Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online): 0493-2137
E-Publication: Online Open Access
Vol:54 Issue:12:2021
DOI 10.17605/OSF.IO/8SAEY

A CONSTANT POWER CONVERTER WITH POWER FACTOR CORRECTION AND INHERENT SOFT SWITCHING

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ABSTRACT

The comparison of the proposed constant power converter with the traditional power converter with inherent soft switching and power factor correction is presented. The constant power converter circuit is implemented and is used to charge a battery. The improvement of the power factor is achieved by the boost converter. The replacement of the single winding transformer by the center tapped transformer increases the output voltage and reduces the size of the circuit. Harmonics and ripples were observed in the circuit which is reduced using filter. The reduction in cost, compactness and power factor correction makes the constant power converter circuit utilization in high frequency applications. A 60% reduction in ripple is achieved by this constant power converter circuit. Hence it provides a better solution compared with the conventional circuit. The objective is to design a constant power converter circuit and also, to simulate the constant power converter circuit as well as the conventional circuit. AC input voltage and current, boost converter voltage, and DC output voltage time waveform of the above-mentioned circuits are observed and analyzed, further being implementing the converter circuit using constant power mode.

Keywords: Zero Voltage Switching, Boost Converter, Power factor correction, Constant power mode

I. Introduction

This paper deals with the simulation and implementation of a constant-power converter circuit with power factor correction and soft switching built in. The main application is battery charging. Basically, batteries are charged by two modes of operation. Constant-voltage and constant-current modes are used. These two modes of operation have some difficulties in thermal installation that is overcome by the constant-power converter circuit. The constant power converter circuit features are, an inherent power limiting characteristic, the thermal installation of the circuit is reduced due to the discontinuous voltage mode operation. The size of the circuit is reduced due to the minimal thermal

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installation, The inherent power factor correction is achieved by using boost converter, Soft switching is done by Zero Voltage Switching, Voltage stress and the current stress are reduced by Zero VoltageSwitching, The constant power converter circuit is used for high frequency applications, Filter circuits are used to remove harmonics.

II. Block Diagram of Constant Power Converter using Conventional Circuit

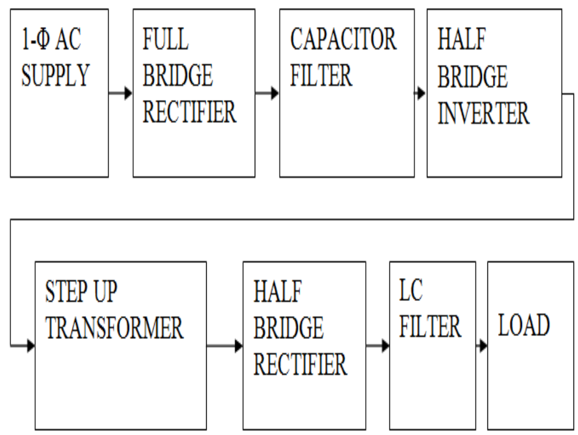

Figure 2.1 Block Diagram of Conventional Circuit

Figure 2.1 depicts the block diagram of the conventional circuit. To convert AC to DC, a complete bridge rectifier receives an AC supply. The full bridge rectifier connected to the capacitive filter is used to filter AC and allow DC. The half bridge inverter is connected to the capacitive filter.

III. Circuit Diagram of Conventional Constant Power Converter

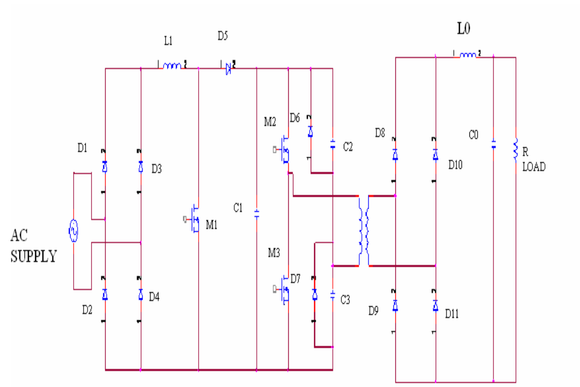

Figure 2.2 Circuit Diagram of Conventional Circuit

The circuit diagram of the traditional circuit is shown in Figure 2.2. During inverter

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action, the MOSFET M1 is turned on, the capacitor C2 is charged, and the capacitor C1 is discharged. The capacitor C1 is charged and the capacitor C2 is discharged when MOSFET M2 is turned on. To raise the voltage, the inverter's output voltage is connected to the primary of the step up transformer (centre tapped). It's linked to a half-bridge converter that converts AC to DC. The half bridge converter's output is connected to an LC filter, which allows only DC and block AC to pass through. The filter output is connected to the load

IV. Block Diagram of Constant Power Converter using Boost Converter

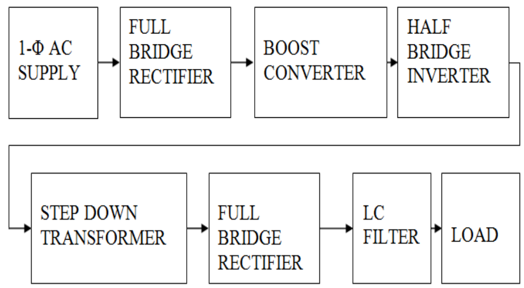

Figure 2.3 Block Diagram of Constant PowerConverter using Boost Converter

Figure 2.3 depicts the block diagram of the constant power converter. This circuit is similar to the conventional circuit. The boost converter for power factor correction is included, as well as the center tapped transformer in the conventional circuit is replaced by the single winding transformer which reduces the size of the circuit. The half bridge converter connected to the secondary side of the transformer in conventional circuit is replaced by fullbridge converter.

V. Circuit Diagram of Constant Power Converter using Boost Converter

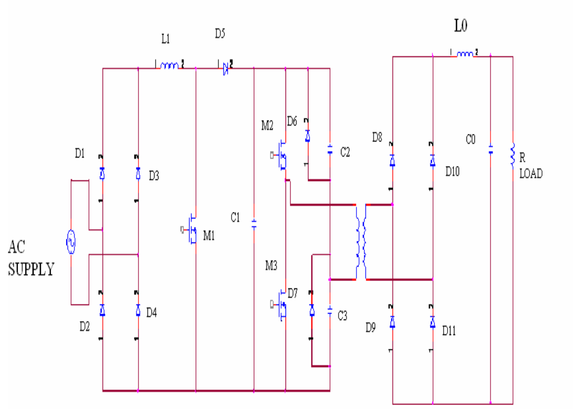

Figure 2.4 Block Diagram of Constant PowerConverter using Boost Converter

The constant power converter's circuit diagram is shown in Figure 2.4.

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VI. Design Procedure for Constant Power Converter

To design the constant power converter circuit assumptions are Frequency f = 10 KHz, Load Resistance R= 1000 Ω, Ripple Factor = 0.02% and Duty cycle δ = 0.5.

Let V_0 = Output Voltage,
V_i = Input Voltage,
L = Inductance of the Boost Converter,
C = Capacitance of the boost converter,
L_0 = Inductance of the boost converter,
C_0 = Capacitance of the boost converter,
i = Current,
ɼ = Ripple.

(i) To design inductance and capacitance value in Boost converter
$V_0 = Vi / (1 - \delta) = 12 / (1 - 0.5) = 24$ V

$L = (V_0 \times \delta) / (f \times i) = (24 \times 0.5) / (10000 \times 2.5) = 3$ mH
$C = \delta / (2 \times f \times R) = 0.5 / (2 \times 10000 \times 1000) = 25$ nF
(ii) To design inductance and capacitance value in LC filterAssume Capacitance C_0 = 250 µF

ɼ = $\sqrt{(3)} / (\omega^2 \times L_0 \times C_0) = 2 \times 10^{-4} = \sqrt{(3)} / ((2 \times 3.14 \times 25000)^2 \times L_0 \times 250 \times 10^{-6}) L_0 = 3.5$ mH

VI. Simulation of Conventional and Constant PowerConverter

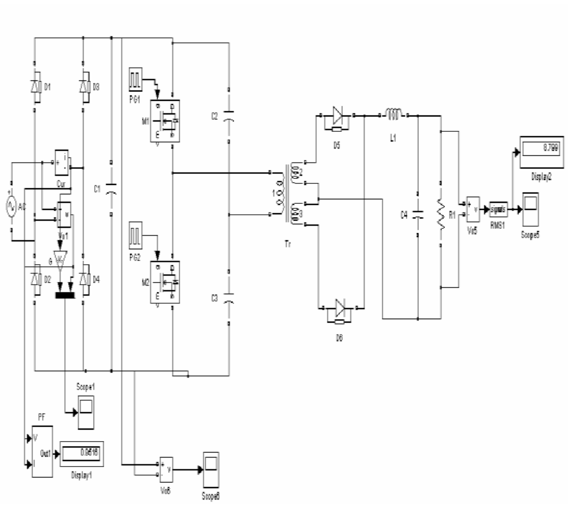

Figure 3.1 Conventional Circuit

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The connection shown in Figure 3.1 shows the conventional circuit. The rectifier is powered by an AC supply. The primary side of the centre tapped transformer is wired to an inverter circuit. The secondary side of the centre tapped transformer is attached to a half bridge converter followed bythe filter and the load. The gate pulse for the switch is provided using a pulse generator. The pulse generators fed to these switches are programmed and fixed at a phase delay of 0% of PG_1 and 0.002% of PG_2. These pulse generators regularize the timely operation of the switches based on the programmed phase delays, opening and closing the switches.

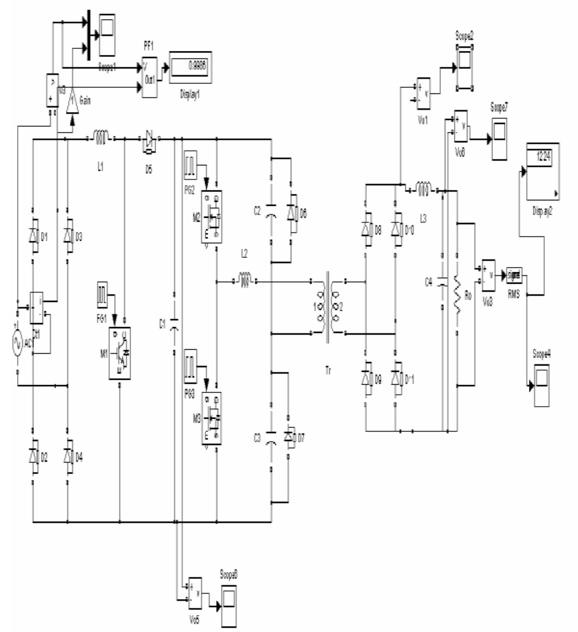

Figure 3.2 Constant Power Converter circuit

The constant power converter circuit is shown in Figure 3.2. The full bridge rectifier, which converts AC to DC, is attached to the AC supply. The boost converter receives the rectifier's production. The primary side of the transformer is connected to a half bridge inverter circuit, while the secondary side is connected to a complete bridge converter. The pulse generators fed to these switches are programmed and fixed at a phase delay of 0% of PG_1, PG_2 and 0.02% of PG_3. The improvement ofpower factor is achieved by the boost converter. A boost converter (also known as a step-up converter) is a power converter that has a higher output DC voltage than its input DC voltage. The replacement of the single winding transformer by the center tapped transformer increases The output voltage as well as the circuit's size are decreased. The proposed circuit is simulated and its output is compared with the conventional circuit.

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TABLE 1 DATA FOR SIMULATION OF THE PROPOSED CIRCUIT

Parameter	Values
Vin	12 V
D	1000 V, 1 A
L	3 mH
C	25 nF
T1, T2, T3	0.1 ms, 4 ms, 4 ms
L_0	3.5 mH
C_0	250 µF
R_0	1000 Ω

VII. SIMULATION OUTPUT

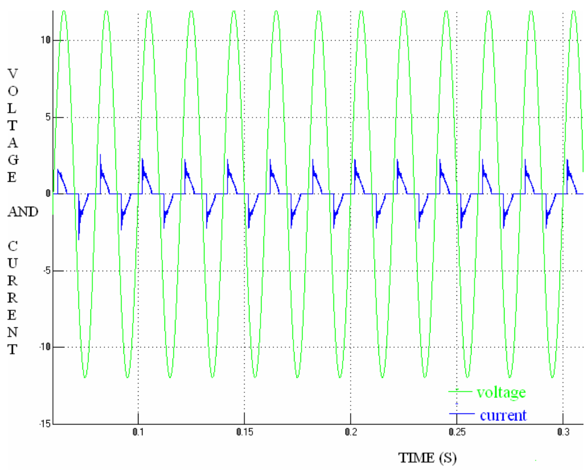

Figure 3.3 AC Input Voltage and Current of the Conventional Circuit

The traditional circuit's AC input voltage and current are shown in Figure 3.3

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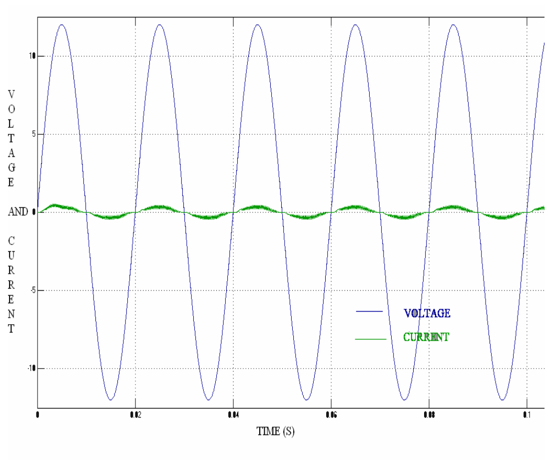

Figure 3.4 AC Input Voltage and Current of the ConstantPower Converter

The traditional circuit's of Figure 3.4 AC input voltage and current of the constant power converter circuit is shown in Figure 3.4. In conventional circuit AC input voltage is a sinusoidal waveform but current is not sinusoidal. It is due to the presence of capacitor connected parallel to full bridge converter on the input side. The phase angle difference of voltage and current has large value so that the power factor is farther to unity.

In constant power converter circuit AC input voltage and current both are sinusoidal due to the connection of boost converter with full bridge converter. Here the phase angle difference of voltage and current has very small value so that the power factor is near to unity.

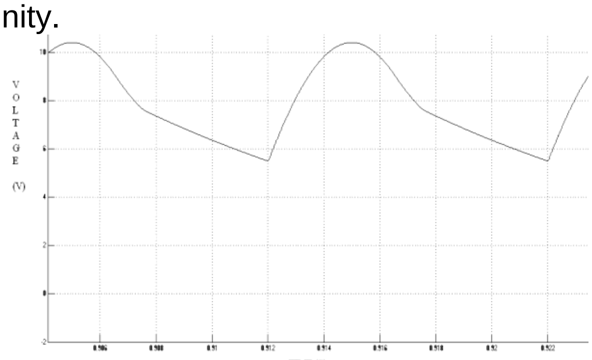

Figure 3.5 Capacitor Filter Voltage of the Conventional Circuit

The Traditional circuit’s of Capacitor filter voltage of the conventionalcircuit is shown in Figure 3.5.

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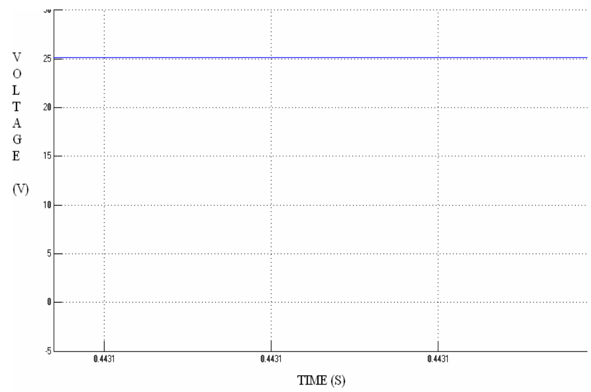

Figure 3.6 Boost Converter Voltage of the ConstantPower Converter Circuit

Figure 3.6 shows the boost converter voltage of the constant power converter circuit. In conventional circuit due to the presence of On the input side, a complete bridge converter is connected to a capacitor filter which allows only DC and block AC but it contains small amount of AC because of that the waveformis not pure DC as shown above. The output voltage of the capacitance filteris 10.2 V.

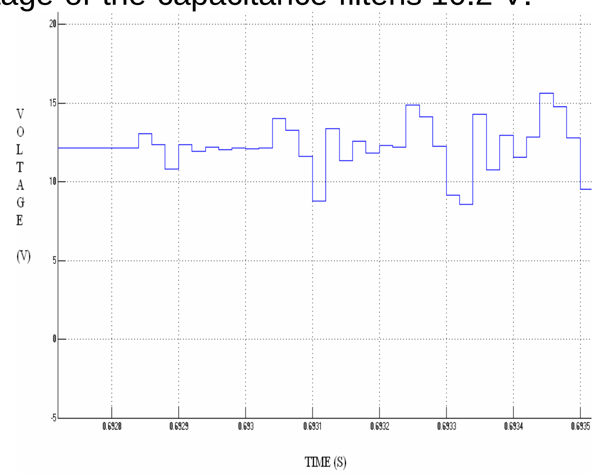

Figure 3.7 Full Bridge Rectifier Voltage before filter ofthe Constant Power Converter

In constant power converter circuit the output voltage is pure DC due to the presence of boost converter connected parallel to full bridge converter connected on input side. The boost converter's output voltage is 25 volts. Full bridge rectifier voltage before filter of the constant power converter is shown in Figure 3.7.This is a DC output but it has some ripple. Filter circuit is added to reduce the ripple.

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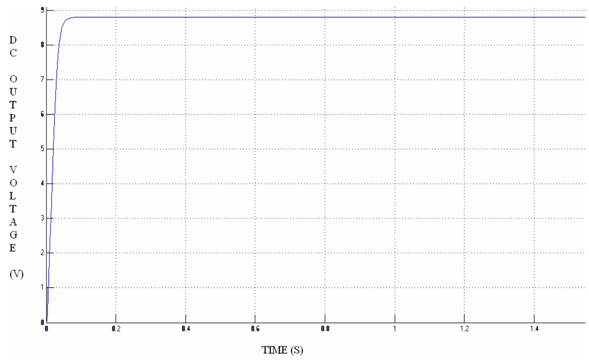

Figure 3.8 DC Output Voltage of the Conventional Circuit

Figure 3.8 shows the DC output voltage of the conventional circuit and Figure 3.9 shows the DC output voltage of constant power converter circuit.

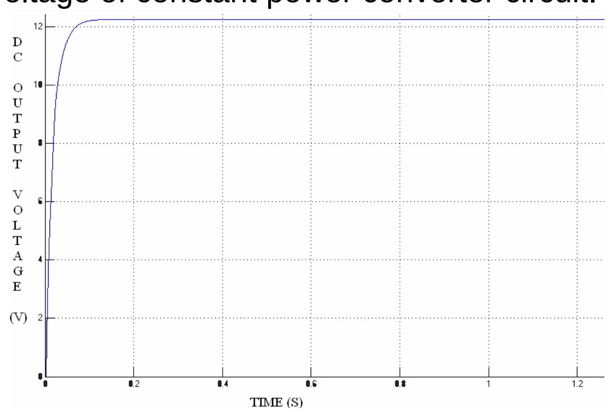

Figure 3.9 DC output voltage of the Constant PowerConverter Circuit

In conventional circuit, the DC output voltage is a pure DC but the obtained DC value is less value due to the connection of half bridge converter with LC filter on the secondary side of the transformer but in constant power converter circuit the output DC value is more than conventional due to the connection of full bridge converter with LC filter on the secondary side of the transformer and also due to boost converter on the primary side of the transformer. The DC output voltage shown in 3.8 and 3.9 are Root Mean Square Voltage. The DC output voltage of the constant power converter circuit has a 40 percent ripple.

TABLE 2 Comparison if the Conventional And Constant Power Converter Circuit

Parameter	Conventional	Constant Power Converter
Input Voltage	12 V	12 V
Output Voltage	8.799 V	12.24 V
Power Factor	0.9516	0.9986

The comparison of the conventional and constant power converter circuit is shown in TABLE 2 which compares the input voltage, output voltage and power factor.

VIII. CONCLUSION

The simulation circuits of the conventional and the constant power converter were discussed and analyzed. The AC input voltage and current, boost converter, and DC output voltage waveforms were all obtained. From the Simulation results, it is proved that the desired output was obtained as per the design calculation for constant power battery charger circuit. The Power factor of the converter circuit was also improved to 0.9986 from conventional value of 0.9516. The Voltage stress and harmonics were also being reduced using Soft switching technique and LC filters.

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