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Simulation of Quasi Z-Source Converter Based Zero Voltage Electronic Loads

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Abstract - Electronic loads are a family of power converters which can be used as a variable impedance load in different applications. This paper analyzes high efficiency zero-voltage electronic loads based on the quasi Z-source converter topology .The proposed topology operate as an ideal current source which enables the operation of the zero input voltage. It can achieve a high efficiency of more than 90% which reduces the system cost. . The validity of this proposed method has been studied by the PSPICE Simulation and prototype experiment.

Index terms- Electronic loads, ideal current source, Z-source converter, Converter

I. INTRODUCTION

Quasi-Z-source inverter (qZSI) is a new promising power conversion technology perfectly suitable for interfacing of renewable (i.e., photovoltaic, wind turbines) and alternative (i.e., fuel cells) energy sources [1-3].The qZSI has the following advantages:

• Boost-buck function by the one-stage conversion;

• Continuous input current (input current never drops to zero, thus featuring the reduced stress of the input voltage source, which is especially topical in such demanding applications as power conditioners for fuel cells and solar panels);

• Excellent reliability due to the shoot-through withstanding capability;

• Low or no in-rush current during start up;

• Low common-mode noise.

However, the efficiency and voltage gain of the qZSI are limited and comparable with the conventional system of a voltage source inverter with the auxiliary step-up DC/DC converter in the input stage [4]. The concept of extending the qZSI gain without increasing the number of active switches was recently proposed by several authors [5-8].

Electronic loads are a family of power converters which can be used as a variable impedance load in different applications. With the continuous development of new dc power supply configurations and the accelerated production of electronic devices, the need of ELs for testing those power supplies is growing [9]–[15]. In order to test these new power supplies with high efficiency, the power recycling concept has been developed to reduce the cost and conserve energy [9]–[15].

The principle of conventional ELs is to behave as a variable resistance. A simple way to realize an EL is by operating a bipolar junction transistor in its linear region and controlling the impedance by varying its base current.

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In this case, the transistor should be rated for the maximum power of the source under test (SUT), which increases the system cost. Another low-cost implementation can be achieved by using a switching device in series with a resistor . In this case, a passive filter that is composed of an inductor and a capacitor is necessary to smooth the input current of the SUT. A more sophisticated method is the use of a dc–dc converter which uses conventional current control methods.[16-21].

The Conventional topologies have two important limitations. First, all the tested powers are dissipated in the EL, either in a transistor or in a resistor, which wastes energy and makes it difficult to increase the power rating of the EL. Second, these topologies require a minimum input voltage to control the input current. Below this minimum voltage, the EL does not work properly.

The Z-source converter was introduced in [22] as an impedance network to overcome the limitation of traditional voltage-source converters and current-source converters. It has been shown that it can be used in virtually all the power conversion range with a novel conversion concept, which can be extended to many applications [23]. The Z-source converter can achieve an efficiency of more than 90% in most of the power operating range [24].

This paper analyzes high efficiency zero-voltage electronic loads based on the quasi Z-source converter topology . The proposed topology operate as an ideal current source which enables the operation of the zero input voltage. It can achieve an efficiency of more than 90% in most of the power operating range . The validity of this proposed method has been studied by the PSPICE Simulation and prototype experiment.

II. QUASI Z-SOURCE CONVERTER

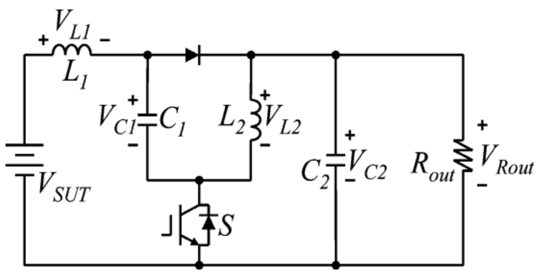

Fig.1.qZ-source-converter

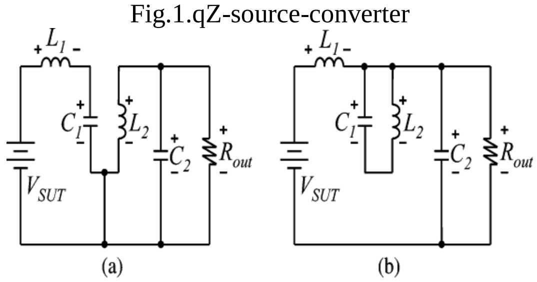

Fig.2. Equivalent circuits for the qZ-source converter. (a) Switch is on.(b) Switch is off.

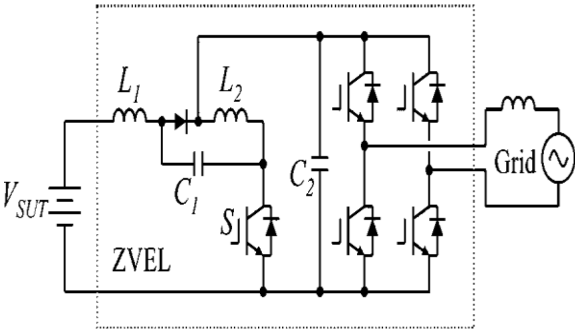

Fig.3.qZ-source-converter-based ZVEL

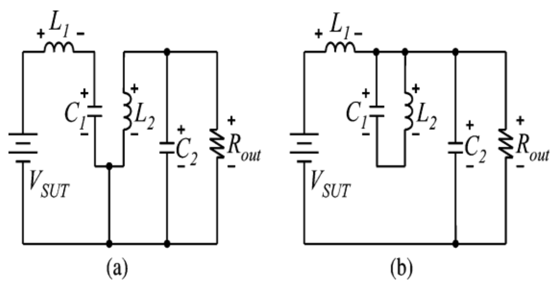

Fig.6. Equivalent circuits for the qZ-source-converter-based ZVEL (a) Switch is on and (b) Switch is off.

Figure 1 and 3 shows a circuit topology of the qZ-source-converter. The SUT voltage appears on the left side, a low-pass filter smoothes the input current, and the Z-source converter is connected after the low-pass filter with only one switch for the Z-source-converter operation. A Z-source network composed of two inductors L_1, L_2,and two capacitors C_1, C_2 is connected to the primary side of the low pass filter. The two inductors have the same value L, and two capacitors have the same value C. When the switch is closed, the shoot-through state occurs and the converter performs the action. When the switch is open, the active (non-shootthrough) state emerges.

Analyzing the circuit shown in Fig. 3, if a dc load is connected to capacitor C_2, such as the case of the AFE converter pushing power onto the grid, or the converter is used on another application, then the circuit becomes the one shown in Fig. 1. For the sake of simplicity, the following schematics show only the voltage polarity assignments.[25].

III. HARDWARE CIRCUIT DIAGRAM

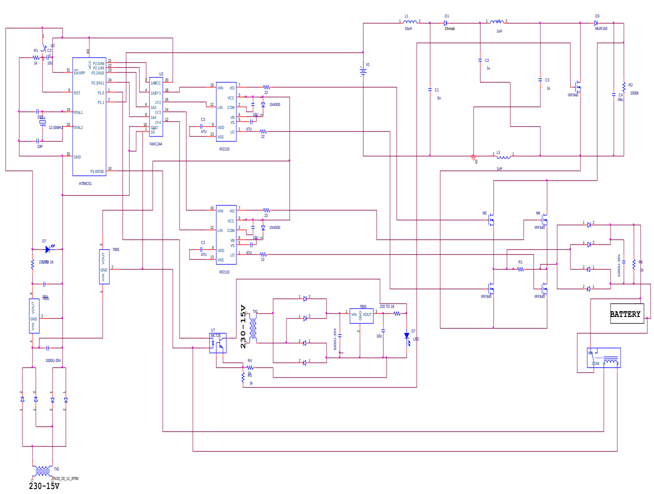

Fig.5.Hardware circuit of the proposed method

The hardware circuit of the proposed method is shown in fig.5. The hardware circuit consists of the following major parts such as power supply unit, microcontroller circuit, buffer circuit and isolation circuit. The qZ-source-converter-based zero voltage electronic load saves one capacitor and one inductor compared with the traditional Z-source converter-based zero voltage electronic load.

IV. SIMULATION RESULTS

In this paper, the simulation model is developed with PSPICE tool .The simulation circuit of the proposed method and the output waveforms are shown in fig.6, 7, 8 and 9. The Supply voltage of qZ-source converter is 20V and achieved output voltage is 25V. The experimental parameters are source inductor=10mH capacitor=1000µF and a resistor load of 100kΩ.

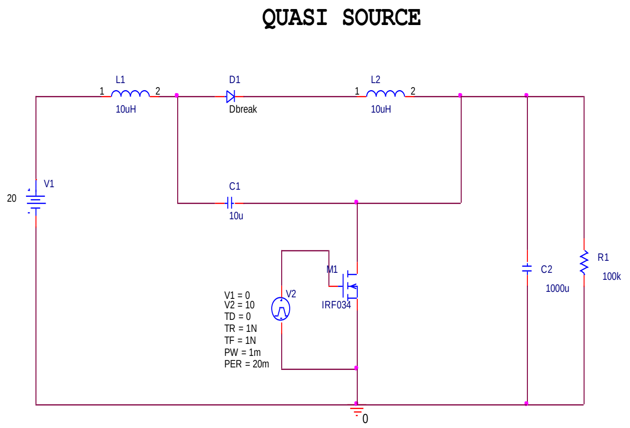

Fig.6.Simulation circuit of the qZ-source-converter

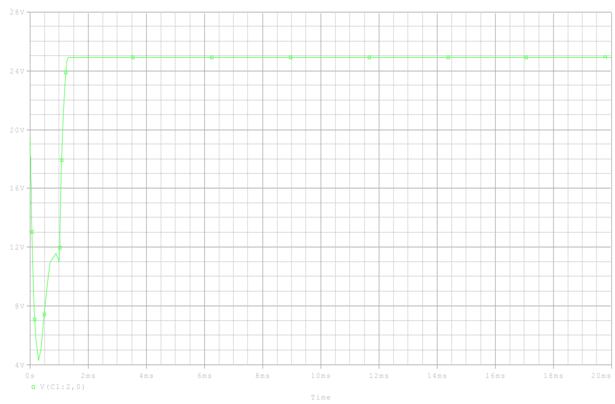

Fig.7.Output waveform

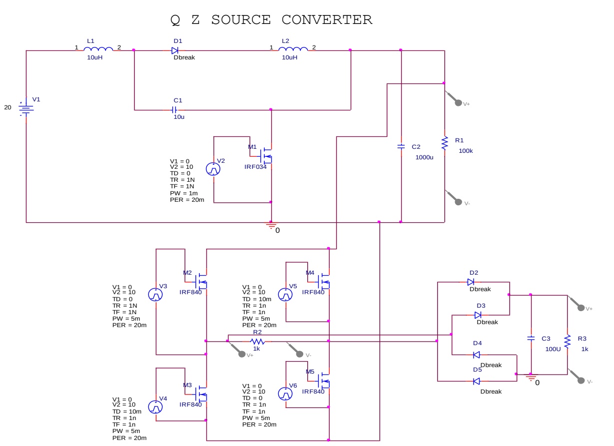

Fig.8. Simulation circuit of the qZ-source-converter-based ZVEL

Fig.9.Output waveform

V. CONCLUSION

In the Present Work, this paper analyzes high efficiency zero-voltage electronic loads based on the quasi Z-source converter topology .The proposed topology operate as an ideal current source which enables the operation of the zero input voltage. It can achieve high efficiency and also reduces the system cost when compared to the traditional Z-source converter. The performance of this proposed method has been studied by the PSPICE Simulation and prototype experiment.

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