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Utilizing Hybrid Technology for MPPT and GMPPT Implementation in Buck-Boost Mode for Quasi-Z-Source Power Converters

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ABSTRACT - Employing hybrid technology and solar energy.To ensure that shoot-through states are only used when the boost function is required and avoided in the buck mode, two distinct control approaches are necessary. This study introduces a unified control system that enables the transition between different control algorithms in the buck and boost modes. Specifically, a hysteresis band is proposed between the buck and boost modes to ensure smooth and stable performance. Additionally, it incorporates the implementation of global maximum power point tracking, allowing for scanning of the entire input voltage range within 10 seconds. Experimental results demonstrate that the proposed control system delivers high and consistent MPPT efficiency across various operating points, showcasing the potential for solar and hybrid technologies. Finally, the key features are validated, along with the advantages, limitations, and potential for other solar applications, in the conclusion.

KEYWORDS: Arduino, MPPT, GMPPT, Quasi Z source converter, Buck Boost Converter

I. INTRODUCTION

The maximum power point tracking implementation for the buck-boost voltage mode control of a single-phase multilevel inverter based on a three-level neutral point clamped quasi-Z-source topology. To utilize shoot-through states only when boost function is needed and avoid it in the buck mode, two different control approaches are required The proposed merged control system which provides switching between different control algorithms in the buck and boost modes. A hysteresis band between the buck and boost modes is proposed which provides smooth and stable performance.

1.1 PROBLEM STATEMENT

Renewable energy sources need to be installed in the power system to achieve the target of sustainability and move away from the traditional energy sources. The Quasi-Z-Source Inverter is a good option in this regard because it is a flexible system that can handle variable input voltages very will. The biggest drawback of using renewable sources is the absence of advanced control strategies, such as Maximum Power Point Tracking and Generalized Maximum Power Point Tracking , with the Buck-Boost mode of the Quasi-Z-Source Inverter.

1.2 OBJECTIVE

- To design a stable and efficient performance of the qZS based inverter without ST utilization in the buck mode, different control strategies were recommended for the realization of the buck and boost mode.
- To design and implement qZS based inverter, requires 2–3 times longer period to find the global maximum.
- Moreover, Global MPPT (GMPPT) is considered as a particular case of MPPT.

1.3 SCOPE AND STUDY

Designing the Buck-Boost control algorithm for the qZSI. Developing MPPT and GMPPT algorithms suitable for the system.Simulating the entire system in software like MATLAB/Simulink or PLECS to observe and analyze its performance. Validating the hardware implementation with real-world experiments. Comparing the efficiency and performance of MPPT and GMPPT in the Buck-Boost mode of the qZSI. Drawing conclusions on the effectiveness of each

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algorithm and their practical implications. Designing control algorithms for Buck-Boost mode that ensure stability and quick response. Developing MPPT and GMPPT algorithms that are efficient and effective in real-world conditions. Integrating these algorithms into the control scheme of the qZSI without introducing complexities or compromising reliability. It's a significant undertaking but can lead to valuable insights for improving the efficiency and performance of renewable energy systems using Quasi-Z-Source Inverters.

II. COMPONENTS

COMPONENTS AND SPECIFICATIONS:

- Arduino uno
- DC-DC converter components
- Inverter components
- Solar panel
- Battery
- Inductor
- Conductor
- Mosfet

DC-DC CONVERTER

DC-to-DC converter is that the inductor in the input resistance has the unexpected variation in the input current. If the switch is on, then the inductor feeds the energy from the input and it stores the energy of magnetic energy. If the switch is closed, it discharges the energy.

INVERTER

An inverter converts the DC electricity from sources such as batteries or fuel cells to AC electricity. The electricity can be at any required voltage; in particular it can operate AC equipment designed for mains operation, or rectified to produce DC at any desired voltage. An inverter is a motor control that adjusts the speed of an AC induction motor. It does this by varying the frequency of the AC power to the motor. An inverter also adjusts the voltage to the motor. This process takes place by using some intricate electronic circuitry that controls six separate power devices.

An inverter converts direct current (DC) from your batteries in to alternating current (AC) through an inverter, the inverter then supplies your house with either 110/220V alternating current.

INDUCTOR

An electronic component known as an inductor has the ability to store electric energy in the form of magnetic energy. An inductor's current flows through its terminals when a voltage is applied across them, producing a magnetic field. In turn, this magnetic field induces a current to flow in the opposite direction.

The SI unit of inductance is Henry abbreviated as 'H'. It is defined as the measure of electric current changes at one ampere per second, resulting in an electromotive force of one volt across the inductor.

CONDUCTOR

A conductor conducts electricity since it offers little or no resistance to the flow of electrons, thus leading to a flow of electrical current. Typically, metals, metal alloys, electrolytes and even some nonmetals, like graphite and liquids, including water, are good electrical conductors.Conductors are the materials or substances which allow electricity to flow through them. They conduct electricity because they allow electrons to flow easily inside them from atom to atom. Also, conductors allow the transmission of heat or light from one source to another.

he current is proportional to the electric field and the conductance of the material. The electric field is created by a potential difference or voltage across the conductor. The conductance is a measure of how easily the material allows charge to flow through it.• Charge Rate : 1-3C Recommended, 5C Max

MPPT

An MPPT, or maximum power point tracker is an electronic DC to DC converter that optimizes the match between the solar array (PV panels), and the battery bank or utility grid. To put it simply, they convert a higher voltage DC output from solar panels (and a few wind generators) down to the lower voltage needed to charge batteries.

Maximum power point tracking (MPPT), or sometimes just power point tracking (PPT), is a technique used with variable power sources to maximize energy extraction as conditions vary. The technique is most commonly used with photovoltaic (PV) solar systems, but can also be used with wind turbines, optical power transmission and thermo photovoltaics.

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Solar cells' non-linear relationship between temperature and total resistance can be analyzed based on the Current-voltage (I-V) curve and the power-voltage (P-V) curves. MPPT samples cell output and applies the proper resistance (load) to obtain maximum power.

GMPPT

Global maximum power point tracking (MPPT) refers to an inverter's ability to periodically sweep the full current-voltage (IV) curve of a solar array to find the operating point at which the array produces the most power. This functionality, in conjunction with bypass diodes inside the solar panels, can have a significant impact on the energy production for installations under partial shading.

Z-SOUCE INVERTER

A Z-source inverter is a type of power inverter, a circuit that converts direct current to alternating current. The circuit functions as a buck-boost inverter without making use of DC-DC converter bridge due to its topology. Impedance (Z) source networks efficiently convert power between source and load from DC to DC, DC to AC, and from AC to AC.

The numbers of modifications and new Z-source topologies have grown rapidly since 2002. Improvements to the impedance networks by introducing coupled magnetics have also been lately proposed for achieving even higher voltage boosting, while using a shorter shoot-through time. They include the Γ-source, T-source, trans-Z-source, TZ-source, LCCT-Z-source that utilizes a high-frequency transformer connected in series with two DC-current-blocking capacitors, high-frequency transformer-isolated, and Y-source networks.

Amongst them, the Y-source network is more versatile and can be viewed as the generic network, from which the Γ-source, T-source, and trans-Z-source networks are derived. The incommensurate properties of this network open a new horizon to researchers and engineers to explore, expand, and modify the circuit for a wide range of power conversion applications.

PASSIVE COMPONENT DESIGN

AThe main aim of the passive component’s selection is to provide proper operation of a solar inverter. The values of components are interconnected with the switching frequency, which, in turn, is interconnected with the efficiency. The components can not be oversized due to the cost limitation.

Passive components of the qZS network are selected to mitigate the double-frequency power ripple along with high switching frequency ripple, which is required in order to provide MPPT efficiency not less than 99 %. The so-called power decoupling approach is widely used in the single-phase systems. Passive elements of the qZS network have to be able to mitigate the double frequency power ripple in order to provide the PV panel’s voltage ripple ΔVPV/VPV not higher than 3–4 %.

This percentage is sufficient to provide the MPPT efficiency not lower than 99 %, which is the industrial standard. At the same time, due to the qZS network structure, the input decoupling capacitors are not required. In this particular case, the input capacitor corresponds to the capacitance of PV panels and is not significant.

CONTROL SYSTEM DESCRIPTION

This section is devoted to the control system description. A general block diagram of the proposed control strategy for an internal capacitor voltage vC (C2 and C3) regulation based on the buck-boost control is presented. In this article, two possible control modes are considered: when the input voltage is below the reference value of the voltagev_C^* (boost mode) or higher (buck mode). This reference voltage across internal capacitors C2 and C3 has fixed and variable component

v_C^*=V_(C_REF)±Δv_c

The variable component is defined by hysteresis band and is described in the next chapter. The fixed component V_(C_REF) is set to 380 V. This voltage can be decreased up to 340 V in the case of low power injection or very low grid impedance. Both modes can be simply referred to by the term: the buck-boost control method. Two independent control systems are proposed correspondingly

Hysteresis Band between Buck and Boost Modes

A quadcopter, also known as a quadrotor, is a type of unmanned aerial vehicle (UAV) characterized by its configuration of four horizontally oriented rotors, each mounted at the end of a separate arm. These rotors generate lift and control the vehicle's motion through differential thrust, allowing for vertical takeoff and landing, as well as agile maneuverability in various directions. To avoid that, the hysteresis band between the buck and boost modes is introduced. At the very beginning, the low irradiance level is considered. The open–circuit voltage of the PV string can be about 400 V. The inverter starts working in the buck mode and the input voltage along with the capacitor voltage is decreasing until lower threshold is achieved. Due to the hysteresis band, the lower threshold reference capacitor voltage is set to 370 V. After that, the boost mode is activated and disturbances are expected. After switching to the boost mode, the upper threshold level is activated and

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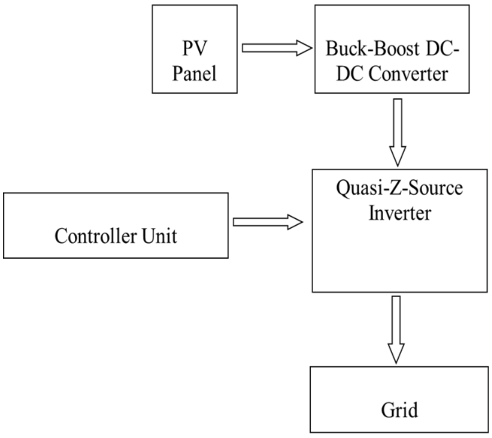
the inverter keeps working in the boost mode. The input voltage continues declining until MPP is reached. In the example case, it is 320 V.

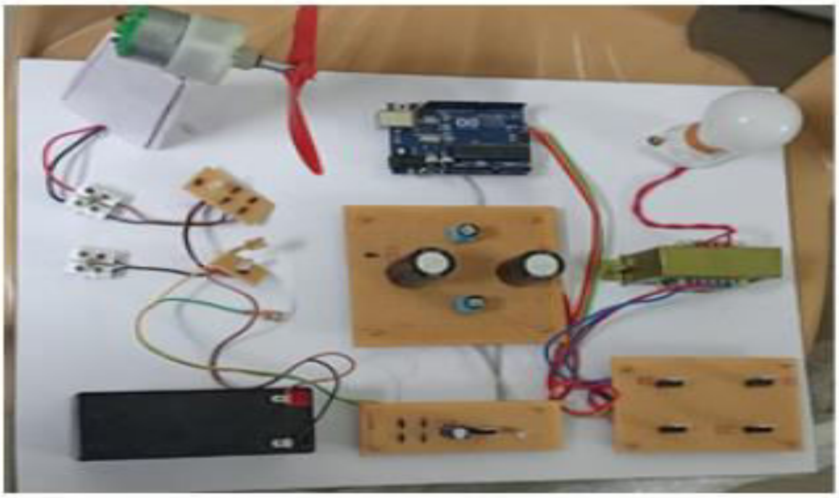
MPPT performance enhancement of low-cost PV micro converters

DC voltage gain of a micro converter should change in a wide range, which requires use of undesirably high or low values of the switch duty cycle that result in high losses in the front-end stage. A reconfigurable rectifier at the output stage of the photovoltaic micro converter enables dc gain control and, consequently, limits variation of the duty cycle to more favorable range. This work proposes use of a reconfigurable rectifier capable of reconfiguring its topology from a voltage double to a voltage quadruple. The paper explains the derivation, operation and the control principle of a reconfigurable rectifier. A single-switch quasi-Z-source front-end stage was used as an application example of the wide input voltage range photovoltaic micro converter in the experimental study.

BLOCK DIAGRAM



WORKING



Z-SOURCE (ZS) and quasi-Z-source (qZS) inverters proposed. They allow overcoming some typical limitations associated with the conventional voltage-source inverters: both have buck and boost operation modes and they are not affected by shoot-through (ST) switching states, which correspond to a short-circuit condition in one or more inverter phase-legs. The main goal of this article is to design an efficient maximum power point tracking (MPPT) for the qZS-based solar inverter, which will combine the buck-boost control capability and the grid-connection algorithm Global MPPT (GMPPT) is considered as a particular case of MPPT. The MPPT efficiency is the main criterion of the control system effectiveness. Simulation and experimental results have been done to demonstrate the validity of the proposed inverter. Switches signals are generated using Arduino micro controller.

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The design and analysis of a two-stage PV converter with quasi-Z source inverter

A fire extinguisher ball is an innovative and compact firefighting device designed to extinguish small fires rapidly. Typically, it is spherical in shape and contains dry chemical powder or other extinguishing agents inside. When exposed to flames, the ball activates automatically, bursting open and releasing the extinguishing agent to smother the fire. This mechanism makes it ideal for use in various environments, including homes, offices, vehicles, and industrial settings. Fire extinguisher balls are known for their simplicity and effectiveness in suppressing fires quickly, potentially preventing them from spreading and causing significant damage or injury.

The design and analysis of a two-stage PV converter with quasi-Z source inverter

The PV converters are implemented either in single stage of two-stage topologies according to intermediate dc bus requirements. In the two-stage topologies, the recent researches are based on transformer less structures to eliminate bulky and lossy transformer isolation. Therefore, several methods including stray current grounding have been proposed in the literature to obtain isolation without the use of transformer. This paper proposes a two-stage PV converter with quasi Z-source (qZS) inverter in the second stage. The first stage of PV converter is comprised by a conventional boost converter that the maximum power point tracking (MPPT) controller is improved with integral regulator addition to incremental conductance algorithm. The MPPT efficiency of improved system is measured as 98.8% regarding to the designed controller. In addition to its efficiency, MPPT controller stabilized the intermediate dc bus voltage against the various irradiation values applied to PV plant

III. CONCLUSION

To ensure stable and efficient performance of the qZS-based inverter without utilizing shoot-through in the buck mode, different control strategies were recommended for the realization of both the buck and boost modes, utilizing hybrid technology and power converters. To facilitate a smooth transition between these two strategies, the implementation of a hysteresis band was suggested. The Incremental Conductance (IC) method with variable sampling frequency and variable integral coefficients of the output integrator is recommended for Maximum Power Point Tracking (MPPT) and Global MPPT (GMPPT) realization, highlighting the advantages of hybrid technology and power converters. It was observed that GMPPT, initially applied in the qZS-based inverter, required 2–3 times longer to find the global maximum, yet proved to be an effective solution, particularly in partial shadow conditions, showcasing the potential of hybrid technology and power converters.

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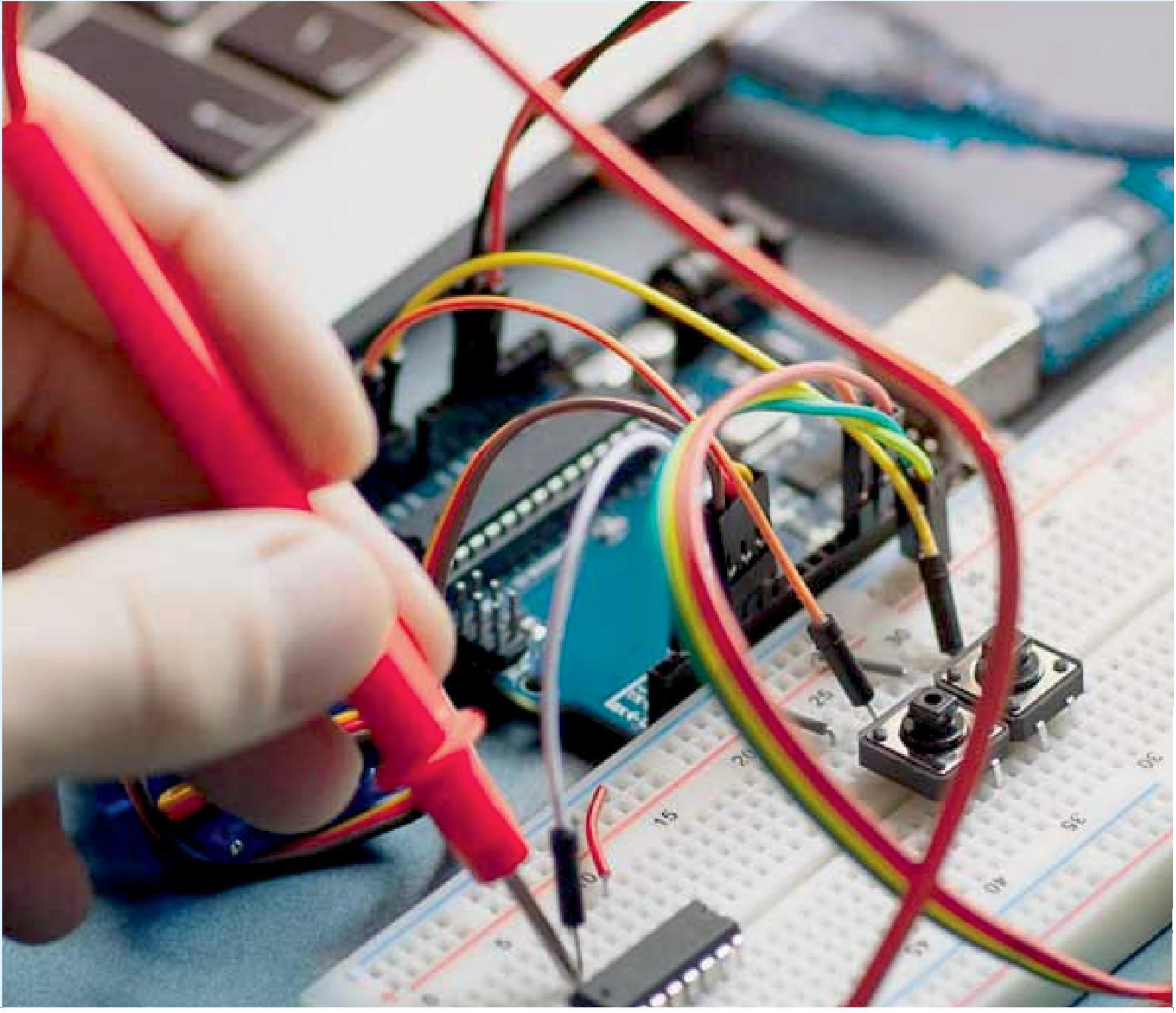

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