way, a hybrid generation plant can, therefore, use, for example, photovoltaic energy when the sun shines and another source, such as wind, in cloudy weather, thus ensuring a more stable and efficient supply. Hybrid installation may or may not always include storage systems.Hybrid Inverter with Solar Battery Charging A 12V battery powers the inverter that makes up the system. With the aid of this inverter, 110V AC can be produced.driver a transformer with a large load and circuits. The mains power supply itself serves as the first of two sources for charging this battery. The relay switches to the connection using the mains power source to supply the load if the mains power supply is available. In order to use the battery as a backup the next time there is a power loss, this power supply also charges the battery. A further benefit of using a solar panel to recharge the battery is having extra power in case the mains power outage lasts longer. So, this inverter has a long life. longer periods of time and offer the consumer an uninterrupted power supply.

However, a hybrid PV - Battery system needs a minimum of One maximum power point tracker (MPPT) controller for the PV and one state of charge (SOC) controller for the battery. In order to provide maximal power harvesting capabilities in various environmental situations, several MPPT strategies were published . Some MPPT approaches employ a single voltage or current sensors are required, whereas other methods employ voltage and current sensors.Actually, because to their higher MPP precision, most MPPT algorithms, including those used in hill climbing, require both voltage and current sensors methods. The state-of-charge (SOC) controller is a component of the power management systems, which keeps the battery from being overcharged or undercharged.Particularly, overcharging or undercharging modern Lithium Ion (Li ion) based battery storage systems causes damage to the batteries, a decrease in battery life, or even serious fire threats that might result in explosions.It is one of the first types of electrical energy storage.The Lithium Ion has advantage like high energy density, specific power, efficiency, and long life.Thus, a distinct it is necessary to have a separate SOC controller for the dc-dc converter.The dc-dc converter must also be built to withstand the entire processed power.In Additional, through hard switching lossy operation, the dc-dc stage is permitted to function across a wider duty cycle range. As a result, architecture

suffers from increased power losses, which eventually limits the scalability of the power converter.These topologies involve a higher number of sensors along with a large DC link buffer to handle the voltage ripple caused by the dc-dc converter stage.

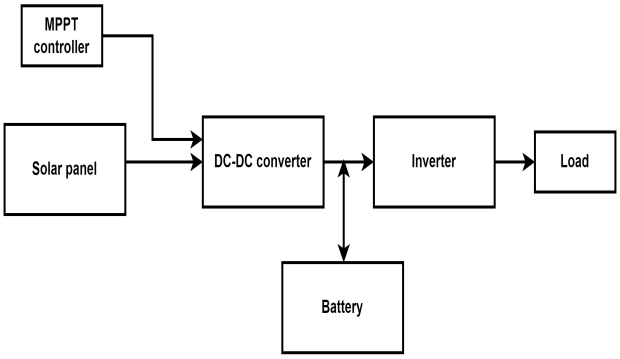

Fig:1 A Transformer-less Hybrid PV Inverter with Integrated Battery Energy Storage

It has the capacity to regulate the PV's maximum power point as well as the charge and discharge processes for the battery storage system via single voltage and current measurements. The suggested control uses a perturb and observe technique to maximize solar power and maintain an appropriate battery state of charge. The interleaved modular multilevel converter that is being suggested raises the voltage of the dc link to enable transformer-free contact with the electric utility.Transformer-less inverters convert A computerised multi-step process involving electronic components is used to convert DC to high frequency AC, back to DC, and then to regular frequency AC.The size, weight, and cost of the solar power conversion system were also decreased in transformer--less inverters as a result of the removal of the transformer.When the transformer is removed, there is a galvanic connection between the PV panels and the grid, which causes leakage current to flow because ground parasitic capacitance is formed.

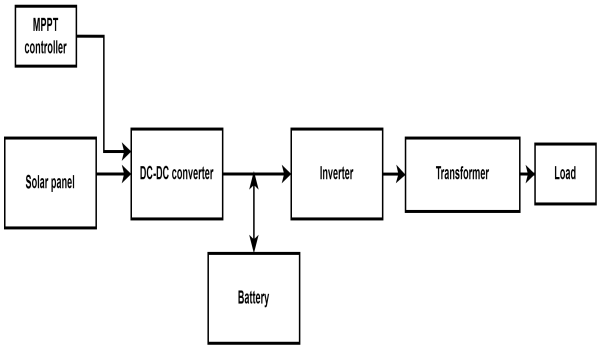

Fig:2 A battery energy storage system integrated into a transformer hybrid PV inverter

A transformer found inside of standard inverters synchronizes the voltage with that of the grid and that of the appliances. The physical size of the transformer is directly related to the amount of power to be desired.There is no conductive route connecting the source and the load when using a transformer to establish galvanic isolation. This isolation is used to transfer power between two circuits that cannot be linked, to guard against electric shock, to muffle electrical noise in delicate electronics, and more.

II.EXPLANATION OF BLOCKS

Solar Panel:

Solar energy is generated by the sun. PV panels, sometimes referred to as solar panels, are used to transform solar light, which is made up of energy particles called photons, into electricity that may be utilized to power electrical loads. In addition to producing electricity for household and commercial solar electric systems, solar panels can also be used for a wide range of other purposes, such as remote power systems for cabins, telecommunications equipment, remote sensing, and many others. Sunlight from solar panels is captured as clean, renewable energy and transformed into electricity, which is then used to power electrical loads.

In this block the function of the solar panel is to collect the solar energy from the sun and it send to the DC-DC converter and it the energy control with the help of the MPPT controller.

DC-DC Converter:

The power electronics circuits known as "dc to dc converters" or "dc choppers" change the value and occasionally the polarity of a dc voltage source to another dc voltage source.. They are two types of DC-DC to converters

1. Boost converter
2. Buck converter

Boost converter:
A boost converter (step-up converter) is a DC-to-DC power converter that increases voltage from its input (supply) to its output while decreasing current (load).In this block step up the voltage and DC current is send to the inverter.A boost converter is a DC to DC converter with an output voltage greater than the source voltage. A boost converter is sometimes called a step-up converter since it steps up the source voltage.Since power must be conserved, the output current is lower than the source current.

The fundamental idea behind the boost converter is the inductor's propensity to resist changes in current by either storing more or less energy in its magnetic field. The output voltage of a boost converter is always greater than the input voltage.

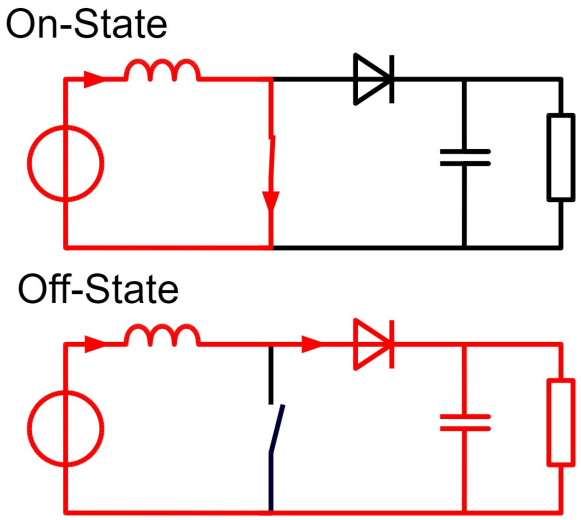

Fig:3 Boost converter

- The inductor generates a magnetic field and current flows through it clockwise when the switch is closed (in the "on" state), allowing the inductor to store some energy. The inductor's left side has positive polarity. As a result of the larger impedance in the open (or "off-state") state of the switch, current will be reduced. To keep the current flowing toward the load, the energy of the magnetic field that was previously generated will be diminished. As a result, the polarity will change (meaning the left side of the inductor will become negative). Due to the series connection of the two sources, a larger voltage will be used to charge the capacitor through the diode D.
- ***Buck converter****:*
- A DC-to-DC power converter known as a buck converter (also known as a step-down converter) steps down voltage from its input (supply) to its output (load). It is a type of switched-mode power supply (SMPS) that frequently includes at least two semiconductors and one energy storage component, such as a capacitor, inductor, or both.The current in an inductor is fundamentally regulated by two switches in the buck converter. These "switches" are actually achieved by a transistor and a diode, or by two transistors, in a practical implementation.

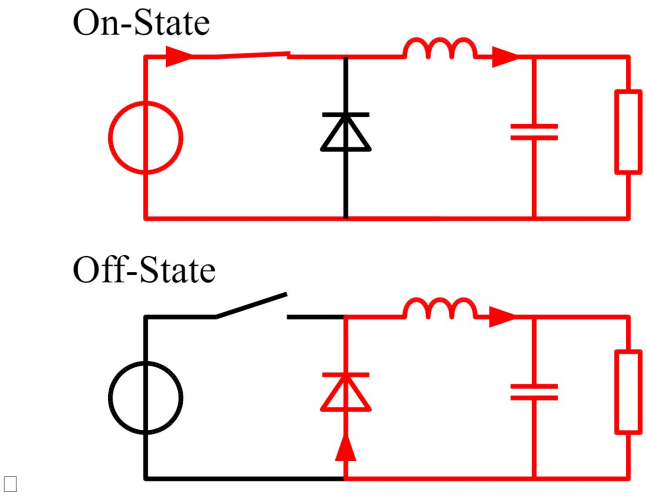

Fig:4 Bust converter

It is believed that every component is flawless. To be more precise, the inductor has zero series resistance, the switch and the diode have zero voltage drop when on and zero current flow when off.

Since neither the input nor the output voltages fluctuate during a cycle, the output capacitance must be infinite.

In this block the step-up converter(buck) is used.

MPPT Controller:

Perturb and observe method is used for maximum power tracking.This method can track maximum power point when they irradiance on the PV array is uniform.The PV curve can be divided into three regions.The LHS region the change in power with respect to voltage is greater than zero.When the voltage increased the power also increases where power and voltage are directly proportional.On the RHS the change in power with respect to voltage is less than zero. If the voltage is increased then power decreases.At the MPP stage change in power is equal to zero which is condition for maximum.

If observes from origin to right:

$$dp/dv>0 \qquad (1)$$

Where from left of the graph :

$$dp/dv<0 \qquad (2)$$

Which the condition for maximum power:

$$dp/dv=0 \qquad (3)$$

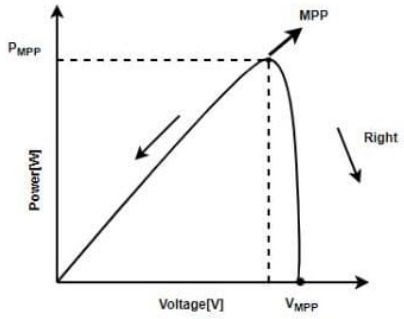

Fig:5 Perturb and observe

Batteries: An apparatus that stores chemical energy and transforms it into electrical energy is a battery. Electrons move from one substance (electrode) to another through an external circuit during chemical reactions in batteries. An electric current can be created by the flow of electrons and employed to perform tasks. There are primarily two categories of batteries:

1. Primary model batteries
2. Secondary model batteries

Primary model batteries:

It is a Portable Voltaic cell that can't be rechargeable and it is a single use galvanic cell that Stores electricity for convenient usage And it consist of good Shelf life. These are classified into 2 type:

*Alkaline battery
*Coin Cell Batteries

Alkaline battery - The corrosion of a long-lasting dry cell with an alkaline electrolyte is reduced, and these alkaline batteries are employed in household appliances.

Coin Cell Batteries- In addition to the ingredients lithium and silver oxides, coin cell batteries also contain alkaline electrolytes. These basic battery types are very effective at maintaining a constant and steady voltage.

Secondary model batteries:

It is a portable voltaic cell that can be chargeable by passing electric current through them this can be used over again. At present scenario four common types are used:

*Lead acid battery
*Lithium ion battery
*Ni-MH battery
*Nickel Cadmium battery

Lead acid battery: It is a type of rechargeable batteries first invented in 1859 compared to modern rechargeable battery it has low density. This batteries uses sulfuric acid for functioning.

Ni-MH batteries: Nickle-Metal hybrid battery it is a rechargeable battery.It has higher Specific energy with fewer toxic metal less effect on memory & generate high peak power.

It is more expensive than alkaline battery. And these are used in hybrid automobile batteries, electric razors, toothbrushes, Medical Instruments.

Nickle cadmium battery: It is a rechargeable battery using nickel oxide, hydroxide and metallic Cadmium as electrode .This is used in Cord less and wireless telephones. It takes low internal resistance and Supply high surge current this batteries Completely surge with lead acid because it has higher energy density (50 -75 wh/kg) It has a longer life (2000-2500cycles).

Lithium- ion battery: An advanced battery technology known as a lithium-ion (Li-ion) battery makes use of lithium ions as a crucial part of its electro chemistry. Lithium atoms in the anode are ionized and separated from their electrons during a discharge cycle.. Li-ion batteries are more stable and may be recharged numerous times. Compared to other rechargeable batteries, they often have a better energy density, higher voltage capacity, and a lower self-discharge rate. A single cell offers a longer charge retention than other battery types, which improves power efficiency. Lithium-Ion power sources are rechargeable and are used in vaping devices, many personal electronics such as cell phones, tablets, and laptops, E-Bikes, electric toothbrushes, tools, hover boards, scooters, and for solar power backup storage.

In is block lead acid battery are used.

Inverter: An inverter transforms DC electricity into AC electricity from sources like batteries or fuel cells. Any required voltage of electricity can be used; in particular, it can power rectified DC at any desired voltage or AC equipment made for mains operation. Inverters include known as AC Drives or VFD (variable frequency drive). They are electronic devices that convert direct current (DC) to alternating current (AC) (Alternating Current). Additionally, it is in charge of regulating the speed and torque of electric motors.They are 2 types of inverters:

1. Voltage Source inverter
2. Current Source inverter

Voltage Source inverter:

A voltage source inverter, often known as a VSI, is a converter that changes a voltage's waveform from one that is unidirectional to one that is bidirectional, or from DC to AC. The optimum voltage source inverter maintains a consistent voltage throughout the operation.

The voltage source inverter are classified into two typologies:

1. Single Phase Voltage source inverter
2. Three phase Voltage source inverter

Single Phase Voltage Source inverter:

It is an apparatus that transforms a single-direction voltage waveform into a dual-direction waveform, or a converter that changes the voltage from dc to ac. And in the single voltage Source Inverter phase They are full bridge and halt bridge inverters, to reiterate. flipped 180 degrees of phase voltage Source Inverter converts a Dc input into a three phase Ac output. Both the 120 degree conduction mode and the 180 degree conduction mode are available for use with these inverters.

Three Phase Voltage Source inverter: An inverter produces a three-phase AC output from a DC input. To provide a three-phase AC supply, its three arms are typically delayed by a 120° angle. Every T/6 of the time T 60°angle interval, an inverter switch with a ratio of 50% will switch A three-phase inverter must be employed in order to achieve the three-phase output from a circuit using dc as the input voltage. Since the inverter is made up of switching components, the output that is produced depends on how the switching is carried out.

Current Source inverter: The current source inverter, sometimes referred to as the current feed inverter, turns the input dc into ac and produces either a single phase or three phase signal. An ideal current source is one that has continuous current and is independent of voltage, according to the definition of a current source. It is employed to regulate the speed of ac motors. electric heating. UPS systems.In this block Voltage source inverter is used for step-up the voltage.

Loads: Resistive loads, inductive loads, and capacitive loads are the three main types of loads.

Resistive load: Any electrical load that includes a heating element is referred to as a resistive load. A sinusoidal waxing and waning pattern of electrical current is drawn by a resistive load in time with a sinusoidal variation in voltage. Therefore, resistive loads can store current and voltage values that are constantly synchronized.

Inductive load:A lagged load that generates inductive fields individually is referred to as an inductive load. Inductive loads, in contrast to resistive loads, have current that follows a sinusoidal pattern and peaks right after the sine waves of the voltage. This indicates that the maximum, minimum, and zero points of each wave are not in phase with one another**.**

Capacitive load:A capacitive load has out-of-phase current and voltage waves, just like an inductive load does. With a capacitive load, the current peaks before the voltage does, which is a significant difference. The biggest power factors are also provided by capacitive load elements, which are frequently utilized to strengthen electrical circuits**.**

III.Conclusion

The suggested transformer-less hybrid PV inverter incorporates both solar PV panels and battery energy storage. Using just one current and one voltage measurement, it has the ability to control the PV's maximum power point as well as the charging and discharging procedures for the battery storage system. This study presents a high-voltage-gain soft-switched coupled inductor converter for low-voltage energy sources.By carefully selecting the coupled inductor's turn ratio, it is possible to further boost the suggested converter's high voltage conversion ratio. Furthermore, it can achieve significant voltage gain while exerting less voltage stress on MOSFET switches and output rectifier diodes.

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