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Quadratic Boost Converter with CLD Cell

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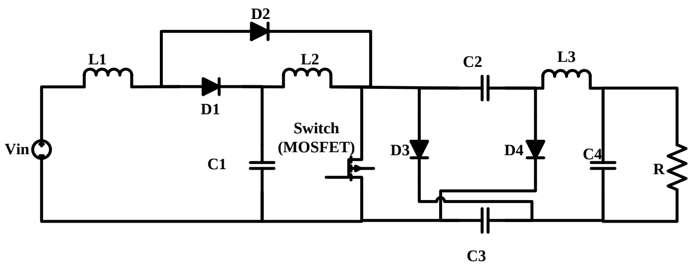
Abstract: A dc-dc converter is essential for Solar PV system to step up the low voltage from Solar panel/array to required voltage. In Solar PV system, the dc-dc converter will be buck-boost or boost converter. Many new boost converters are derived nowadays. In these, one of the modern converters is quadratic boost converter. Boost converters are required to operate with high duty ratio to achieve the higher output voltage. This high duty ratio limits the switching frequency because of high reverse recovery time, also it results poor efficiency and electromagnetic interference. In existing boost converters, the switches are suffered with high voltage stress. This project doesn't consider the electromagnetic interference but rest of the issues are taken care by incorporating Capacitor, Inductor, Diode (CLD) with the Quadratic boost converter. This quadratic boost converter with CLD is compared with other boost converters. In this proposed converter high output voltage is obtained with low duty ratio. Thus, it eliminates the problem of high reverse recovery time and limitation in using high switching frequency. It also reveals that the efficiency of the quadratic boost converter with CLD cell is higher than other boost converters and voltage stress is drastically reduced for the same output. Therefore, quadratic boost converter with CLD cell is well suited for solar PV applications.

Key Word: Quadratic Boost Converter; LCD Display; Current and Voltage Sensor; Power Supply12v &5v; Micro controller

1. Introduction

To overcome the problems in the quadratic boost converter and other converters introduced CLD cell to improve the switching frequency and to reduce the stress on the switches. In order to simplify the analysis, all components of the quadratic boost converter with CLD cell are treated as ideal. Assume that the quadratic boost converter with CLD cell operates in continuous conduction mode (CCM) and the switching frequency of the quadratic boost converter with CLD cell is much higher than its natural frequency. Then the capacitor voltages and inductor currents can be regarded as constant with relatively small AC ripple, and the quadratic boost converter with CLD cell circuit diagram is shown below,



2. Material and Methods

1. Existing System

1. J.A. Morales-Saldana, R. Galarza-Quirino (2013) proposed a controller design methodology for a quadratic boost converter with a single switch using current-programmed control in 2010. Nonlinear and linear models are developed; the later exhibits fourth-order characteristic dynamics with complex right-half plane zeros. The proposed control scheme is based on sensing the current of the switch and using it for feedback purposes. The design-oriented analytic results allow the designer to easily pinpoint

the control circuit parameters that optimize the converter's performance. At the end, experimental results are given for a 23 W quadratic boost converter where open loop and closed-loop response are compared

2.Yuang-ShungLee (2013) have suggested quadratic boost converter topology based on a high conversion ratio dc/dc converter with an active zero-voltage switching (ZVS) snubber circuit is developed for PV system application. Combined with a reboost inductor, a coupled inductor and charge-pump circuits are proposed to achieve high voltage gain with quadratic function. A front inductor is proposed to reboost the voltage gain to make the output voltage higher. The converter operating principle of the proposed conversion scheme is described in the detailed converter analysis.

3.Yuang-ShungLee (2013) have suggested quadratic boost converter topology based on a high conversion ratio dc/dc converter with an active zero-voltage switching (ZVS) snubber circuit is developed for PV system application. Combined with a reboost inductor, a coupled inductor and charge-pump circuits are proposed to achieve high voltage gain with quadratic function. A front inductor is proposed to reboost the voltage gain to make the output voltage higher. The converter operating principle of the proposed conversion scheme is described in the detailed converter analysis.

4. Yuan-mao Ye (2013) have proposed a new quadratic boost converter with the conventional quadratic boost converter, where the proposed converter has the feature of lower buffer capacitor voltage stress. This advantage is very valuable for high voltage gain applications. The proposed converter also employed only one active switch and two LC filters.

2. Literature Survey

The converter with less duty ratio and reduces the limitation of high switching frequency. Also to reduces the voltage stress across the switches and improve efficiency.

2.1 Continuous Conduction Mode (2020): Sungsik Park [8] (2020) has proposed a new soft-switched continuous conduction mode (CCM) boost converter suitable for high-power applications such as power factor correction, hybrid electric vehicles and fuel cell. The proposed converter achieves Zero-Voltage-Switched (ZVS) turn-on of active switches in CCM and Zero-Current-Switched (ZCS) turn-off of diodes leading to negligible reverse-recovery loss. The components' voltage ratings and energy volumes of passive components of the proposed converter are greatly reduced compared to the conventional zero-voltage-transition converter.

2.2 Single Switch Mode (2020): K.H .Beena, Anish Benny [6] (2020) have explained about the quadratic boost converter in single switch mode and it was used to boost the 18 volt DC battery voltage to 70 volts output level using a single switch in a geometric approach. The Quadratic boost converter for its application in 50W load is designed. The converter gains and passive elements values can be theoretically calculated using design equations. The Experiment result shows the performance of the converter designed for 50W load.

2.3 Quadratic Boost Converter with 23W(2021): J.A. Morales-Saldana, R. Galarza-Quirino [1] (2021) proposed a controller design methodology for a quadratic boost converter with a single switch using current-programmed control in 2010. Nonlinear and linear models are developed; the later exhibits fourth-order characteristic dynamics with complex right-half plane zeros. The proposed control scheme is based on sensing the current of the switch and using it for feedback purposes. The design-oriented analytic results allow the designer to easily pinpoint the control circuit parameters that optimize the converter's performance. At the end, experimental results are given for a 23 W quadratic boost converter where open loop and closed-loop response are compared.

2.4 Zero-Voltage Switching Snubber Circuit(2021): Yuang-Shung Lee [2] (2021) have suggested quadratic boost converter topology based on a high conversion ratio dc/dc converter with an active zero-voltage switching (ZVS) snubber circuit is developed for PV system application. Combined with a reboost inductor, a coupled inductor and charge-pump circuits are proposed to achieve high voltage gain with quadratic function. A front inductor is proposed to reboost the voltage gain to make the output voltage higher. The converter operating principle of the proposed conversion scheme is described in the detailed converter analysis.

2.5Reduced Reduntant Power Processing (2022): Jorge Alberto Morales-Saldaña [4] (2022) have presented a study of a quadratic boost converter based on the Reduced Redundant Power Processing (R^2P^2) principle, as well as the controller design methodology using current-programmed control to satisfy the specifications of output voltage regulation. When the current loop is implemented, the fourth-order dynamics are changed to a dominant first order, which simplifies the controller design of outer loop. For this loop, a conventional controller is designed. At the end, experimental results are given for a 23 W quadratic boost converter, where open-loop and closed-loop responses are compared.

2.6 Conventional Quadratic Boost Converter (2022): Yuan-mao Ye [5] (2022) have proposed a new quadratic boost converter with the conventional quadratic boost converter, where the proposed converter has the feature of lower buffer capacitor voltage stress. This advantage is very valuable for high voltage gain applications. The proposed converter also employed only one active switch and two LC filters.

2.7 Quadratic Boost Converter (2019):K.Tattiwong [7] (2019) have presents analysis, design and experimentation of a Quadratic Boost Converter (QBC). Operation of the QBC is analyzed, leading to mathematical expressions that can be used to design the converter. Based on the derived analytical expressions, a 100W, 12V-to-48V, quadratic boost converter is designed and built. Experiment result shows that the prototyped converter operates satisfactorily throughout its operating range and achieves the highest efficiency of 83%.

3. Proposed System

The block diagram of the proposed system is explained in figure 1. The proposed system consists of battery and different sensors like the current sensor, voltage sensor, a quadratic boost converter and then power supply for with lcd display achieve high voltage gain in the converter with less duty ratio and reduces the limitation of high switching frequency. Also to reduces the voltage stress across the switches and improve efficiency

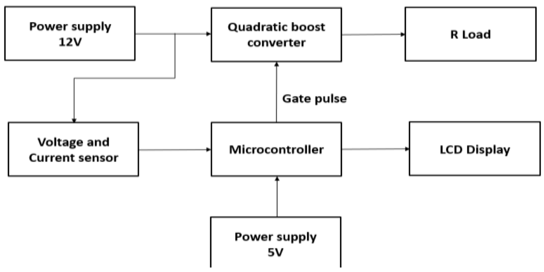


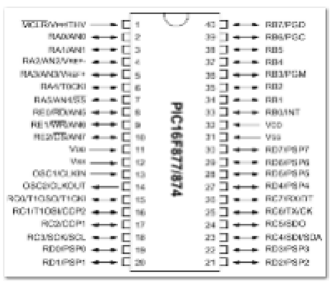
Figure 1 Block Diagram of proposed system

3.1 Power Supply Unit

A power supply (sometimes known as a power supply unit or PSU) is a device or system that supplies electrical or other types of energy to an output load or group of loads. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others**.** All digital circuits work only with low DC voltage. A power supply unit is required to provide the appropriate voltage supply. This unit consists of transformer, rectifier, filter and a regulator. AC voltage typically of 230Vrms is connected to a transformer which steps that AC voltage down to the desired AC voltage level. A diode rectifier then provides a full wave rectified voltage that is initially filtered by a simple capacitor filter to produce a DC voltage. This resulting DC voltage usually has some ripple or AC voltage variations. The required DC supply is obtained from the available AC supply after rectification, filtration and regulation. The main components used in the power supply unit are Transformer, Rectifier, Filter and Regulator. The 230V AC supply is converted into 9V AC supply through the transformer. The output of the transformer has the same frequency as in the input AC power. This AC power is converted into DC power through diodes. Here the bridge diode is used to convert AC supply to the DC power supply. This converted DC power supply has the ripple content and for normal operation of the circuit, the ripple content of the DC power supply should be as low as possible. Because the ripple content of the power supply will reduce the life of the circuit. So, to reduce the ripple content of the DC power supply, the large value of capacitance filter is used. This filtered output will not be the regulated voltage. For this purpose, IC7805 regulator IC is used in the circuit.

3.1.1 Microcontroller
PIC16F877A Microcontroller

PIC is a family of modified Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1650 originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to "Peripheral Interface Controller". PICs are popular with both industrial developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability



3.1.2Diode IN4007

General Purpose Diode in DO-214AC (SMA) package (surface mount version of 1N4007). The 1N4001 series is a family of popular 1.0 Amps general-purpose silicon rectifierdiodes commonly used in AC adapters for common household appliances. Blocking voltage varies from 50 to 1000 volts. This diode is made in an axial-lead DO-41 plastic package. These diodes are typically available in the larger DO-201AD axial package to dissipate heat better. These are fairly low-speed rectifier diodes, being inefficient for square waves of more than 15 kHz. In the version of these components manufactured for Fairchild Semiconductor in Suzhou, the silicon chip that rectifies the current weights just 880 micrograms. These used in general purpose rectification of power supplies, inverters, converters and freewheeling diodes application.

3.1.3 Inductor Design

Inductors are designed by using ferrite core. High magnetic permeability with low electrical conductivity and low losses at high frequencies are the major properties of ferrite core. It highly increases the inductance value for the same amount of copper used, meanwhile it increases the quality factor (Q) of the inductor. So the ferrite cores are chosen to make inductors for converters.

3.1.4 Mosfet P55NF06

The N-Channel Power Mosfet Transistor P55NF06 is three-terminal silicon device with current conduction capability of about 50A and fast switching speed with Low on-state resistance, breakdown voltage rating of 60V and maximum threshold voltages of 4 volt. It is mainly suitable for electronic ballast, and low power switching mode appliances

3.2 Transformer

Transformer is a device used either for stepping-up or stepping-down the AC supply voltage with a corresponding decrease or increases in the current. Here, a transformer is used for stepping-down the voltage so as to get a voltage that can be regulated to get a constant 5V.

3.3 Rectifier

A rectifier is a device capable of converting sinusoidal input waveform into a unidirectional waveform, with non-zero average component.

.3.4 Filters

Capacitors are used as filters in the power supply unit. The action of the system depends upon the fact, that the capacitors stores energy during the conduction period and delivers this energy to the load during the inverse or non-conducting period. In this way, time during which the current passes through the load are prolonged and ripple is considerably reduced.

3.5 Voltage Regulator

The LM78XX is three terminal regulators available with several fixed output voltages making them useful in a wide range of applications. IC7805 is a fixed voltage regulator used in this circuit. Circuit diagram of such power supply.

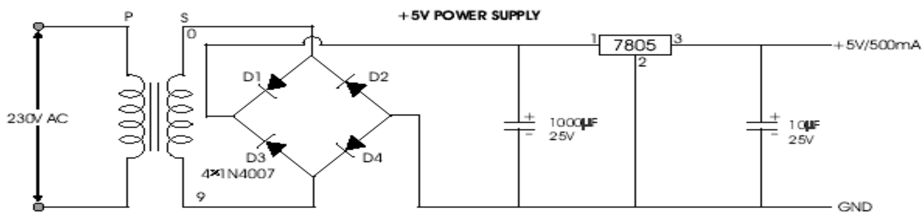


Figure 2: Volts Power Supply Circuit

3. Results

The hardware setup of the Quadratic Boost Converter. The output of Quadratic Boost Converter with with CLD Cell is shown in below figure 3:

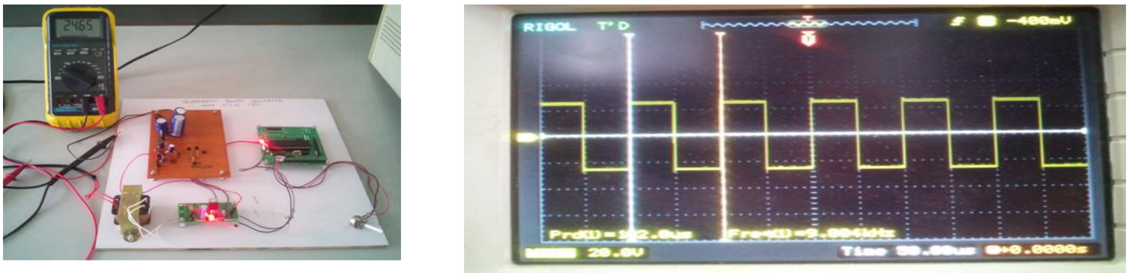


Figure 3: Quadratic Boost Converter

4. Discussion

The Quadratic Boost Converter with CLD cell is Implemented and results are compared with the simulation output PIC16F877A microcontroller based control circuit is used for providing gate pulse to the switch. And the input voltage 5v of quadratic Boost Converter with CLD Cell. The Gate Pulse wave form measured from DSO for MOSFET 0fQuadratic Boost Converter with CLD Cell from the duty ratio value set to 0.3.

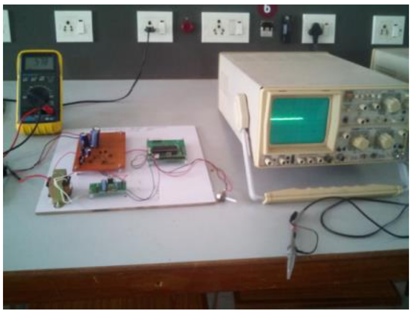


Figure 4: Hardware ouputs

5. Conclusion

In this project CLD cell is incorporated with conventional boost and quadratic boost converter and new topologies were derived. These two converters are compared with boost and quadratic boost converters. The simulation results shows that quadratic boost converter with CLD topology has the higher voltage gain than other three boost converters for the same duty ratio. It is also observed that in quadratic boost converter with CLD topology, the voltage stress is minimized and high efficiency is achieved for same output voltage than other boost converters.

Even for small duty ratio, quadratic boost converter with CLD topology offers high voltage gain. This behaviour allows the converter to operate in high swiching frequency range. The performance of a proposed converter is validated by the hardware results. Hence the quadratic boost converter with CLD topology is more convenient for solar PV applications.

The other many DC-DC converter are proposed by authors. The CLD structure can incorporated with those converters and can measure the performance and suitability for renewable energy sources. Also the MPPT techniques is to be incorporate with the proposed converter and make this converter as more suited for solar PV applications.

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