Grid Tied Photovoltaic Power System Incorporated With a PWM Modulated Single Phase Quasi Z Source

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Abstract

A hybrid pulse width modulated single-phase quasi-Z-source inverter (qZSI) based grid connected Photovoltaic (PV) power system is proposed. The hybrid pulse width modulation (HPWM) conducts Pulse width modulation when the required AC output voltage is lower than the DC source voltage, otherwise it performs pulse-amplitude modulation (PAM) for the single-phase qZSI. The low-frequency ripple voltage of dc link is utilized, resulting in reduction of quasi-Z-source inductance and capacitance, and power devices switching actions. A grid-connected current controller, combining with the plug-in monotonous control and proportional-resonant regulator, is employed to attain strong harmonic suppression, fast convergence, and nil tracking error.

\textbf{Key Words:} Pulse-width modulation, photovoltaic power system, quasi-Z-source inverter, single-phase grid-tie control.

1 Introduction

The non-stop increase of power call for is motivating a quick development of grid-connected photovoltaic (PV) power era. The
quasi-Z-supply inverter (qZSI) changed into widely investigated for PV strength systems due to its singlestage energy conversion in managing the 1:2 PV-panel voltage variant [1]-[4]. even though the traditional voltage source inverter (VSI) plus the dc-dc raise converter-based totally two-level VSI can also achieve the voltage increase, the preceding contrast between the conventional two-stage inverter and the qZSI in [5] and [6] confirmed that the qZSI supplied smaller passive additives, decrease fee, much less lively switches, and nearly the equal or better performance [5]. The effects of the assessment proved that the qZSI is a promising alternative at the utility areas requiring 1 2 enhance ratio [5], [6]. The single-phase qZSI turned into used as a power module in the cascaded multilevel inverter (CMI) [7]-[10] or as an impartial power conversion gadget in [11]-[14]. No matter which utility it’s far in, the double-line-frequency (2ω) pulsating electricity will float backward and forward among ac and dc sides of the single-phase qZSI. the consequent 2ω voltage ripple of dc link has to be limited in the engineering tolerant variety within the traditional pulse-width modulation (PWM)-primarily based single-section qZSI [11]-[14], to make certain first-class ac output voltage. The qZS capacitance, qZS inductance, and PV panel terminal capacitance have been designed to lessen the 2ω voltage and current additives of dc side in [8], [13] and [14]. however, large qZS capacitance and inductance were inevitable. furthermore, the conventional PWM strategies precipitated excessive switching loss of the qZSI because of additional shoot-through actions and high switching voltage stress. The discount of qZS capacitance and inductance and electricity loss is still an open subject matter for the single-phase qZSI. This paper proposes a hybrid pulse-width modulation (HPWM) to reduce the strength loss and qZS capacitance and inductance for the unmarried-phase qZSI-primarily based PV energy machine with the aid of combining PWM and pulse-amplitude modulation (PAM). on the PWM period, the qZSI works because the traditional VSI with out shoot-thru action also with low dc-hyperlink voltage. at the PAM length, the qZSI has best shootthrough switching one time in step with manage cycle, and there may be no any conventional lively movement for all switches, because of low switching frequency. each contribute to enhance the qZSI performance. furthermore, the HPWM lets in dc-link 2ω voltage envelope, which
benefits the qZS network with small capacitance and inductance. For the traditional PWM-based unmarried-phase qZSI, the shoot-thru responsibility cycle $D$ is responsible for dc-hyperlink voltage manipulate and the modulation index $M$ is used to alter the output strength, but both are restricted with the aid of $M+D<1$ [13], [14]. For the proposed HPWM-based unmarried-section qZSI, there’s no dilemma of $M+D<1$, however they’re established in each other. As a result, one impartial manipulate variable, i.e., the modulation index, is available to manipulate the dc-hyperlink voltage, the most power point monitoring (MPPT) of PV panel, and the strength injection into grid. A way to obtain these functions in this example can be spoke back with the aid of this paper. Further, the controller’s potential to suppress low-order harmonics is good sized for the grid-tie single-phase machine. The modern contributions have been dedicated to the traditional single-phase grid-tie VSI [15]-[31]. They used the proportional-resonant (PR) manage to song the sinusoidal reference, but the endless gain changed into simplest on the essential frequency [24], [25]. The multi-PR manage eliminated the harmonic additves at multiples of the fundamental frequency, but because of the excessive computation burden [24]. The inner version principle based repetitive controller (RC) in a easy way is capable of suppress harmonic components at multiple frequencies, and the convergence is progressed while combining with a proportional-necessary (PI) or PR regulator [25]-[29]. Therefore, the mixture of RC and PR is evolved to control the HPWM-based totally singlephase qZSI PV energy gadget on this paper. The newness of the paper is to advise a HPWM-based single-segment grid-tie qZS-PV power machine. Segment II addresses the proposed HPWM for the unmarried-section qZSI; phase III evaluates the energy loss and section IV affords the design of machine impedance parameters beneath the HPWM; the grid-tie manipulate system design of HPWM-primarily based unmarried-segment qZSI PV energy generation is advanced in section V; experimental assessments and contrast with the conventional PWM-based unmarried-section qZSI are mentioned in section VI; eventually, segment VII concludes this work.

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2 PROPOSED HPWM FOR SINGLE-PHASE QZSI

2.1 SINGLE-PHASE QZSI

Fig. 1 suggests the discussed single-segment qZSI for grid-tie PV energy conversion. A capacitor \( C_p \) is attached in parallel to the PV panel terminal. The qZS network consists of the inductors \( L_1 \) and \( L_2 \), the capacitors \( C_1 \) and \( C_2 \), and the diode \( D_1 \) to boost PV voltage. The H-bridge segment legs 1 and a pair of are related to the single-phase ac grid via a filter out inductor \( L_f \). Capacitors \( C_1 \) and \( C_2 \); \( v_{D1} \) denotes the qZS diode voltage; \( v_{DC} \) and \( i_{DC} \) denote the dc-hyperlink voltage and contemporary, respectively. On the non-shoot-thru kingdom of Fig. 2(b), the PV panel and qZS inductors charge the qZS capacitors and provide the strength to the ac output, and the diode \( D_1 \) turns on.

![Fig. 1. Single-phase qZSI-based grid-tie PV power system.](image1)

![Fig. 2. Equivalent circuits of single-phase qZSI in (a) shoot-through state and (b) non-shoot-through state.](image2)
3 PROPOSED HPWM FOR SINGLE-PHASE QZSI

The HPWM is proposed in Fig. three for the unmarried-segment qZSI thru combining the PWM and the PAM. usually, the shoot-thru motion will value more loss inside the qZSI. it’s far better to avoid the shoot-thru occasion if the voltage boost is not wanted. For the single-phase qZSI, when the ac output voltage vo of H-bridge inverter is better than the common PVpanel voltage VPV, or decrease than VPV, the PV-panel voltage must be boosted to a high price before interfacing with the grid voltage, so the shoot-via movement is important and the PAM works; otherwise the qZSI can not inject modern-day into the grid.

4 CONCLUSION

On this paper, a HPWM-primarily based single-section qZS grid-tie PV strength gadget turned into proposed. to start with, the pro-
posed HPWM ended in reduction of energy loss, qZS capacitance, and qZS inductance. The new gadget used an independent manipulate variable, i.e., modulation signal to manipulate the MPPT of PV panel, grid-tie energy injection, and dc-hyperlink voltage. The outer-loop PV panel voltage manage and the internal-loop grid-tie modern-day control had been blended to fulfill the three desires. The grid-tie modern-day manipulate employed the PR and plug-in RC regulators to achieve zero errors monitoring and improve harmonic restraint. The power loss estimation and impedance layout were certain. A 500-W prototype turned into constructed to affirm the proposed HPWM-based totally single-segment qZS grid-tie PV strength system. assessment of the HPWM-based and PWM-based totally unmarried-segment qZSIs were completed in phrases of passive aspect parameter values, experimental waveforms, harmonic distortions, and performance. Experimental consequences demonstrated the brand new system and the theoretical analysis; an improved efficiency and smaller capacitance and inductance had been completed.

References


